sending a transmit power control (TPC) command (Page 4, line 17-Page 5, line 8);

receiving an uplink signal from the remote transceiver at a calculated transmit power level based on a path loss and the TPC command *(Page 4, line 18-Page 5, line 8, Zeira teaches the first station (base station) transmits power commands based on in part a reception quality of the received communications. The first station (base station) transmits a second communication (remote terminal) having a transmission power level in a first time slot. The second station receives the second communication and the power commands. A power level of the second communication as received is measured (calculated). A path loss estimate is determined based on in part the measured received second communication power level and the first communication power level)*, but fails to teach on a shared physical channel used to carry allocation and scheduling information from the base station to the remote transceiver, sending an allocation of a scheduled uplink transmission resource.

However, in related art, Chen teaches on a downlink dedicated control channel (DCCH) channel used to carry allocation and scheduling information from the base station to the remote transceiver, sending an allocation of a scheduled uplink transmission resource *(Paragraphs 0012,0052-0057, especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches the transmitting unit 15 is configured to notify the radio resources allocated by the resource allocating 14 to the* *mobile station via a downlink dedicated control channel (DCCH). Paragraph 0052, Chen teaches the resource allocating unit 14 is configured to allocate a radio resource which is used in uplink packet communications with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).* Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

The combination of Zeira and Chen fail to teach on a shared physical channel used to carry allocation and scheduling information.

However, Van Lieshout teaches on a shared physical channel (shared radio channel) used to carry allocation and scheduling information (Para. 0006). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of van Lieshout to Zeira and Chen so that the mobile unit can find out the available resources that it can use from the base station.

9. Claims 8 and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Chen et al. (US Pub. No. 2005/0025056) in view of Van Lieshout et al. (US Pub. No. 2001/0036823) and further in view of Shiu et al. (US Patent #6,983,166).

Regarding claims 8 and 34, the combination of Zeira, Chen, and Van Lieshout fails to teach the method of power control, wherein the calculated transmit power level is based on parameter associated with a selected transport format.

However, in related art, Shiu teaches the method of power control, wherein the calculated transmit power level is based on parameter associated with a selected transport format. (Col 3, lines 27-41).Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Shiu to Zeira, Chen, and Van Lieshout in order to adjust transmit power and achieve target block error rate (BLERs) (See Shiu, Col 3, line 31).

10. Claims 16,17,30,31,44,45,47, and 48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Chen et al. (US Pub. No. 2005/0025056) in view of Van Lieshout et al. (US Pub. No. 2001/0036823) and further in view of Krishnan et al. (US Pub. No. 2005/0176455).

Regarding claims 16,30,44, and 47, the combination of Zeira, Chen, and Van Lieshout fail to teach the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

However, in related art, Krishnan teaches the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only (Paragraphs 0047-0050, especially, Paragraphs 0049-0050). Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Krishnan to Zeira, Chen, and Van Lieshout in order to provide the transmitting terminal feedback regarding the power of signals received at the receiving terminal.

Regarding claim 17,31,45, and 48, the combination of Zeira, Chen, and Van Lieshout fail to teach the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control.

However, in related art, Krishnan teaches the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control (Paragraphs 0047-0050, especially, Paragraphs 0049-0050).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Krishnan to Zeira, Chen, and Van

Lieshout in order to provide the transmitting terminal feedback regarding the power of signals received at the receiving terminal.

11. Examiner has cited particular columns and line numbers in the references applied to the claims above for the convenience of the applicant. Although the specified citations are representative of the teachings of the art and are applied to specific limitations within the individual claim, other passages and figures may apply as well. It is respectfully requested from the applicant in preparing responses, to fully consider the references in entirety as potentially teaching all or part of the claimed invention, as well as the context of the passage as taught by the prior art or disclosed by the Examiner. SEE MPEP 2141.02 [R-5] VI. PRIOR ART MUST BE CONSIDERED IN ITS ENTIRETY, INCLUDING DISCLOSURES THAT TEACH AWAY FROM THE CLAIMS: A prior art reference must be considered in its entirety, i.e., as a whole, including portions that would lead away from the claimed invention. W.L. Gore & Associates, Inc. v. Garlock, Inc., 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) In re Fulton, 391 F.3d 1195, 1201,73 USPQ2d 1141, 1146 (Fed. Cir. 2004). >See also MPEP §2123.

Response to Arguments

12. Applicant's arguments with respect to claims 1-4,7,8,15-17,26,28,30-34, and 43-48 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

13. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Miyoshi et al. (US Pub. No. 2004/0171387), Kim et al. (US Pub. No. 2003/0032411, Para. 0008), Jiang et al. (US Pub. No. 2005/0041673, Para. 0005), Hwang et al. (US Pub. No. 2005/0207359, Para. 0038), Petrovic et al. (US Pub. No. 2007/0081492, Para. 0010 and 0117), Chao et al. (US Pub. No. 2009/0028111, Claims 1 and 5).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to DOMINIC E. REGO whose telephone number is (571)272-8132. The examiner can normally be reached on Monday-Friday, 8:30 am-5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Duc M. Nguyen can be reached on 571-272-7503. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dominic E. Rego
/Dominic E Rego/
Examiner, Art Unit 2618
Tel 571-272-8132

/Duc Nguyen/
Supervisory Patent Examiner, Art Unit 2618

Notice of References Cited	Application/Control No. 10/917,968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLI	
	Examiner DOMINIC E. REGO	Art Unit 2618	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2001/0036823	11-2001	Van Lieshout et al.	455/418
*	B	US-2004/0171387	09-2004	Miyoshi et al.	455/452.2
*	C	US-2003/0032411	02-2003	Kim et al.	455/414
*	D	US-2005/0041673	02-2005	Jiang et al.	370/401
*	E	US-2005/0207359	09-2005	Hwang et al.	370/278
*	F	US-2007/0081492	04-2007	Petrovic et al.	370/331
*	G	US-2009/0028111	01-2009	Chao et al.	370/331
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No. 10917968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLIAM
	Examiner DOMINIC E REGO	Art Unit 2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/14/2007	03/13/2008	07/28/2008	03/15/2009					
	1	✓	÷	✓	✓					
	2	✓	÷	✓	✓					
	3	✓	÷	✓	✓					
	4	✓	÷	✓	✓					
	5	✓	÷	-	-					
	6	✓	÷	-	-					
	7	✓	÷	✓	✓					
	8	✓	÷	✓	✓					
	9	✓	÷	✓	-					
	10	✓	÷	N	-					
	11	✓	÷	N	-					
	12	✓	÷	✓	-					
	13	✓	÷	N	-					
	14		÷	✓	-					
	15		÷	✓	✓					
	16		÷	✓	✓					
	17		÷	✓	✓					
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	21		÷	✓	-					
	22		÷	N	-					
	23		÷	✓	-					
	24		÷	✓	-					
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	26		÷	✓	✓					
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	28		÷	✓	✓					
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	30		÷	✓	✓					
	31		÷	✓	✓					
	32		÷	✓	✓					
	33		÷	✓	✓					
	34		÷	✓	✓					
	35		÷	✓	-					

Index of Claims	Application/Control No. 10917968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLIAM
	Examiner DOMINIC E REGO	Art Unit 2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	06/14/2007	03/13/2008	07/28/2008	03/15/2009					
	36		÷	✓	-					
	37		÷	✓	-					
	38		÷	✓	-					
	39		÷	✓	-					
	40		÷	N	-					
	41		÷	N	-					
	42		÷	N	-					
	43		÷	✓	✓					
	44		÷	✓	✓					
	45		÷	✓	✓					
	46		÷	✓	✓					
	47		÷	✓	✓					
	48		÷	✓	✓					

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10917968	ANDERSON, NICHOLAS WILLIAM
	Examiner	**Art Unit**
	DOMINIC E REGO	2618

SEARCHED

Class	Subclass	Date	Examiner
455	522,68,69,115.3,126,127.1,296,127.2,67.11,434,436,135,226.3,277.2	7/28/2008	DR
370	331,320,335,342,318,392,252,276,280	7/28/2008	DR
375	147,130	7/28/2008	DR

SEARCH NOTES

Search Notes	Date	Examiner
Consulted SPE Duc Nguyen regarding Restriction requirement	3/13/08	DR
Updated East Search	7/28/2008	DR
Updated East, Google, Inventor, and NPL search	3/15/2009	DR

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S56	28	shar$3 near2 physical near2 channel same allocat$3 with schedul$3 with resource	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 17:22
S59	130	shar$3 near4 channel same allocat$3 with schedul$3 with resource	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 17:28
S60	43	S59 and (@ad <= "20040812" @rlad <= "20040812" @pd <= "20040812")	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 17:28
S61	9	shar$3 near4 channel same allocat$3 same schedul$3 same resource same (power near4 control$4)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 19:14
S62	12	(d$2s$2ch shar$3 near4 channel) same allocat$3 same schedul$3 same resource same (power near4 control$4)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 19:18
S65	4	power near4 control$4 same allocat$3 same schedul$3 same resource same (share near4 channel d$2s$2ch)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 19:32

S68	9	power near4 control$4 same allocat$3 same schedul$3 same (share near4 channel d$2s$2ch)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 19:42
S69	44	(tpc power near4 control$4 near2 command$3) near5 (share near4 channel d$2s $2ch)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 19:45
S70	34	S69 and (@ad <= "20040812" @rlad <= "20040812" @pd <= "20040812")	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 19:46
S72	8	allocat$3 same schedul$3 same resource same (forward$3 up $link) same (transmit$4 near power near control tpc) near3 command$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 19:56
S73	134	(d$2s$2ch shar$3 near4 channel) with resource near3 available	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 20:27
S74	8	(d$2s$2ch shar$3 near2 physical near2 channel) near5 resource near3 available	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 20:28
S75	79	S73 and (@ad <= "20040812" @rlad <= "20040812" @pd <= "20040812")	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 20:30

S76	6	S73 same (power near3 control$4)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 20:30
S77	66	S73 and (tpc power near3 control$4)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 20:32
S78	41	S77 and (@ad <= "20040812" @rlad <= "20040812" @pd <= "20040812")	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2009/03/24 20:32

3/25/2009 11:11:02 AM
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PTO/SB/30 (12-08)
Approved for use through 01/31/2009. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Request for Continued Examination (RCE) Transmittal		
Address to: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450	Application Number	10/917,968
	Filing Date	August 12, 2004
	First Named Inventor	Nicholas W. ANDERSON
	Art Unit	2618
	Examiner Name	D. E. Rego
	Attorney Docket Number	562492000500

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).
   - a. [X] Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.
     - i. [ ] Consider the arguments in the Appeal Brief or Reply Brief previously filed on ______
     - ii. [X] Other Amendment filed December 23, 2008.
   - b. [X] Enclosed
     - i. [ ] Amendment/Reply
     - ii. [ ] Affidavit(s)/Declaration(s)
     - iii. [ ] Information Disclosure Statement (IDS)
     - iv. [X] Other Petition for Extension of Time
2. Miscellaneous
   - a. [ ] Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of ______ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)
   - b. [ ] Other ______
3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.
   - a. [X] The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any Overpayments, to Deposit Account No. 03-1952.
     - i. [X] RCE fee required under 37 CFR 1.17(e)
     - ii. [X] Extension of time fee (37 CFR 1.136 and 1.17)
     - iii. [ ] Other ______
   - b. [ ] Check in the amount of $ ______ enclosed
   - c. [ ] Payment by credit card (Form PTO-2038 enclosed)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED			
Signature	[signature]	Date	1/27/09
Name (Print/Type)	Robert A. Saltzberg	Registration No.	36,910

sf-2635084

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) FY 2009 *(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)*	Docket Number (Optional) 562492000500
Application Number 10/917,968	Filed August 12, 2004
For POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM	
Art Unit 2618	Examiner D. E. Rego

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	
☐	One month (37 CFR 1.17(a)(1))	$130	$65	$ ______
☐	Two months (37 CFR 1.17(a)(2))	$490	$245	$ ______
X	Three months (37 CFR 1.17(a)(3))	$1110	$555	$ 1,110.00
☐	Four months (37 CFR 1.17(a)(4))	$1730	$865	$ ______
☐	Five months (37 CFR 1.17(a)(5))	$2350	$1175	$ ______

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

X The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 03-1952.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

X attorney or agent of record. Registration Number 36,910

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 ______

Robert Saltzberg
Signature

1/27/09
Date

Robert A. Saltzberg
Typed or printed name

(415) 268-6428
Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

X Total of 1 forms are submitted.

Electronic Patent Application Fee Transmittal

Application Number:	10917968
Filing Date:	12-Aug-2004
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Filer:	Robert A. Saltzberg/Linda Clinkenbeard
Attorney Docket Number:	562492000500

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 3 months with $0 paid	1253	1	1110	1110

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	1801	1	810	810
	Total in USD ($)			**1920**

Electronic Acknowledgement Receipt

EFS ID:	4686988
Application Number:	10917968
International Application Number:	
Confirmation Number:	3609
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Customer Number:	25226
Filer:	Robert A. Saltzberg/Linda Clinkenbeard
Filer Authorized By:	Robert A. Saltzberg
Attorney Docket Number:	562492000500
Receipt Date:	27-JAN-2009
Filing Date:	12-AUG-2004
Time Stamp:	19:03:59
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1920
RAM confirmation Number	4305
Deposit Account	031952
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	RCE.pdf	35155 ca803ef284376903eb6ae16ee58eaf8191873e1f	no	1

Warnings:

This is not a USPTO supplied RCE SB30 form.

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Extension of Time	Peition.pdf	29170 3b096511a64780943b798a7a86724b95fefb090a	no	1

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Fee Worksheet (PTO-06)	fee-info.pdf	32129 9ce1de078d8121fef9e1011f2cf9051d3281e0c4	no	2

Warnings:

Information:

Total Files Size (in bytes):	96454

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number	Filing Date	
10/917,968	08/12/2004	☐ To be Mailed

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

AMENDMENT

01/27/2009	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 22	Minus	** 46	= 0	X $ =		OR	X $52=	0
Independent (37 CFR 1.16(h))	* 4	Minus	***10	= 0	X $ =		OR	X $220=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/JOY DOBBS/

No, do not enter
dr

Docket No.: 562492000500
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Nicholas W. ANDERSON

Application No.: 10/917,968

Confirmation No.: 3609

Filed: August 12, 2004

Art Unit: 2618

For: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

Examiner: D. E. Rego

AMENDMENT AFTER FINAL ACTION UNDER 37 C.F.R. 1.116

MS AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

INTRODUCTORY COMMENTS

This is in response to the final Office Action dated August 1, 2008 (Paper No. 20080722), for which a response was due on November 1, 2008. Filed herewith is a Petition and fee for a two-month extension of time, thereby extending the deadline for response to January 1, 2009. Accordingly, this response is timely filed. Reconsideration and allowance of the pending claims, as amended, in light of the remarks presented herein are respectfully requested.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 6 of this paper.

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/917,968	08/12/2004	Nicholas William Anderson	562492000500	3609

25226 7590 01/09/2009
MORRISON & FOERSTER LLP
755 PAGE MILL RD
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EXAMINER	
REGO, DOMINIC E	

ART UNIT	PAPER NUMBER
2618	

MAIL DATE	DELIVERY MODE
01/09/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Advisory Action Before the Filing of an Appeal Brief	**Application No.** 10/917,968	**Applicant(s)** ANDERSON, NICHOLAS WILLIAM	
	Examiner DOMINIC E. REGO	**Art Unit** 2618	

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 23 December 2008 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

1. ☒ The reply was filed after a final rejection, but prior to or on the same day as filing a Notice of Appeal. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114. The reply must be filed within one of the following time periods:
   a) ☒ The period for reply expires *3* months from the mailing date of the final rejection.
   b) ☐ The period for reply expires on: (1) the mailing date of this Advisory Action, or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   Examiner Note: If box 1 is checked, check either box (a) or (b). ONLY CHECK BOX (b) WHEN THE FIRST REPLY WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37 CFR 41.37(a).

AMENDMENTS

3. ☒ The proposed amendment(s) filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   (a) ☒ They raise new issues that would require further consideration and/or search (see NOTE below);
   (b) ☐ They raise the issue of new matter (see NOTE below);
   (c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   (d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.
   NOTE: *Applicant added more limitations to claims 1,26, and 43 which require more search or consideration because it wasn't cited before*. (See 37 CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☐ Applicant's reply has overcome the following rejection(s): _____.
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☒ For purposes of appeal, the proposed amendment(s): a) ☒ will not be entered, or b) ☐ will be entered and an explanation of how the new or amended claims would be rejected is provided below or appended.
   The status of the claim(s) is (or will be) as follows:
   Claim(s) allowed: _____.
   Claim(s) objected to: _____.
   Claim(s) rejected: *1-4,7,8,15-17,26,28,30-34,43-48*.
   Claim(s) withdrawn from consideration: _____.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ The affidavit or other evidence filed after a final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
9. ☐ The affidavit or other evidence filed after the date of filing a Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing a good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
10. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

11. ☐ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: _____.
12. ☐ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
13. ☐ Other: _____.

/Duc Nguyen/
Supervisory Patent Examiner, Art Unit 2618

Docket No.: 562492000500
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Nicholas W. ANDERSON

Application No.: 10/917,968

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Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 6 of this paper.

sf-2578636

AMENDMENTS TO THE CLAIMS

1. (Currently amended): A method of power control in a radio communications system, the method comprising:

determining a path loss for a radio channel between a base station and a remote transceiver; and

~~receiving on a downlink~~ on a shared physical channel used to carry allocation and scheduling information from the base station to the remote transceiver, receiving an allocation of a scheduled uplink transmission resource and a transmit power control (TPC) command ~~commands transmitted to the remote transceiver from the base station~~; and

calculating, at the remote transceiver, a transmit power level for the scheduled uplink transmission resource based upon the path loss and the TPC command.

2. (Currently amended): The method of power control of claim 1, the method further comprising transmitting an uplink signal from the remote transceiver at ~~a~~ the calculated transmit power level.

3. (Original): The method of power control of claim 1, wherein determining the path loss includes:

receiving a downlink signal transmitted from the base station, wherein the downlink signal signals a transmitted power level of the downlink signal; and

measuring a received power level of the downlink signal.

4. (Original): The method of power control of claim 3, wherein determining the path loss further includes computing a difference between the signaled transmit power level and the measured received power level.

5-6. (Canceled)

7. (Original): The method of power control of claim 2, wherein the calculated transmit power level is based on a spreading factor parameter.

8. (Currently amended): The method of power control of claim 2, wherein the calculated transmit power level is based on parameters associated with a selected transport format ~~parameter~~.

9. – 14. (Canceled)

15. (Previously presented): The power control method of claim 1, further comprising calculating a transmit power level for transmission by the remote transceiver on the scheduled uplink transmission resource based on the path loss and an accumulated TPC command.

16. (Previously presented): The power control method of claim 15, further comprising receiving a signal from the base station for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

17. (Previously presented): The power control method of claim 15, further comprising receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control.

18.- 25. (Canceled)

26. (Currently amended): A computer-readable medium ~~comprising program code~~ encoded with a computer program for controlling power in a radio communication system, the ~~program code~~ computer program comprising instructions for:

determining a path loss for a radio channel between a base station and a remote transceiver; and

~~receiving on a downlink~~ on a shared physical channel used to carry allocation and scheduling information from the base station to the remote transceiver, receiving an allocation of a scheduled uplink transmission resource and a transmit power control (TPC) command ~~commands transmitted to the remote transceiver from the base station, wherein the TPC commands are generated by the base station by comparing a received signal quality measure to a target signal quality value~~; and

calculating a transmit power level for the remote transceiver based on the path loss and an accumulated TPC command.

27. (Canceled)

28. (Previously presented): The computer-readable medium of claim 26, wherein determining the path loss includes:

receiving a downlink signal transmitted from the base station, wherein the downlink signal signals a transmitted power level of the downlink signal; and

measuring a received power level of the downlink signal.

29. (Canceled)

30. (Currently amended): The computer-readable medium of claim 29, the computer program further comprising ~~program code~~ instructions for receiving a signal from the base station for instructing the remote transmitter to utilize the accumulated TPC command only when calculating the transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

31. (Currently amended): The computer-readable medium of claim 29, the computer program further comprising ~~program code~~ instructions for receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when calculating the transmit power level, thereby disabling use of closed loop power control and enabling use of open loop power control only.

32. (Currently amended): The computer-readable medium of claim 29, the computer program further comprising ~~program code~~ instructions for transmitting an uplink signal from the remote transceiver at the calculated transmit power level.

33. (Previously presented): The computer-readable medium of claim 29, wherein calculating the transmit power level is additionally based on a spreading factor parameter.

34. (Currently amended): The computer-readable medium of claim 29, wherein calculating the transmit power level is additionally based on parameters associated with a selected transport format ~~parameter~~.

35.-42. (Canceled)

43. (Currently amended): A method of power control in a radio communications system, the method comprising:

on a shared physical channel used to carry allocation and scheduling information from the base station to the remote transceiver, sending ~~on a downlink channel~~ an allocation of a scheduled uplink transmission resource and a transmit power control (TPC) command ~~commands transmitted to the remote transceiver from the base station~~; and

receiving an uplink signal from the remote transceiver at a calculated transmit power level based on a path loss and the TPC ~~commands~~ command.

44. (Previously presented): The power control method of claim 43, further comprising sending a signal to the remote transceiver for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby instructing

the remote transmitter to disable use of open loop power control and enable use of closed loop power control only.

45. (Previously presented): The power control method of claim 43, further comprising sending a signal from the base station to the remote transceiver for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby instructing the remote transmitter to enable use of open loop power control only and disable use of closed loop power control.

46. (Currently amended): A computer-readable medium ~~comprising program code~~ encoded with a computer program for controlling power in a radio communication system, the ~~program code~~ computer program comprising instructions for:

on a shared physical channel used to carry allocation and scheduling information from the base station to the remote transceiver, sending ~~on a downlink channel~~ an allocation of a scheduled uplink transmission resource and a transmit power control (TPC) command ~~commands transmitted to the remote transceiver from the base station~~; and

receiving an uplink signal from the remote transceiver at a calculated transmit power level based on a path loss and the TPC ~~commands~~ command.

47. (Currently amended): A computer-readable medium of claim 46, the computer program further comprising ~~program code~~ instructions for sending a signal to the remote transceiver for instructing the remote transmitter to utilize only the TPC commands when deriving the calculated transmit power level, thereby instructing the remote transmitter to disable use of open loop power control and enable use of closed loop power control only.

48. (Currently amended): A computer-readable medium of claim 46, the computer program further comprising ~~program code~~ instructions for sending a signal from the base station to the remote transceiver for instructing the remote transmitter to disregard the TPC commands when deriving the calculated transmit power level, thereby instructing the remote transmitter to enable use of open loop power control only and disable use of closed loop power control.

REMARKS

Claims 1-4, 7-9, 11, 12, 14-21, 23-39, and 43-48 were rejected. By virtue of this Response, claims 1, 2, 8, 26, 30-32, 34, 43, and 46-48 are amended. Claims 5-6, 9-14, 18-25, 27, 29, and 35-42 are canceled. Claims 1-4, 7, 8, 15-17, 26, 28, 30-34, and 43-48 remain pending.

I. Rejections under 35 U.S.C § 112

In the final Office Action, claims 8, 12, 17, 18, 19, 20, 23, 24, 26-39 and 44-48 were rejected under 35 U.S.C. §112, first paragraph, as allegedly failing to comply with the written description requirement.

MPEP 2163(I)(B) requires that new or amended claims be "supported in the specification through express, implicit, or inherent disclosure." The same section goes on to state that "[t]he fundamental factual inquiry is whether the specification conveys with reasonable clarity to those skilled in the art that ... applicant was in possession of the invention as now claimed."

A. Claim 12

Claim 12 is canceled.

B. Claim 8

Applicant respectfully submits that support for amended claim 8 can be found in at least paragraphs 0060 and 0061. In part, these paragraphs support setting the transmit power based on the selected transport format. The term "transport format" is commonly understood by those skilled in the art of wireless communications and is also of particular relevance to 3GPP UTRA systems such as those referred to by, for example, paragraphs 0033, 0034 and 0035. Thus, at least the combination of these paragraphs "conveys with reasonable clarity to those skilled in the art that ... applicant was in possession of the invention as now claimed." Therefore, Applicant respectfully asserts that amended claim 8 complies with the written description requirement of 35 U.S.C. 112, first paragraph.

C. Claim 15

Applicant respectfully submits that support for claim 15 can be found in at least paragraphs 0047, 0061, 0067, 0068, and 0076. In part, these paragraphs support setting the transmit power based on accumulating TPC commands and "convey[] with reasonable clarity to those skilled in the art that ... applicant was in possession of the invention as now claimed." Therefore, Applicant respectfully asserts that amended claim 15 complies with the written description requirement of 35 U.S.C. 112, first paragraph.

D. Claims 16, 19, 23, 30, 38, 44, and 47

Applicant respectfully submits that support for claim 16, 30, 44, and 47 can be found in at least paragraph 0087. These claims, in part, recite "utiliz[ing] only the accumulated TPC commands . . . thereby disabling use of open loop power control and enabling use of closed loop power control only." Paragraph 0087 states that "[a] parameter may indicate whether a UE is to use open loop power control, closed loop power control or a combined scheme." Throughout the specification, closed loop power control is described as using TPC commands. Thus, paragraph 0087 inherently supports that when open loop power control is not used, only TPC commands are used to implement the close loop power control. This paragraph "conveys with reasonable clarity to those skilled in the art that ... applicant was in possession of the invention as now claimed." Therefore, Applicant respectfully asserts that amended claim 16, 30, 44, and 47 complies with the written description requirement of 35 U.S.C. 112, first paragraph.

E. Claims 17, 20, 24, 31, 39, 45, and 48

Applicant respectfully submits that support for claim 17, 31, 45, and 48 can be found in at least paragraph 0087. These claims, in part, recite "disregard[ing] the accumulated TPC commands . . . thereby enabling use of open loop power control only and disabling use of closed loop power control." Paragraph 0087 states that "[a] parameter may indicate whether a UE is to use open loop power control, closed loop power control or a combined scheme." Throughout the specification, closed loop power control is described as using TPC commands whereas open loop power control does not rely on TPC commands. Thus, paragraph 0087 inherently supports that when closed loop power control is not used, TPC commands are ignored. This paragraph "conveys with reasonable clarity to those skilled in the art that … applicant was in possession of the invention as now claimed." Therefore, Applicant respectfully asserts that amended claim 17, 31, 45, and 48 complies with the written description requirement of 35 U.S.C. 112, first paragraph.

F. Claims 26-39 and 46-48

Applicant respectfully submits that support for claim 26, 28, 30-34, and 46-48 can be found in at least paragraph 0026. These claims recite, in part, "a computer-readable medium encoded with a computer program." Paragraph 0026 states that each step of the claims "may be performed by hardware, software, firmware, or combinations thereof." This paragraph "conveys with reasonable clarity to those skilled in the art that … applicant was in possession of the invention as now claimed." Therefore, Applicant respectfully asserts that amended claims 26, 28, 30-34, and 46-48 comply with the written description requirement of 35 U.S.C. 112, first paragraph.

II. Rejections under 35 U.S.C. § 101

Claims 26, 28, 30-34, and 46-48 were rejected under 35 U.S.C. 101 as being directed towards non-statutory subject matter. MPEP 2106.01(I) states that "a computer-readable medium encoded with a computer program … [is] statutory." Claims 26, 28, 30-34, and 46-48 recite "a computer-readable medium encoded with a computer program." Therefore, Applicant respectfully asserts that amended claims 26, 28, 30-34, and 46-48 are statutory subject matter under 35 U.S.C. 101.

III. Rejections under 35 U.S.C. § 103(a)

A. Claims 1-4, 7, 9, 12, 15, 18, 26, 28, 29, 32, 33, 35, 37, 43 and 46

Claims 1-4, 7, 9, 12, 15, 18, 26, 28, 29, 32, 33, 35, 37, 43 and 46 were rejected under 35 U.S.C. §103(a) as being unpatentable over International Publication Number WO 00/57574 (Zeira) in view of US Pub. No. 2005/0025056 (Chen).

Amended independent claims 1, 26, 43, and 46 recite utilizing a "shared physical channel used to carry allocation scheduling information" for sending and receiving "an allocation of a scheduled uplink transmission resource and a transmit power control (TPC) command." Thus, TPC commands and allocations of scheduled uplink transmission resources are sent and received together on a shared physical channel.

Zeira discloses TPC commands that are sent on dedicated control channels. (Page 8, lines 7-8.) By sending TPC commands on dedicated channels, the transmission of TPC commands can be maintained at a specific rate. (Page 12, lines 11-13.)

Chen discloses allocating resources "via a downlink dedicated control channel (DCCH)." (¶ 0054.) Allocations for resources are given based on the number of packets that need to be transmitted from a particular mobile station. (¶¶ 0034-0035.) Therefore, the rate at which resource allocations are made will vary depending on the number of packets the mobile station needs to send and whether other mobile stations need to send packets. (¶ 0109.)

In the final Office Action, the Examiner states that it would have been obvious to combine Zeira and Chen to send TPC commands and allocations of scheduled uplink transmission resources together. However, Applicant submits that it is not obvious to combine Zeira and Chen.

In Chen, allocations are sent sporadically because they are based on the dynamic status of multiple mobile stations. Typically, as suggested by Zeira, TPC commands would be transmitted using a dedicated channel and at a constant rate to maintain power control feedback. Thus, the problem of the intermittent nature of uplink transmissions and appropriate control of their transmission power (as referred to, for example, in paragraphs 0051, 0053, 0054, 0075 of the current application) is not recognized or addressed by Zeira. Additionally, neither Zeira nor Chen recognizes or addresses the signaling efficiency benefits of the amended independent claims by transmitting TPC commands together with scheduling information to a user on an allocation scheduling channel, as described in paragraphs 0085 and 0086 of the current application. Thus, the requirement of a constant rate of TPC commands in Zeira teaches against sending TPC commands with the sporadic allocations of resources in Chen.

Even if Zeira and Chen were combined, the combination only suggests and teaches a system with uplink scheduling on one channel and a separate dedicated channel with a constant update rate for conveying TPC commands. Applicant respectfully submits that a combination of Zeira and Chen does not result in the same power control feedback signaling efficiency of the amended independent claims. Thus, transmitting TPC commands and allocations of scheduled uplink transmission resources together is not obvious in view of Zeira and Chen.

Therefore, Applicant respectfully asserts that independent claims 1, 26, 43, and 46 are allowable over the cited references for at least the reason that it is not obvious to combine Zeira and Chen to transmit "allocations of scheduled uplink transmission resources [with] a transmit power control (TPC) command," as recited by the amended independent claims. Furthermore, Applicant respectfully asserts that claims, 2-4, 7, 15, 28, 32, and 33, which variously depend on independent claims 1 and 26, are allowable for at least the reason that they depend on allowable independent claims.

B. <u>Claims 8 and 34</u>

Claims 8 and 34 were rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira in view of Chen and further in view of US Patent 6,983,166 (Shiu).

Applicant respectfully asserts that claims, 8 and 34, which depend on independent claims 1 and 25, respectively, are allowable for at least the reason that they depend on allowable independent claims.

C. <u>Claims 14, 21, 25, 27 and 36</u>

Claims 14, 21, 25, 27 and 36 are rejected under 35 U.S.C. §103(a) as being unpatentable over Zeira in view of Chen and further in view of US Pub. No. 2003/0134655 (Chen03).

Claims 14, 21, 25, 27, and 36 have been canceled.

D. Claims 16, 17, 19, 20, 23, 24, 30, 31, 38, 39, 44, 45, 47 and 48

Claims 16, 17, 19, 20, 23, 24, 30, 31, 38, 39, 44, 45, 47 and 48 are rejected under 35 U.S.C. §103(a) as being unpatentable over Zeira, Chen and further in view of US Pub. No. 2005/0176455 (Krishnan).

Applicant respectfully asserts that claims, 16, 17, 30, 31, 44, 45, 47, and 48, which variously depend on independent claims 1, 26, 43, and 46, are allowable for at least the reason that they depend on allowable independent claims.

IV. Conclusion

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejection of the claims and to pass this application to issue. If it is determined that a telephone conference would expedite the prosecution of this application, the Examiner is invited to telephone the undersigned at the number given below.

In the event the U.S. Patent and Trademark office determines that an extension and/or other relief is required, applicant petitions for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to Deposit Account No. 03-1952 referencing docket no. 562492000500. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Dated: December 23, 2008

Respectfully submitted,

By Rob S Saltzberg

Robert A. Saltzberg
Registration No.: 36,910
MORRISON & FOERSTER LLP
425 Market Street
San Francisco, California 94105-2482
(415) 268-6428

Electronic Patent Application Fee Transmittal

Application Number:	10917968
Filing Date:	12-Aug-2004
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Filer:	Robert A. Saltzberg/Linda Clinkenbeard
Attorney Docket Number:	562492000500

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 2 months with $0 paid	1252	1	490	490

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**490**

Electronic Acknowledgement Receipt

EFS ID:	4517731
Application Number:	10917968
International Application Number:	
Confirmation Number:	3609
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Customer Number:	25226
Filer:	Robert A. Saltzberg/Linda Clinkenbeard
Filer Authorized By:	Robert A. Saltzberg
Attorney Docket Number:	562492000500
Receipt Date:	23-DEC-2008
Filing Date:	12-AUG-2004
Time Stamp:	20:24:38
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$490
RAM confirmation Number	5098
Deposit Account	031952
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	transmittal.pdf	23396 e6908cc7553fa8ae3f07d452519b0fcd56286e4d	no	1
Warnings:					
Information:					
2	Extension of Time	petition.pdf	28695 b275824ee80633860c725bdae638fa8e607704a8	no	1
Warnings:					
Information:					
3		amendmentafterfinal.pdf	367259 5321d15b4b8d412db3a0e3b8e7c1fb86e831b2c7	yes	12

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment After Final	1	1
Claims	2	5
Applicant Arguments/Remarks Made in an Amendment	6	12

Warnings:					
Information:					
4	Fee Worksheet (PTO-06)	fee-info.pdf	30269 0257492c700ac88050e1208562cd9e1de030b867	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			449619		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/21 (11-08)
Approved for use through 12/31/2008. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas W. ANDERSON
Art Unit	2618
Examiner Name	D. E. Rego
Attorney Docket Number	562492000500
Total Number of Pages in This Submission	14

ENCLOSURES (*Check all that apply*)

- [ ] Fee Transmittal Form
  - [ ] Fee Attached
- [X] Amendment/Reply (12 pages)
  - [X] After Final
  - [ ] Affidavits/declaration(s)
- [X] Extension of Time Request (1 page)
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ______
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Other Enclosure(s) (please Identify below):

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	MORRISON & FOERSTER LLP (Customer No. 20872)		
Signature	Robert Saltzberg		
Printed name	Robert A. Saltzberg		
Date	December 23, 2008	Reg. No.	36,910

sf-2623008

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)
FY 2009
(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)

Docket Number (Optional) 562492000500

Application Number 10/917,968 | Filed August 12, 2004

For POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

Art Unit 2618 | Examiner D. E. Rego

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	
☐ One month (37 CFR 1.17(a)(1))	$130	$65	$
☒ Two months (37 CFR 1.17(a)(2))	$490	$245	$ 490.00
☐ Three months (37 CFR 1.17(a)(3))	$1110	$555	$
☐ Four months (37 CFR 1.17(a)(4))	$1730	$865	$
☐ Five months (37 CFR 1.17(a)(5))	$2350	$1175	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 03-1952 .

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the ☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

☒ attorney or agent of record. Registration Number 36,910

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 ____________

Robert Saltzberg (signature)
Signature

December 23, 2008
Date

Robert A. Saltzberg
Typed or printed name

(415) 268-6428
Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

☒ Total of 1 forms are submitted.

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/917,968	08/12/2004	Nicholas William Anderson	562492000500	3609

25226 7590 08/01/2008
MORRISON & FOERSTER LLP
755 PAGE MILL RD
PALO ALTO, CA 94304-1018

EXAMINER	
REGO, DOMINIC E	
ART UNIT	**PAPER NUMBER**
2618	
MAIL DATE	**DELIVERY MODE**
08/01/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/917,968	ANDERSON, NICHOLAS WILLIAM	
	Examiner	Art Unit	
	DOMINIC E. REGO	2618	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _11 April 2008_.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _4,7-9,11,12,14-21,23-39 and 43-48_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) _4,7-9,11,12,14-21,23-39 and 43-48_ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08)
Paper No(s)/Mail Date _10/3/2007_.
4) ☐ Interview Summary (PTO-413)
Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 112

1. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claims 8,12,15-17,18,19,20,23,24,26-39, and 44-48 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. **Regarding claim 12**, Applicant recites limitations "calculating a transmit power level associated with the scheduled uplink transmission resource based on the power level of the received signal and the accumulated TPC command". The underlining parts are not found in the specification. In the specification, paragraph 0088, recites "calculates a transmit power level based on the power level of the received signal and the TPC command" which are not same as above claimed limitations. "accumulating the TPC commands to obtain an accumulated TPC command" means more than one TPC command according to claim 12, but paragraph 0088 states "the UE measures a power level of a received signal, receives a TPC command, and calculates a transmit power level based on the power level of the received signal and the TPC command" which is a single command. Again, recited limitations in claim 12, "calculating a transmit power level associated with the scheduled uplink transmission resource" are a new matter and the Examiner can't find in the specification. **Regarding claim 8**, recited limitations "calculating transmit power level is based on parameter associated with a selected transport format parameter" are not same as in the specification, paragraph 0060 which states "an optional auxiliary process in the UE adjusts the transmit power based upon: (a) gamma (SF), the spreading factor (SF) of the physical channel; and (b) beta (TFC), the selected transport format (TFC). These paragraph (0060) is same as original dependent claim 8. **Regarding claim 15**, Applicant recites limitations "The power control method of claim l, further comprising calculating a transmit power level for transmission by the remote transceiver on the scheduled uplink transmission resource based on the path loss and an accumulated TPC command". The underlining parts are not found in the specification. The limitations "an accumulated TPC command" means more than one command, but in the specification, paragraph 0014 states "calculating a transmit power level for the remote transceiver based on the path loss and the TPC command (one command) are not same as above claimed limitations. **Regarding claims 16,19,23,30,38,44, and 47**, Applicant recites limitations "The power control method of claim 15, further comprising receiving a signal from the base station for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only". The underlining parts are not found in the specification. Paragraph 0087 in the specification recites "a Node-B or RNC may be implemented with a new parameter, either included in a signalling command or a broadcast message, where the new parameter instructs a UE to enable or disable the setting of uplink transmit power level based on both the path loss estimation and the TPC commands. A parameter may indicate whether a UE is to use open loop power control, closed loop power control or a combined scheme" which are not same as above claimed limitations. **Regarding claims 17,20,24,31,39,45, and 48**, Applicant recites limitations "The power control method of claim 15, further comprising receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control". The underlining parts are not found in the specification. Paragraph 0087 in the specification recites "a Node-B or RNC may be implemented with a new parameter, either included in a signalling command or a broadcast message, where the new parameter instructs a UE to enable or disable the setting of uplink transmit power level based on both the path loss estimation and the TPC commands. A parameter may indicate whether a UE is to use open loop power control, closed loop power control or a combined scheme" which are not same as above claimed limitations. **Regarding claims 26-39 and 46-48**, Applicant recites the limitations "A computer-readable medium comprising program code for controlling power in a radio communication system, the program code for" is not found in the Specification. Paragraph 0026, recites "Some portions of the detailed description which follows are presented in terms of procedures, steps, logic blocks, processing, and other symbolic representations of operations on data bits that can be performed on computer memory. A procedure, computer executed step, logic block, process etc., are here conceived to be a self-consistent sequence of steps or instructions leading to a desired result. The steps are those utilizing physical manipulations of physical quantities. These quantities can take the form of electrical, magnetic, or radio signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. These signals may be referred to at times as bits, values, elements, symbols, characters, terms, numbers, or the like. Each step may be performed by hardware, software, firmware, or combinations thereof" which are not same as above claimed limitations.

Claim Rejections - 35 USC § 101

2. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

3. Claims 26-39 and 46-48 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter. Since the claimed "A computer-readable medium comprising program code for controlling power in a radio communication system" is not necessarily encoded or embodied or stored on the computer readable medium, there is no interrelationship between the claimed medium with the rest of the computer to permit the program's functionality to be realized. Thus, claims 26-39 and 46-48 are non-statutory.

Claim Rejections - 35 USC § 103

4. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

5. Claims 1-4,7,9,12,15,18,26,28,29,32,33,35,37,43, and 46 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Chen et al. (US Pub. No. 2005/0025056).

Regarding claim 1, Zeira teaches a method of power control in a radio communications system (See Abstract), the method comprising:

determining a path loss of a radio channel between a base station and a remote transceiver (Page 2, lines 14- 21; Page 4, line 17-Page 5, line 8);

transmit power control (TPC) command transmitted to the remote transceiver from the base station (Page 4, line 17-Page 5, line 8) except for receiving on a downlink channel an allocation of a scheduled uplink transmission resource.

However, in related art, Chen teaches receiving on a downlink channel an allocation of a scheduled uplink transmission resource *(Paragraphs 0012,0052-0057, especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches* *the transmitting unit 15 is configured to notify the radio resources allocated by the resource allocating 14 to the mobile station via a* *<u>downlink dedicated control channel (DCCH)</u>. Paragraph 0052, Chen teaches the resource allocating unit 14 is <u>configured to allocate a radio resource which is used in uplink packet communications</u> with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).*

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

Regarding claims 2 and 32, the combination of Zeira and Chen teach all the claimed elements in claims 1 and 29. In addition, Zeira teaches the method of power control, the method further comprising transmitting an uplink signal from the remote transceiver at a calculated transmit power level (Page 5, lines 4-8).

Regarding claims 3 and 28, the combination of Zeira and Chen teach all the claimed elements in claims 1 and 26. In addition, Zeira teaches the method of power control, wherein determining the path loss includes: receiving a downlink signal transmitted from the base station, wherein the downlink signal signals a transmitted power level of the downlink signal; and measuring a received power level of the downlink signal (Page 2, lines 14-21; Page 4, lines 17-page 8).

Regarding claim 4, the combination of Zeira and Chen teach all the claimed elements in claim 1. In addition, Zeira teaches the method of power control, wherein determining the path loss further includes computing a difference between the signaled transmit power level and the measured received power level (Page 2, lines 1-lines 21; Page 5, lines 2-lines 4).

Regarding claims 7 and 33, the combination of Zeira and Chen teach all the claimed elements in claims 1 and 29. In addition, Zeira teaches the method of power control, wherein the calculated the transmit power level is based on a spreading factor parameter (Page 13, lines 2-15).

Regarding claim 9, Zeira teaches a method of power control in a radio communications system (See Abstract), the method comprising:

receiving a signal at a second transceiver (UE 32) transmitted from a first transceiver (base station 30) (Page 2, lines 14-17; Page 4, lines 18-20);

measuring a power level of the received signal at the second transceiver to obtain a measured received power level *(Page 2, lines 14-18: Zeira teaches the UE 32 receives the reference communication and measures its received power level)*;

transmit power control (TPC) command at the second transceiver transmitted from the first transceiver (Page 4, line 17-Page 5, line 8), except for receiving on a downlink channel an allocation of a scheduled uplink transmission resource.

However, in related art, Chen teaches receiving on a downlink channel an allocation of a scheduled uplink transmission resource *(Paragraphs 0012,0052-0057, especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches the transmitting unit 15 is configured to notify the radio resources allocated by the* *resource allocating 14 to the mobile station via a downlink dedicated control channel (DCCH). Paragraph 0052, Chen teaches the resource allocating unit 14 is configured to allocate a radio resource which is used in uplink packet communications with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).*

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

Regarding claim 12, as best understood by 112 1st, Zeira teaches a method comprising:

measuring a power level of a received signal (Page 2, lines 14-18);

receiving a transmit power control (TPC) commands (Page 4, line 18-Page 5, line 1; Claims 1, lines 9-18);

accumulating the TPC commands to obtain an accumulated TPC command *(Abstract; Page 4, line 18-Page 5, line 1; Claims 1, lines 9-18, especially, Claim 1, lines 9-10, Zeira teaches receiving at the second communication station (mobile terminal) the first communication (base station) and the power commands (more than one command). Once mobile terminal receives the power commands from the base station, it accumulates to obtain an accumulated TPC command, so it's obvious)*; and

calculating a transmit power level associated with the scheduled uplink transmission resource based on the power level of the received signal and the accumulated TPC command (Page 4, line 18-Page 5, line 8), except for receiving on a downlink channel an allocation of a scheduled uplink transmission resource.

However, in related art, Chen teaches receiving on a downlink channel an allocation of a scheduled uplink transmission resource *(Paragraphs 0012,0052-0057, especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches the transmitting unit 15 is configured to notify the radio resources allocated by the resource allocating 14 to the mobile station via a downlink dedicated control channel (DCCH). Paragraph 0052, Chen teaches the resource allocating unit 14 is configured to allocate a radio resource which is used in uplink packet communications with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).*

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

Regarding claims 15,18, and 37, the combination of Zeira and Chen teach all the claimed elements in claims 1,9, and 37. In addition, Zeira teaches the power control method, further comprising calculating a transmit power level for transmission by the remote transceiver on the scheduled uplink transmission resource based on the path loss and an accumulated TPC command (Page 4, line 17-Page 5, line 8).

Regarding claim 26, Zeira teaches a computer-readable medium comprising program code for controlling power in a radio communication system, the program code for:

determining a path loss for a radio channel between a base station and a remote transceiver (Page 2, lines 14- 21; Page 4, line 17-Page 5, line 8);

and

transmit power control (TPC) commands transmitted to the remote transceiver from the base station (Page 4, line 17-Page 5, line 8), wherein the TPC commands are generated by the base station by comparing a received signal quality (SIR) measure to a target signal quality value (Page 7, lines 9-15), except for receiving on a downlink channel an allocation of scheduled uplink transmission resource.

However, in related art, Chen teaches receiving on a downlink channel an allocation of scheduled uplink transmission resource *(Paragraphs 0012,0052-0057, especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches the transmitting unit 15 is configured to notify the radio resources allocated by the resource allocating 14 to the mobile station via a <u>downlink dedicated control channel (DCCH)</u>. Paragraph 0052, Chen teaches the resource allocating unit 14 is <u>configured to allocate a radio resource which is used in uplink packet communications</u> with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).*

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

Regarding claim 29, the combination of Zeira and Chen teach all the claimed elements in claim 26. In addition, Zeira teaches the computer-readable medium, further comprising program code for calculating a transmit power level for the remote transceiver based on the path loss and an accumulated TPC command to obtain a calculated transmit power level (Page 2, lines 14-21; Page 4, lines 17-page 8).

Regarding claim 35, Zeira teaches a computer-readable medium comprising program code for controlling power in a radio communication system (See Abstract), the program code for:

receiving a signal at a second transceiver (UE 32) transmitted from a first transceiver (base station 30) (Page 2, lines 14-17; Page 4, lines 18-20);

measuring a power level of the received signal to obtain a measured received power level *(Page 2, lines 14-18: Zeira teaches the UE 32 receives the reference communication and measures its received power level)*; and

transmit power control (TPC) commands at the second transceiver transmitted from the first transceiver (Page 4, line 17-Page 5, line 8), except for receiving a downlink signal comprising an allocation of scheduled uplink transmission resources.

However, in related art, Chen teaches receiving on a downlink channel an allocation of a scheduled uplink transmission resource *(Paragraphs 0012,0052-0057,* *especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches the transmitting unit 15 is configured to notify the radio resources allocated by the resource allocating 14 to the mobile station via a downlink dedicated control channel (DCCH). Paragraph 0052, Chen teaches the resource allocating unit 14 is configured to allocate a radio resource which is used in uplink packet communications with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).*

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

Regarding claim 43, Zeira teaches a method of power control in a radio communications system (See Abstract), the method comprising:

sending transmit power control (TPC) commands transmitted to a remote transceiver from a base station (Page 4, line 17-Page 5, line 8); and

receiving an uplink signal from the remote transceiver at a calculated transmit power level based on a path loss and the TPC commands (Page 2, lines 14-21; Page 4, lines 17-page 8), except for sending on a downlink channel an allocation of a scheduled uplink transmission resource.

However, in related art, Chen teaches sending on a downlink channel an allocation of a scheduled uplink transmission resource *(Paragraphs 0012,0052-0057,* *especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches the transmitting unit 15 is configured to notify the radio resources allocated by the resource allocating 14 to the mobile station via a <u>downlink dedicated control channel (DCCH)</u>. Paragraph 0052, Chen teaches the resource allocating unit 14 is <u>configured to allocate a radio resource which is used in uplink packet communications</u> with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).*

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

Regarding claim 46, Zeira teaches a computer-readable medium comprising program code for controlling power in a radio communication system (See Abstract),, the program code for:

sending transmit power control (TPC) commands transmitted to a remote transceiver from a base station (Page 4, line 17-Page 5, line 8);

receiving an uplink signal from the remote transceiver at a calculated transmit power level based on a path loss and the TPC commands (Page 2, lines 14-21; Page 4, lines 17-page 8), except for sending on a downlink channel an allocation of a scheduled uplink transmission resource.

However, in related art, Chen teaches sending on a downlink channel an allocation of a scheduled uplink transmission resource *(Paragraphs 0012,0052-0057, especially, paragraph 0012, Chen teaches it is an object of the present invention to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method. Paragraph 0054, Chen teaches the transmitting unit 15 is configured to notify the radio resources allocated by the resource allocating 14 to the mobile station via a <u>downlink dedicated control channel (DCCH)</u>. Paragraph 0052, Chen teaches the resource allocating unit 14 is <u>configured to allocate a radio resource which is used in uplink packet communications</u> with the mobile station, by referring to the virtual buffer corresponding to the mobile station 30).*

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen to Zeira in order to perform the efficient scheduling processing and to allocate radio resources efficiently in the uplink high-speed packet communications method (Chen, paragraph 0012).

6. Claims 8 and 34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Chen et al. (US Pub. No. 2005/0025056) and further in view of Shiu et al. (US Patent #6,983,166).

Regarding claims 8 and 34, as best understood 112 1st, Zeira fails to teach the method of power control, wherein the calculated transmit power level is based on parameter associated with a selected transport format parameter.

However, in related art, Shiu teaches the method of power control, wherein the calculated transmit power level is based on parameter associated with a selected transport format parameter. (Col 3, lines 27-41).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Shiu to Zeira and Chen in order to achieve target block error rate (BLERs) (See Shiu, Col 3, line 31).

7. Claims 14,21,25,27, and 36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Chen et al. (US Pub. No. 2005/0025056) and further in view of Chen et al. (US Pub. No. 2003/0134655).

Regarding claims 14,21,25,27, and 36, the combination of Zeira and Chen et al. (US Pub. No. 2005/0025056) fail to teach the power control method, wherein the TPC commands are transmitted on a shared physical channel.

However, in related art, Chen et al. (US Pub. No. 2003/0134655) teaches the power control method, wherein the TPC commands are transmitted on a shared physical channel (Claims 1-5).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Chen et al. (US Pub. No. 2003/0134655) to Zeira and Chen et al. (US Pub. No. 2005/0025056) in order to enable communication services in an existing cellular communication system infrastructure.

8. Claims 16,17,19,20,23,24,30,31,38,39,44,45,47, and 48 are rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Chen et al. (US Pub. No. 2005/0025056) and further in view of Krishnan et al. (US Pub. No. 2005/0176455).

Regarding claims 16,19,23,30,38,44, and 47, the combination of Zeira and Chen fail to teach the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

However, in related art, Krishnan teaches the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only (Paragraphs 0047-0050, especially, Paragraphs 0049-0050).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Krishnan to Zeira and Chen in order to provide the transmitting terminal feedback regarding the power of signals received at the receiving terminal.

Regarding claim 17,20,24,31,39,45, and 48, the combination of Zeira and Chen fail to teach the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control.

However, in related art, Krishnan teaches the power control method, further comprising receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control (Paragraphs 0047-0050, especially, Paragraphs 0049-0050).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Krishnan to Zeira and Chen in order to provide the transmitting terminal feedback regarding the power of signals received at the receiving terminal.

Response to Arguments

9. Applicant's arguments with respect to claims 1-4,7-9,12,14-21,23-39, and 43-48 have been considered but are moot in view of the new ground(s) of rejection.

Conclusion

10. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP

§ 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to DOMINIC E. REGO whose telephone number is (571)272-8132. The examiner can normally be reached on Monday-Friday, 8:30 am-5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew D. Anderson can be reached on 571-272-4177. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dominic E. Rego
/Dominic E Rego/
Examiner, Art Unit 2618
Tel 571-272-8132

/Matthew D. Anderson/
Supervisory Patent Examiner, Art Unit 2618

Notice of References Cited	Application/Control No. 10/917,968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLI	
	Examiner DOMINIC E. REGO	Art Unit 2618	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2005/0025056	02-2005	Chen et al.	370/235
*	B	US-2003/0134655	07-2003	Chen et al.	455/522
*	C	US-2005/0176455	08-2005	Krishnan et al.	455/522
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Index of Claims	Application/Control No. 10917968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLIAM
	Examiner DOMINIC E REGO	Art Unit 2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/13/2008	07/28/2008							
	1	÷	✓							
	2	÷	✓							
	3	÷	✓							
	4	÷	✓							
	5	-	-							
	6	-	-							
	7	÷	✓							
	8	÷	✓							
	9	÷	✓							
	10	÷	N							
	11	÷	N							
	12	÷	✓							
	13	÷	N							
	14	÷	✓							
	15	÷	✓							
	16	÷	✓							
	17	÷	✓							
	18	÷	✓							
	19	÷	✓							
	20	÷	✓							
	21	÷	✓							
	22	÷	N							
	23	÷	✓							
	24	÷	✓							
	25	÷	✓							
	26	÷	✓							
	27	÷	✓							
	28	÷	✓							
	29	÷	✓							
	30	÷	✓							
	31	÷	✓							
	32	÷	✓							
	33	÷	✓							
	34	÷	✓							
	35	÷	✓							

Index of Claims	Application/Control No. 10917968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLIAM
	Examiner DOMINIC E REGO	Art Unit 2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/13/2008	07/28/2008							
	36	÷	✓							
	37	÷	✓							
	38	÷	✓							
	39	÷	✓							
	40	÷	N							
	41	÷	N							
	42	÷	N							
	43	÷	✓							
	44	÷	✓							
	45	÷	✓							
	46	÷	✓							
	47	÷	✓							
	48	÷	✓							

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10917968	ANDERSON, NICHOLAS WILLIAM
	Examiner	**Art Unit**
	DOMINIC E REGO	2618

SEARCHED

Class	Subclass	Date	Examiner
455	522,68,69,115.3,126,127.1,296,127.2,67.11,434,436,135,226.3,277.2	7/28/2008	DR
370	331,320,335,342,318,392,252,276,280	7/28/2008	DR
375	147,130	7/28/2008	DR

SEARCH NOTES

Search Notes	Date	Examiner
Consulted SPE Duc Nguyen regarding Restriction requirement	3/13/08	DR
Updated East Search	7/28/2008	DR

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2729	(disabl3 enabl $3) same ((open outer) same (clos$3 inner)) near4 loop	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/27 23:40
L2	138	1 same (tpc (power near2 control$4))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/27 23:40
L3	10	1 same (tpc (power near2 control$4 near2 command$3))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/27 23:41
L4	167	disabl3 same enabl$3 same ((open outer) same (clos$3 inner)) near4 loop	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/27 23:47
L5	22	disabl3 with ((open outer) near4 loop same enabl$3 with (clos$3 inner)) near4 loop	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/27 23:50
S29	18	fast near4 allocation same (up$link up adj link) with resource	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:08

S30	77	(up$link up adj link) with resource near5 use	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:16
S32	1930	(up$link up adj link) near3 resource	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:18
S33	1673	(up$link up adj link) near2 resource	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:18
S34	884	S33 same allocat $3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:18
S35	228	S34 same schedul$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:19
S36	119	(up$link up adj link) near2 resource near6 allocat$3 near6 schedul$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:20
S37	41	S36 same (base $station base adj station)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/22 14:20
S42	160	allocat$3 same schedul$3 same (tpc(control$4 near2 command $3))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/23 22:55

S43	71	S42 same resource	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/23 22:55
S44	39	allocat$3 same schedul$3 same (tpc(power near2 control$4 near2 command $3))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/23 22:56
S46	28	(tpc(power near2 control$3 near2 command)) near4 shared near3 channel	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2008/07/25 06:33

7/28/2008 1:50:14 AM
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ALTERNATIVE TO PTO/SB/08A/B (04/07)

Substitute for form 1449/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application Number	10/917,968
	Filing Date	August 12, 2004
	First Named Inventor	Nicholas W. ANDERSON
	Art Unit	2618
(Use as many sheets as necessary)	Examiner Name	D. E. Rego
Sheet 1 of 1	Attorney Docket Number	562492000500

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number: Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1.	US-5,719,583-A	02-17-1998	Kanai	
	2.	US-5,887,245-A	03-23-1999	Lindroth et al.	
	3.	US-6,137,993-A	10-24-2000	Almgren et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	4.	GB-2350522-A	11-29-2000	Roke Manor Research Limited		
	5.	EP-1176739-A1	01-30-2002	Matsushita Electric Industrial Co., Ltd.		

*EXAMINER: Initial if information considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	6.	"Recommendation ITU-R M.1225: Guidelines for Evaluation of Radio Transmission Technologies for IMT-2000," International Telecommunication Union/ITU Radiocommunication Sector, January 1, 1997, Rec. ITU-R M.1225, pp. 1-61.	
	7.	Great Britain Search Report mailed May 14, 2002, for Great Britain Application No. 0125504.1 filed October 24, 2001, 1 page.	
	8.	International Search Report mailed December 22, 2005, for PCT Application No. PCT/EP2005/053931 filed August 10, 2005, 4 pages.	
	9.	International Search Report mailed January 21, 2003, for PCT Application No. PCT/GB02/04811 filed October 24, 2002, 3 pages.	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English language Translation is attached.

Examiner Signature	/Dominic Rego/	Date Considered	07/21/2008

sf-2365891

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /DR/

Docket No.: 562492000500
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Nicholas William ANDERSON

Application No.: 10/917,968

Filed: August 12, 2004

For: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

Confirmation No.: 3609

Art Unit: 2618

Examiner: D. Rego

RESPONSE TO RESTRICTION REQUIREMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This is in response to the restriction requirement dated March 19, 2008 for which a response is due by April 19, 2008. Accordingly, this response is timely filed.

Restriction has been required as between the following allegedly distinct groups of inventions:

Group I. Claims-1-4, 7-9, 12, 14-21, 23-39, and 43-48 drawn to determining a path loss for a radio channel between a base station and a remote transceiver, measuring power level of the received signal at the second transceiver to obtain a measure received power level and receiving a downlink channel on allocation of a scheduled uplink transmission resource, classified in class 455, subclass 522.

Group II. Claims 10, 11, 22 and 40-42 drawn to measuring a received signal quality measure of the uplink signal to obtain a measured received signal quality value, comparing the measured received signal quality value with a target quality value and assigning a fist value to a step indication if the measured received signal quality value is greater than target signal quality value and assigning a second value to a step indicator if the measured received signal quality value is less than target signal quality value, classified in class 455, subclass 115.3 or 135.

Group III. Claim 13 drawn to an accumulator having an input for accepting step increase and decrease instructions and an output providing an accumulated history of the step increases and decreases, a power level circuit setting circuit coupled to the accumulator output and couple to the receiver output, where the power level setting circuit sets a transmit power for the scheduled uplink transmission resource based on the accumulator output and the measured power level to obtain a set transmit power, classified in class 455, subclass 522.

Applicant hereby provisionally elects Group I (claims 1-4, 7-9, 12, 14-21, 23-39, and 43-48) without traverse. Applicant expressly reserve their rights under 35 U.S.C. § 121 to file a divisional application directed to the nonelected subject matter during the pendency of this application, or an application claiming priority from this application.

In the unlikely event that the transmittal form is separated from this document and the Patent Office determines that an extension and/or other relief is required, Applicant petitions for any required relief including extensions of time and authorize the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing Docket No. 562492000500. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Dated: April 11, 2008

Respectfully submitted,

By: /Elahe Toosi/
Elahe Toosi
Registration No.: 57,740
MORRISON & FOERSTER LLP
12531 High Bluff Drive, Suite 100
San Diego, California 92130-2040
(858) 314-7546

Docket No.: 562492000500
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: Nicholas William ANDERSON	
Application No.: 10/917,968	Confirmation No.: 3609
Filed: August 12, 2004	Art Unit: 2618
For: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM	Examiner: D. Rego

RESPONSE TO RESTRICTION REQUIREMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
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Dear Sir:

This is in response to the restriction requirement dated March 19, 2008 for which a response is due by April 19, 2008. Accordingly, this response is timely filed.

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Group II. Claims 10, 11, 22 and 40-42 drawn to measuring a received signal quality measure of the uplink signal to obtain a measured received signal quality value, comparing the measured received signal quality value with a target quality value and assigning a fist value to a step indication if the measured received signal quality value is greater than target signal quality value and assigning a second value to a step indicator if the measured received signal quality value is less than target signal quality value, classified in class 455, subclass 115.3 or 135.

Group III. Claim 13 drawn to an accumulator having an input for accepting step increase and decrease instructions and an output providing an accumulated history of the step increases and decreases, a power level circuit setting circuit coupled to the accumulator output and couple to the receiver output, where the power level setting circuit sets a transmit power for the scheduled uplink transmission resource based on the accumulator output and the measured power level to obtain a set transmit power, classified in class 455, subclass 522.

Applicant hereby provisionally elects Group I (claims 1-4, 7-9, 12, 14-21, 23-39, and 43-48) without traverse. Applicant expressly reserve their rights under 35 U.S.C. § 121 to file a divisional application directed to the nonelected subject matter during the pendency of this application, or an application claiming priority from this application.

In the unlikely event that the transmittal form is separated from this document and the Patent Office determines that an extension and/or other relief is required, Applicant petitions for any required relief including extensions of time and authorize the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing Docket No. 562492000500. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Dated: April 11, 2008

Respectfully submitted,

By: /Elahe Toosi/
Elahe Toosi
Registration No.: 57,740
MORRISON & FOERSTER LLP
12531 High Bluff Drive, Suite 100
San Diego, California 92130-2040
(858) 314-7546

Electronic Acknowledgement Receipt

EFS ID:	3140107
Application Number:	10917968
International Application Number:	
Confirmation Number:	3609
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Customer Number:	25226
Filer:	Elahe S. Toosi/Judy Calem
Filer Authorized By:	Elahe S. Toosi
Attorney Docket Number:	562492000500
Receipt Date:	11-APR-2008
Filing Date:	12-AUG-2004
Time Stamp:	18:49:38
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	TransforResptoRR.pdf	27059 b983f223b21d2df3e3ce79b23edb63b49e736f04	no	1

Warnings:

Information:

2	Response to Election / Restriction Filed	ResptoRR.pdf	25155 f543988f48f9c0399e5b715395cce2249e6b069a	no	2

Warnings:

Information:

Total Files Size (in bytes):	52214

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/21 (01-08)
Approved for use through 04/30/2008. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas William ANDERSON
Art Unit	2618
Examiner Name	D. Rego
Attorney Docket Number	562492000500
Total Number of Pages in This Submission	3

ENCLOSURES (*Check all that apply*)

- [ ] Fee Transmittal Form
  - [ ] Fee Attached
- [x] Amendment/Reply (2 pages)
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ______
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Other Enclosure(s) (please Identify below):

Remarks

CUSTOMER NO.: 25225

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	MORRISON & FOERSTER LLP		
Signature	/Elahe Toosi/		
Printed name	Elahe Toosi		
Date	April 11, 2008	Reg. No.	57,740

sd-420222

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/917,968	08/12/2004	Nicholas William Anderson	562492000500	3609

25226 7590 03/19/2008
MORRISON & FOERSTER LLP
755 PAGE MILL RD
PALO ALTO, CA 94304-1018

EXAMINER	
REGO, DOMINIC E	

ART UNIT	PAPER NUMBER
2618	

MAIL DATE	DELIVERY MODE
03/19/2008	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/917,968	ANDERSON, NICHOLAS WILLIAM	
	Examiner	Art Unit	
	DOMINIC E. REGO	2618	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _1_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _28 December 2007_.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _1-4 and 7-48_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) _1-4 and 7-48_ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. This communication is responsive to application filed on December 28, 2007. Claims 1-4 and 7-48 are pending.

Election/Restrictions

Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-4,7-9,12,14-21,23-39, and 43-48 drawn to determining a path loss for a radio channel between a base station and a remote transceiver, measuring a power level of the received signal at the second transceiver to obtain a measure received power level and receiving on a downlink channel an allocation of a scheduled uplink transmission resource, classified in class 455, subclass 522.

II. Claims 10,11,22,and 40-42 drawn to measuring a received signal quality measure of the uplink signal to obtain a measured received signal quality value, comparing the measured received signal quality value with a target quality value and assigning a first value to a step indication if the measured received signal quality value is greater than target signal quality value, and assigning a second value to a step indicator if the measured received signal quality value is less than target signal quality value, classified in class 455, subclass 115.3 or 135.

III. Claim 13 drawn to an accumulator having an input for accepting step increase and decrease instructions and an output providing an accumulated history of the step increases and decreases, a power level circuit setting circuit coupled to the accumulator output and couple to the receiver output, where the power level setting circuit sets a transmit power for the scheduled uplink transmission resource based on the accumulator output and the measured power level to obtain a set transmit power, classified in class 455, subclass 522.

2. The inventions are distinct, each from the other because of the following reasons:

Subcombination-Usable Together

3. Inventions I, II, and III are related as subcombinations disclosed as usable together in a single combination. The subcombinations are distinct if they do not overlap in scope and are not obvious variants, and if it is shown that at least one subcombination is separately usable. In the instant case, inventions I and II are related as subcombination II has separate utility such as measuring a received signal quality measure of the uplink signal to obtain a measured received signal quality value, comparing the measured received signal quality value with a target quality value and assigning a first value to a step indication if the measured received signal quality value is greater than target signal quality value, and assigning a second value to a step indicator if the measured received signal quality value is less than target signal quality value. Inventions I and III are related as subcombination III has separate utility such as

an accumulator having an input for accepting step increase and decrease instructions and an output providing an accumulated history of the step increases and decreases, a power level circuit setting circuit coupled to the accumulator output and couple to the receiver output, where the power level setting circuit sets a transmit power for the scheduled uplink transmission resource based on the accumulator output and the measured power level to obtain a set transmit power. Inventions I and III are related as subcombination III has separate utility such as an accumulator having an input for accepting step increase and decrease instructions and an output providing an accumulated history of the step increases and decreases, a power level circuit setting circuit coupled to the accumulator output and couple to the receiver output, where the power level setting circuit sets a transmit power for the scheduled uplink transmission resource based on the accumulator output and the measured power level to obtain a set transmit power. See MPEP § 806.05(d).

4. Because these inventions are independent or distinct for the reasons given above and have acquired a separate status in the art in view of their different classification, restriction for examination purposes as indicated is proper.

5. Because these inventions are independent or distinct for the reasons given above and the inventions require a different field of search (see MPEP § 808.02), restriction for examination purposes as indicated is proper.

6. Because these inventions are independent or distinct for the reasons given above and have acquired a separate status in the art because of their recognized divergent subject matter, restriction for examination purposes as indicated is proper.

Applicant is advised that the reply to this requirement to be complete must include (i) an election of a species or invention to be examined even though the requirement be traversed (37 CFR 1.143) and (ii) identification of the claims encompassing the elected invention.

The election of an invention or species may be made with or without traverse. To reserve a right to petition, the election must be made with traverse. If the reply does not distinctly and specifically point out supposed errors in the restriction requirement, the election shall be treated as an election without traverse.

Should applicant traverse on the ground that the inventions or species are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions or species to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C.103(a) of the other invention.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to DOMINIC E. REGO whose telephone number is

(571)272-8132. The examiner can normally be reached on Monday-Friday, 8:30 am-5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew D. Anderson can be reached on 571-272-4177. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dominic E. Rego
/Dominic E Rego/
Examiner, Art Unit 2618
Tel 571-272-8132

/Matthew D. Anderson/
Supervisory Patent Examiner, Art Unit 2618

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10917968	ANDERSON, NICHOLAS WILLIAM
	Examiner	**Art Unit**
	DOMINIC E REGO	2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/13/2008								
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	35	÷								

Index of Claims	Application/Control No. 10917968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLIAM
	Examiner DOMINIC E REGO	Art Unit 2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	03/13/2008								
	36	÷								
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	39	÷								
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	42	÷								
	43	÷								
	44	÷								
	45	÷								
	46	÷								
	47	÷								
	48	÷								

Search Notes	Application/Control No. 10917968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLIAM
	Examiner DOMINIC E REGO	Art Unit 2618

SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
Consulted SPE Duc Nguyen regarding Restriction requirement	3/13/08	DR

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

Docket No.: 562492000500
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Nicholas W. ANDERSON

Application No.: 10/917,968 — Confirmation No.: 3609

Filed: August 12, 2004 — Art Unit: 2618

For: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM — Examiner: D. E. Rego

AMENDMENT IN RESPONSE TO NON-FINAL OFFICE ACTION

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

INTRODUCTORY COMMENTS

This is in response to the non-final Office Action dated July 2, 2007 (Paper No. 20070614), for which a response was due on October 2, 2007. Filed herewith is a Petition and fee for a three month extension of time, thereby extending the deadline for response to January 2, 2008 Accordingly, this response is timely filed. Reconsideration and allowance of the pending claims, as amended, in light of the remarks presented herein are respectfully requested.

Amendments to the Abstract begin on page 2.

Amendments to the Claims are reflected in the listing of claims which begins on page 3 of this paper.

Remarks/Arguments begin on page 14 of this paper.

AMENDMENTS TO THE ABSTRACT

Please replace the original abstract in its entirety with the following amended version:

A method, system and apparatus for setting a transmit power control level in a wireless communication system. Aspects of both open loop and closed loop transmit power control schemes are used to determine a transmit power level. A method includes measuring a power level of a received signal, receiving on a downlink channel an allocation of a scheduled uplink transmission resource and a transmit power control (TPC) commands. The method calculates and calculating a transmit power level associated with the scheduled uplink transmission resource based on the power level of the received signal and the TPC commands. The method also allows disregarding or utilizing the TPC commands when calculating the transmit power level, thereby disabling or exclusively enabling use of closed loop power control, and accordingly exclusively enabling or disabling the use of open loop power control.

AMENDMENTS TO THE CLAIMS

1. **(Currently amended)** A method of power control in a radio communications system, the method comprising:

determining a path loss for a radio channel between a base station and a remote transceiver; and

receiving on a downlink channel an allocation of a scheduled uplink transmission resource and [[~~a~~]]transmit power control (TPC) commands transmitted to the remote transceiver from the base station[[;]].

~~calculating a transmit power level for the remote transceiver based on the path loss and the TPC command.~~

2. **(Currently Amended)** The method of power control of claim 1, the method further comprising transmitting an uplink signal from the remote transceiver at ~~the~~ a calculated transmit power level.

3. **(Original)** The method of power control of claim 1, wherein determining the path loss includes:

receiving a downlink signal transmitted from the base station, wherein the downlink signal signals a transmitted power level of the downlink signal; and

measuring a received power level of the downlink signal.

4. **(Original)** The method of power control of claim 3, wherein determining the path loss further includes computing a difference between the signaled transmit power level and the measured received power level.

5. **(Canceled)**

6. **(Canceled)**

7. **(Currently Amended)** The method of power control of claim 2 ~~6~~, wherein the ~~adjustment factor incorporates~~ calculated ~~the~~ transmit power level is based on a spreading factor parameter.

8. **(Currently Amended)** The method of power control of claim 2 6, wherein the adjustment factor incorporates calculated transmit power level is based on parameters associated with a selected transport format parameter.

9. **(Currently Amended)** A method of power control in a radio communications system, the method comprising:

receiving a signal at a second transceiver transmitted from a first transceiver;

measuring a power level of the received signal at the second transceiver to obtain a measured received power level; and

receiving on a downlink channel an allocation of a scheduled uplink transmission resource and [[a]] transmit power control (TPC) commands at the second transceiver transmitted from the first transceiver[[;]]. and

calculating a transmit power level for the second transceiver based on the power level of the received signal and the TPC command.

10. **(Currently Amended)** A method of uplink power control in a CDMA radio communications system, the method comprising:

receiving an uplink signal;

measuring a received SNIR signal quality measure of the uplink signal to obtain a measured received signal quality value SNIR;

comparing the measured received SNIR signal quality value of with [[an]] a SNIR target signal quality value;

assigning a first value to a step indicator if the measured received SNIR signal quality value is greater than the SNIR target signal quality value, and assigning a second value to a step indicator if the measured received SNIR signal quality value is less than the SNIR target signal quality value;

transmitting a signal carrying both an allocation of a scheduled uplink transmission resource and a transmit power control (TPC) command instructing a transmitter to adjust an uplink transmit power level associated with the allocated uplink transmission resource based on the step indicator;

receiving the TPC command including the step indicator;

accumulating the step indicator values to obtain an accumulated step indicator value;

broadcasting a downlink signal including an indication of a downlink power level, wherein the downlink signal is transmitted at the downlink power level;

measuring ~~the~~ a received power level of the downlink signal; and

setting a transmit power level based on the received power level, the indication of the downlink power level, and the accumulated step indicator value.

11. **(Currently Amended)** The method of power control of claim 10, further comprising:

determining an error metric of the uplink signal;

updating the ~~SNIR~~ target signal quality value based on the error metric;

measuring an interference value in the received uplink signal; and

updating an interference measurement table with the interference value;

wherein broadcasting the downlink signal further includes the interference measurement table; and

wherein setting the transmit power level is further based on a value in the interference measurement table.

12. **(Currently Amended)** A method comprising:

measuring a power level of a received signal;

receiving on a downlink channel an allocation of a scheduled uplink transmission resource and [[~~a~~]] transmit power control (TPC) commands;

accumulating the TPC commands to obtain an accumulated TPC command; and

calculating a transmit power level associated with the scheduled uplink transmission resource based on the power level of the received signal and the accumulated TPC command.

13. **(Currently Amended)** A radio comprising:

a receiver including an output to provide a measured received power level and to receive an allocation of scheduled uplink transmission resource;

an accumulator having an input for accepting step increase and decrease instructions and an output providing an accumulated history of the step increases and decreases ~~sum of past step~~

~~instructions~~; and

a power level setting circuit coupled to the accumulator output and coupled to the receiver output, wherein the power level setting circuit sets a transmit power ~~bases~~ for the scheduled uplink transmission resource based on the accumulator output and the measured received power level to obtain a set transmit power,; and

a transmitter, ~~wherein the transmitter~~ configured to transmit[[s]] a signal on the scheduled uplink transmission resource at the set transmit power.

14. **(New)** The power control method of claim 1, wherein the TPC commands are transmitted on a shared physical channel.

15. **(New)** The power control method of claim 1, further comprising calculating a transmit power level for transmission by the remote transceiver on the scheduled uplink transmission resource based on the path loss and an accumulated TPC command.

16. **(New)** The power control method of claim 15, further comprising receiving a signal from the base station for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

17. **(New)** The power control method of claim 15, further comprising receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control.

18. **(New)** The power control method of claim 9, further comprising calculating a transmit power level to use for transmission by the second transceiver on the scheduled uplink transmission

resource based on the power level of the received signal and an accumulated TPC command.

19. **(New)** The power control method of claim 18, further comprising receiving a signal from the first transceiver for instructing the second transceiver to utilize only the accumulated TPC command when calculating transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

20. **(New)** The power control method of claim 18, further comprising receiving a signal from the first transceiver for instructing the second transceiver to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control.

21. **(New)** The power control method of claim 9, wherein the downlink channel is a shared physical channel.

22. **(New)** The uplink power control method of claim 10, wherein the received signal quality measure comprises signal-to-noise plus interference ratio (SNIR).

23. **(New)** The method of claim 12, further comprising utilizing only the accumulated TPC command when calculating the transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

24. **(New)** The method of claim 12, further comprising disregarding the accumulated TPC command when calculating the transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control.

25. **(New)** The method of claim 12, wherein the downlink channel is a shared physical channel.

26. **(New)** A computer-readable medium comprising program code for controlling power in a radio communication system, the program code for:

determining a path loss for a radio channel between a base station and a remote transceiver; and

receiving on a downlink channel an allocation of scheduled uplink transmission resource and transmit power control (TPC) commands transmitted to the remote transceiver from the base station, wherein the TPC commands are generated by the base station by comparing a received signal quality measure to a target signal quality value.

27. **(New)** The computer-readable medium of claim 26, wherein the downlink channel is a shared physical channel.

28. **(New)** The computer-readable medium of claim 26, wherein determining the path loss includes:

receiving a downlink signal transmitted from the base station, wherein the downlink signal signals a transmitted power level of the downlink signal; and

measuring a received power level of the downlink signal.

29. **(New)** The computer-readable medium of claim 26, further comprising program code for calculating a transmit power level for the remote transceiver based on the path loss and an accumulated TPC command to obtain a calculated transmit power level.

30. **(New)** The computer-readable medium of claim 29**,** further comprising program code for receiving a signal from the base station for instructing the remote transmitter to utilize the accumulated TPC command only when calculating the transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

31. **(New)** The computer-readable medium of claim 29, further comprising program code for receiving a signal from the base station for instructing the remote transmitter to disregard the accumulated TPC command when calculating the transmit power level, thereby disabling use of closed loop power control and enabling use of open loop power control only.

32. **(New)** The computer-readable medium of claim 29, further comprising program code for transmitting an uplink signal from the remote transceiver at the calculated transmit power level.

33. **(New)** The computer-readable medium of claim 29, wherein calculating the transmit power level is additionally based on a spreading factor parameter.

34. **(New)** The computer-readable medium of claim 29, wherein calculating the transmit power level is additionally based on parameters associated with a selected transport format parameter.

35. **(New)** A computer-readable medium comprising program code for controlling power in a radio communication system, the program code for:

receiving a signal at a second transceiver transmitted from a first transceiver;

measuring a power level of the received signal to obtain a measured received power level; and

receiving a downlink signal comprising an allocation of scheduled uplink transmission resources and transmit power control (TPC) commands at the second transceiver transmitted from the first transceiver.

36. **(New)** The computer-readable medium of claim 35, wherein the TPC commands are transmitted on a shared physical channel.

37. **(New)** The computer-readable medium of claim 35, further comprising program code for calculating a transmit power level to use for transmission by the second transceiver on the scheduled uplink resources based on the path loss and an accumulated TPC command.

38. **(New)** The computer-readable medium of claim 37, further comprising program code for receiving a signal from the first transceiver for instructing the second transceiver to utilize the accumulated TPC commands only when calculating the transmit power level, thereby disabling use of open loop power control and enabling use of closed loop power control only.

39. **(New)** The computer-readable medium of claim 37, further comprising program code for receiving a signal from the first transceiver for instructing the second transceiver to disregard the accumulated TPC command when calculating the transmit power level, thereby enabling use of open loop power control only and disabling use of closed loop power control.

40. **(New)** A computer-readable medium comprising program code for controlling uplink power in a CDMA radio communication system, the program code for:

receiving an uplink signal to obtain a received uplink signal;

measuring a received signal quality measure of the uplink signal to obtain a measured received signal quality value;

comparing the measured received signal quality value with a target signal quality value;

assigning a first value to a step indicator if the measured received signal quality value is greater than the target signal quality value, and assigning a second value to a step indicator if the measured received signal quality value is less than the target signal quality value;

transmitting a signal carrying an allocation of uplink transmission resource and a transmit power control (TPC) command instructing a transmitter to adjust an uplink transmit power level associated with the allocated uplink transmission resource based on the step indicator;

receiving the TPC command including the step indicator;

accumulating step indicator values to obtain an accumulated step indicator value;

broadcasting a downlink signal including an indication of a downlink power level, wherein the downlink signal is transmitted at the downlink power level;

measuring a received power level of the downlink signal; and

setting a transmit power level based on the received power level, the indication of the downlink power level, and the accumulated step indicator value.

41. **(New)** The computer-readable medium of claim 40, further comprising program code for:

determining an error metric of the uplink signal;

updating the target signal quality value based on the error metric;

measuring an interference value in the received uplink signal; and

updating an interference measurement table with the interference value;

wherein broadcasting the downlink signal further includes the interference measurement table; and

wherein setting the transmit power level is further based on a value in the interference measurement table.

42. **(New)** The computer-readable medium of claim 40, wherein the received signal quality measure comprises SNIR.

43. **(New)** A method of power control in a radio communications system, the method comprising:

sending on a downlink channel an allocation of a scheduled uplink transmission resource and transmit power control (TPC) commands transmitted to a remote transceiver from a base station; and

receiving an uplink signal from the remote transceiver at a calculated transmit power level based on a path loss and the TPC commands.

44. **(New)** The power control method of claim 43, further comprising sending a signal to the remote transceiver for instructing the remote transmitter to utilize only the accumulated TPC commands when deriving the calculated transmit power level, thereby instructing the remote transmitter to disable use of open loop power control and enable use of closed loop power control only.

45. **(New)** The power control method of claim 43, further comprising sending a signal from the base station to the remote transceiver for instructing the remote transmitter to disregard the accumulated TPC command when deriving the calculated transmit power level, thereby instructing the remote transmitter to enable use of open loop power control only and disable use of closed loop power control.

46. **(New)** A computer-readable medium comprising program code for controlling power in a radio communication system, the program code for:

sending on a downlink channel an allocation of a scheduled uplink transmission resource and transmit power control (TPC) commands transmitted to a remote transceiver from a base station;

receiving an uplink signal from the remote transceiver at a calculated transmit power level based on a path loss and the TPC commands.

47. **(New)** A computer-readable medium of claim 46, further comprising program code for sending a signal to the remote transceiver for instructing the remote transmitter to utilize only the TPC commands when deriving the calculated transmit power level, thereby instructing the remote transmitter to disable use of open loop power control and enable use of closed loop power control only.

48. **(New)** A computer-readable medium of claim 46, further comprising program code for sending a signal from the base station to the remote transceiver for instructing the remote transmitter to disregard the TPC commands when deriving the calculated transmit power level, thereby instructing the remote transmitter to enable use of open loop power control only and disable use of closed loop power control.

REMARKS

In the July 02, 2007 Office Action, claims 1-13 were rejected. This Response amends claims 1-2, and 7-13, cancels claims 5 and 6 (without prejudice or disclaimer of the subject matter), and introduces new claims 14-48. No new matter has been introduced by the present amendments. After entry of the foregoing amendments, claims 1-4, and 7-48 (46 total claims; 10 independent claims) remain pending in the application. With respect to all amendments, Applicants have not dedicated or abandoned any unclaimed subject matter and moreover have not acquiesced to any rejections made by the Patent Office. Reconsideration of the application is respectfully requested in view of the above amendments and the following remarks.

Objection under 35 U.S.C. § 112

The Office action has rejected claim 13 under 35 U.S.C. § 112, first paragraph, as failing to comply with the written description requirement. Claim 13 has been amended to address the Examiner's rejection. Claim 13 now recites "an output providing an accumulated history of the step increases and decreases", which is enabled by at least paragraph 65 lines 4-5 of Applicants' application, which states "The UE accumulates the TPC commands and uses the accumulated TPC commands", and paragraph 59 lines 4-6 of Applicants' application, which states "step is the magnitude of the amount added to an accumulator upon receipt of each TPC command". Accordingly, Applicants request the withdrawal of the §112 rejection of claim 13.

Rejections under 35 U.S.C. § 102

The Office Action has rejected claims 1-7, 9, 10, 12, and 13, under U.S.C. § 102(b) as being anticipated by Zeira et al., International Application Publication No. (WO 00/57574) published September 28, 2000 (hereinafter "Zeira"). Applicants respectfully traverse the rejections.

Regarding independent claim 1, 9, and 12, Applicants teach a physical channel on the downlink that is used to carry fast allocation and scheduling information to a user thereby informing the user equipment (UE) of the uplink resources that it may use. Additionally this physical channel is used as a feedback channel for power control also carrying transmit power control (TPC) commands (paragraph 84 of Applicants' application). Accordingly independent claims 1, 9 and 12, recite "receiving on a downlink channel *an allocation of a scheduled uplink transmission resource* *and transmit power control (TPC) commands* transmitted to the remote transceiver from the base station". This feature, is not taught by Zeira, and therefore, Zeira does not anticipate the methods as recited in independent claims 1, 9, and 12.

Additionally, regarding independent claim 12, Applicants teach a power control algorithm based in part on *accumulated* TPC commands (paragraph 66, lines 5-6 of Applicants' application). Accordingly, claim 12 recites "calculating a transmit power level *associated with the scheduled uplink transmission resource* based on the power level of the received signal and the *accumulated TPC command'*. This feature, is not taught by Zeira, therefore for at least this additional reason, Zeira does not anticipate the method as recited in independent claim 12.

Regarding independent claim 10, applicant teaches a method for *carrying both an allocation of a scheduled uplink transmission resource and transmit power control (TPC) commands on a transmitting signal* for instructing a transmitter to adjust the uplink transmit power level associated with the *allocated uplink transmission resource* based on a step indicator. This feature, is not taught by Zeira, and therefore, Zeira does not anticipate the method as recited in the independent claim 10.

Regarding independent claim 13, Applicants teach a system for performing a power control algorithm using *accumulated* power control instructions. Accordingly, claim 13 recites "an *accumulator* having an input for accepting step increase and decrease instructions and an output providing an *accumulated* history of the step increases and decreases" (paragraph 74, and paragraph 59 lines 4-6 of Applicants' application). This feature and in particular the "*accumulated* history of the step increases and decreases" is not taught by Zeira, therefore, Zeira does not anticipate the method as recited in claim 13.

Furthermore, claim 13 recites "sets the transmit power *for the scheduled uplink transmission resource*" and "to transmit a signal *on the scheduled uplink transmission resource...*". This feature, is not taught by Zeira, therefore for this additional reason, Zeira does not anticipate the system as recited in independent claim 13.

For at least the above reasons, Zeira does not anticipate the method as recited in independent claims 1, 9-10, and 12 and the system as recited in independent claim 13. For at least the same reasons, claims 2-4, and 7 (which variously depend from claim 1), are also not anticipated by Zeira. Accordingly, Applicants request the withdrawal of the §102 rejection of claims 1-4, 7, 9-10, and 12-13. Claims 5-6 are cancelled, and therefore the rejections to claims 5-6 are now moot.

Rejections under 35 U.S.C. § 103

Applicant respectfully submits that the Office Action has not met all of the criteria to establish a case of obviousness.

Claim 8 was rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Zeira in view of Zeira et al., U.S. Patent Application Publication No. (2004/0141483) published July 22, 2004 (hereinafter "Zeira US"), in view of Bevan et al., U.S. Patent Application Publication No. (2004/0162093) published Aug. 19, 2004 (hereinafter "Bevan"), and further in view of Kamel et al., U.S. Patent No. (7,190,688) issued Mar. 13, 2007 (hereinafter "Kamel"). Applicants respectfully traverse the rejections.

For the reasons discussed above, Zeira fails to teach or suggest the "receiving on a downlink channel *an allocation of scheduled uplink transmission resource and transmit power control (TPC) commands...*" limitations of independent claim 1, and consequently Zeira also fails to teach or suggest the same limitations in claim 8 (which depends from claim 1). For at least the above reasons, claim 8 is not unpatentable over Zeira in view of Zeira US, in view of Bevan, and further in view of Kamel, and Applicants respectfully request the withdrawal of the rejection of claim 8 under §103(a).

Claim 11 was rejected under 35 U.S.C. § 103(a) as being allegedly unpatentable over Zeira in view of Shiu et al., U.S. Patent No. (6,983,166) issued Jan. 3, 2006 (hereinafter "Shiu"). Applicants respectfully traverse the rejections.

For the reasons discussed above, Zeira fails to teach or suggest "*carrying both an allocation of a scheduled uplink transmission resource and transmit power control (TPC) commands on a transmitting signal...*" limitation in claim 10. Consequently Zeira also fails to teach or suggest the same limitation in claim 11 (which depends from claim 10). Therefore, for at least the above reasons, claim 11 is not unpatentable over Zeira in view of Shiu, and Applicants respectfully request the withdrawal of the rejection of claim 11 under §103(a).

New Claims

New claims 14-48 have been introduced and support for the new claims can be found throughout the application and particularly in paragraphs 73, 84 and 85 of the applicants' specification.

Abstract

The abstract has been amended to better reflect the Application. No new matter has been introduced by the present amendments.

Conclusion

In view of the above, each of the presently pending claims in this application is believed to be in immediate condition for allowance. Accordingly, the Examiner is respectfully requested to withdraw the outstanding rejection of the claims and to pass this application to issue. If it is determined that a telephone conference would expedite the prosecution of this application, the Examiner is invited to telephone the undersigned at the number given below.

In the event the U.S. Patent and Trademark office determines that an extension and/or other relief is required, Applicants' petition for any required relief including extensions of time and authorizes the Commissioner to charge the cost of such petitions and/or other fees due in connection with the filing of this document to Deposit Account No. 03-1952 referencing docket no.562492000500. However, the Commissioner is not authorized to charge the cost of the issue fee to the Deposit Account.

Dated: __December 28, 2007_____

Respectfully submitted,

Electronic signature: /Elahe Toosi/
Elahe Toosi
Registration No.: 57,740
MORRISON & FOERSTER LLP
12531 High Bluff Drive, Suite 100
San Diego, California 92130-2040
(858) 314-7546

Electronic Patent Application Fee Transmittal

Application Number:	10917968
Filing Date:	12-Aug-2004
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Filer:	Elahe S. Toosi/Peggy Bozym
Attorney Docket Number:	562492000500
Filed as Large Entity	

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in excess of 20	1202	26	50	1300
Independent claims in excess of 3	1201	5	210	1050
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Extension - 3 months with $0 paid	1253	1	1050	1050
Miscellaneous:				
		Total in USD ($)		**3400**

Electronic Acknowledgement Receipt

EFS ID:	2652954
Application Number:	10917968
International Application Number:	
Confirmation Number:	3609
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Customer Number:	25226
Filer:	Elahe S. Toosi/Peggy Bozym
Filer Authorized By:	Elahe S. Toosi
Attorney Docket Number:	562492000500
Receipt Date:	28-DEC-2007
Filing Date:	12-AUG-2004
Time Stamp:	20:43:06
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$3400
RAM confirmation Number	3179
Deposit Account	031952
Authorized User	

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	Transmittal.pdf	27400 79fe67e8aaf115f25fe73ee46bb1612eb77700fe	no	1
Warnings:					
Information:					
2	Extension of Time	Petition_for_Extension.pdf	30936 87a5e67c910347e1f9f646a7ce4e2b3422e6be9b	no	1
Warnings:					
Information:					
3		Response_to_Non_Final_OA.pdf	78358 2dae46977c913ced130520e512c3b32d5240348e	yes	17

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment - After Non-Final Rejection	1	2
Claims	3	13
Applicant Arguments/Remarks Made in an Amendment	14	17

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)
Warnings:					
Information:					
4	Fee Worksheet (PTO-06)	fee-info.pdf	8447 23983c511b1baa63be64d5bd21610aaaa2c583e6	no	2
Warnings:					
Information:					

Total Files Size (in bytes): 145141

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/21 (12-07)
Approved for use through 12/31/2007. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas W. ANDERSON
Art Unit	2618
Examiner Name	D. E. Rego
Attorney Docket Number	562492000500
Total Number of Pages in This Submission	19

ENCLOSURES (*Check all that apply*)

- [ ] Fee Transmittal Form
  - [ ] Fee Attached
- [x] Amendment/Reply (17 pgs)
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [x] Extension of Time Request (1 pg)
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ______
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- [ ] Proprietary Information
- [ ] Status Letter
- [ ] Other Enclosure(s) (please Identify below):

Remarks

Customer No. 25225

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	MORRISON & FOERSTER LLP		
Signature	/Elahe Toosi/		
Printed name	Elahe Toosi		
Date	December 28, 2007	Reg. No.	57,740

sd-406146

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) FY 2008 *(Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)*	Docket Number (Optional) 562492000500
Application Number 10/917,968	Filed August 12, 2004
For POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM	
Art Unit 2618	Examiner D. E. Rego

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

		Fee	Small Entity Fee	
☐	One month (37 CFR 1.17(a)(1))	$120	$60	$ ______
☐	Two months (37 CFR 1.17(a)(2))	$460	$230	$ ______
X	Three months (37 CFR 1.17(a)(3))	$1050	$525	$ 1,050.00
☐	Four months (37 CFR 1.17(a)(4))	$1640	$820	$ ______
☐	Five months (37 CFR 1.17(a)(5))	$2230	$1115	$ ______

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

X The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 03-1952 ~~I have enclosed a duplicate copy of this sheet. Fee Transmittal form (PTO/SB/17) is attached to this submission in duplicate.~~

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

X attorney or agent of record. Registration Number 57,740

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34 ______

/Elahe Toosi/	December 28, 2007
Signature	Date
Elahe Toosi	(858) 314-7546
Typed or printed name	Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below.

X Total of 1 forms are submitted.

PTO/SB/06 (12-04)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number: 10/917,948

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))							
SEARCH FEE (37 CFR 1.16(k), (i), or (m))							
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))							
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X =		OR	X =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X =			X =	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
			TOTAL			TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

APPLICATION AS AMENDED – PART II

12/28/07

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 46	Minus	** 20	= 26	x25 =		OR	x50 =	1,300.00
Independent (37 CFR 1.16(h))	* 10	Minus	*** 5	= 5	x100 =		OR	x200 =	1,050.00
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	2,350.00

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X =		OR	X =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X =		OR	X =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Patent
Docket No. 562492000500

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: Nicholas W. ANDERSON	Confirmation No.: 3609
Serial No.: 10/917,968	Examiner: D. E. Rego
Filing Date: August 12, 2004	Group Art Unit: 2618
For: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM	

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. § 1.97 & 1.98

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Pursuant to 37 C.F.R. §1.97 and § 1.98, Applicants submit for consideration in the above-identified application the documents listed on the attached Form PTO/SB/08a/b. Copies of foreign documents and non-patent literature are submitted herewith. The Examiner is requested to make these documents of record.

sf-2365894

This Supplemental Information Disclosure Statement is submitted:

☐ With the application; accordingly, no fee or separate requirements are required.

☐ Before the mailing of a first Office Action after the filing of a Request for Continued Examination under § 1.114. However, if applicable, a certification under 37 C.F.R. § 1.97 (e)(1) has been provided.

☐ Within three months of the application filing date or before mailing of a first Office Action on the merits; accordingly, no fee or separate requirements are required. However, if applicable, a certification under 37 C.F.R. § 1.97 (e)(1) has been provided.

☒ **After receipt of a first Office Action on the merits but before mailing of a final Office Action or Notice of Allowance.**

- ☐ A fee is required. A check in the amount of __ is enclosed.
- ☒ **A fee is required. Accordingly, a Fee Transmittal form (PTO/SB/17) is attached to this submission in duplicate.**
- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above; accordingly; no fee is believed to be due.

☐ After mailing of a final Office Action or Notice of Allowance, but before payment of the issue fee.

- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above and a check in the amount of __ is enclosed.
- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above and a Fee Transmittal form (PTO/SB/17 is attached to this submission in duplicate.)

Applicants would appreciate the Examiner initialing and returning the Form PTO/SB/08a/b, indicating that the information has been considered and made of record herein.

The information contained in this Supplemental Information Disclosure Statement under 37 C.F.R. § 1.97 and § 1.98 is not to be construed as a representation that: (i) a complete search has been made; (ii) additional information material to the examination of this application does not exist; (iii) the information, protocols, results and the like reported by third parties are accurate or enabling; or (iv) the above information constitutes prior art to the subject invention.

In the unlikely event that the transmittal form is separated from this document and the Patent and Trademark Office determines that an extension and/or other relief (such as payment of a fee under 37 C.F.R. § 1.17 (p)) is required, Applicants petition for any required relief including extensions of time and authorize the Commissioner to charge the cost of such petition and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing 562492000500.

Dated: October 2, 2007

Respectfully submitted,

By_/Elahe Toosi/_______________________

Elahe Toosi
Registration No.: 57,740
MORRISON & FOERSTER LLP
12531 High Bluff Drive, Suite 100
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Substitute for form 1449/PTO				Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	10/917,968
				Filing Date	August 12, 2004
				First Named Inventor	Nicholas W. ANDERSON
				Art Unit	2618
(Use as many sheets as necessary)				Examiner Name	D. E. Rego
Sheet	1	of	1	Attorney Docket Number	562492000500

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1.	US-5,719,583-A	02-17-1998	Kanai	
	2.	US-5,887,245-A	03-23-1999	Lindroth et al.	
	3.	US-6,137,993-A	10-24-2000	Almgren et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	4.	GB-2350522-A	11-29-2000	Roke Manor Research Limited		
	5.	EP-1176739-A1	01-30-2002	Matsushita Electric Industrial Co., Ltd.		

*EXAMINER: Initial if information considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	6.	"Recommendation ITU-R M.1225: Guidelines for Evaluation of Radio Transmission Technologies for IMT-2000," International Telecommunication Union/ITU Radiocommunication Sector, January 1, 1997, Rec. ITU-R M.1225, pp. 1-61.	
	7.	Great Britain Search Report mailed May 14, 2002, for Great Britain Application No. 0125504.1 filed October 24, 2001, 1 page.	
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Examiner Signature		Date Considered	

sf- 2365891

(12) UK Patent Application (19) GB (11) 2 350 522 (13) A

(43) Date of A Publication 29.11.2000

(21) Application No 9912090.9

(22) Date of Filing 25.05.1999

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(51) INT CL^7
H04B 7/005 , H04Q 7/32

(52) UK CL (Edition R)
H4L LDH L1H10

(56) Documents Cited
GB 2268365 A EP 0668664 A1 US 5631921 A

(58) Field of Search
UK CL (Edition Q) **H4L LDH LECX**
INT CL^6 **H03G 3/20 3/30 , H04B 7/005 , H04Q 7/32**
ONLINE - EPODOC, WPI

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(54) Abstract Title
Power control in mobile telecommunications systems

(57) In an UTRA-TDD communications system, a mobile terminal implements open loop power control of its transmitter power by identifying downlink time slots in which reference signals, comprising mid-amble codes, are transmitted from a base station. For power control of an uplink time slot, that one of such identified downlink slots which is closest in time to immediately before the uplink slot is selected and the reference signal energy (or power) measurement for that downlink slot is used by the mobile terminal to infer the path loss in order to control its transmit power in the uplink slot. The fact that measured mid-amble energy should exceed total noise energy by a predetermined margin in any downlink slot containing a mid-amble code is used to identify such slots. To effect this identification, the signal 80 received by the mobile is passed via an A-D converter (not shown) to a matched filter 10 in which correlation against the mid-able code is achieved by means of a shift register 110 and multipliers 130 to 144 which receive respective bit codes corresponding to the mid-amble code. The output 90 of a summator 150 passes to an energy measuring circuit 20 which computes the modulus squared to provide an energy measure for a particular path. As signal 80 is clocked through shift register 110, circuit 20 determines energy values for other paths, and an accumulator 30 provides an output 100 indicative of the total energy for all the paths for a given period of the mid-amble code. The input signal 80 is also passed directly to an energy measuring circuit 40 connected to an accumulator 50, the output of which corresponds to the noise energy summed for all paths over the given period of the mid-amble code. The output of accumulator 30 and the output from accumulator 50, weighted in unit 60, are input to a comparator 70 which gives a "1" output when a downlink slot containing a reference signal (mid-amble code) has been identified.

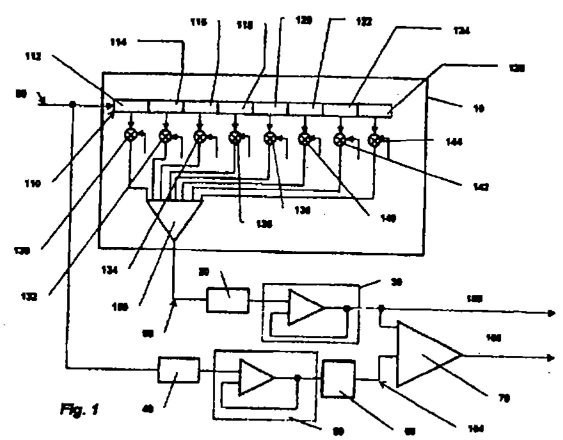

Fig. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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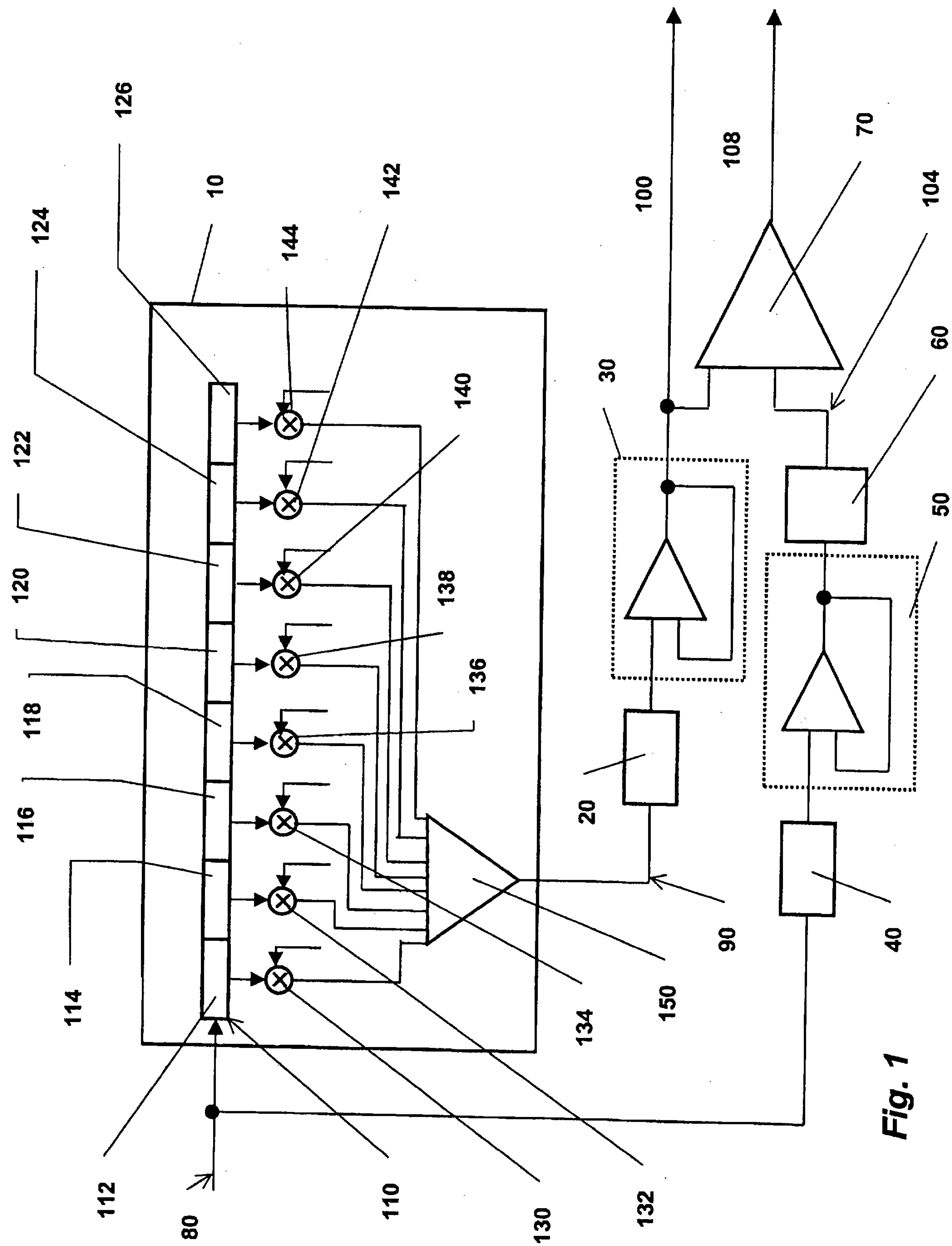
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Fig. 1

IMPROVEMENTS IN OR RELATING TO MOBILE TELECOMMUNICATIONS SYSTEMS

The present invention relates to improvements in or relating to mobile telecommunications systems, and is more particularly concerned with open loop power control for such systems.

The UMTS terrestrial radio access (UTRA) – time division duplex (TDD) system is based on a combination of code division multiple access (CDMA) and hybrid time division multiple access (TDMA) and TDD. (UMTS is an acronym for universal mobile telecommunication system as understood by persons skilled in the art.)

As the UTRA-TDD system is based on CDMA, its performance is dependent on the operation of power control, particularly, for the uplink connection, that is, the connection from a mobile terminal to a base station. Furthermore, as the system is also based on TDD, the uplink and downlink (base station to mobile terminal) connections use the same frequency and so the channel is reciprocal. Measurements of the received power on the downlink connection can be used to estimate the path loss if the base station transmit power is known at the mobile station. Therefore, if the level of interference present and the required signal-to-noise ratio of the base station are communicated to the mobile station, the mobile station can combine this information to set the correct power for reception at the base station. This procedure is known as open loop power control.

The UTRA-TDD system has a TDMA/TDD frame consisting of sixteen time slots over a period of 10ms, each time slot lasting 0.625ms. Within such a system, some time slots are permanently assigned to downlink connections for broadcast purposes, and at least one other time slot to the uplink connection for access purposes. The remaining time slots may freely be assigned to either uplink or downlink connections as traffic requirements dictate. The time slots in which downlink connections are transmitted include reference signals of known data patterns which assist in the decoding of the transmission.

The UTRA-TDD system will usually be deployed in a cellular configuration in which the same frequency will be re-used in all cells – each cell comprising a base station and a plurality of mobile terminals within an area covered by the base station. Moreover the TDMA/TDD frames of all cells will be synchronised. However, in many cases, the inter-cell interference will be too great to permit traffic to be actively transmitted in all time slots in all cells. Accordingly, it has been proposed that the time slots be allocated to cells according to a dynamic channel assignment (DCA) algorithm to reduce inter-cell interference to acceptable levels.

As described above, a measurement of power in a downlink time slot provides an estimate of the path loss. However, if a mobile terminal is moving at relatively high speed this path loss will be rapidly changing. Thus, if, for example, a measurement is performed on time slot 0, that is, at the beginning of a frame, the path loss estimated from this measurement will be out of date by, say, time slot 8. Thus, an open loop power control scheme which performed measurements in slot 0 and used these measurements to set the transmit power in slot 8 would not control the received signal-to-noise ratio at the base station very accurately. In fact, the best performance that can be achieved will apply when the power measurement is performed in time slot N and is used to set the transmit power in time slot $N + 1$, where, for UTRA-TDD, $0 \leq N \leq 15$. In some cases, the best that can be achieved will be to perform the power measurement in time slot N and set the transmit power in time slot $N + M$ where M is made as small as possible and where, for UTRA-TDD, $0 \leq N \leq (16 - M)$.

It is therefore an object of the present invention to provide a method which allows the best performance to be achieved wherever practically possible.

In particular, within the structure of UTRA-TDD, all time slot transmissions consist of three elements, which, in time order, are - data burst 1, a reference signal and data burst 2. Because UTRA-TDD is based on CDMA, the data bursts may consist of several spread spectrum modulated components each carrying data and summed together. For the downlink, and where smart antennas are not applied, there is only one common reference signal transmitted. The reference signal comprises a fixed code against which correlations are performed for the purpose of deriving channel estimates.

Within a downlink time slot transmission, the different codes transmitting the data bursts may be intended for reception at different mobile stations. In general, in order to minimise inter-cell interference, and therefore to maximise system capacity, the powers of the individual codes are controlled independently so as to transmit only enough power to satisfy the signal-to-noise plus interference requirements at each mobile station. According to known techniques, the reference signal transmit power is set to be equal to the sum of the powers of the individual codes.

In accordance with one aspect of the present invention, there is provided a method of providing open loop power control in a hybrid TDD/TDMA mobile telecommunications system wherein reference signals of known data patterns are transmitted in downlink time slots, using reference signal energy measurements, the telecommunications system comprising at least one base station and at least one mobile terminal, the method comprising:-

a) receiving an input signal at the mobile terminal;

b) measuring and summing the energy of the reference signals in the input signal in one or more multipath components by correlation against the reference signal to obtain an overall received reference signal energy measurement;

c) measuring the total received signal energy;

d) comparing the received reference signal energy measurement with the total received signal energy measurement to obtain an indication of the presence of a reference signal;

e) selecting the reference signal position for which the time difference to the next uplink transmission from the terminal is substantially minimised; and;

f) using the corresponding reference signal energy measurement for open loop power control.

It will readily be appreciated that although reference is made to 'energy' measurements, these measurements are interchangeable wwith 'power' measurements to provide open loop power control.

It is preferred that, in all active downlink slots, that is, downlink slots in which one or more data burst codes are being transmitted, the power of the reference signals in the same time slot in adjacent frames should be held constant and the reference signal energy measurements should be used for open loop power control.

By keeping the power of the reference signals constant, and either by making this power a global constant, known to the mobile terminals or by signalling this value to the mobile terminals at suitable intervals from each base station, the mobile terminal can infer the path loss from measurements of the reference signal. However, it will be appreciated that the reference signal power need not be held constant and each time slot may have its own individual reference signal power.

For a better understanding of the present invention, reference will now be made, by way of example only, to the accompanying drawing, the single Figure of which illustrates a block diagram of a circuit for detecting the presence of a reference signal and for measuring the energy of such a signal in accordance with the present invention.

In accordance with the present invention, a mobile terminal performs measurements of reference signal energy in all time slots, other than those time slots in which it is transmitting. These time slots can be divided into three categories, namely, time slots in which no transmissions are being made either in the uplink or the downlink direction, time slots in which uplink transmissions are being made, and time slots in which downlink transmissions are being made. However, only time slots which are in the last of these categories are of interest.

In order to determine the reference signal energy for the time slots in which downlink transmissions are being made, it is necessary to identify these time slots. In the present case, the reference signals comprise mid-amble codes as they are transmitted midway through a downlink time slot. However, it will be appreciated that the reference signals can be transmitted at other positions within the time slot.

One embodiment of a circuit for determining the presence of a mid-amble code and measuring its energy is shown in Figure 1. The circuit shown in Figure 1 comprises a matched filter 10, a first energy measuring circuit 20, a first accumulator 30, a second energy measuring circuit 40, a second accumulator 50, a weighting unit 60, and a comparator 70. The matched filter 10 is connected to receive a complex baseband data input signal 80, and to provide an output signal 90. The matched filter 10 is matched to the mid-amble code for the system.

As shown, the matched filter 10 comprises a shift register 110 having eight elements 112, 114, 116, 118, 120, 122, 124, 126, eight multipliers 130, 132, 134, 136, 138, 140, 142, 144, and a summator 150. It will readily be appreciated that although the shift register is shown as having eight elements, any other suitable number may be used according to the particular application. It will, however, be noted that the number of multipliers is the same as the number of elements in the shift register and the number of elements in the code.

The baseband data input signal 80 is applied to the elements 112, 114, 116, 118, 120, 122, 124, 126 of the shift register 110 and the values stored in each element is passed to a respective one of the multipliers 130, 132, 134, 136, 138, 140, 142, 144 where they are combined with a respective bit code corresponding to the mid-amble code of the system. Output signals from the multipliers 130, 132, 134, 136, 138, 140, 142, 144 are then passed to summator 150 where they are summed and the output signal 90 is produced. Output signal 90 corresponds to the path gain for a particular path.

Output signal 90 is then passed to the first energy measuring circuit 20 where the modulus squared thereof is computed to provide an energy value for the path.

As the input signal 80 is clocked through the shift register 110, the energy values for other paths are determined in energy measuring circuit 20 and passed to the first accumulator 30 where the energy values for each path are summed with the accumulated energy values for previous paths. Accumulator 30 provides an output signal 100 which is indicative of the total energy for all the paths for a given period of the mid-amble code.

In any downlink slot containing a mid-amble code, the measured mid-amble energy as measured after correlation in the matched filter 10 should exceed the total noise energy by a predetermined margin. Thus, the presence of a downlink mid-amble code is determined by measuring the noise energy over the period of the mid-amble code and comparing with output signal 100.

To effect this comparison, the input signal 80 is passed directly to the second energy measuring circuit 40 where the energy value in each path is determined as before. The accumulations are arranged to continue over the period of the mid-amble code as described above in accumulator 50 to provide the noise energy corresponding to all the path. However, as several path positions are added together, the noise energy measurement must be weighted accordingly. In UTRA-TDD, the period over which paths are measured is n chips, for example, $n = 57$. Path energy measurements for all n positions will multiply the noise energy or power level by n.

Alternatively, the weighting factor can be reduced if path thresholding is performed. This can be done by taking longer term averages over mid-amble code measurements for those time slots in which the downlink mid-amble code is known to be transmitted, such as, the time slot known to contain the common control physical channel (CCPCH). In this way, the exact chip positions of known mid-amble code paths, assuming that the mid-amble code is transmitted, can be identified for the entire frame. If, for example, a maximum of eight paths are taken to be non-zero, then the noise energy for comparison will be weighted only by 8 rather than by n.

The energy values for all paths in the period of the mid-amble code are passed to weighting unit 60 so that the noise energy values can have the appropriate weighting applied as described above prior to providing output signal 104 as shown.

Output signal 104 is then passed to the comparator 70. Output signal 100 from the first accumulator 30 is also passed to the comparator 70. Comparator 70 compares the two signals 100, 104 and provides an output signal 108 which is indicative of that comparison. Output signal 108 from the comparator 70 either comprises a '0' or a '1'. In the former case, this means that the difference between signal 100 and signal 104 does not exceed the predetermined margin, as defined by the value incorporated into the signal by weighting unit 60, and therefore the energy values measured relate to noise as no mid-amble code is present. In the latter case, this means that the difference between signal 100 and signal 104 exceeds the predetermined margin and a mid-amble code has been detected.

Thus, in accordance with the present invention described above, it is possible to identify downlink time slots containing mid-amble codes. The measurements of the downlink energy values can be further improved by subtracting the noise measurements in order to obtain unbiased measurements of the signal only component (not shown). Having identified the downlink slots containing mid-amble codes, it remains only to select the most appropriate mid-amble code for open loop power control. This consists of selecting the mid-amble code, which is closest in time to immediately before the uplink time slot. Where available the immediately preceding time slot would be used. However, if the mobile terminal receiver is implemented in such a way that there is some latency in the measurement of the time slot energy, for example, one time slot, then the minimum gap will clearly increase (to one time slot in this specific example) for this latency.

It will be appreciated that the circuit described above operates in the digital domain, the complex baseband input signal 80 being in digital form after being processed by an analogue-to-digital converter (ADC) (not shown).

Automatic gain control (AGC) may be applied to set the levels of the signals passing into the ADC. However, it will be noted that the analogue AGC will operate on the composite input signal rather than any specific component such as a mid-amble.

As described above, the mobile terminal makes autonomous selection of the downlink time slots to use for open loop power control. However, the process cannot compensate for unfortuitous assignments of the time slots by the base station. Accordingly, also in accordance with the present invention, the time slots in the base station can be assigned in such a way as to maximise the benefits of energy measurements for open loop power control. There are several approaches which can be implemented to achieve an optimisation of these measurements.

In one embodiment, a mid-amble code is transmitted in every time slot which has been assigned to downlink operation in that base station, whether data bursts are being transmitted in that time slot or not. This increases the number of downlink time slots containing mid-amble code transmissions.

In another embodiment, a mid-amble code is transmitted in every time slot, which has been assigned to downlink operation, in every base station operating within the system.

A further embodiment utilises the fact that whenever a call is set up in UTRA-TDD, at least one resource unit must be allocated in both the uplink and the downlink. A resource unit is defined as a combination of a time slot and a spread spectrum code. In this embodiment, the call set up procedure in the base station is arranged to assign downlink resource unit(s) in a time slot as close in time to immediately before the time slot assigned for the uplink resource unit(s) as possible. Where the required number of resource units in either or both directions dictates that more than one time slot be assigned for that direction, these time slots should be assigned in such a way as to maximise the benefit for open loop power control. Except where unavoidable, consecutive time slots should not be assigned to uplink operation since the power setting for the later time slots will be further from that required than the power setting for the first time slots. In most cases, it should be possible to satisfy the condition since asymmetrical operation will most often be required to provide greater downlink than uplink data rates.

Additionally, the operation of the dynamic channel assignment (DCA) can be optimised. Optimum operation arises when the uplink time slots for a given base station are close in time following the downlink time slots for that same base station. By constraining the DCA algorithm to allocate contiguous blocks of time slots to each base station, the operation can be optimised. Moreover, the allocation for each base station should arrange for the first time slot to be dedicated to downlink operation and the last to uplink with the intermediate time slots assigned to optimise the operation of open loop power control but consistently with the long to medium term balance between uplink and downlink traffic loads.

CLAIMS:

1. A method of providing open loop power control in a hybrid TDD/TDMA mobile telecommunications system wherein reference signals of known data patterns are transmitted in downlink time slots, using reference signal energy measurements, the telecommunications system comprising at least one base station and at least one mobile terminal, the method comprising:-

a) receiving an input signal at the mobile terminal;

b) measuring and summing the energy of the reference signals in the input signal in one or more multipath components by correlation against the reference signal to obtain an overall received reference signal energy measurement;

c) measuring the total received signal energy;

d) comparing the received reference signal energy measurement with the total received signal energy measurement to obtain an indication of the presence of a reference signal;

e) selecting the reference signal position for which the time difference to the next uplink transmission from the terminal is substantially minimised; and;

f) using the corresponding reference signal energy measurement for open loop power control.

2. A method according to claim 1, further comprising the step of:-

g) assigning time slots in the base station for maximising measurements for open loop power control.

3. A method according to claim 2, wherein step g) comprises transmitting a reference signal in every time slot.

4. A method according to claim 3, further comprising transmitting a reference signal in every time slot for every base station.

5. A method according to claim 2, wherein step g) comprises allocating at least one resource unit in a downlink connection in a time slot as close in time to immediately before a time slot allocated for at least one resource unit in an uplink connection.

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Application No: GB 9912090.9
Claims searched: 1 to 5
Examiner: M J Billing
Date of search: 25 October 1999

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4L LDG, LECX.

Int Cl (Ed.6): H03G 3/20, 3/30; H04B 7/005; H04Q 7/32.

Other: ONLINE - EPODOC, WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2268365A	(ROKE MANOR) - page 7 line 1 to page 8 line 17	1
A	EP0668664A1	(MATSUSHITA) - Abstract	1
A	US5631921	(INTERDIGITAL) - Figs.3,5	1

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(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 176 739 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
30.01.2002 Bulletin 2002/05

(21) Application number: 01906346.0

(22) Date of filing: 27.02.2001

(51) Int Cl.7: H04B 7/26

(86) International application number:
PCT/JP01/01458

(87) International publication number:
WO 01/67639 (13.09.2001 Gazette 2001/37)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 06.03.2000 JP 2000060155

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(54) TRANSMITTING APPARATUS AND TRANSMITTING METHOD

(57) Transmit power determining section 100 determines a transmit power value based on the condition of the propagation path estimated from a propagation loss and the number of times the random access channel signal is retransmitted. Midamble pattern determining section 103 determines a midamble pattern corresponding to the transmit power value from among a plurality of midamble patterns. Time multiplexing section 102 creates a transmission signal by multiplexing transmission data subjected to spreading processing and the midamble pattern. Radio section 104 applies predetermined transmission processing to the transmission signal generated and transmits the transmission signal subjected to the transmission processing above using the determined transmit power value as a random access channel signal.

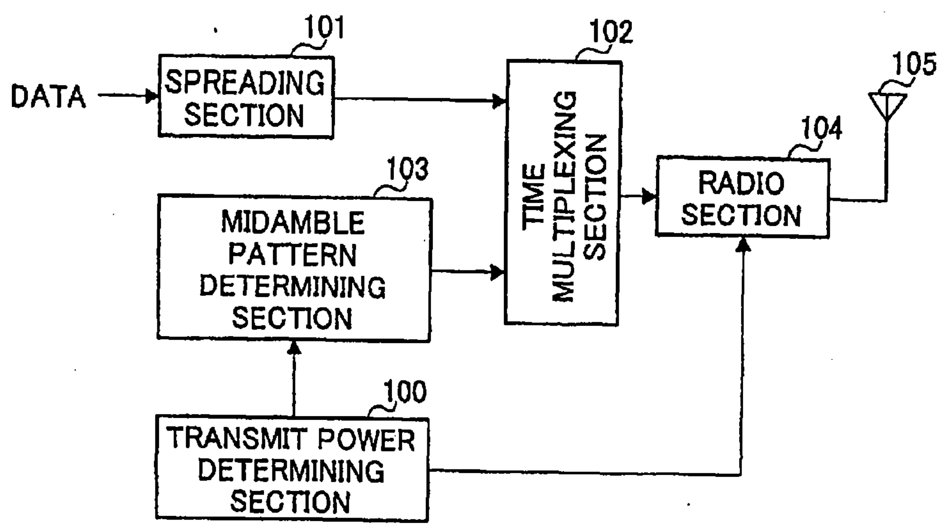

FIG.8

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Description

Technical Field

[0001] The present invention relates to a communication apparatus that cancels interference using matrix calculations in a CDMA (Code Division Multiple Access) based communication, and more particularly, to a communication apparatus that cancels interference during a random access communication.

Background Art

[0002] One of conventional methods of extracting a demodulated signal by eliminating various kinds of interference such as interference due to multi-path fading, inter-symbol interference and multiple access interference is an interference signal elimination method using Joint Detection (hereinafter referred to as "JD"). This JD is disclosed in the "zero Forcing and Minimum Mean-Square-Error Equalization for Multiuser Detection in Code-Division Multiple-Access Channels" (Klein A., Kaleh G.K., Baier P.W., IEEE Trans . Vehicular Technology, vol.45, pp.276-287, 1996.).

[0003] This interference signal elimination method using JD is also used for a random access communication carried out when a mobile station apparatus starts to communicate with a base station apparatus.

[0004] The conventional interference signal elimination method using JD will be explained below taking a case where a mobile station apparatus carries out a random access communication with a base station apparatus as an example.

[0005] In a random access communication, the mobile station apparatus that attempts to start a communication sends a signal for requesting the start of a communication via a random access channel ("RACH") to the base station apparatus first. In this transmission, the mobile station apparatus also sends a known reference signal called "midamble code". For convenience of explanations, the signal sent by the mobile station apparatus through the random access channel is called a "RACH signal".

[0006] The pattern of a midamble code (hereinafter referred to as "midamble pattern") is created as follows. FIG.1 is a schematic view showing a method of creating a midamble pattern in a conventional CDMA communication system.

[0007] As shown in FIG.1, the midamble pattern used for each mobile station apparatus (each channel) is created using a basic code that is repeated a cycle of 456 (=8W) chips following the procedure shown below. This basic code is known to the base station apparatus and includes 8 blocks A to H made up of mutually different codes each having a length of W (=57) chips.

[0008] As a first step, a reference block is set for the basic code above. Here, suppose the reference block is "A". As a second step, the phase of the reference block above is shifted leftward in the figure by {W x (n-1)} for every channel. Here, W=57 chips and n is a channel number. As a third step, for every channel in the basic code above, 512 chips are extracted from the leading section of the reference block whose phase has been shifted in the second step. In this way, a midamble pattern with a length of 512 chips as a whole is created for every channel.

[0009] The mobile station apparatus transmits an RACH signal shown in FIG.2 using any one of midamble patterns created as shown above. FIG. 2 is a schematic view showing transmission timing of each mobile station apparatus in a conventional CDMA communication system.

[0010] As shown in FIG.2, each mobile station apparatus transmits a transmission signal with a midamble code inserted between data section 1 and data section 2. The signal transmitted by data section 1 or data section 2 corresponds to a signal requesting for the start of a communication as described above. This signal transmits, for example, an ID number of a mobile station apparatus. In FIG.2, the transmission signals of channels 1 to 8 correspond to the RACH signals transmitted by mobile station apparatuses 1 to 8, respectively.

[0011] Then, processing by the base station apparatus that has received the RACH signals will be explained with reference to FIG.3 to FIG.5. FIG.3 is a schematic view conceptually showing a first example of a situation in which a base station apparatus in a conventional CDMA communication system receives an RACH signal from each mobile station apparatus. FIG.4 is a block diagram showing a configuration of a base station apparatus to which a conventional interference signal elimination method using JD is applied. FIG.5 is a schematic view showing a first example of a delay profile obtained by the base station apparatus to which the conventional interference signal elimination method using JD is applied.

[0012] Each mobile station apparatus is located at a certain distance from the base station apparatus and the distance between each mobile station apparatus and the base station apparatus varies from one mobile station apparatus to another. Thus, as shown in FIG.3, a propagation delay is produced by the time an RACH signal sent from each mobile station apparatus arrives at the base station apparatus, which produces variations in propagation delays among the mobile station apparatuses. That is, propagation delays produced until the RACH signals sent from mobile station apparatuses 1, 2, 3, ···, 8 arrive at the base station are propagation delays 1, 2, 3, ···, 8, respectively. The signal received by the base station apparatus is a signal resulting from multiplexing the RACH signals from the respective mobile station apparatuses with the respective propagation delays shown in FIG.3.

[0013] The base station apparatus carries out the following processing to extract data for each mobile station apparatus by eliminating interference such as interference caused by multi-path fading, inter-symbol interference and multiple access interference.

[0014] According to FIG.4, the received signal resulting from multiplexing the RACH signals sent from the respective mobile station apparatuses is subjected to predetermined radio processing such as frequency conversion and then sent to delay section 11 and matched filter (MF) 12. Delay section 11 delays the received signal by a predetermined time and sends the delayed signal to multiplier 14, which will be described later.

[0015] Matched filter 12 carries out correlation value calculation processing using the midamble code section and the above-described cyclic basic code in the received signal and thereby calculates a channel estimated value corresponding to each mobile station apparatus. Furthermore, applying a power calculation to the calculated channel estimated values gives delay profiles as shown in FIG.5. According to FIG.5, when a propagation delay of each mobile station apparatus is smaller than a W-chip length, the section in which a delay profile appears is determined for each mobile station apparatus. That is, in the above case, the delay profiles corresponding to mobile station apparatuses 1 to 8 appear in sections 1 to 8 each having a length of W chips (hereinafter referred to as "W-chip section").

[0016] According to FIG.4, the channel estimated values of the respective mobile station apparatuses calculated by matched filter 12 are sent to joint detection (hereinafter referred to as "JD") section 13.

[0017] JD section 13 performs the following matrix calculations using the channel estimated values of the respective mobile station apparatuses. That is, by carrying out convolutional calculations between the channel estimated values of the respective mobile station apparatuses and spreading codes applied to data sections assigned to the respective mobile station apparatuses, convolutional calculation results (matrix) for the respective mobile station apparatuses are obtained. Through these calculations, a matrix is obtained in which the convolutional calculation results of the respective mobile station apparatuses are regularly placed (hereinafter referred to as "system matrix"). Here, for convenience of explanations, the system matrix is expressed as [A].

[0018] Further, by carrying out a matrix calculation using the system matrix as shown in the following expression, matrix [B] is obtained.

$$[B] = ([A]^H \cdot [A])^{-1} \cdot [A]^H \qquad ①$$

where $[A]^H$ is a conjugate transposed matrix of the system matrix and $([A]^H \cdot [A])^{-1}$ is an inverse matrix of $[A]^H \cdot [A]$.

[0019] Matrix [B] obtained from such a matrix calculation is sent to multiplication section 14.

[0020] Multiplication section 14 carries out multiplication processing (that is, interference elimination demodulation processing) between the data section of the received signal from delay section 11 and the matrix from JD section 13 and obtains data stripped of interference for the respective mobile station apparatuses. Thus, the base station apparatus recognizes ID numbers of the mobile station apparatuses that have requested for the start of a communication and thereby accepts these mobile station apparatuses as the mobile station apparatuses with which to communicate.

[0021] After such a random access communication, the base station apparatus sends a signal indicating that these mobile station apparatuses have been accepted via a forward access channel (FACH). For convenience of explanations, a signal sent by the base station apparatus via a forward access channel is called an "FACH signal".

[0022] Each mobile station apparatus that has sent an RACH signal can recognize whether the communication request has been accepted by the base station apparatus or not by checking the content of the received FACH signal. The mobile station apparatus whose communication request has been accepted performs a normal communication with the base station apparatus. The mobile station apparatus whose communication request has not been accepted performs a random access communication again.

[0023] However, in the above-described conventional interference signal elimination method using JD, as the radius of a cell increases, an RACH signal sent from a mobile station apparatus farther from the base station apparatus has a greater propagation delay, and therefore the sum of the propagation delay and delay variance of this RACH signal may exceed the W-chip length. In this case, the delay profile corresponding to the above mobile station apparatus does not appear in an expected W-chip section as shown in FIG.5, but appears in another W-chip section.

[0024] This case will be explained with reference to FIG.6 and FIG.7. FIG. 6 is a schematic view conceptually showing a second example of a situation in which a conventional base station apparatus based on a CDMA communication system receives an RACH signal from each mobile station apparatus. FIG.7 is a schematic view showing a second example of delay profiles obtained from a base station apparatus to which a conventional interference signal elimination method using JD is applied. Here, suppose a propagation delay of an RACH signal sent from mobile station apparatus 2 (channel 2) is greater than the W-chip length.

[0025] Since mobile station apparatus 2 is located far from the base station apparatus, the propagation delay of the RACH signal sent from mobile station apparatus 2 is large as shown in FIG.6. For this reason, the propagation delay corresponding to mobile station apparatus 2 is greater than the W-chip length as shown in FIG. 7. As a result, the delay profile corresponding to mobile station apparatus 2 does not appear in the expected W-chip section (that is, W-chip section "2"). The delay profile corresponding to mobile station apparatus 2 may appear another W-chip section (that is, for example, W-chip section "3").

[0026] As described above, delay profiles obtained by the base station apparatus corresponding to mobile station apparatuses located far from the base station apparatus do not appear in expected W-chip sections, and therefore it is not possible to calculate channel estimated values corresponding to the above mobile station apparatuses. Furthermore, the delay profiles corresponding to the above mobile station apparatuses appear in W-chip sections corresponding to other mobile station apparatuses, causing the channel estimated values corresponding to the other mobile station apparatuses to become inaccurate.

[0027] As a result, the result of the matrix calculation carried out by above-described JD section 13 (see FIG. 4) becomes inaccurate, deteriorating the characteristic of the interference elimination demodulation processing of multiplication section 14 degrades. Thus, the base station apparatus cannot perform demodulation for the user who is so distant that the propagation delay is greater than W chips. Thus, the base station apparatus may be unable to recognize not only the ID number of the above mobile station apparatus but also the ID numbers of other mobile station apparatuses, making it impossible to accept these mobile station apparatuses as the mobile station apparatuses with which to communicate.

[0028] As shown above, according to the conventional interference signal elimination method using JD, when a mobile station apparatus located in a place where the sum of a propagation delay and delay variance exceeds the W-chip length carries out random access, not only this mobile station apparatus but also other mobile station apparatuses carrying out random access communication are unlikely to be accepted by the base station apparatus.

[0029] In the case where the base station apparatus sends a control command for adjusting the transmission timing of each mobile station apparatus taking into account a propagation delay to each mobile station apparatus using the downlink, the delay profile corresponding to each mobile station apparatus will appear in the expected W-chip section. However, a random access communication is a kind of communication whereby each mobile station apparatus sends an RACH signal to the base station apparatus before the base station apparatus carries out transmission to each mobile station apparatus using an individual downlink. Therefore, in a random access communication, the base station apparatus cannot control the transmission timing of each mobile station apparatus .

[0030] As a measure to prevent this problem, there is a method of increasing the width of the W-chip section by increasing phase W to be shifted in the first step above. However, according to this method, the number of users (number of communication terminal apparatuses) who can be accommodated through matrix calculations using JD will be reduced on condition that the midamble length is fixed. Increasing the length of a midamble makes it possible to increase the width of the W section without changing the number of users who can be accommodated, but since the proportion of the midamble section in the entire RACH signal increases, which results in a decrease of the transmission capacity.

Disclosure of Invention

[0031] It is an object of the present invention to provide a transmission apparatus capable of improving the probability of successful random access communications without affecting the number of communication terminal apparatuses that can be accommodated and transmission capacity.

[0032] First, in view that the condition of a propagation path differs from one communication terminal apparatus to another and that a propagation delay of a communication terminal apparatus that has sent an RACH signal via a propagation path with a small propagation loss is small, while a propagation delay of a communication terminal apparatus that has sent an RACH signal via a propagation path with a large propagation loss is large, the present inventor et al. has come up with the present invention by discovering that assigning a known reference signal which will reduce the length of a delay profile that can be created to a communication terminal apparatus with a small propagation loss and assigning a known reference signal which will increase the length of a delay profile that can be created to a communication terminal apparatus with a large propagation loss will increase the probability that the delay profile corresponding to each communication terminal apparatus will appear in an expected section without increasing the proportion of the known reference signal section in the communication format.

[0033] Second, in view that a communication terminal apparatus fails in a random access communication because the delay profile corresponding to this communication terminal apparatus does not appear in the expected section, the present inventor et al. has come up with the present invention by discovering that assigning a known reference signal with a longer delay profile than the previous one to this communication terminal apparatus will increase the probability that the delay profile corresponding to this communication terminal apparatus will appear in the expected section.

[0034] The object of the present invention is attained by setting a known reference signal to be assigned to each communication terminal apparatus based on at least one of the condition of a propagation path and the number of times the random access channel signal is retransmitted. Furthermore, the object of the present invention is attained by controlling not only a known reference signal to be assigned to each communication terminal apparatus but also a transmit power value of the random access channel signal of each communication terminal apparatus based on at least one of the propagation path condition and the number of times the random access channel signal is retransmitted.

Brief Description of Drawings

[0035]

FIG.1 is a schematic view showing a method of creating midamble patterns in a conventional CDMA communication system;
FIG.2 is a schematic view showing transmission timing of each mobile station apparatus in a conventional CDMA communication system;
FIG.3 is a schematic view conceptually showing a first example of a situation in which a base station apparatus in a conventional CDMA communication system receives an RACH signal from each mobile station apparatus;
FIG.4 is a block diagram showing a configuration of a base station apparatus to which a conventional interference signal elimination method using JD is applied;
FIG.5 is a schematic view showing a first example of delay profiles obtained by the base station apparatus to which the conventional interference signal elimination method using JD is applied;
FIG.6 is a schematic view conceptually showing a second example of a situation in which the conventional base station apparatus based on a CDMA communication system receives an RACH signal from each mobile station apparatus;
FIG.7 is a schematic view showing a second example of delay profiles obtained from the base station apparatus to which the conventional interference signal elimination method using JD is applied;
FIG.8 is a block diagram showing a configuration of a mobile station apparatus equipped with a transmission apparatus according to Embodiment 1 of the present invention;
FIG.9 is a block diagram showing a configuration of a base station apparatus equipped with a reception apparatus according to Embodiment 1 of the present invention;
FIG.10 is a schematic view showing a procedure for creating midamble patterns used for the mobile station apparatus equipped with the transmission apparatus according to Embodiment 1 above;
FIG.11 is a table used by a midamble pattern determining section in the mobile station apparatus equipped with the transmission apparatus according to Embodiment 1 above;
FIG.12 is a schematic view showing transmission timing of the mobile station apparatus equipped with the transmission apparatus according to Embodiment 1 above;
FIG.13 is a schematic view showing an example of delay profiles created by the base station apparatus equipped with the reception apparatus according to Embodiment 1 above;
FIG.14 is a schematic view showing a procedure for creating midamble patterns used for a mobile station apparatus equipped with a transmission apparatus according to Embodiment 2 of the present invention;
FIG.15 is a schematic view showing transmission timing of the mobile station apparatus equipped with the transmission apparatus according to Embodiment 2 above; and
FIG.16 is a schematic view showing an example of delay profiles created by a base station apparatus equipped with a reception apparatus according to Embodiment 2 above.

Best Mode for Carrying out the Invention

[0036] With reference now to the attached drawings, embodiments of the present invention will be explained in detail below.

(Embodiment 1)

[0037] FIG.8 is a block diagram showing a configuration of a mobile station apparatus equipped with a transmission apparatus according to Embodiment 1 of the present invention. In FIG.8, transmit power determining section 100 calculates a propagation loss between this mobile station apparatus and a base station apparatus using a signal transmitted through an information channel (hereinafter referred to as "information channel signal"). Furthermore, transmit power determining section 100 determines a transmit power value of an RACH signal according to the calculated propagation loss and the number of times the RACH signal is retransmitted. The determined transmit power value is sent to midamble pattern determining section 103 and radio section 104.

[0038] Spreading section 101 performs spreading processing on the transmission data using a spreading code assigned to this mobile station apparatus. This transmission data corresponds to data subjected to predetermined modulation processing, for example, the ID number of this mobile station apparatus. The transmission data subjected to spreading processing is sent to time multiplexing section 102.

[0039] Midamble pattern determining section 103 selects any one of a plurality of midamble patterns provided based on the transmit power value determined by transmit power determining section 100 and sends to time multiplexing section 102. The midamble pattern is a known reference signal used for channel estimation at the base station apparatus that receives the signal sent by this mobile station apparatus . Details of the midamble pattern will be explained later.

[0040] Time multiplexing section 102 creates a transmission signal by multiplexing the midamble pattern from midamble pattern determining section 103 and the transmission data subjected to spreading processing on a frame. As a frame format, as in the case of the frame format shown in FIG.2, the format including data section 1, midamble section and data section 2 is used. The midamble section is the part in which a midamble pattern is inserted.

[0041] Radio section 104 carries out predetermined processing such as frequency conversion on the transmission signal created by time multiplexing section 102 and sends the transmission signal subjected to the above-described predetermined processing as an RACH signal via antenna 105. During this transmission, radio section 104 transmits the RACH signal using the transmit power value determined by transmit power determining section 100.

[0042] FIG.9 is a block diagram showing a configuration of the base station apparatus equipped with a reception apparatus according to Embodiment 1 of the present invention. In FIG.9, the signal received (received signal) via an antenna (not shown) is subjected to predetermined radio processing such as frequency conversion and sent to delay section 201 and matched filter (MF) 202. This received signal is mainly a signal with the RACH signals sent from a plurality of mobile station apparatuses multiplexed on a same frequency band. Furthermore, the above-described plurality of mobile station apparatuses each has the configuration shown in FIG.8.

[0043] Delay section 201 delays the received signal by a predetermined time and sends the delayed received signal to multiplication section 204. Matched filter 202 performs correlation value calculation processing using the midamble code section in the received signal and a known basic code to calculate a channel estimated value for each mobile station apparatus. JD section 203 performs a matrix calculation using the channel estimated value from matched filter 202 and sends the matrix calculation result to multiplication section 204. Multiplication section 204 performs interference elimination demodulation processing using the received signal from delay section 201 and the matrix calculation result from JD section 203.

[0044] Then, the method of creating a midamble pattern to be assigned to each mobile station apparatus will be explained with reference to FIG.10. In this embodiment, suppose the total number of midamble patterns is 8 as an example. FIG.10 is a schematic view showing a procedure for creating midamble patterns used for a mobile station apparatus equipped with a transmission apparatus according to Embodiment 1 of the present invention. As shown in FIG.10, a midamble pattern used for each mobile station apparatus (each channel) is created using a basic code that is repeated in a cycle of 456 chips (=8W) according to the following procedure.

[0045] This basic code includes 8 blocks "A" to "H" with mutually different codes and chip lengths (code lengths) and is known to the base station apparatus shown in FIG.9. Furthermore, the chip length of each block is set to increase in the ascending order of A to G. Here, H is assumed to have a length of 57 chips. More specifically, this basic code contains a plurality of codes formed by a plurality of blocks with mutually different codes and code lengths sequentially arranged according to the code length (here, codes "A", "B" to "G" "H" in a length of 456 chips).

[0046] As a first step, a reference block is set in the above-described basic code. Here, the reference block is assumed to be "A" as an example. As a second step, the phase of the above-described reference block is shifted leftward in the figure by 0, W1, W1+W2, ···, W1+W2+ ···+W5+W6, , W1+W2, W6+W7 (W1<W2<···<W6<W7) for the respective channels (channels 1, 2, 3, ···, 7, 8). In this way, reference blocks of the respective channels (channels 1, 2, 3, ···, 7, 8) are "A", "B", "C", ···, "G", "H".

[0047] As a third step, for every channel in the basic code above, 512 chips are extracted from the leading section of the reference block whose phase has been shifted in the second step. Thus, a midamble pattern of 512 chips as a whole is created for each channel. FIG. 10 shows midamble patterns of channels 1, 2, 3, 4 and 8.

[0048] Then, operations in a random access communication of the mobile station apparatus equipped with the transmission apparatus in the above configuration and the base station apparatus equipped with the reception apparatus in the above configuration will be explained. First, an operation of the mobile station apparatus equipped with the transmission apparatus according to this embodiment will be explained.

[0049] When power to the mobile station apparatus shown in FIG.8 is turned on, transmit power determining section 100 calculates a propagation loss between the mobile station apparatus and the base station apparatus using an information channel signal sent from the base station apparatus shown in FIG. 9 based on the transmit power value of the information channel signal at the base station apparatus and the receive power value of an information channel signal at the mobile station apparatus.

[0050] The calculated propagation loss becomes an index to indicate the condition of the propagation path. When propagation loss is large, the distance between the mobile station apparatus and the base station apparatus may be large or even if the distance between the mobile station apparatus and the base station apparatus is small, radio waves may be attenuating due to reflections by obstacles or buildings, etc.

[0051] Furthermore, transmit power determining section 100 determines the transmit power value of the RACH signal based on the calculated propagation loss and the number of times the RACH signal is retransmitted.

[0052] More specifically, by adding an offset value according to the number of retransmissions to a preset basic value, a new basic value is calculated. Then, by adding a propagation loss to the basic value calculated in this way, a transmit power value is determined. Thus, as the propagation loss or the number of retransmissions increases, the transmit power value determined increases.

[0053] For example, in the case where the number of retransmissions of an RACH signal is 0 (that is, when a random access communication is performed for the first time), a value obtained by adding a propagation loss to the basic value becomes the transmit power value. When the number of retransmissions of the RACH signal is 1, a value obtained by adding an offset value to the basic value becomes a new basic value and a value obtained by adding a propagation loss to this basic value becomes a transmit power value. As the number of retransmissions further increases, the basic value increases and the transmit power value of the RACH signal increases. At this time, as the propagation loss increases, the transmit power value further increases. The determined transmit power value is sent to midamble pattern determining section 103 and radio section 104.

[0054] Midamble determining section 103 selects a midamble pattern based on the transmit power value determined by transmit power determining section 100. The method of selecting a midamble pattern will be explained with reference to FIG.11. FIG.11 shows a table used by midamble pattern determining section 103 at a mobile station apparatus equipped with the transmission apparatus according to Embodiment 1 of the present invention. In FIG.11, the "transmit power value" field shows transmit power values (P1 to P8 (P1<P2<···<P8<··· <P7)) determined by transmit power determining section 100 and the "reference block" field shows reference blocks (A to H) in the midamble patterns corresponding to these transmit power values. This reference block corresponds to the reference block set in the second step when a midamble pattern is created.

[0055] First, a reference block corresponding to the transmit power value determined by transmit power determining section 100 is selected using the table shown in FIG.11. Then, the midamble pattern having the selected reference block at the leading section thereof is selected as the midamble pattern to be inserted into this RACH signal. For example, in the case where the transmit power value is "P3", "C" is selected as the reference block, and therefore the "midamble pattern of channel 3" shown in FIG.10 is selected as the midamble pattern.

[0056] Here, in view that the chip length of the reference block corresponds to the length of the W-chip section of a delay profile created by the base station apparatus, the transmit power value and reference block in the table shown in FIG.11 are set as follows. That is, the W-chip section of the delay profile is set to be greater than a propagation delay which is estimated to occur when the RACH signal propagates through a propagation path estimated from a propagation loss, and any one of the reference blocks having a length equal to or greater than this W-chip section is selected.

[0057] According to this selection method, when a propagation loss between the mobile station apparatus and the base station apparatus is large or when the number of retransmissions of the RACH signal is large, a midamble pattern including a reference block with a large chip length is selected. On the contrary, when the propagation loss between the mobile station apparatus and the base station apparatus is small or when the number of retransmissions of the RACH signal is small, a midamble pattern including a reference block with a small chip length is selected. The midamble pattern selected as shown above is sent to time multiplexing section 102.

[0058] In time multiplexing section 102, the transmission data subjected to spreading processing and midamble patterns are multiplexed on frames, for example, as shown in FIG.12 to create transmission signals. FIG.12 is a schematic view showing transmission timing of mobile station apparatuses equipped with the transmission apparatus according to Embodiment 1 of the present invention.

[0059] That is, the transmission data subjected to spreading processing is inserted into the data section (here, data section 1 and data section 2) on the frames shown in FIG.12 and the midamble patterns are inserted into the midamble sections (512-chip sections) on the above-described frames to create transmission signals. The frames here are just shown by way of example and it is possible to change the positions of the midamble section and data sections as appropriate.

[0060] Radio section 104 performs predetermined transmission processing such as frequency conversion on the transmission signal created by time multiplexing section 102. Furthermore, the transmission signal subjected to the predetermined transmission processing above is sent as RACH signals from antenna 105. During this transmission, the transmit power value of the RACH signal is controlled to a transmit power value determined. by transmit power determining section 100.

[0061] The mobile station apparatus shown in FIG.8 sends the RACH signal requesting for the start of a communication in this way. After this, the mobile station apparatus monitors an FACH signal sent from the base station apparatus shown in FIG. 9 to check whether this FACH signal includes the ID number of the mobile station apparatus or not. When the request for a communication is accepted by the base station apparatus (the ID number of the mobile station apparatus is included in the FACH signal), the mobile station apparatus starts a normal communication with the base station apparatus. On the contrary, when the request for a communication is not accepted by the base station apparatus (the ID number of the mobile station apparatus is not included in the FACH signal), the mobile station apparatus resends the RACH signal. This completes the explanation about how the mobile station apparatus equipped with the transmission apparatus according to this embodiment operates.

[0062] Then, an operation of the base station apparatus equipped with the reception apparatus according to this embodiment will be explained with reference to FIG. 9. A received signal is sent to delay section 201 and matched filter 202. Delay section 201 delays the received signal by a predetermined time and sends the delayed signal to multiplication section 204.

[0063] Matched filter 202 carries out correlation value calculation processing using the midamble code section and the above-described cyclic basic code in the received signal, and thereby calculates a channel estimated value corresponding to each channel. Furthermore, applying a power calculation to the calculated channel estimated values obtains delay profiles as shown in FIG. 13. The calculated channel estimated values are sent to JD section 203.

[0064] FIG.13 is a schematic view showing an example of delay profiles created by the base station apparatus equipped with the reception apparatus according to Embodiment 1 of the present invention. As shown in FIG.13, the chip length of the reference block of the midamble pattern corresponds to the length of the W-chip section of the delay profile of the mobile station apparatus using this midamble pattern. For example, in the case of the mobile station apparatus using a midamble pattern of channel 4, the chip length of reference block "D" of this midamble pattern is "W4", and therefore a delay profile having a length of "W4" is created.

[0065] JD section 203 performs the following matrix calculation using the channel estimated values calculated by matched filter 202. That is, the length of the channel estimated value of each channel calculated by matched filter 202 is adjusted to the length of the longest channel estimated value (W7). More specifically, "0" is added to the end of channel estimated values of channels other than channel 7 as appropriate so that these estimated values have the same length as the length of the estimated value of channel 7. This is because, in this embodiment, the chip length of the reference block differs from one channel to another, as opposed to the conventional system in which the chip length of the reference block is common to all channels.

[0066] Then, by carrying out convolutional calculations between the channel estimated values whose length has been adjusted and spreading codes of data sections assigned to the respective channels, results (matrix) of convolutional calculations for the respective channels are obtained. Through these calculations, a matrix [A] is obtained in which the convolutional calculation results of the respective channels are regularly placed. Further, carrying out a matrix calculation shown in expression ① using system matrix [A] gives matrix [B] shown in expression ② . Matrix [B] obtained through such a matrix calculation is sent to multiplication section 204.

[0067] Multiplication section 204 carries out multiplication processing (that is, interference elimination demodulation processing) between the data section of the received signal from delay section 201 and the matrix from JD section 203 and obtains data stripped of interference for the respective channels. Thus, the base station apparatus recognizes ID numbers of the mobile station apparatuses that have requested for the start of a communication, and thereby accepts these mobile station apparatuses as the mobile station apparatuses with which to communicate.

[0068] After such a random access communication, the base station apparatus sends a signal indicating that these mobile station apparatuses have been accepted via a forward access channel as an FACH signal. This completes the explanation about how the base station apparatus equipped with the reception apparatus according to this embodiment operates.

[0069] Then, the effects of the mobile station apparatus equipped with the transmission apparatus according to this embodiment and the base station apparatus equipped with the reception apparatus according to this embodiment will be explained more specifically in two cases; one case where the mobile station apparatus carries out a random access communication for the first time and the other case where the mobile station apparatus carries out a random access communication for a second time.

[0070] First, the case where the mobile station apparatus carries out a random access communication for the first time will be explained. In the mobile station apparatus, transmit power determining section 100 calculates a propagation loss using the received information channel signal and determines a transmit power value based on this propagation loss. As described above, the propagation loss can be uses as an index to indicate the condition of the propagation path between the mobile station apparatus and base station apparatus.

Furthermore, midamble pattern determination section 103 determines a reference block based on the transmit power value determined by transmit power determining section 100 and selects a midamble pattern having this reference block.

[0071] Therefore, it can be said that the midamble pattern determined by midamble pattern determining section 100 is selected taking into account the condition of the propagation path between the mobile station apparatus and base station apparatus.

[0072] More specifically, according to FIG.11, when the transmit power value is large (that is, a propagation loss during propagation between the mobile station apparatus and base station apparatus is large) , a midamble pattern with a reference block of a large chip length is selected. That is, in this case, since the propagation delay of the RACH signal sent by the mobile station apparatus is estimated to increase, a midamble pattern with a reference block of a large chip length is selected to expand the W-chip section of the delay profile that can be created. This makes it possible to increase the probability that the delay profile of the mobile station apparatus will appear in the W-chip section corresponding to this mobile station apparatus. In other words, it is possible to decrease the probability that the delay profile of the mobile station apparatus will appear in the W-chip sections corresponding to other mobile station apparatuses.

[0073] On the contrary, when the transmit power value is small (that is, when a propagation loss during propagation between the mobile station apparatus and base station apparatus is small), a midamble pattern with a reference block of a small chip length is selected. That is, in this case, since the propagation delay of the RACH signal sent by the mobile station apparatus is estimated to decrease, a midamble pattern with a reference block of a small chip length is selected to reduce the W-chip section of the delay profile.

[0074] As described above, based on the transmit power value determined using the propagation loss, in other words, based on the condition of the propagation path between the mobile station apparatus and base station apparatus, a midamble pattern to be inserted into the RACH signal is selected so that the length of the W-chip section of the delay profile created by the base station apparatus exceeds the propagation delay. In the delay profile created by the base station apparatus, this makes it possible to increase the probability that the delay profile of a mobile station apparatus will appear in the expected W-chip section. Therefore, the base station apparatus can exactly extract channel estimated values corresponding to the respective mobile station apparatuses, and can thereby reduce the frequency with which RACH signals are retransmitted by the mobile station apparatuses.

[0075] Then, the case where the mobile station apparatus carries out a random access communication for a second time will be explained. For the above-described reason, this embodiment can reduce the frequency with which the mobile station apparatuses retransmit RACH signals. However, there are also cases where an RACH signal sent by a mobile station apparatus is not accepted by the base station apparatus and the mobile station apparatus resends the RACH signal.

[0076] Reasons for this can be: (1) Because the mobile station apparatus is located very far from the base station apparatus, the delay profile of this mobile station apparatus created by the base station apparatus does not appear in the expected W-chip section, (2) the transmit power value of the mobile station apparatus is too small with respect to the condition of the propagation path between the mobile station apparatus and base station apparatus, or (3) a mobile station has performed transmission using the same midamble as that of another mobile station apparatus simultaneously, causing the RACH signals to collide with each other, etc.

[0077] Thus, when the mobile station apparatus resends the RACH signal, transmit power determining section 100 further increases the transmit power value determined as described above according to the number of times the RACH signal is retransmitted. The increased transmit power value is sent to midamble pattern determining section 103 and radio section 104.

[0078] Midamble pattern determining section 103 determines a reference block based on the transmit power value increased by transmit power determining section 100 and selects a midamble pattern with this reference block. Furthermore, radio section 104 sends an RACH signal using the transmit power value increased by transmit power determining section 100.

[0079] Therefore, it can be said that the midamble pattern determined by midamble pattern determining section 103 has been selected taking into account not only the condition of the propagation path between the mobile station apparatus and base station apparatus but also the number of times the RACH signal is retransmitted.

[0080] More specifically, when the number of times RACH signals are retransmitted is large, a midamble pattern with a reference block of a larger chip length is selected and the RACH signal is transmitted with a larger transmit power value.

[0081] That is, in view that the propagation delay during transmission of the previous RACH signal exceeded the W-chip section of the delay profile, a midamble pattern having a reference block of a larger chip length is selected to expand the W-chip section of the delay profile. This makes it possible to increase the probability that the delay profile of the mobile station apparatus will appear in the W-chip section corresponding to this mobile station apparatus. At the same time, in view that the transmit power value of the previous RACH signal was too small with respect to the condition of the propagation path between the mobile station apparatus and base station apparatus, the transmit power value is also increased.

[0082] As described above, a midamble pattern to be inserted into the RACH signal is selected based on not only the condition of the propagation path between the mobile station apparatus and base station apparatus but also the number of times the RACH signal is retransmitted so that the length of the W-chip section of the delay profile created by the base station apparatus exceeds the propagation delay, and the transmit power value of the RACH signal is increased as well. This makes it possible to increase the probability that the delay profile of a certain mobile station apparatus will appear in the expected W-chip section in the delay profile created by the base station apparatus. Thus, the base station apparatus can exactly extract the channel estimated values corresponding to the respective mobile station apparatuses, and even if the RACH signal needs to be retransmitted for some reasons, it is possible to reduce the frequency with which the RACH signal is retransmitted thereafter by the mobile station apparatuses.

[0083] Thus, this embodiment selects a midamble pattern to be inserted into the RACH signal based on the condition of the propagation path between the mobile station apparatus and base station apparatus and the number of times the RACH signal is retransmitted so that the length of the W-chip section of the delay profile that can be created by the base station apparatus exceeds the propagation delay and increases the transmit power value of the RACH signal, and can thereby increase the probability that the delay profiles of the respective mobile station apparatuses will appear in the respective expected W-chip sections.

[0084] Furthermore, this embodiment uses a plurality of midamble patterns created using a basic code having a plurality of blocks with mutually different chip lengths and code contents, and can thereby prevent influences on the number of users that can be accommodated in JD and the transmission capacity.

[0085] Therefore, this embodiment can improve the probability that the communication terminal apparatus carrying out a random access communication will be accepted without affecting the number of communication terminal apparatuses that can be accommodated and transmission capacity.

[0086] In order to explain the most appropriate embodiment, this embodiment has described the case where a midamble pattern is set based on the condition of the propagation path and the number of times the RACH signal is retransmitted and the transmit power value of the RACH signals is set based on the condition of the propagation path and the number of times the RACH signal is retransmitted.

[0087] However, it goes without saying that even in the case where a midamble pattern is set based on either the condition of the propagation path or the number of times the RACH signal is retransmitted, it is possible to increase the probability that the delay profiles of the respective mobile station apparatuses will appear in their respective expected W-chip sections. In this case, it goes without saying that it is also possible to further improve the above probability by setting the transmit power value of an RACH signal based on at least one of the condition of the propagation path and RACH signal.

(Embodiment 2)

[0088] This embodiment will explain a case where when a delay profile of a certain mobile station apparatus according to Embodiment 1 does not appear in an expected W-chip section, deterioration of channel estimated values of other mobile station apparatuses will be prevented. The mobile station apparatus equipped with a transmission apparatus according to this embodiment and the base station apparatus equipped with a reception apparatus according to this embodiment will be explained below focused on differences from Embodiment 1 with reference to FIG.14 to FIG.16.

[0089] FIG.14 is a schematic view showing a procedure for creating midamble patterns used for mobile station apparatuses equipped with a transmission apparatus according to Embodiment 2 of the present invention. FIG.15 is a schematic view showing transmission timing of the mobile station apparatuses equipped with the transmission apparatus according to Embodiment 2 of the present invention. FIG.16 is a schematic view showing an example of delay profiles created by a base station apparatus equipped with a reception apparatus according to Embodiment 2 of the present invention.

[0090] The configurations of the mobile station apparatus equipped with the transmission apparatus according to this embodiment and the base station apparatus equipped with the reception apparatus according to this embodiment are the same as those according to Embodiment 1 except for the method of creating midamble patterns used, and therefore detailed explanations thereof will be omitted.

[0091] The method of creating midamble patterns to be assigned to the respective mobile station apparatuses will be explained with reference to FIG.14. In this embodiment, suppose the total number of midamble patterns is 8 as an example.

[0092] As shown in FIG.14, a midamble pattern used for each mobile station apparatus (channel) is created using a basic code that is repeated in a cycle of 456 chips (=8W) following the procedure shown below. This basic code includes 8 blocks "A" to "H" with mutually different codes and chip lengths and is known to the base station apparatus shown in FIG.9.

[0093] The basic code shown in FIG.14 is obtained by changing the basic code shown in FIG.10 as follows. That is, while the basic code shown in FIG.10 consists of blocks arranged in the order of "A" to "G" in such a way that the chip length increases from the 1st chip to the 456th chip, the basic code shown in FIG.14 consists of blocks arranged in the order of "A" to "H" so that a difference in a chip length between at least some adjacent blocks becomes as large as possible from the 1st chip to 456th chip. In other words, the basic code shown in FIG.14 includes a plurality of codes formed by a plurality of blocks with mutually different codes and code lengths (here codes "H", "D" to "F" "A" of a length of 456 chips).

[0094] As a first step, a reference block is set in the above-described basic code. Here, the reference block is assumed to be "A" as an example. As a second step, the phase of the above-described reference block is shifted leftward in the figure by 0, W1, W1+W6, ···, W1+W2+W3+W5+W6+W7, W1+W2+W3+W4+W5+W6+W7 (W1<W2<··· <W6<W7) for the respective channels (channels 1, 2, 3, ···, 7, 8). In this way, reference blocks of the respective channels (channels 1, 2, 3, ···, 7, 8) are "A", "F", "B", ···, "D", "H".

[0095] As a third step, for the respective channels, 512 chips are extracted from the leading section of the respective reference blocks whose phase has been shifted in the second step in the above basic code. Thus, a midamble pattern of 512 chips as a whole is created for each channel. FIG.14 shows midamble patterns of channels 1, 2, 3, 4 and 8.

[0096] Then, operations of the mobile station apparatus equipped with the transmission apparatus in the above configuration and the base station apparatus equipped with the reception apparatus in the above configuration during a random access communication will be explained.

[0097] The mobile station apparatus selects any one midamble pattern from a plurality of midamble patterns according to the content of the table shown in FIG.11 as in the case of Embodiment 1 and transmits an RACH signal with the selected midamble pattern inserted according to the frame shown in FIG.15.

[0098] The base station apparatus receives the RACH signal sent from the mobile station apparatus and creates a delay profile as in the case of Embodiment 1. At this time, an example of delay profiles created is shown in FIG.16. As is apparent from FIG. 16, the chip length of the reference block in the midamble pattern corresponds to the length of the W-chip section of the delay profile about the mobile station apparatus using this midamble pattern as in the case of Embodiment 1.

[0099] Then, the effects of the mobile station apparatus equipped with the transmission apparatus according to this embodiment and the base station apparatus equipped with the reception apparatus according to this embodiment will be explained using the delay profiles according to Embodiment 1 (FIG.13) in contrast to the delay profiles according to Embodiment 2 (FIG.16). Here, a case where mobile station apparatus 1 sends an RACH signal using a midamble pattern corresponding to channel 1 and the delay profile of mobile station apparatus 1 does not appear in the expected W-chip section at the base station apparatus will be explained as an example. In FIG.13 and FIG.16, suppose path 601 and path 602 are the paths in the delay profile of mobile station apparatus 1 (hereinafter simply referred to as "path of mobile station apparatus 1") and the phases of path 601 and path 602 are identical in FIG.13 and FIG. 16.

[0100] In FIG.13, path 601 and path 602 of mobile station apparatus 1 (channel 1) appear in the W-chip sections corresponding to channel 2 and channel 3. Thus, path 601 is detected as the channel estimated value of channel 2 and path 602 is detected as the channel estimated value of channel 3. As a result, not only the channel estimated value of channel 2 but also the channel estimated values of channel 2 and channel 3 degrade. Therefore, the interference elimination demodulation results of channels 1, 2 and 3 degrade.

[0101] On the other hand, in this embodiment, the above-described basic code consists of blocks "A" to "G" arranged so that a difference in a chip length between at least some adjacent blocks (for example, "A" and "F", "F" and "B", "B" and "G" and "G" and "C", etc.) becomes as large as possible. Thus, the length of the W-chip section corresponding to mobile station apparatus 1 (channel 1) using the midamble pattern with "A" as the reference block is "W1", while the length of the W-chip section corresponding to the mobile station apparatus (channel 2) using the midamble pattern with block "F" adjacent to "A" as the reference block is "W6".

[0102] Thus, in FIG.16, path 601 and path 602 of mobile station apparatus 1 (channel 1) only appear in the W-chip section corresponding to channel 2. Thus, path 601 and path 602 are detected as channel estimated values of channel 2. In this way, the channel estimated value of channel 2 degrades in the same way as Embodiment 1, whereas the channel estimated value of channel 3 does not degrade unlike Embodiment 1.

[0103] This embodiment describes the case where the mobile station apparatus sends an RACH signal using the midamble pattern corresponding to channel 1 as an example, but effects similar to those in the case above will also be obtained when the mobile station apparatus uses midamble patterns corresponding to other channels.

[0104] Here, when the mobile station apparatus uses a midamble pattern having a reference block of a large chip length (for example, "G"), this apparently produces inconvenience. That is, since the length of the chip section of W-chip section "5" adjacent to W-chip section "4" corresponding to this mobile station apparatus is small, if the propagation delay of the RACH signal sent from this mobile station apparatus is large as in the example above, the path corresponding to this mobile station apparatus seems to appear not only in W-chip section "5" but also in W-chip section "6". On the other hand, the length of W-chip section "4" corresponding to this mobile station apparatus itself is large, and it is less likely that the propagation delay produced as in the above example will exceed the sum total of W-chip section "4" and W-chip section "5".

[0105] Thus, according to this embodiment, midamble patterns are created so that the lengths of delay profiles of the respective channels become irregular, for example, a difference in the length of delay profile between at least some adjacent delay profiles becomes large. Furthermore, a midamble pattern to be inserted into an RACH signal is selected based on the condition of the propagation path between the mobile station apparatus and base station apparatus and the number of times the RACH signal is retransmitted so that the length of the W-chip section of the delay profile created by the base station apparatus exceeds the propagation delay and it is possible to increase the probability that the delay profiles of the respective mobile station apparatuses will appear in their respective expected W-chip sections by increasing the transmit power of the RACH signal.

[0106] Furthermore, the lengths of delay profiles between adjacent mobile station apparatuses vary even in the case where the mobile station apparatus that has carried out a random access communication is not accepted by the base station apparatus, and therefore it is possible to suppress the number of mobile station apparatuses that will be affected by the path corresponding to this mobile station apparatus. When the delay profile of a certain mobile station apparatus does not appear in the expected W-chip section, this makes it possible to prevent deterioration of channel estimated values about other mobile station apparatuses. Thus, it is possible to improve the probability that the mobile station apparatus will be accepted by the base station apparatus through a random access communication.

[0107] This embodiment has described the case using a basic code with blocks with mutually different chip lengths and codes arranged so that a difference in the chip length between at least some adjacent blocks becomes as large as possible. In other words, this embodiment has described the case where a plurality of midamble patterns is created so that the chip length of at least some adjacent blocks becomes as large as possible. However, the present invention is not limited to this, but is also applicable to a case where the procedure for creating a basic code or midamble pattern is changed under conditions under which the lengths of delay profiles between adjacent channels become irregular.

[0108] As described above, the present invention sets a known reference signal to be assigned to each communication terminal apparatus based on at least one of the condition of the propagation path and the number of times the random access channel signal is retransmitted, and can thereby improve the probability of successful random access communications without affecting the number of communication terminal apparatuses that can be accommodated and transmission capacity.

[0109] This application is based on the Japanese Patent Application No.2000-060155 filed on March 6, 2000, entire content of which is expressly incorporated by reference herein.

Industrial Applicability

[0110] The present invention is ideally applicable to a communication apparatus that cancels interference using matrix calculations in a CDMA-based communication, and more particularly, to the filed of a communication apparatus that cancels interference during a random access communication.

Claims

1. A transmission apparatus comprising:

    reference signal setting means for setting known reference signals to be inserted into random access channel signal based on the condition of propagation path; and
    transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

2. A transmission apparatus comprising:

    reference signal setting means for setting known reference signals to be inserted into random access channel signal based on the number of times the random access channel signal is retransmitted; and
    transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

3. The transmission apparatus according to claim 1, wherein the reference signal setting means uses any one of known reference signals created by extracting a predetermined length from the leading section of each block of a reference signal having a plurality of codes formed by sequentially placing a plurality of blocks with mutually different codes and code lengths according to said code lengths, as a known reference signal to be inserted in the random access channel signal.

4. The transmission apparatus according to claim 2, wherein the reference signal setting means uses any one of known reference signals created by extracting a predetermined length from the leading section of each block of a reference signal having a plurality of codes formed by sequentially placing a plurality of blocks with mutually different codes and code lengths according to said code lengths, as a known reference signal to be inserted in the random access channel signal.

5. The transmission apparatus according to claim 1, wherein the reference signal setting means uses any one of known reference signals created by extracting a predetermined length from the leading section of each block of a reference signal having a plurality of codes formed by irregularly and sequentially placing a plurality of blocks with mutually different codes and code lengths, as a known reference signal to be inserted in the random access channel signal.

6. The transmission apparatus according to claim 2, wherein the reference signal setting means uses any one of known reference signals created by extracting a predetermined length from the leading section of each block of a reference signal having a plurality of codes formed by irregularly and sequentially placing a plurality of blocks with mutually different codes and code lengths, as a known reference signal to be inserted in the random access channel signal.

7. The transmission apparatus according to claim 5, wherein the reference signal setting means uses a

second reference code having a plurality of codes formed by sequentially placing a plurality of blocks with mutually different codes and code lengths so that the code length between at least some adjacent blocks increases, as a reference code.

8. The transmission apparatus according to claim 6, wherein the reference signal setting means uses a second reference code having a plurality of codes formed by sequentially placing a plurality of blocks with mutually different codes and code lengths so that the code length between at least some adjacent blocks increases, as a reference code.

9. The transmission apparatus according to claim 1, further comprising power value setting means for setting a transmit power value based on at least one of the condition of the propagation path or the number of times the random access channel signal is retransmitted, wherein the transmitting means controls the transmission of said random access signal using the set transmit power value.

10. The transmission apparatus according to claim 2, further comprising power value setting means for setting a transmit power value based on at least one of the condition of the propagation path or the number of times the random access channel signal is retransmitted, wherein the transmitting means controls the transmission of said random access signal using the set transmit power value.

11. A reception apparatus comprising:

receiving means for receiving a random access channel signal sent from a transmission apparatus;
calculating means for calculating a channel estimated value by calculating a correlation value using the received signal and a reference signal;
joint detection calculating means for calculating joint detection using the calculated channel estimated value; and
demodulating means for extracting information on a request for the start of a communication from said transmission apparatus by carrying out demodulation processing using the result of said joint detection calculation and said received signal,

wherein said transmission apparatus comprises reference signal setting means for setting known reference signals to be inserted into the random access channel signal based on the condition of the propagation path; and transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

12. A reception apparatus comprising:

receiving means for receiving a random access channel signal sent from a transmission apparatus;
calculating means for calculating a channel estimated value by calculating a correlation value using the received signal and a reference signal;
joint detection calculating means for calculating joint detection using the calculated channel estimated value; and
demodulating means for extracting information on a request for the start of a communication from said transmission apparatus by carrying out demodulation processing using the result of said joint detection calculation and said received signal,

wherein said transmission apparatus comprises reference signal setting means for setting known reference signals to be inserted into the random access channel signal based on the number of times the random access channel signal is retransmitted; and
transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

13. A communication terminal apparatus equipped with a transmission apparatus, said transmission apparatus comprising:

reference signal setting means for setting known reference signals to be inserted into a random access channel signal based on the condition of the propagation path; and
transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

14. A communication terminal apparatus equipped with a transmission apparatus, said transmission apparatus comprising:

reference signal setting means for setting known reference signals to be inserted into a random access channel signal based on the number of times the random access channel signal is retransmitted; and
transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

15. A base station apparatus equipped with a reception apparatus comprising:

receiving means for receiving a random access channel signal sent from a transmission apparatus;
calculating means for calculating a channel estimated value by calculating a correlation value using the received signal and a reference signal;
joint detection calculating means for calculating joint detection using the calculated channel estimated value; and
demodulating means for extracting information on a request for the start of a communication from said transmission apparatus by carrying out demodulation processing using the result of said joint detection calculation and said received signal,

wherein said transmission apparatus comprises reference signal setting means for setting known reference signals to be inserted into the random access channel signal based on the condition of the propagation path and transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

16. A base station apparatus equipped with a reception apparatus comprising:

receiving means for receiving a random access channel signal sent from a transmission apparatus;
calculating means for calculating a channel estimated value by calculating a correlation value using the received signal and a reference signal;
joint detection calculating means for calculating joint detection using the calculated channel estimated value; and
demodulating means for extracting information on a request for the start of a communication from said transmission apparatus by carrying out demodulation processing using the result of said joint detection calculation and said received signal,

wherein said transmission apparatus comprises reference signal setting means for setting known reference signals to be inserted into the random access channel signal based on the number of times the random access channel signal is retransmitted and transmitting means for transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

17. A transmission method comprising:

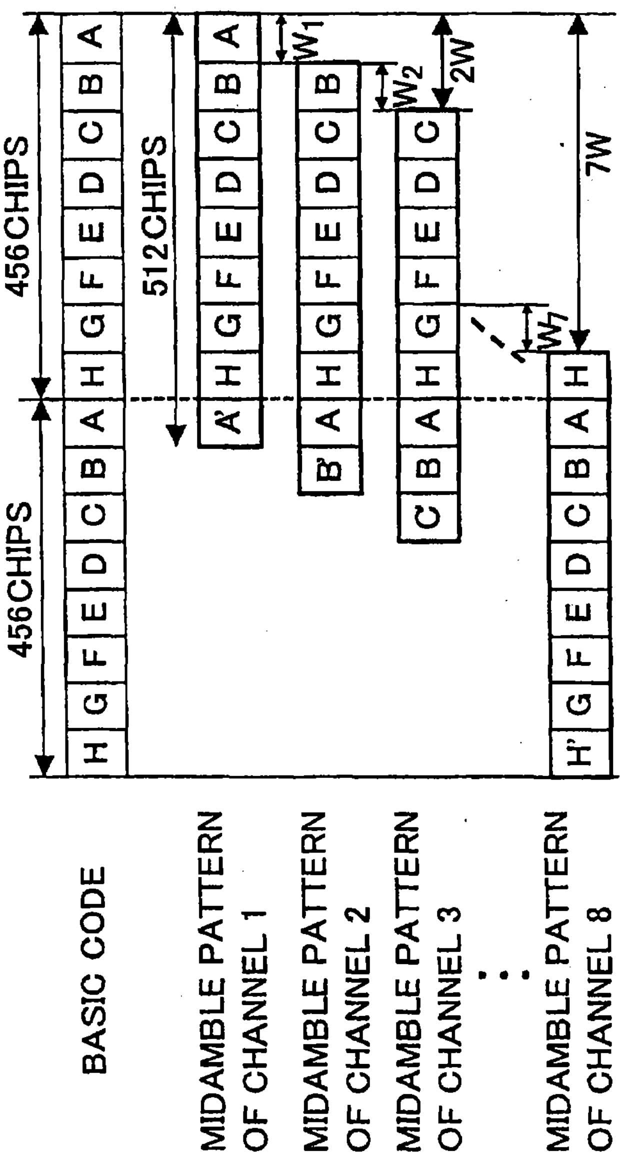
a reference signal setting step of setting known reference signals to be inserted into a random access channel signal based on the condition of the propagation path; and
a transmitting step of transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

18. A transmission method comprising:

a reference signal setting step of setting known reference signals to be inserted into the random access channel signal based on the number of times a random access channel signal is retransmitted; and
a transmitting step of transmitting the random access channel signal in which the set known reference signals and information on a request for the start of a communication are inserted.

19. The transmission method according to claim 17, further comprising a power value setting step of setting a transmit power value based on at least one of the condition of the propagation path or the number of times the random access channel signal is retransmitted, wherein the transmitting step controls the transmission of said random access signal using the set transmit power value.

20. The transmission method according to claim 18, further comprising a power value setting step of setting a transmit power value based on at least one of the condition of the propagation path or the number of times the random access channel signal is retransmitted, wherein the transmitting step controls the transmission of said random access signal using the set transmit power value.



456CHIPS
456CHIPS
512CHIPS
BASIC CODE
MIDAMBLE PATTERN OF CHANNEL 1
MIDAMBLE PATTERN OF CHANNEL 2
MIDAMBLE PATTERN OF CHANNEL 3
MIDAMBLE PATTERN OF CHANNEL 8
H G F E D C B A H G F E D C B A
A' H G F E D C B A
B' A H G F E D C B
C B A H G F E D C
H' G F E D C B A H
W1
W2
2W
W7
7W

FIG.1

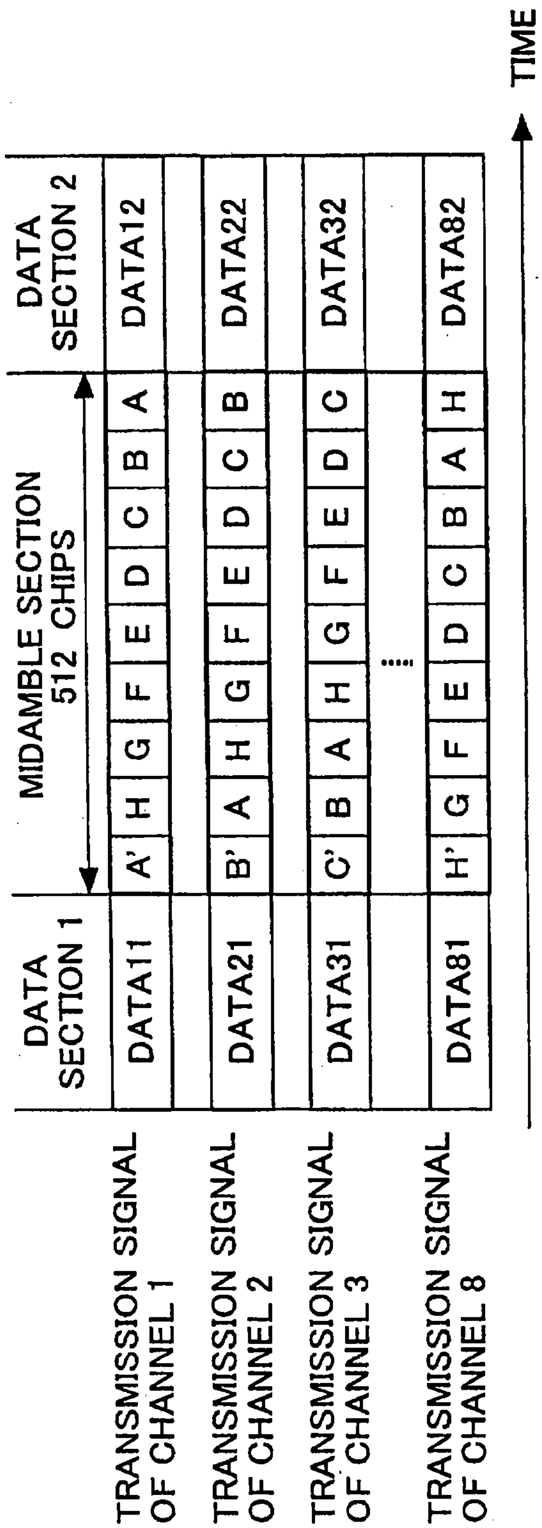

TIME
DATA SECTION 1
MIDAMBLE SECTION 512 CHIPS
DATA SECTION 2
TRANSMISSION SIGNAL OF CHANNEL 1
DATA11
A' H G F E D C B A
DATA12
TRANSMISSION SIGNAL OF CHANNEL 2
DATA21
B' A H G F E D C B
DATA22
TRANSMISSION SIGNAL OF CHANNEL 3
DATA31
C' B A H G F E D C
DATA32
.....
TRANSMISSION SIGNAL OF CHANNEL 8
DATA81
H' G F E D C B A H
DATA82

FIG.2

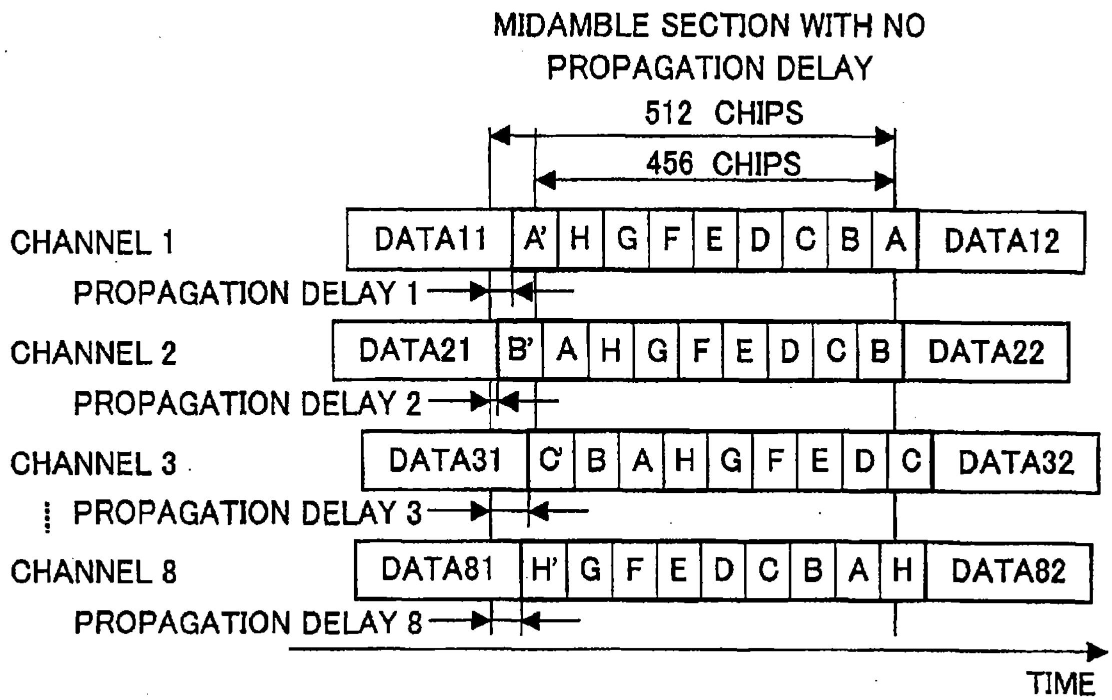

MIDAMBLE SECTION WITH NO PROPAGATION DELAY
512 CHIPS
456 CHIPS
CHANNEL 1
DATA11
A'
H
G
F
E
D
C
B
A
DATA12
PROPAGATION DELAY 1
CHANNEL 2
DATA21
B'
A
H
G
F
E
D
C
B
DATA22
PROPAGATION DELAY 2
CHANNEL 3
DATA31
C'
B
A
H
G
F
E
D
C
DATA32
PROPAGATION DELAY 3
CHANNEL 8
DATA81
H'
G
F
E
D
C
B
A
H
DATA82
PROPAGATION DELAY 8
TIME

FIG.3

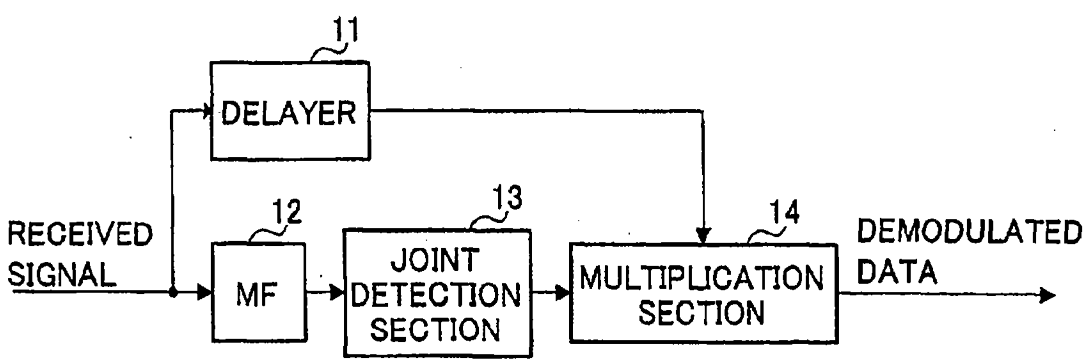

11
DELAYER
RECEIVED SIGNAL
12
MF
13
JOINT DETECTION SECTION
14
MULTIPLICATION SECTION
DEMODULATED DATA

FIG.4

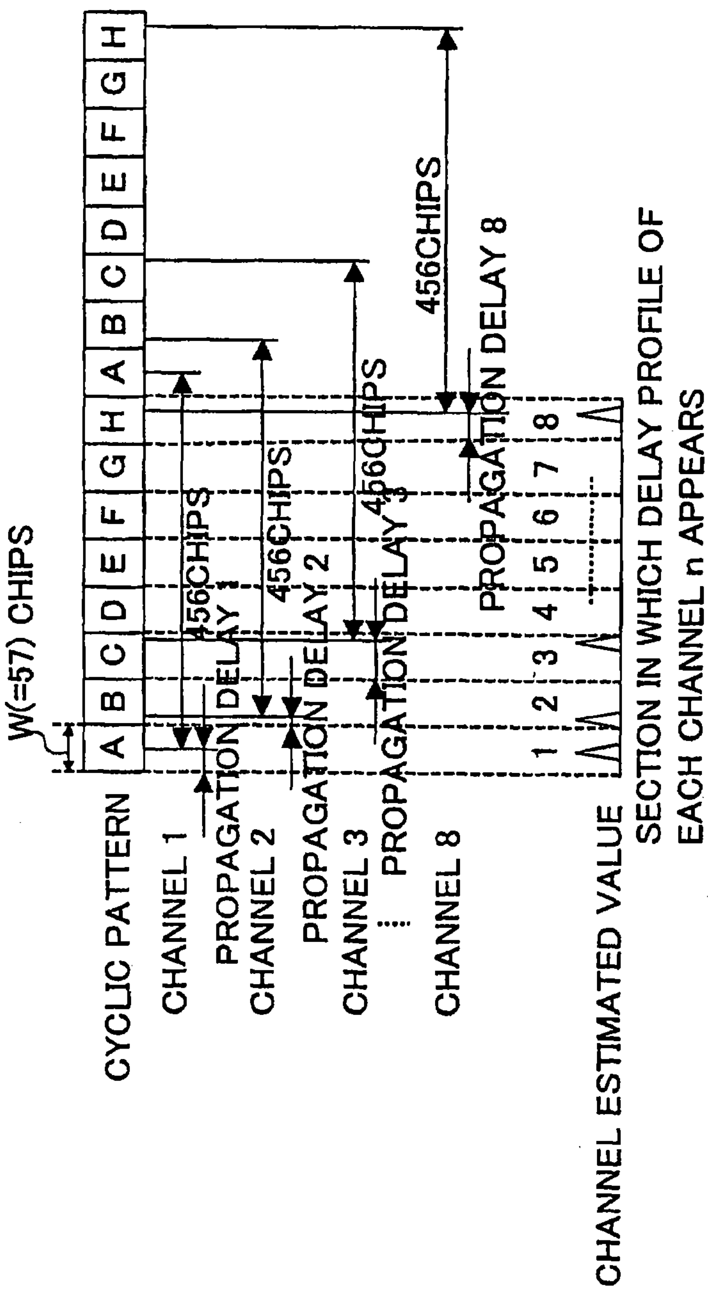

W(=57) CHIPS
CYCLIC PATTERN
A B C D E F G H A B C D E F G H
CHANNEL 1
456CHIPS
PROPAGATION DELAY 1
CHANNEL 2
456CHIPS
PROPAGATION DELAY 2
CHANNEL 3
456CHIPS
PROPAGATION DELAY 3
CHANNEL 8
456CHIPS
PROPAGATION DELAY 8
1 2 3 4 5 6 7 8
CHANNEL ESTIMATED VALUE
SECTION IN WHICH DELAY PROFILE OF
EACH CHANNEL n APPEARS

FIG.5

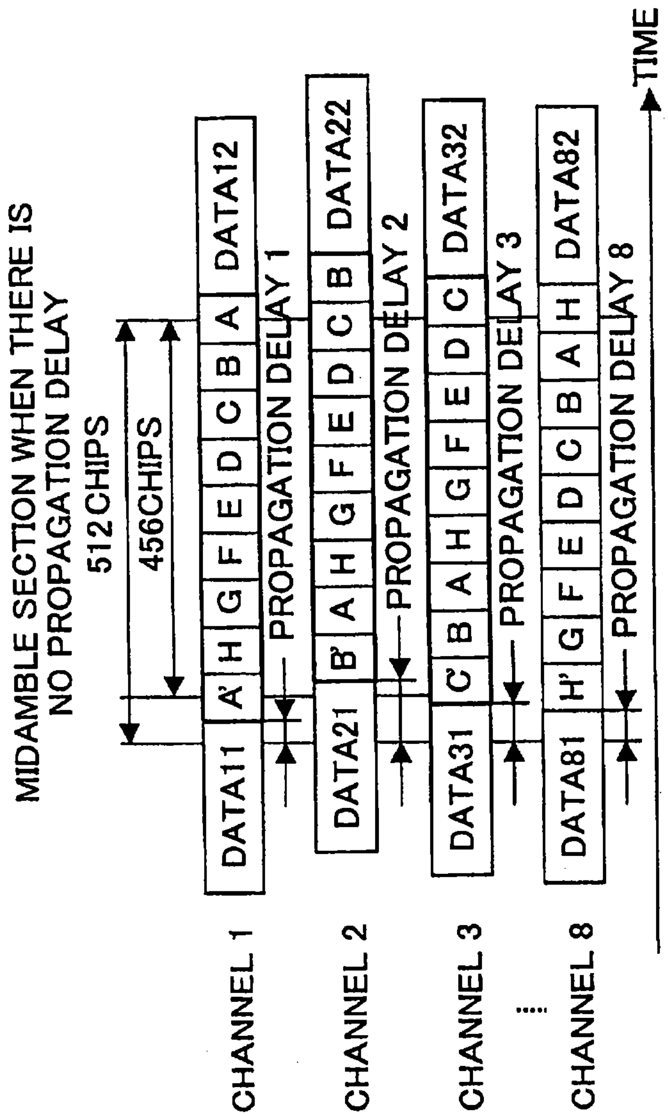
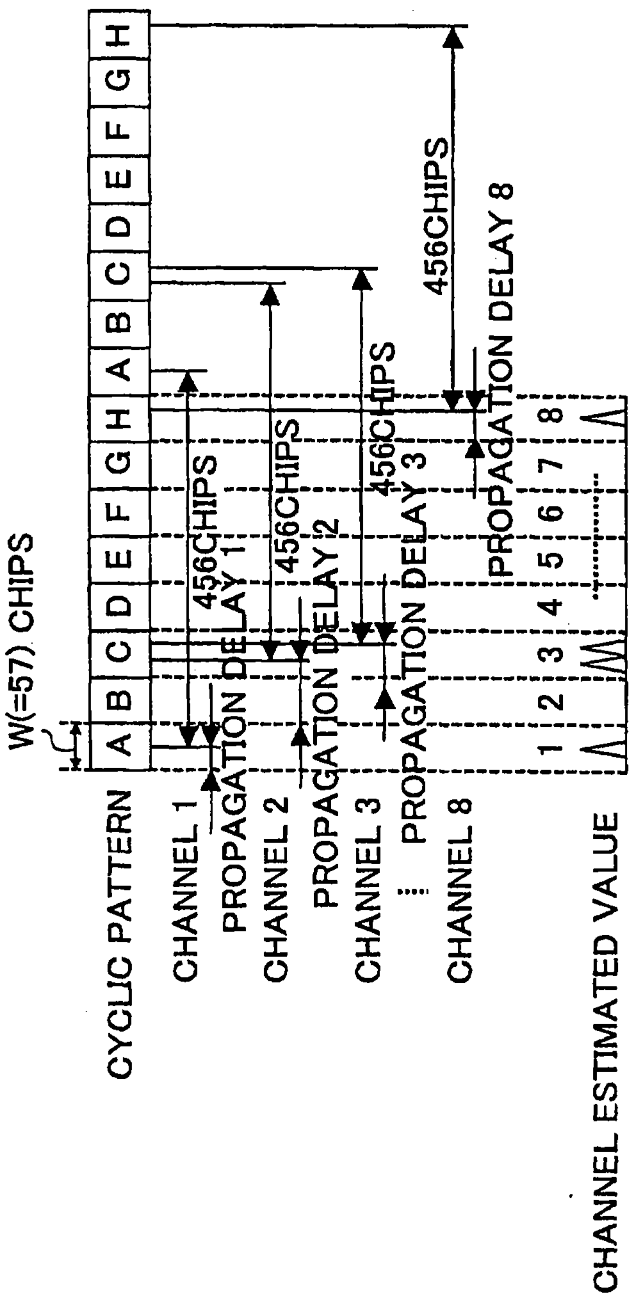

MIDAMBLE SECTION WHEN THERE IS NO PROPAGATION DELAY
512CHIPS
456CHIPS
CHANNEL 1
DATA11
A' H G F E D C B A
DATA12
PROPAGATION DELAY 1
CHANNEL 2
DATA21
B' A H G F E D C B
DATA22
PROPAGATION DELAY 2
CHANNEL 3
DATA31
C' B A H G F E D C
DATA32
PROPAGATION DELAY 3
CHANNEL 8
DATA81
H' G F E D C B A H
DATA82
PROPAGATION DELAY 8
TIME

FIG.6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CYCLIC PATTERN
A
B
C
D
E
F
G
H
A
B
C
D
E
F
G
H
CHANNEL 1
456CHIPS
PROPAGATION DELAY 1
CHANNEL 2
456CHIPS
PROPAGATION DELAY 2
CHANNEL 3
456CHIPS
PROPAGATION DELAY 3
CHANNEL 8
456CHIPS
PROPAGATION DELAY 8
CHANNEL ESTIMATED VALUE
1
2
3
4
5
6
7
8

FIG.7

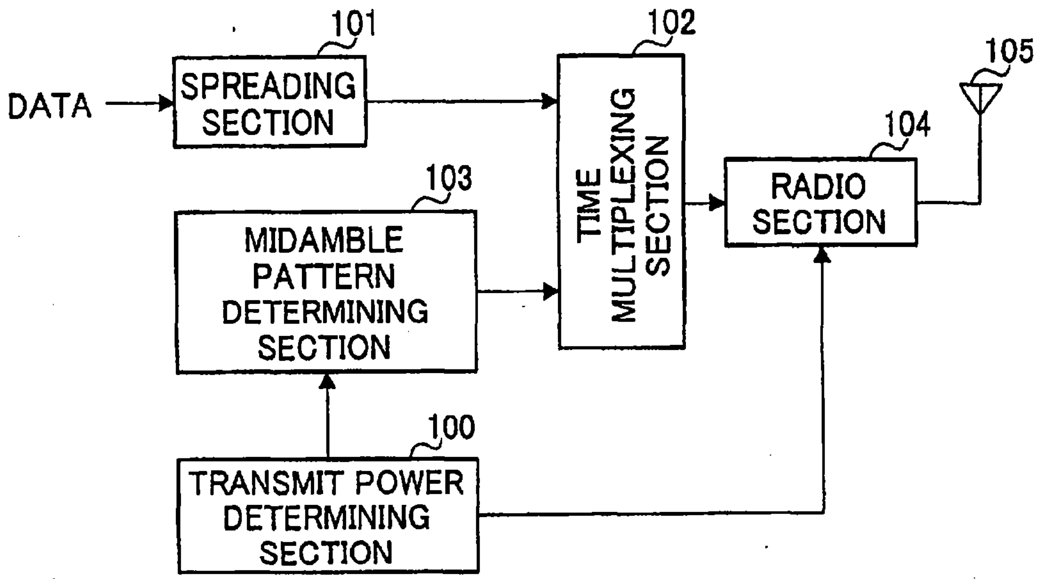
101
102
105
DATA
SPREADING SECTION
104
103
TIME MULTIPLEXING SECTION
RADIO SECTION
MIDAMBLE PATTERN DETERMINING SECTION
100
TRANSMIT POWER DETERMINING SECTION

FIG.8

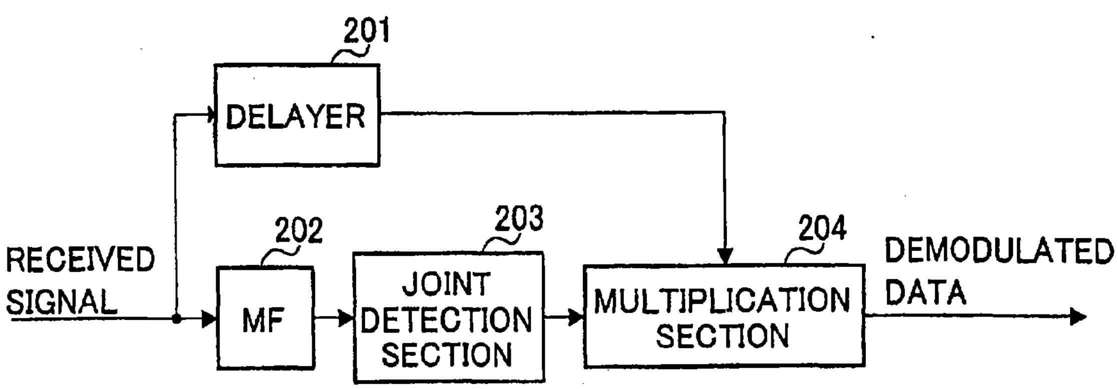
201
DELAYER
202
203
204
RECEIVED SIGNAL
MF
JOINT DETECTION SECTION
MULTIPLICATION SECTION
DEMODULATED DATA

FIG.9

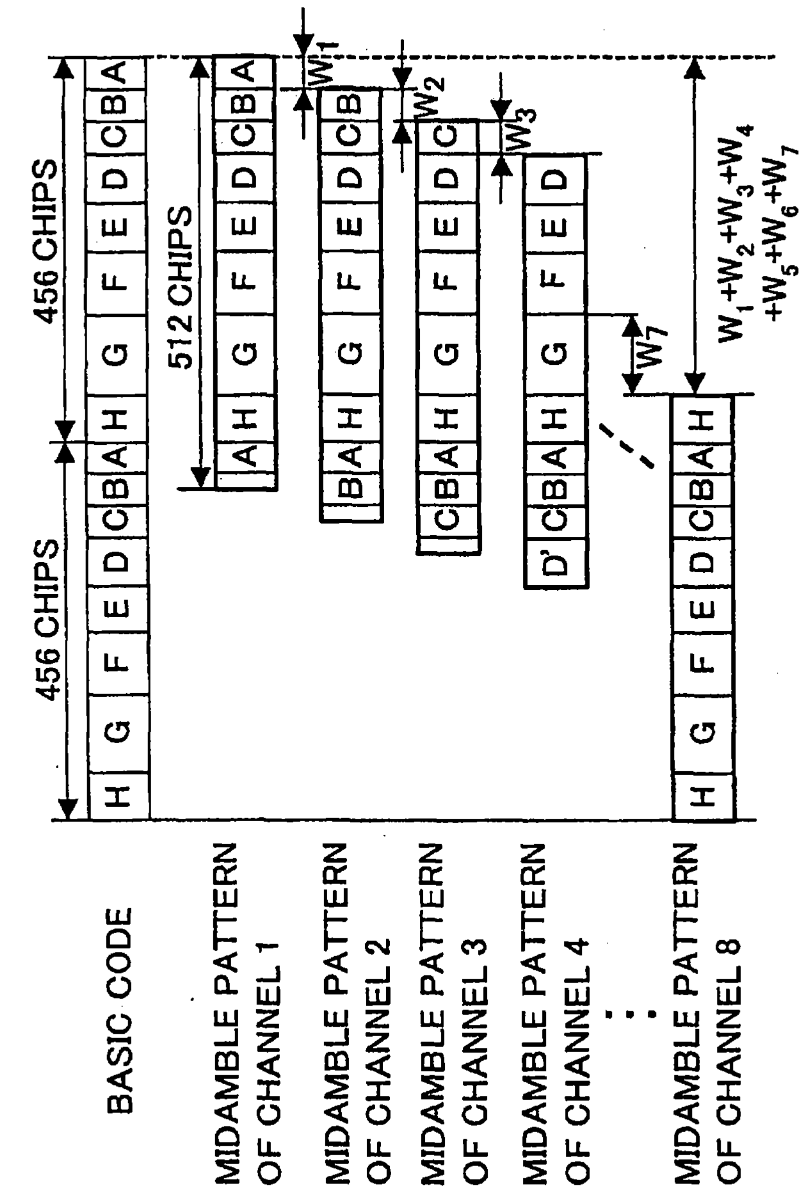
BASIC CODE
MIDAMBLE PATTERN OF CHANNEL 1
MIDAMBLE PATTERN OF CHANNEL 2
MIDAMBLE PATTERN OF CHANNEL 3
MIDAMBLE PATTERN OF CHANNEL 4
MIDAMBLE PATTERN OF CHANNEL 8
456 CHIPS
456 CHIPS
512 CHIPS
W1
W2
W3
W7
W1+W2+W3+W4
+W5+W6+W7

FIG.10

TRANSMIT POWER VALUE	P1	P2	P3	P4	P5	P6	P7	P8
REFERENCE BLOCK	A	B	C	D	E	F	G	H

FIG.11

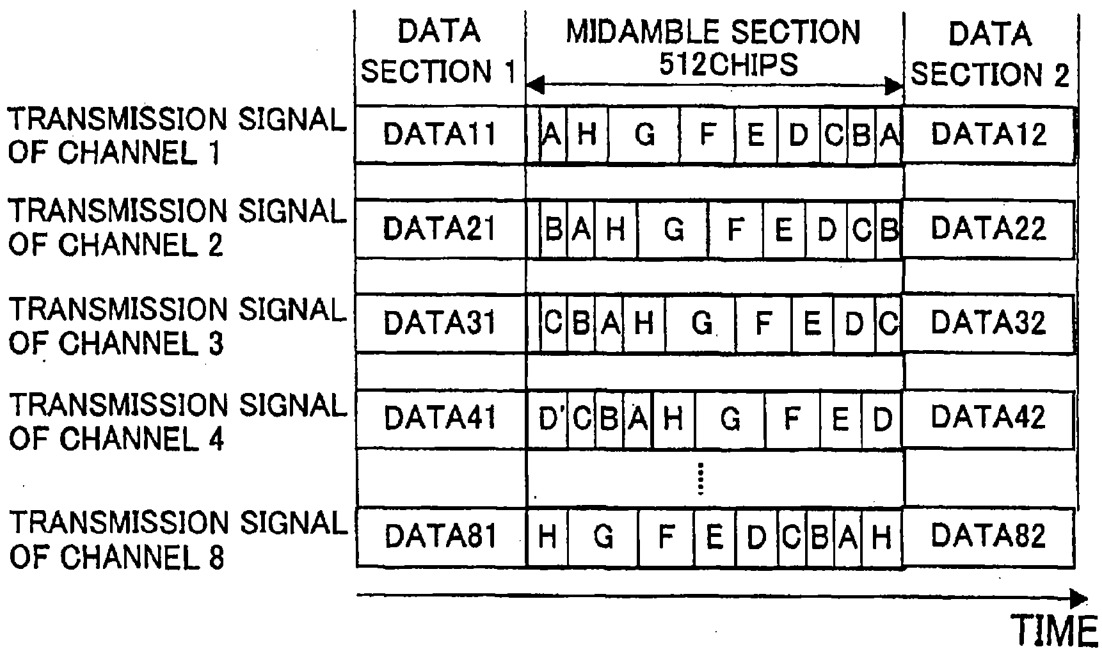

FIG.12

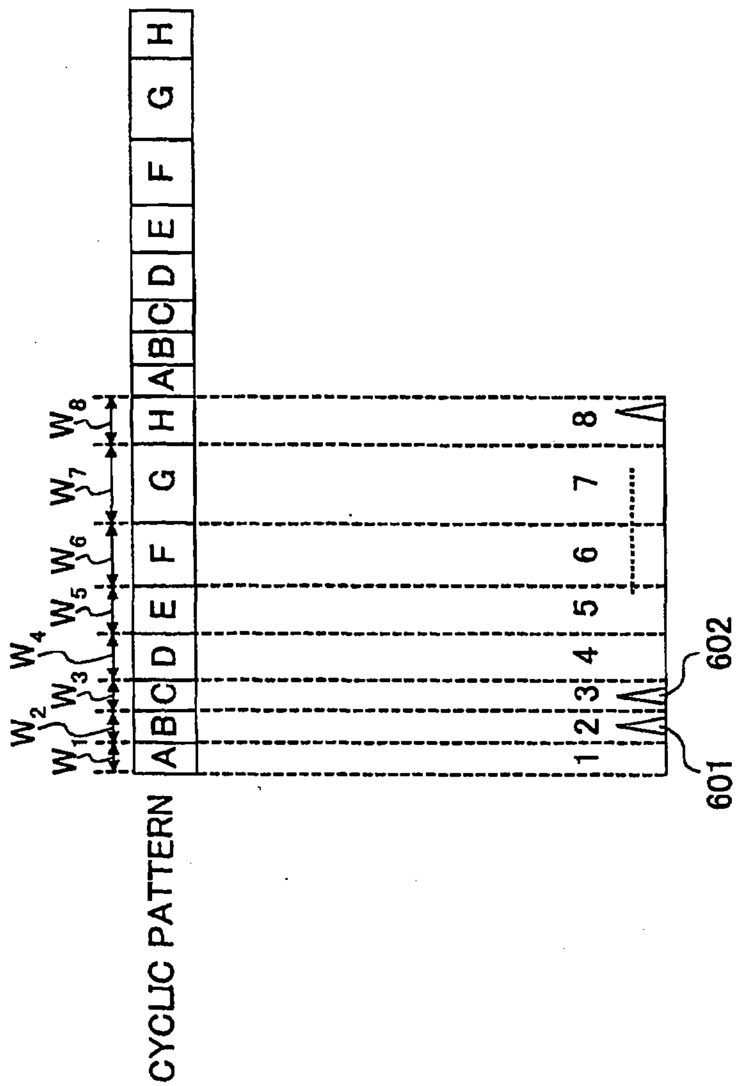
CYCLIC PATTERN
A B C D E F G H A B C D E F G H
W1 W2 W3 W4 W5 W6 W7 W8
1 2 3 4 5 6 7 8
601
602

FIG.13

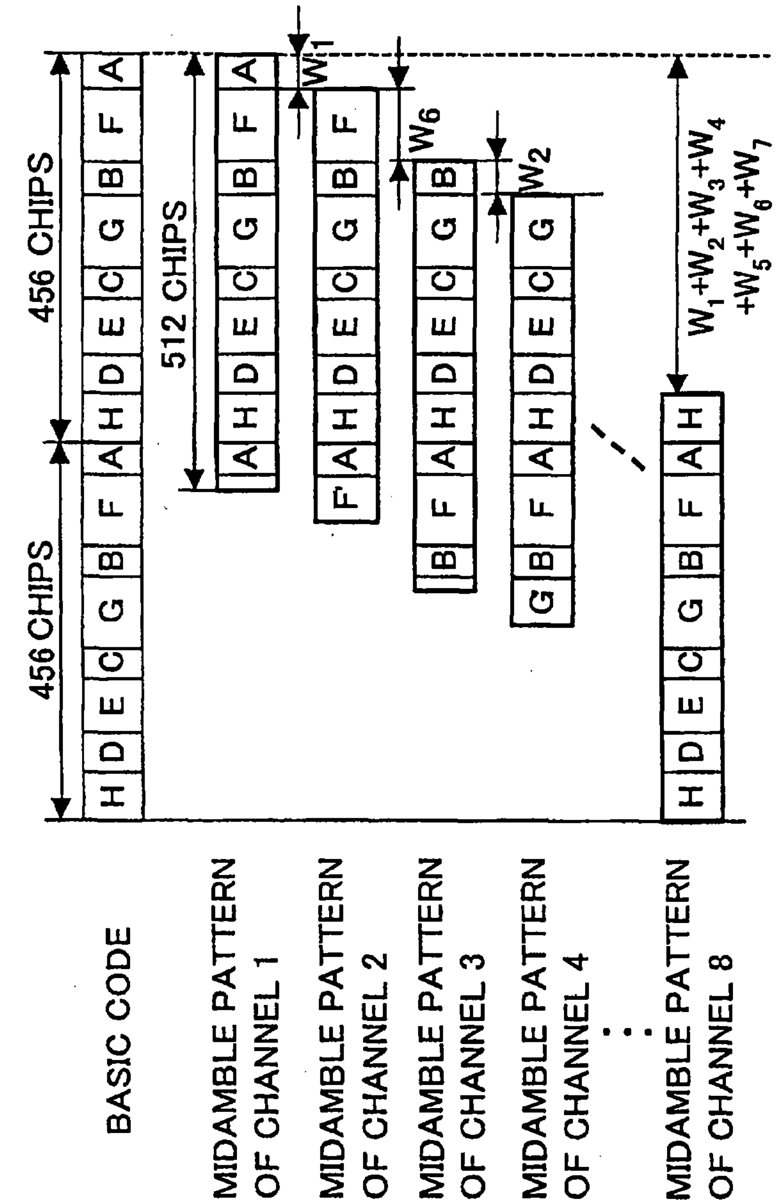
456 CHIPS
456 CHIPS
512 CHIPS
W1
W6
W2
W1+W2+W3+W4
+W5+W6+W7
BASIC CODE
MIDAMBLE PATTERN OF CHANNEL 1
MIDAMBLE PATTERN OF CHANNEL 2
MIDAMBLE PATTERN OF CHANNEL 3
MIDAMBLE PATTERN OF CHANNEL 4
MIDAMBLE PATTERN OF CHANNEL 8

FIG.14

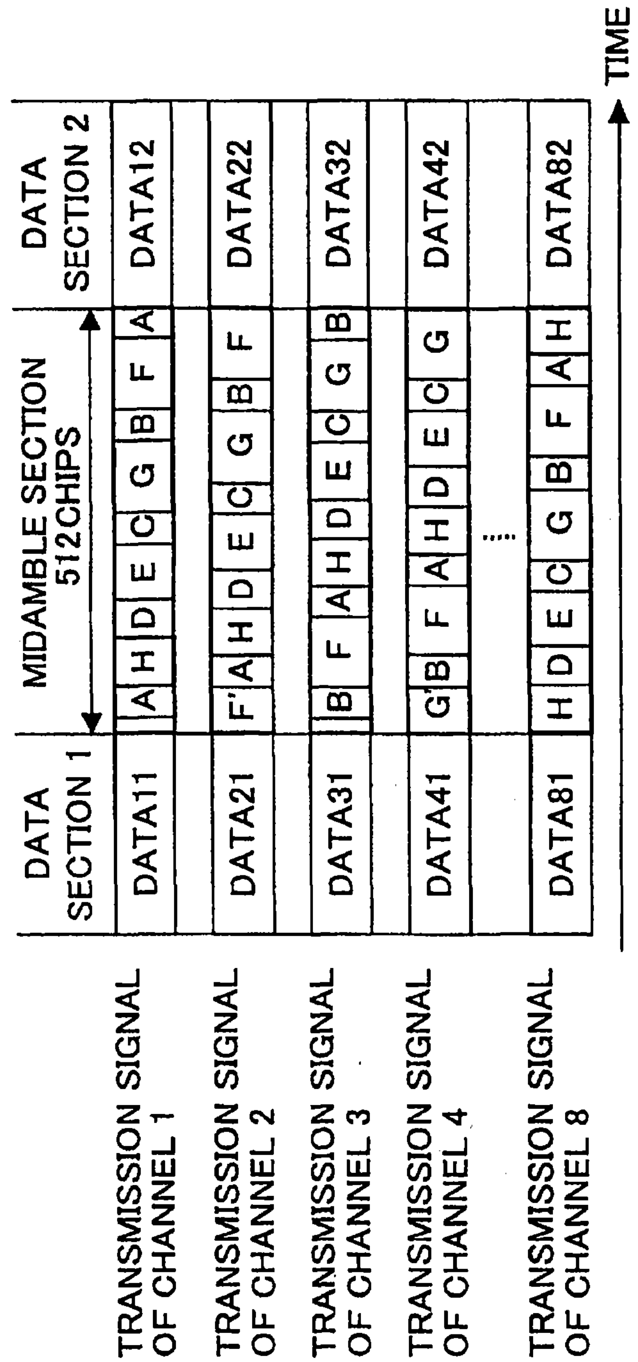
DATA SECTION 1
MIDAMBLE SECTION 512CHIPS
DATA SECTION 2
TRANSMISSION SIGNAL OF CHANNEL 1
DATA11
A H D E C G B F A
DATA12
TRANSMISSION SIGNAL OF CHANNEL 2
DATA21
F' A H D E C G B F
DATA22
TRANSMISSION SIGNAL OF CHANNEL 3
DATA31
B F A H D E C G B
DATA32
TRANSMISSION SIGNAL OF CHANNEL 4
DATA41
G' B F A H D E C G
DATA42
TRANSMISSION SIGNAL OF CHANNEL 8
DATA81
H D E C G B F A H
DATA82
TIME

FIG.15

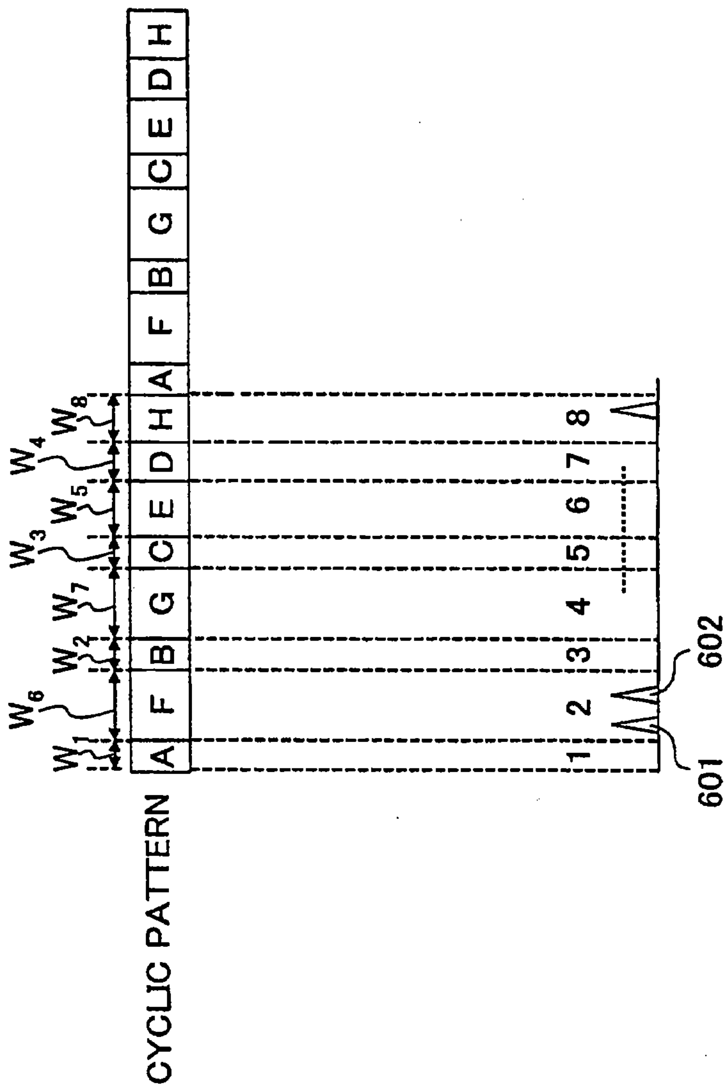
CYCLIC PATTERN
A
F
B
G
C
E
D
H
A
F
B
G
C
E
D
H
W1
W6
W2
W7
W3
W5
W4
W8
1
2
3
4
5
6
7
8
601
602

FIG.16

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/01458

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] H04B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] H04B7/24-7/26, 102, H04Q7/00-7/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2001
Kokai Jitsuyo Shinan Koho 1971-2001 Jitsuyo Shinan Toroku Koho 1996-2001

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Klein A, Kaleh G.K., Baier P.W., "Zero Forcing and Minimum Mean-Square-Error Equalization for Multi-user Detection in Code-Division Multiple-Access Channels", IEEE Trans. Vehicular Technology, Vol.45, No.2, May, 1996	1-20
A	JP, 2000-31870, A (Lucent Technologies Inc.), 28 January, 2000 (28.01.00) & EP, 952711, A2 & US, 6144710, A	1-20

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May, 2001 (15.05.01)	29 May, 2001 (29.05.01)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

Electronic Patent Application Fee Transmittal

Application Number:	10917968
Filing Date:	12-Aug-2004
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Filer:	Elahe S. Toosi/Peggy Bozym
Attorney Docket Number:	562492000500

Filed as Large Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
	Total in USD ($)			**180**

Electronic Acknowledgement Receipt

EFS ID:	2268850
Application Number:	10917968
International Application Number:	
Confirmation Number:	3609
Title of Invention:	Power control in a wireless communication system
First Named Inventor/Applicant Name:	Nicholas William Anderson
Customer Number:	25226
Filer:	Elahe S. Toosi/Peggy Bozym
Filer Authorized By:	Elahe S. Toosi
Attorney Docket Number:	562492000500
Receipt Date:	03-OCT-2007
Filing Date:	12-AUG-2004
Time Stamp:	20:44:38
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	$180
RAM confirmation Number	3665
Deposit Account	031952

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:
Charge any Additional Fees required under 37 C.F.R. Section 1.16 and 1.17

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	Transmittal_of_SIDS.pdf	27566 db42dd76667fa9ab54fc2ecfbd2ec59d33641f88	no	1
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Filed	SIDS.pdf	25790 76c312b2d11c7281f313b6eda6f2eb3ad1379813	no	3
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Miscellaneous Incoming Letter	SIDS_SB_08.pdf	29916 dea8af799f24899576daaaf931ff22c48e6ef841	no	1
Warnings:					
Information:					
4	Foreign Reference	2350522.pdf	626921 58c1f1c720f6967a7ea9e1d8bb3d86ecf6b06c5a	no	15
Warnings:					
Information:					
5	Foreign Reference	EP1176739.pdf	1490782 63035330dcd217d162abea62531d8538f8cf3c18	no	28
Warnings:					
Information:					
6	NPL Documents	GBSearch.pdf	42527 e0da9c8e9c4816801b33ee4069ea86b2ac334f0c	no	1
Warnings:					
Information:					
7	NPL Documents	IntSearch2003.pdf	109909 f72c5d0aa3d13896e329c55c86f6d90fe4279195	no	3
Warnings:					
Information:					
8	NPL Documents	IntSearch2005.pdf	129327 125d9f88f56eb5758357e19656cebdd3ea568760	no	4
Warnings:					
Information:					

9	NPL Documents	RecommendationITURM1225.pdf	2822210 506e1182f94272a4291f0cfdc93e355d5b081480	no	61
Warnings:					
Information:					
10	Fee Worksheet (PTO-06)	fee-info.pdf	8179 7f6ca9bfe01cadfd8a1a97c9f28946864e0074e7	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	5313127	

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas W. ANDERSON
Art Unit	2618
Examiner Name	D. E. Rego
Attorney Docket Number	562492000500
Total Number of Pages in This Submission	5

ENCLOSURES (*Check all that apply*)

- [ ] Fee Transmittal Form
  - [ ] Fee Attached
- [ ] Amendment/Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [x] Information Disclosure Statement (3 pgs.)
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ______
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC **(Appeal Notice, Brief, Reply Brief)**
- [ ] Proprietary Information
- [ ] Status Letter
- [x] Other Enclosure(s) (please Identify below):

PTO/SB/08A/B (1 pg.)
References 6

Remarks

Customer No. 25225

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	MORRISON & FOERSTER LLP		
Signature	/Elahe Toosi/		
Printed name	Elahe Toosi		
Date	October 2, 2007	Reg. No.	57,740

sf-2398170

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/917,968	08/12/2004	Nicholas William Anderson	562492000500	3609

25226 7590 07/02/2007
MORRISON & FOERSTER LLP
755 PAGE MILL RD
PALO ALTO, CA 94304-1018

EXAMINER	
REGO, DOMINIC E	

ART UNIT	PAPER NUMBER
2618	

MAIL DATE	DELIVERY MODE
07/02/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)	
	10/917,968	ANDERSON, NICHOLAS WILLIAM	
	Examiner	Art Unit	
	Dominic E. Rego	2618	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _12 August 2004_.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) _1-13_ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) _1-13_ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _04/23/2007_.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____.
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 112

1. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

2. Claim 13 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. The claimed limitations "an output providing a sum of past step instruction" are not found in the specification and it is non-enabling.

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

4. Claims 1-7,9,10,12,and 13 are rejected under 35 U.S.C. 102(e) as being anticipated by Zeira et al. (International Publication Number #WO 00/57574).

Regarding claim 1, Zeira teaches a method of power control in a radio communications system (See Abstract), the method comprising:

determining a path loss of a radio channel between a base station and a remote transceiver (Page 2, lines 14- 21; Page 4, line 17-Page 5, line 8);

receiving a transmit power control (TPC) command transmitted to the remote transceiver from the base station (Page 4, line 17-Page 5, line 8); and

calculating a transmit power level for the remote transceiver based on the path loss and the TPC command (Page 4, line 17-Page 5, line 8).

Regarding claim 2, Zeira teaches the method of power control, the method further comprising transmitting an uplink signal from the remote transceiver at the calculated transmit power level (Page 5, lines 4-8).

Regarding claim 3, Zeira teaches the method of power control, wherein determining the path loss includes: receiving a downlink signal transmitted from the base station, wherein the downlink signal signals a transmitted power level of the downlink signal; and measuring a received power level of the downlink signal (Page 2, lines 14-21; Page 4, lines 17-page 8).

Regarding claim 4, Zeira teaches the method of power control, wherein determining the path loss further includes computing a difference between the signaled transmit power level and the measured received power level (Page 2, lines 1-lines 21; Page 5, lines 2-lines 4).

Regarding claim 5, Zeira teaches the method of power control, the method further comprising:

generating the TPC command; and transmitting the TPC command from the base station (Page 4, line 21-Page 5, line 1).

Regarding claims 6 and 7, Zeira teaches the method of power control, wherein the calculating the transmit power level is additionally based on an adjustment factor, wherein the adjustment factor incorporates a spreading factor parameter (Page 13, lines 2-9).

Regarding claim 9, Zeira teaches a method of power control in a radio communications system (See Abstract), the method comprising:

receiving a signal at a second transceiver transmitted from a first transceiver (Page 2, lines 14-17; Page 4, lines 18-20);

measuring a power level of the received signal (Page 2, lines 14-18);

receiving a transmit power control (TPC) command at the second transceiver transmitted from the first transceiver (Page 4, line 18-Page 5, line 1); and

calculating a transmit power level for the second transceiver based on the power level of the received signal and the TPC command (Page 4, line 18-Page 5, line 8).

Regarding claim 10, Zeira teaches a method of uplink power control in a CDMA radio communications system, the method comprising:

receiving an uplink signal (Page 3, lines 1-7; Page 6, lines 1-9);

measuring a received SNIR of the uplink signal (Page 3, lines 1-7;Page 7, lines 9-15);

comparing the measured received SNIR with an SNIR target (Page 3, lines 1-7; Page 7, lines 9-15);

assigning a first value to a step indicator if the measured received SNIR is greater than the SNIR target, and assigning a second value to a step indicator if the measured received SNIR is less than the SNIR target (Page 3, lines 1-7; Page 3, line 16-8);

transmitting a transmit power control (TPC) command instructing a transmitter to adjust an uplink transmit power level based on the step indicator *(Page 3, lines 1-7: Zeira teaches the determined SIR is compared to a target SIR (SIR target). Based on the comparison, the base station 30 transmits a power command. After receiving the power command, the UE 32(1) increase or decrease its transmission power level based on the received power command)*;

receiving the TPC command including the step indicator; accumulating the step indicator value *(Page 3, lines 1-7: Zeira teaches after receiving the power command, the UE 32(1) increase or decrease (step indicator) its transmission power level based on the receive power command)*;

broadcasting a downlink signal including an indication of a downlink power level, wherein the signal is transmitted at the downlink power level *(Page 3, lines 1-7: Zeira teaches based on the comparison between the determined SIR with a target SIR (SIR target), base station 30(1) transmits a power command; Also see page 3, line 16-Page 4, line 8)*;

measuring the received power of the downlink signal; and setting a transmit power level based on the received power level, the indication of the downlink power level, and the accumulated step indicator value *(Page 3, lines 1-7: Zeira teaches after receiving the power command, the UE 32(1) increase or decrease its transmission* *power level based on the received power command; Page 3, line 16-Page 4, line 8; Page 7, lines 9-15).*

Regarding claim 12, Zeira teaches a method comprising:

measuring a power level of a received signal (Page 2, lines 14-18);

receiving a transmit power control (TPC) command (Page 4, line 18-Page 5, line 1); and

calculating a transmit power level based on the power level of the received signal and the TPC command (Page 4, line 18-Page 5, line 8).

Regarding claim 13, as best understood in 112 1st paragraph, Zeira teaches a radio comprising:

a receiver including an output to provide a measured received power level (Page 2, lines 14-18);

an accumulator having an input for accepting step increase and decrease instructions and an output providing a sum of past step instructions *(Page 3, lines 1-7: Zeira teaches the base station 30(1) determines the signal to interference ratio (SIR) of a communication received from the UE 32(1). The determined SIR is compared to a target SIR (SIR target). Based on the comparison, the base station 30(1) transmits a power command. After receiving the power command, the UE 32(1) increase or decrease its transmission power level based on the received power command)*;

a power level setting circuit coupled to the accumulator output and coupled to the receiver output, wherein the power level setting circuit sets a transmit power bases on the accumulator output and the measured received power level; and a transmitter, wherein the transmitter transmits a signal at the set transmit power *(Page 3, lines 1-7: Zeira teaches the base station 30(1) determines the signal to interference ratio (SIR) of a communication received from the UE 32(1). The determined SIR is compared to a target SIR (SIR target). Based on the comparison, the base station 30(1) transmits a power command. After receiving the power command, the UE 32(1) increase or decrease its transmission power level based on the received power command; Page 3, line 16-Page 4, line 8; Page 7, lines 9-15).*

Claim Rejections - 35 USC § 103

5. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

6. Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Shiu et al. (US Patent #6,983,166).

Regarding claim 8, Zeira fails to teach the method of power control, wherein the adjustment factor incorporates a selected transport format parameter.

However, in related art, Shiu teaches the method of power control, wherein the adjustment factor incorporates a selected transport format parameter (Col 3, lines 27-41).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Shiu to Zeira in order to achieve target BLERs (See Shiu, Col 3, line 31).

7. Claim 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over Zeira et al. (International Publication Number #WO 00/57574) in view of Zeira et al. (US Patent Application Publication #2004/0141483) in view of Bevan et al. (US Patent Application Publication #2004/0162093) and further in view of Kamet et al. (US Patent #7,190,688).

Regarding claim 11, Zeira (WO 00/57574) fails to teach the method of power control, further comprising:

determining an error metric of the uplink signal;

updating the SNIR target based on the error metric;

measuring an interference value in the received uplink signal; and

updating an interference measurement table with the interference value;

wherein broadcasting the downlink signal further includes the interference measurement table; and

wherein setting the transmit power level is further based on a value in the interference measurement table.

However, in related art, Zeira (US 2004/0141483) teaches determining an error metric of the uplink signal; updating the SNIR target based on the error metric (Paragraph 0039).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Zeira (US 2004/0141483) to Zeira (WO 00/57574) in order to achieve the desired BLER (Paragraph 0041).

The combination of Zeira (US 2004/0141483) and Zeira (WO 00/57574) fails to teach measuring an interference value in the received uplink signal; and updating an interference measurement table with the interference value.

However, in related art, Bevan teaches measuring an interference value in the received uplink signal; and updating an interference measurement table with the interference value (Paragraph 0063).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Bevan to Zeira (US 2004/0141483) and Zeira (WO 00/57574) in order to adjust the transmission power level.

The combination of Zeira (US 2004/0141483), Zeira (WO 00/57574), and Bevan fails to teach wherein broadcasting the downlink signal further includes the interference measurement table; and wherein setting the transmit power level is further based on a value in the interference measurement table.

However, in related art, Kamel teaches wherein broadcasting the downlink signal further includes the interference measurement table; and wherein setting the transmit power level is further based on a value in the interference measurement table (Col 3, lines 29-lines 51).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the above teaching of Kamel to Zeira (US 2004/0141483), Zeira (WO 00/57574) and Bevan, in order to adjust the power level.

Conclusion

8. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Shinozaki (US 2005/0130690) teaches transmission power control method and transmission power control device.

Simonsson et al. (US 2005/0136961) teaches power control method.

Zhang et al. (US 2005/0113127) teaches method and apparatus for efficient processing of data for transmission in a communication system.

Butala (US 2004/0203987) teaches reducing interference with a multiple format channel in a communication system.

Oh et al. (US 2004/0137860) teaches fast converging power control for wireless communication systems.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Dominic E. Rego whose telephone number is 571-272-8132. The examiner can normally be reached on Monday-Friday, 8:30 am-5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nay Maung can be reached on 571-272-7882. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Dominic E. Rego

6/22/07

PHILIP J. SOBUTKA
PATENT EXAMINER

OIPE APR 2 3 2007 PATENT & TRADEMARK OFFICE

ALTERNATIVE TO PTO/SB/08A/B (09/06)

Substitute for form 1449/PTO				*Complete if Known*	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	10/917,968
				Filing Date	August 12, 2004
				First Named Inventor	Nicholas W. ANDERSON
				Art Unit	Not Yet Assigned
(Use as many sheets as necessary)				Examiner Name	Not Yet Assigned
Sheet	1	of	1	Attorney Docket Number	562492000500

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
/DR/	1.	US-2003/0103530-A1	06-05-2003	Durastante	
/DR/	2.	US-2005/0003846-A1	01-06-2005	Anderson	
/DR/	3.	US-6,085,106-A	07-04-2000	Sendonaris et al.	
/DR/	4.	US-6,442,398-B1	08-27-2002	Padovani et al.	
/DR/	5.	US-6,512,931-B1	01-28-2003	Kim et al.	
/DR/	6.	US-6,597,723-B1	07-22-2003	Zeira et al.	
/DR/	7.	US-6,628,956-B2	09-30-2003	Bark et al.	
/DR/	8.	US-6,823,194-B2	11-23-2004	Haim	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
/DR/	9.	EP-1 071 227-A2	01-24-2001	NTT DoCoMo Inc		
/DR/	10.	EP-1 367 740-A1	12-03-2003	Interdigital Technology Corporation (4-0108)		
/DR/	11.	WO-96/31009-A1	10-03-1996	Celsat America Inc		
/DR/	12.	WO-99/07105-A2	02-11-1999	Tomlinson		
/DR/	13.	WO-00/57574-A2	09-28-2000	Zeira et al.		
/DR/	14.	WO-01/08322-A1	02-01-2001	Simonsson et al.		
/DR/	15.	WO-03/036816-A1	05-01-2003	IPWireless, Inc.		

*EXAMINER: Initial if information considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English language Translation is attached.

Examiner Signature	/Dominic Rego/	Date Considered	06/14/2007

sf-2287270

Notice of References Cited	Application/Control No. 10/917,968	Applicant(s)/Patent Under Reexamination ANDERSON, NICHOLAS WILLI	
	Examiner Dominic E. Rego	Art Unit 2618	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,983,166	01-2006	Shiu et al.	455/522
*	B	US-2004/0141483	07-2004	Zeira et al.	370/335
*	C	US-2004/0162093	08-2004	Bevan et al.	455/502
*	D	US-7,190,688	03-2007	Kamel et al.	370/342
*	E	US-2005/0130690	06-2005	Shinozaki, Atsushi	455/522
*	F	US-2005/0136961	06-2005	Simonsson et al.	455/522
*	G	US-2004/0203987	10-2004	Butala, Amit	455/522
*	H	US-2004/0137860	07-2004	Oh et al.	455/127.1
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
*	N	WO-00/57574	09-2000	US	Zeira, Ariela	H04B 7/005
	O					
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	Q					
	R					
	S					
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NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Search Notes

Application/Control No.	Applicant(s)/Patent under Reexamination
10/917,968	ANDERSON, NICHOLAS WILLIAM
Examiner	**Art Unit**
Dominic E. Rego	2618

SEARCHED			
Class	Subclass	Date	Examiner
455	522,68	6/14/2007	DR
	69,296	6/14/2007	DR
	135,226.3	6/14/2007	DR
	277.2	6/14/2007	DR

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)	DATE	EXMR
East Search	6/14/2007	DR

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

Bib Data Sheet

CONFIRMATION NO. 3609

SERIAL NUMBER	FILING OR 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/917,968	08/12/2004 RULE	455	2618	562492000500

APPLICANTS

Nicholas William Anderson, Bristol, UNITED KINGDOM;

** **CONTINUING DATA** ************************** NC, DR

** **FOREIGN APPLICATIONS** ********************* NO, DR

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 10/14/2004

	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☐ yes ☑ no 35 USC 119 (a-d) conditions met ☐ yes ☑ no ☐ Met after Allowance Verified and Acknowledged ______ Examiner's Signature DR Initials	UNITED KINGDOM	4	13	5

ADDRESS
25226

TITLE

Power control in a wireless communication system

FILING FEE RECEIVED		
1072	FEES: Authority has been given in Paper No. _________ to charge/credit DEPOSIT ACCOUNT No. _________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ____________ ☐ Credit

Index of Claims

Application/Control No.	Applicant(s)/Patent under Reexamination
10/917,968	ANDERSON, NICHOLAS WILLIAM
Examiner	**Art Unit**
Dominic E. Rego	2618

√	Rejected	–	(Through numeral) Cancelled	N	Non-Elected	A	Appeal
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Claim		Date								
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EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S4	60	(power near level) same (transport near format)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 10:27
S5	123491	"455"/$.ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 10:28
S6	29	S4 and S5	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 10:29
S12	89	((error near2 metric)(ber(bit near error near rate))(ber(block near error near rate))) same (sir snir) same interference same (up$link)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 15:24
S13	111	((error near2 metric)(ber(bit near error near rate))(bler)(ber(block near error near rate))) same (sir snr snir) same interference same (up$link)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 15:25
S14	22	((error near2 metric)(ber(bit near error near rate))(bler)(ber(block near error near rate))) same (sir snr snir) same interference same (up$link) same updat$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 15:26
S15	22	((error near2 metric)(ber(bit near error near rate))(bler)(ber(block near error near rate))) same (sir snr snir) same interference same (up$link) same (upgrad$3 updat$3 amend$3)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 16:38
S17	53	(upgrad$3 updat$3 amend$3) near5 ((sir snr snir) and (interference))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 16:49

EAST Search History

S18	134	(upgrad$3 updat$3 amend$3) near5 ((sir snr snir) and (interference noise))	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 16:41
S20	23	(upgrad$3 updat$3 amend$3) with (interference near3 table)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 17:22
S22	13	(power near level) with (interference near3 table)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 17:28
S24	70	(transmi$6 send$3) with (interference near3 table)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 17:30
S25	46	(transmit$4 send$3) with (interference near3 table)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 17:30
S26	28	(transmit$4 send$3) near6 (interference near3 table)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 17:32
S28	7	(transmit$4 send$3) same (interference near3 table) same power same (uplink downlink forward reverse)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2007/06/19 17:34

PTO/SB/21 (09-04)
Approved for use through 07/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas W. ANDERSON
Art Unit	2681
Examiner Name	Not Yet Assigned
Attorney Docket Number	562492000500
Total Number of Pages in This Submission	5 + 7 refs

ENCLOSURES (*Check all that apply*)

- [ ] Fee Transmittal Form
  - [ ] Fee Attached
- [ ] Amendment/Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [x] Information Disclosure Statement w/ Form PTO/SB/08a/b (4 pages)
- [ ] Certified Copy of Priority Document(s)
- [ ] Reply to Missing Parts/ Incomplete Application
  - [ ] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ______
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC (Appeal Notice, Brief, Reply Brief)
- [ ] Proprietary Information
- [ ] Status Letter
- [x] Other Enclosure(s) (please Identify below):

1. One copy each of 7 cited references
2. Return receipt postcard.

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	MORRISON & FOERSTER LLP (Customer No. 20872)		
Signature	[signature]		
Printed name	Michael S. Garrabrants		
Date	April 19, 2007	Reg. No.	51,230

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being deposited with the U.S. Postal Service on the date shown below with sufficient postage as First Class Mail, in an envelope addressed to: MS Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Dated: April 20, 2007 Signature: [signature] (Leah Kjellen)

sf-2303038

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Dated: April 20, 2007 Signature: [signature] (Leah Kjellen)

Patent
Docket No. 562492000500

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Nicholas W. ANDERSON

Serial No.: 10/917,968

Filing Date: August 12, 2004

For: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

Examiner: Not Yet Assigned

Group Art Unit: 2681

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. § 1.97 & 1.98

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Pursuant to 37 C.F.R. §1.97 and § 1.98, Applicant submits for consideration in the above-identified application the documents listed on the attached Form PTO/SB/08a/b. Copies of foreign documents are submitted herewith. The Examiner is requested to make these documents of record.

This Information Disclosure Statement is submitted:

☐ With the application; accordingly, no fee or separate requirements are required.

☐ Before the mailing of a first Office Action after the filing of a Request for Continued Examination under § 1.114. However, if applicable, a certification under 37 C.F.R. § 1.97 (e)(1) has been provided.

☒ **Within three months of the application filing date or before mailing of a first Office Action on the merits; accordingly, no fee or separate requirements are required. However, if applicable, a certification under 37 C.F.R. § 1.97 (e)(1) has been provided.**

☐ After receipt of a first Office Action on the merits but before mailing of a final Office Action or Notice of Allowance.

- ☐ A fee is required. A check in the amount of __ is enclosed.
- ☐ A fee is required. Accordingly, a Fee Transmittal form (PTO/SB/17) is attached to this submission in duplicate.
- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above; accordingly; no fee is believed to be due.

☐ After mailing of a final Office Action or Notice of Allowance, but before payment of the issue fee.

- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above and a check in the amount of __ is enclosed.
- ☐ A Certification under 37 C.F.R. § 1.97(e) is provided above and a Fee Transmittal form (PTO/SB/17 is attached to this submission in duplicate.)

Applicant would appreciate the Examiner initialing and returning the Form PTO/SB/08a/b, indicating that the information has been considered and made of record herein.

The information contained in this Information Disclosure Statement under 37 C.F.R. § 1.97 and § 1.98 is not to be construed as a representation that: (i) a complete search has been made; (ii) additional information material to the examination of this application does not exist; (iii) the information, protocols, results and the like reported by third parties are accurate or enabling; or (iv) the above information constitutes prior art to the subject invention.

In the unlikely event that the transmittal form is separated from this document and the Patent and Trademark Office determines that an extension and/or other relief (such as payment of a fee under 37 C.F.R. § 1.17 (p)) is required, Applicant petitions for any required relief including extensions of time and authorize the Commissioner to charge the cost of such petition and/or other fees due in connection with the filing of this document to **Deposit Account No. 03-1952** referencing **562492000500.**

Dated: April 19, 2007

Respectfully submitted,

By [signature]
Michael S. Garrabrants
Registration No.: 51,230

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ALTERNATIVE TO PTO/SB/08A/B (09/06)

Substitute for form 1449/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas W. ANDERSON
Art Unit	Not Yet Assigned
Examiner Name	Not Yet Assigned
Attorney Docket Number	562492000500

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number: Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1.	US-2003/0103530-A1	06-05-2003	Durastante	
	2.	US-2005/0003846-A1	01-06-2005	Anderson	
	3.	US-6,085,106-A	07-04-2000	Sendonaris et al.	
	4.	US-6,442,398-B1	08-27-2002	Padovani et al.	
	5.	US-6,512,931-B1	01-28-2003	Kim et al.	
	6.	US-6,597,723-B1	07-22-2003	Zeira et al.	
	7.	US-6,628,956-B2	09-30-2003	Bark et al.	
	8.	US-6,823,194-B2	11-23-2004	Haim	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document: Country Code[3]-Number[4]-Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
	9.	EP-1 071 227-A2	01-24-2001	NTT DoCoMo Inc		
	10.	EP-1 367 740-A1	12-03-2003	Interdigital Technology Corporation (4-0108)		
	11.	WO-96/31009-A1	10-03-1996	Celsat America Inc		
	12.	WO-99/07105-A2	02-11-1999	Tomlinson		
	13.	WO-00/57574-A2	09-28-2000	Zeira et al.		
	14.	WO-01/08322-A1	02-01-2001	Simonsson et al.		
	15.	WO-03/036816-A1	05-01-2003	IPWireless, Inc.		

*EXAMINER: Initial if information considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1] Applicant's unique citation designation number (optional). [2] See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. [6] Applicant is to place a check mark here if English language Translation is attached.

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1]Applicant's unique citation designation number (optional). [2]Applicant is to place a check mark here if English language Translation is attached.

Examiner Signature		Date Considered	

sf-2287270

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

Appln No. 10/917,968
Docket No. 562492000500

(11) EP 1 071 227 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.01.2001 Bulletin 2001/04

(51) Int. Cl.[7]: **H04B 7/005**

(21) Application number: **00306147.0**

(22) Date of filing: **19.07.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **21.07.1999 JP 20678999**

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(54) CDMA reception apparatus and received signal power measuring apparatus in CDMA mobile communication system

(57) In a CDMA reception apparatus, averaging means (412) for averaging at least one of vector, amplitude and power of received signal of a plurality of transmit power control sections is provided. Further, propagation path variation estimation means (407) for estimating a propagation path variation of the present transmit power control section from respective transmit power control sections in the past to obtain a propagation path variation estimation value (408) and propagation path variation correction means (multiplier) for correcting by the propagation path variation estimation value (408) are further provided, wherein the averaging means (412) averages at least one of vector, amplitude and power of received signal of the plurality of transmit power control sections corrected by the propagation path variation correction means (multiplier). With this configuration, the measurement accuracy is improved by measuring received signal power using a plurality of slots including past slots, more accurate transmit power control is performed, thereby achieving improved communication quality, a reduced transmit power, and an increased capacity.

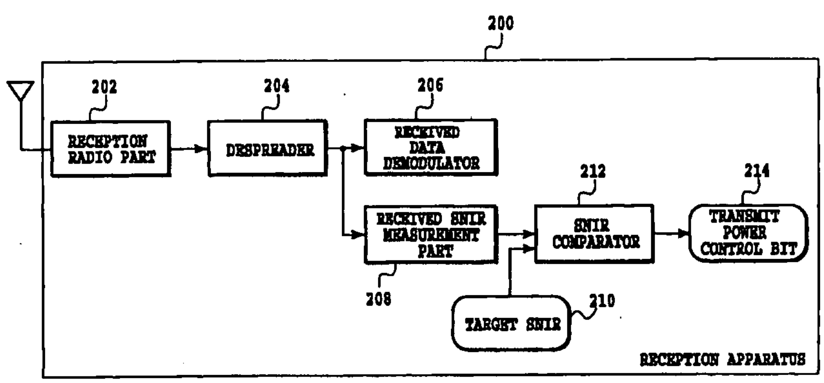

FIG.2

EP 1 071 227 A2

Description

[0001] The present invention relates to a mobile communication reception apparatus in mobile communications applied with digital radio communication system, particularly with CDMA (code division multiple access) system, more specifically to received signal power measurement for transmit power control.

[0002] An example of relationship between flow of transmit power control of CDMA mobile communication system by the prior art and radio slot configuration is schematically shown in Fig. 1.

[0003] As shown in Fig. 1, 1) received signal power measurement is performed for each transmit power control section (hereinafter referred to as "slot"), 2) the measurement result is subjected to a division calculation using a measurement result of noise interference power to obtain a received SNIR (signal power to interference power ratio), the received SNIR is compared with a reference SNIR, 4) a transmit power control bit is transmitted designating a transmit power control indicator of the received side channel, so that when the comparison result exceeds the reference SNIR, a base station transmit power is decreased, or when the comparison result is below the reference SNIR, the base station transmit power is increased.

[0004] As shown in Fig. 1, in the traffic channel, there exists not only a fixed transmit part (shaded in Fig. 1) in which the number of transmit bits is unchanged, but also a variable transmit part in which the transmit bit number is successively changed according to a change in information speed of transmitted data, when there is no data, transmit is stopped. In this case, the fixed transmit part is applied to received signal power measurement.

[0005] As shown above, received signal power measurement in a CDMA reception apparatus is performed using a fixed transmit part, however, there is a problem that when signal power of the fixed transmit part is small, measurement accuracy of received signal power is deteriorated, and transmit power control is not performed with good accuracy.

[0006] As described above, accuracy degradation of transmit power control has resulted in an increase in transmit power and deterioration of channel capacity.

[0007] An object of the present invention is to improve the measurement accuracy by measuring received signal power using a plurality of slots including past slots, thereby performing even more accurate transmit power control. With this, the object is to achieve improvement of communication quality, reduction of transmit power and increase of capacity.

[0008] Further, when using received signals of a plurality of slots including past slots in measurement of received power, measurement accuracy is improved when the traveling speed of the mobile terminal is slow since the propagation path variation is small, however, when the traveling speed of the mobile terminal is high, since the propagation path variation is large, there is a possibility that the measurement accuracy is deteriorated. As shown, the number of slots used for received signal power measurement suitable for accuracy is varied with the traveling speed. Further, to use signals of past slots for measurement of received signal power, by averaging a result of multiplying a change in variation of propagation path and a change in transmit power changed by transmit power control from a past to present, measurement accuracy can be improved. In particular, other than a dedicated traffic channel which is applied to transmit power control, in a downlink here channel reception of a common channel of fixed transmit power is possible such as a pilot channel, it is possible to estimate propagation path variation using the common channel. However, as there is a variation in propagation path or as estimation accuracy of change in transmit power is degraded, there may be a case where received signal power measurement accuracy is deteriorated by using past slot signals for measurement. In particular, when the fixed transmit part in the above-described slot is large, since many measurable received signals are present in 1 slot, the accuracy is better than averaging many slots, when the number of slots to be averaged is small, or in some case, when there is only one slot to be averaged. Still further, also in a downlink, when the propagation path of common channel is different from the propagation path of a dedicated traffic channel such as in the case where a transmit adaptive array antenna is applied to the transmit side, that is, the base station side, propagation path estimation is difficult, and there may be a case where the accuracy is deteriorated by using a plurality of slots of the past. As shown, the optimum number of slots used for received signal power measurement is changed.

[0009] Then, an object of the present invention is to achieve received signal power measurement suitable for respective systems and propagation environments by changing the number of averaging slots according to traveling speed, channel format, and system details without changing the algorithm, improve the measurement accuracy, achieve a reduction of transmit power and an increase of capacity, and suppress complexity of reception apparatus, especially complexity of mobile communication terminal apparatus.

[0010] In accordance with the present invention which attains the above objects, there is provided a received signal power measurement using a plurality of past slots for improving measurement accuracy of received signal power, making a transmit power control highly accurate, thereby enabling high communication quality, reduction of transmit power, and increased capacity. Further, by changing the number of averaging slots according to the traveling speed, channel format, and system details, it is possible to perform received signal power measurement suitable for respective environments without changing the algorithm, thereby reducing the transmit power, increasing the capacity and suppressing the size of the reception apparatus.

[0011] The CDMA reception apparatus and received signal power measurement method described in respective claims are as what follows.

[0012] In a first aspect of the present invention, there is provided a CDMA reception apparatus comprising:

propagation path variation estimation means for estimating a propagation path variation in a present transmit power control section from respective transmit power control sections in the past to obtain a propagation path variation estimation value;
propagation path variation correction means for correcting at least one of vector, amplitude and/or power of a received signal of the plurality of transmit power control sections with the propagation path variation estimation value obtained by the propagation path variation estimation means; and
averaging means for averaging at least one of vector, amplitude and/or power of received signal of the plurality of transmit power control sections corrected by the propagation path variation correction means.

[0013] According to the present invention, by using a plurality of slots including past slots for received signal power measurement, measurement accuracy of received signal power can be improved. Further, when using the past slots for received signal power measurement, by making a correction using an estimation value of propagation path variation from the past slot timing up to the present timing, it is possible to perform received signal power measurement more accurately.

[0014] In a second aspect of the present invention, there is provided a CDMA reception apparatus comprising:

transmit power changing amount estimation means for estimating a changing amount of transmit power of a communication partner station varied by transmit power control in the present transmit power control section from respective transmit power control sections in the past;
transmit power changing amount correction means for correcting at least one of vector, amplitude and/or power of a received signal of the plurality of transmit power control sections with the transmit power changing amount estimation value obtained by the transmit power changing amount estimation means; and
averaging means for averaging at least one of vector, amplitude and/or power of received signal of the plurality of transmit power control sections corrected by the transmit power changing amount correction means.

[0015] According to the present invention, when using the past slots for received signal power measurement, by correcting using a change amount of transmit power from the past slot timing up to the present timing, it is possible to perform received signal power measurement more accurately.

[0016] The averaging means may be provided with vector addition means for performing vector addition;

division means for dividing a vector added by the vector addition means with a number of vectors added; and
means for converting vector divided by the division means into a power.

[0017] According to the present invention, when averaging received signals of a plurality of slots including past slots, by performing averaging by vector addition, it is possible to suppress effects of noise and measurement accuracy of received signal power can be improved.

[0018] The averaging means may be provided with

amplitude addition means for performing amplitude addition;
division means for dividing an amplitude added by the amplitude addition means with a number of amplitudes added; and
means for converting amplitude divided by the division means into a power.

[0019] According to the present invention, when averaging received signals of a plurality of slots including past slots, by performing averaging by amplitude addition, simpler and more accurate averaging is possible.

[0020] The averaging means may be provided with power addition means for performing power addition;

division means for dividing a power added by the power addition means with a number of powers added.

[0021] According to the present invention, when averaging received signals of a plurality of slots including past slots, by performing averaging by power addition, simpler and more accurate averaging is possible.

[0022] The propagation path variation estimation means may estimate a propagation path variation using a channel not performing transmit power control.

[0023] According to the present invention, when estimating propagation path variation, by using a channel not performing transmit power control (for example, common channel or the like), propagation path variation estimation of high accuracy can be performed.

[0024] The transmit power changing amount estimation means may estimate a transmit power changing amount using a transmit power control indicator transmitted from own station.

[0025] According to the present invention, when estimating a transmit power changing amount, by using a transmit power control indicator (for example, transmit power control bit) transmitted from its own station, a high accuracy transmit power changing amount estimation is possible.

[0026] The averaging means may further comprise averaging section setting means for setting an averaging section.

[0027] According to the present invention, by selecting an appropriate averaging section according to the system details and propagation environment, it is possible to perform measurement of received signal power suited to environment without changing the algorithm.

[0028] The averaging section setting means may comprise:

means for setting the averaging section to a small section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is high; and
means for setting the averaging section to a large section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is small.

[0029] According to the present invention, depending on the power of received signal subjected to received signal power measurement existing between respective transmit power control sections, when the power is high, the averaging section is reduced to decrease effects of error of past received signals, or when the power is low, the averaging section is increased to reduce effects of measurement error due to noise, it is possible to set an averaging section for optimum measurement accuracy.

[0030] The averaging section setting means may comprise:

means for setting the averaging section to a large section, when a partner transmit station performs transmit power control, there is a channel other than channel transmitting to the received station and transmitting a channel not performing transmit power control with the same antenna and directivity, and propagation path variation estimation using the channel not performing transmit power control is possible; and
means for setting the averaging section to a small section, when a partner transmit station performs transmit power control, there is not a channel other than channel transmitting to the reception station and transmitting a channel not performing transmit power control with the same antenna and directivity, or even when transmitting but not performing transmit power control, and propagation path variation estimation using the channel not performing transmit power control is not possible.

[0031] According to the present invention, when estimation of propagation path variation is impossible, since when signals of past slots are used, received power measurement accuracy is deteriorated due to effects of propagation path variation, it is possible to reduce the averaging section and enhance the measurement accuracy.

[0032] The averaging section setting means may comprise:

traveling speed detection means for detecting a relative traveling speed between a communication partner station and own station; and
means for setting the averaging section to a small section when the detected traveling speed is large, and for setting the averaging section to a large section when the detected traveling speed is small.

[0033] According to the present invention, when a traveling speed is high between the opposite transmit station and the own station, by decreasing the averaging section, it is possible to prevent deterioration of received signal power measurement accuracy due to propagation path variation.

[0034] In a third aspect of the present invention, there is provided a received signal power measurement method of a CDMA reception apparatus, comprising:

a propagation path variation estimation step for estimating a propagation path variation in a present transmit power control section from respective transmit power control sections in the past to obtain a propagation path variation estimation value;
a propagation path variation correction step for correcting at least one of vector, amplitude and/or power of a

received signal of the plurality of transmit power control sections with the propagation path variation estimation value obtained by the propagation path variation estimation step; and

an averaging step for averaging at least one of vector, amplitude and/or power of received signal of the plurality of transmit power control sections corrected by the propagation path variation correction step.

[0035] According to the present invention, by using a plurality of slots including past slots for received signal power measurement, received signal power measurement accuracy can be improved. Further, when using past slots for received signal power measurement, by correcting using an estimation amount of propagation path variation from the past slot timing up to the present timing, it is possible to perform received signal power measurement more accurately.

[0036] In a fourth aspect of the present invention, there is provided a received signal power measurement method of a CDMA reception apparatus, comprising:

a transmit power changing amount estimation step for estimating a changing amount of transmit power of a communication partner station varied by transmit power control in the present transmit power control section from respective transmit power control sections in the past;

a transmit power changing amount correction step for correcting at least one of vector, amplitude and/or power of a received signal of the plurality of transmit power control sections with the transmit power changing amount estimation value obtained by the transmit power changing amount estimation step; and

an averaging step for averaging at least one of vector, amplitude and/or power of received signal of the plurality of transmit power control sections corrected by the transmit power changing amount correction step.

[0037] According to the present invention, when using past slots for received signal power measurement, by correcting using an estimation value of change amount of transmit power from the past slot timing up to the present timing, it is possible to perform received signal power measurement more accurately.

[0038] The averaging step may be provided with a vector addition step for performing vector addition;

a division step for dividing a vector added by the vector addition step with a number of vectors added; and

a step for converting vector divided by the division step into a power.

[0039] According to the present invention, when averaging received signals of a plurality of slots including past slots, by performing averaging by vector addition, it is possible to suppress effects of noise and measurement accuracy of received signal power can be improved.

[0040] The averaging step may be provided with an amplitude addition step for performing amplitude addition;

a division step for dividing an amplitude added by the amplitude addition step with a number of amplitudes added; and

a step for converting amplitude divided by the division step into a power.

[0041] According to the present invention, when averaging received signals of a plurality of slots including past slots, by performing averaging by amplitude addition, simpler and more accurate averaging is possible.

[0042] The averaging step may be provided with a step for performing power addition;

a division step for dividing a power added by the power addition step with a number of powers added.

[0043] According to the present invention, when averaging received signals of a plurality of slots including past slots, by performing averaging by power addition, simpler and more accurate averaging is possible.

[0044] The propagation path variation estimation step may estimate a propagation path variation using a channel not performing transmit power control.

[0045] According to the present invention, when estimating propagation path variation, by using a channel not performing transmit power control (for example, common channel or the like), propagation path variation estimation of high accuracy can be performed.

[0046] The transmit power changing amount estimation step may estimate a transmit power changing amount using a transmit power control indicator transmitted from own station.

[0047] According to the present invention, when estimating a transmit power changing amount, by using a transmit power control indicator (for example, transmit power control bit) transmitted from its own station, a high accuracy transmit power changing amount estimation is possible.

[0048] The averaging step may further comprise an averaging section setting step for setting an averaging section.

[0049] According to the present invention, by selecting an appropriate averaging section according to the system details and propagation environment, it is possible to perform measurement of received signal power suited to environment without changing the algorithm.

[0050] The averaging section setting step may comprise:

a step for setting the averaging section to a small section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is high; and
a step for setting the averaging section to a large section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is small.

[0051] According to the present invention, depending on the power of received signal subjected to received signal power measurement existing between respective transmit power control sections, when the power is high, the averaging section is reduced to decrease effects of error of past received signals, or when the power is low, the averaging section is increased to reduce effects of measurement error due to noise, it is possible to set an averaging section for optimum measurement accuracy.

[0052] The averaging section setting step may comprise:

a step for setting the averaging section to a large section, when a partner transmit station performs transmit power control, there is a channel other than channel transmitting to the reception station and transmitting a channel not performing transmit power control with the same antenna and directivity, and propagation path variation estimation using the channel not performing transmit power control is possible; and
a step for setting the averaging section to a small section, when a partner transmit station performs transmit power control, there is not a channel other than channel transmitting to the reception station and transmitting a channel not performing transmit power control with the same antenna and directivity, or even when transmitting but not performing transmit power control, and propagation path variation estimation using the channel not performing transmit power control is not possible.

[0053] According to the present invention, when estimation of propagation path variation is impossible, since when signals of past slots are used, received power measurement accuracy is deteriorated due to effects of propagation path variation, it is possible to reduce the averaging section and enhance the measurement accuracy.

[0054] The averaging section setting step may comprise:

a step for detecting a relative traveling speed between a communication partner station and own station; and
a step for setting the averaging section to a small section when the detected traveling speed is large, and for setting the averaging section to a large section when the detected traveling speed is small.

[0055] According to the present invention, when a traveling speed is high between the opposite transmit station and the own station, by decreasing the averaging section, it is possible to prevent deterioration of received signal power measurement accuracy due to propagation path variation.

[0056] The above and other objects, effects, features and advantages of the present invention will become more apparent from the following description of embodiments thereof taken in conjunction with the accompanying drawings.

Fig. 1 is a diagram schematically showing an example of relationship between flow of transmit power control of a prior art CDMA mobile communication system and radio slot configuration;
Fig. 2 is a block diagram showing an example of construction of reception apparatus in the CDMA mobile terminal in an embodiment 1 of the present invention;
Fig. 3 is a block diagram showing an example of construction of a received SNIR measurement part 208 in Fig. 2;
Fig. 4 is a diagram showing the relationship of Figs. 4A and 4B.
Fig. 4A is a block diagram showing an example of construction of a received signal power measurement part 304 in Fig. 3;
Fig. 4B is a block diagram showing an example of construction of a received signal power measurement part 304 in Fig. 3;
Fig. 5 is a block diagram showing an example of construction of a propagation path estimation part to which the present invention is applied;
Fig. 6 is a block diagram showing an example of construction of a transmit power changing amount estimation part to which the present invention is applied;
Fig. 7 is a block diagram showing an example of construction of a received signal power measurement part in an

embodiment 2 of the present invention;

Fig. 8 is a flow chart for explaining a setting method of averaging section in the embodiment 1 of the present invention;

Fig. 9 is a flow chart for explaining a setting method of a forgetting factor a in embodiment 2 of the present invention; and

Fig. 10 is a flow chart showing an example of operation of a received signal power measurement part.

[0057] In the following, embodiments of the present invention will be described with reference to the drawings.

[0058] The present invention can be applied to a base station reception apparatus as an uplink receiver, however, because the above-described estimation of propagation path variation can be performed by a channel not performing the transmit power control, an example of downlink receiver, that is, a case where a reception apparatus of a mobile communication terminal is used will be described as the following embodiment.

(Embodiment 1)

[0059] Fig. 2 is a block diagram showing an example of construction of a reception apparatus in a CDMA mobile terminal in the embodiment 1 of the present invention.

[0060] A reception apparatus 200 includes a reception radio part 202, a despreader 204, a received data demodulator 206, a received SNIR measurement part 208 and a SNIR comparator 212.

[0061] The reception radio part 202 receives a radio signal transmitted from a radio base station, performs frequency conversion and filtering, and outputs a baseband signal.

[0062] In the despreader 204, despreading of the baseband signal is performed, and a received despread signal is outputted to the received data decoder 206 and a received SNIR calculator 208.

[0063] In the received data demodulator 206, RAKE combining, error correction decoding and the like are performed to demodulate the received data. At the same time, the received despread signal is inputted to the received SNIR measurement part 208 to output a received SNIR at every slot, a comparison of the outputted value with a target SNIR 210 is performed in the SNIR comparator 212, according to the comparison result, a transmit power control bit 214 (transmit power control indicator) to be transmitted is outputted.

[0064] Fig. 3 is a block diagram showing an example of construction of the received SNIR measurement part 208 in Fig. 2.

[0065] The received SNIR measurement part 208 comprises a received signal power measurement part 304, a noise interference power measurement part 306 and a divider 308.

[0066] The received despread signal 302 outputted from the despreader 204 is inputted respectively to the received signal power measurement part 304 and the received noise interference power measurement part 306, and the respective measurement results A and B are divided in the divider 308 to obtain a received SNIR 310.

[0067] Figs. 4A and 4B is a block diagram showing an example of construction of the received signal power measurement part 304 in Fig. 3.

[0068] Here, in Figs. 4A and 4B, alphabet n shows a present number of slots, and K a maximum number of received signal slots for performing averaging.

[0069] The received signal power measurement part 304 includes a RAKE combiner 404, a delayer 406, a propagation path estimator 407, a transmit power changing amount estimator 409, an averaging part 412, a received signal power calculator 407, and an averaging section setting part 416.

[0070] The received despread signal 402 of fixed transmit part of the dedicated traffic channel is RAKE combined by the RAKE combiner 404, and an average value of received signal of each slot is stored in the delayer 406. The stored value can be any of vector, amplitude and/or power. Received signal of past slots stored in the delayer 406 is multiplied by the multiplier with the propagation path variation estimation value 408 of the past slot timing and the present timing generated in the propagation path estimator 407. Further, after multiplication by the multiplier with the estimation value 410 of changing amount of transmit power by transmit power control of the past slot timing and the present timing, averaging is performed along with the present slot in the averaging part 412. Still further, when the stored value is vector or amplitude, it is converted into power by the received signal power calculator 414, and outputted as received signal power.

[0071] In the averaging section setting part 416, as will be described later, the averaging section is appropriately set according to the propagation environment and environment of the system in communication.

[0072] Fig. 10 is a flow chart showing an example of operation of the received signal power measurement part 304.

[0073] First, received despread signal 402 of fixed transmit part of a dedicated traffic channel is RAKE combined by the RAKE combiner 404 (step S1002).

[0074] Next, an average value of received signal of each slot is stored in the delayer 406 (step S1004). The stored value can be any of vector, amplitude and/or power.

[0075] Next, in the propagation path estimator 407, propagation path variation in the present transmit control section is estimated from information of respective past transmit power control sections to obtain a propagation path variation estimation value 408 (step S1006).

[0076] Next, at least one of vector, amplitude and/or power of received signals of a plurality of transmit power control sections is corrected by multiplying using the propagation path variation estimation value 408 obtained by the propagation path estimator 407 (step S1008).

[0077] Next, in the transmit power changing amount estimator 409, a changing amount of transmit power changed by transmit power control of the communication partner station in the present transmit power control section is estimated from information of past respective transmit power control sections (for example, past transmit power control bit data stored in any of storage apparatus (not shown) in the reception apparatus) to obtain a transmit power changing amount estimation value 410 (step S1010).

[0078] Next, at least one of vector, amplitude and/or power of received signals of a plurality of transmit power control sections is corrected by multiplying using the transmit power changing amount estimation value 410 obtained by the transmit power changing amount estimator 409 (step S1012).

[0079] Next, in the averaging part 412, at least one of vector, amplitude and/or power of the corrected received signals of the plurality of transmit power control sections is averaged (step S1014).

[0080] Next, an averaging section setting method in the averaging section setting part 416 will be described with reference to Fig. 8.

[0081] First, for example, the amount of power allocated to the fixed transmit part of signal from the communication partner station corresponding to the shaded part in Fig. 1 is judged from the channel format in communication (step S802), setting is made so that the averaging section is decreased when the power is large (step S804), or the averaging section is increased when the power is small (step S806). Alternatively, a judgment is made from informed information from the system as to whether or not there is a common channel transmitted without performing transmit power with the same antenna and directivity and propagation path estimation is possible (step S808), when propagation path estimation is possible the averaging section is increased (step S810), or when propagation path estimation is impossible the averaging section is decreased (step S812). On the other hand, when propagation path estimation is not performed, traveling speed of the traveling machine is detected (step S814), when the traveling speed is high and variation of propagation path is large, the averaging section is set small (step S816), or when the traveling speed is low and variation of propagation path is small, the averaging section is set large (step S818).

[0082] Fig. 5 is a block diagram showing an example of construction of the propagation path estimator 407 in Figs. 4A and 4B.

[0083] Here, alphabet n in Fig. 5 shows a present slot number, and K a slot number of largest received signal for averaging.

[0084] The propagation path estimator 407 includes a delayer 504 and a divider 506.

[0085] In the propagation path estimator 407, amplitude of a received signal 502 after RAKE combining of the common channel not performing transmit power control is stored in the delayer 504 for each slot, by performing division calculation A/B of the received signal A of the present slot and the received signal B of respective past slot in the divider 506, thereby outputting a propagation path variation estimation value 508 of the present slot from the past respective slots.

[0086] Fig. 6 is a block diagram showing an example of construction of the transmit power changing amount estimator 409 in Figs. 4A and 4B.

[0087] Here, alphabet n in Fig. 6 shows a present slot number, and K a slot number of largest received signal for averaging.

[0088] The transmit power changing amount estimator 409 includes a transmit power changing amount converter 604 and a delayer 606.

[0089] The transmit power changing amount estimator 409 estimates a changing amount of transmit power from a radio base station from the transmit power control bit 602 transmitted by the mobile terminal to the radio base station.

[0090] First, in the transmit power changing amount converter 604, the transmit power control bit 602 transmitted from the mobile terminal is converted into a transmit power changing amount in consideration of the transmit power control bit to obtain a transmit power control estimation value 608. Next, output after changing is multiplied with the transmit power changing amount from each slot timing up to the present stored in the delayer 606 to obtain a new transmit power control estimation value 608.

(Embodiment 2)

[0091] In the following, an embodiment 2 according to the present invention will be described with reference to Fig. 7.

[0092] Fig. 7 is a block diagram showing an example of construction of a received signal power measurement part in the embodiment 2 of the present invention. In the receiver, construction other than the received signal power measurement part is similar to that in the embodiment 1.

[0093] A received signal power measurement part 700 in the embodiment 2 includes an α multiplier 702, a delayer 704, a propagation path estimator 705, a transmit power changing amount estimator 707, a received signal power calculator 710, an averaging section setting part 712, a RAKE combiner 716 and a 1-α multiplier 718.

[0094] The delayer 704, the propagation path estimator 705, the transmit power changing amount estimator 707, the received signal power calculator 710, the averaging section setting part 712, and the RAKE combiner 716 have the same functions as those described in Figs. 4 to 9, and the α multiplier 702 and the 1-α multiplier respectively have functions for multiplying the input with α or 1-α.

[0095] The received signal power measurement part 700 has a form of a feedback type filter which performs averaging of the received signal of the present slot and the received signal of the past slot using a forgetting factor α 702. That is, for the received signal of the past slot stored in the delayer 704, after multiplication with the propagation path variation estimation value 706 between 1 slot previous timing and the present timing and the transmit power changing amount estimation value 708, it is multiplied with the forgetting factor α in the α multiplier 702 to perform averaging with the received signal of the present slot. In the received signal power calculator 710, a received signal power is calculated from received signal after averaging and the result is outputted. On the other hand, received signal after averaging is stored again in the delayer 704. In the averaging section setting part 712, α is appropriately set according to the propagation environment and details of the system in communication.

[0096] Next, setting method of the forgetting factor α will be described with reference to Fig. 9.

[0097] First, for example, the amount of power allocated to the fixed transmit part of signal from the communication partner station corresponding to the shaded part in Fig. 1 is judged from the channel format in communication (step S902), setting is made so that α is decreased when the power is large (step S904), or α is increased when the power is small (step S906). Alternatively, a judgment is made from informed information from the system as to whether or not there is a common channel transmitted without performing transmit power with the same antenna and directivity and propagation path estimation is possible (step S908), when propagation path estimation is possible α is increased (step S910), or when propagation path estimation is impossible α is decreased (step S912). On the other hand, when propagation path estimation is not performed, traveling speed of the traveling machine is detected (step S914), when the traveling speed is high and variation of propagation path is large, α is set small (step S916), or when the traveling speed is low and variation of propagation path is small, α is set large (step S918).

(Effects of the Invention)

(Effects of embodiment 1)

[0098] As shown in Fig. 3, by obtaining the received signal power by averaging a plurality of slots including past slots, even when the fixed transmit part included in 1 slot is small, the effective measurement bit number can be increased, and received power measurement of higher accuracy can be performed.

[0099] Further, for the above-shown averaging of a plurality of slots, when a common channel cannot be used for estimation, or when the propagation path fixed transmit part is large, the number of slots for averaging is decreased, or depending on the case, only the present slot is used, averaging by an appropriate averaging slot number can be performed without changing the construction of the receiver and measurement algorithm, whereby high quality communication, reduction of transmit power, and increased channel capacity can be achieved, and complexity of the mobile terminal can be suppressed.

(Effects of embodiment 2)

[0100] With the construction as in the embodiment 2, the same effects as shown in embodiment 1 can be obtained, and averaging of the received signal power is performed by weighting average using the forgetting factor α, buffers such as delayer for storing past received signals can be reduced.

[0101] For example, in embodiment 1, averaging of a plurality of slots is calculated by Formula 1 shown below.

$$averagedR\_n=(R\_n+R\_\{n-1\}+R\{n-2\}+R\_\{n-3\})/4 \qquad \text{[FORMULA 1]}$$

[0102] The formula (1) is a formula for averaging using past 4 slots, in which R_n shows a received power value of n'th slot. Further, for simplicity of description, cancel due to variation is not considered.

[0103] While, an ordinary averaging using FIR filter as shown above is performed in embodiment 1, averaging in embodiment 2 is represented by averagedR_n=Rn* +averagedR_{n-1}*(1-) [FORMULA 2]

and exponential weighted averaging (averaging using IIR filter) is performed using the forgetting factor α. For example, when it is assumed as α = 0.25, the same averaging effect as averaging of about 4 slots can be obtained. Therefore, by performing such exponential weighted averaging, only one previous value (in the above formula, averaged R_(n-1)) of past received power value may be stored, thereby reducing the calculation amount.

[0104] Further, the propagation path variation estimation value and the transmit power changing amount estimation value are also calculation for immediately 1 slot previous values, and the calculation amount can be reduced.

[0105] Still further, when the effect of the value using received signals of past slots is to be changed, it can be achieved by changing the factor α.

[0106] The present invention has been described in detail with respect to various embodiments, and it will now be apparent from the foregoing to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and it is the intention, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit of the invention.

Claims

1. A CDMA reception apparatus characterized by comprising:

propagation path variation estimation means for estimating a propagation path variation in a present transmit power control section from respective transmit power control sections in the past to obtain a propagation path variation estimation value;
propagation path variation correction means for correcting at least one of vector, amplitude and/or power of a received signal of said plurality of transmit power control sections with said propagation path variation estimation value obtained by said propagation path variation estimation means; and
averaging means for averaging at least one of vector, amplitude and/or power of received signal of said plurality of transmit power control sections corrected by said propagation path variation correction means.

2. A CDMA reception apparatus characterized by comprising:

transmit power changing amount estimation means for estimating a changing amount of transmit power of a communication partner station varied by transmit power control in the present transmit power control section from respective transmit power control sections in the past;
transmit power changing amount correction means for correcting at least one of vector, amplitude and/or power of a received signal of said plurality of transmit power control sections with said transmit power changing amount estimation value obtained by said transmit power changing amount estimation means; and
averaging means for averaging at least one of vector, amplitude and/or power of received signal of said plurality of transmit power control sections corrected by said transmit power changing amount correction means.

3. The CDMA reception apparatus as claimed in Claim 1 or 2, characterized in that said averaging means is provided with

vector addition means for performing vector addition;
division means for dividing a vector added by said vector addition means with a number of vectors added; and
means for converting vector divided by said division means into a power.

4. The CDMA reception apparatus as claimed in Claim 1 or 2, characterized in that said averaging means is provided with

amplitude addition means for performing amplitude addition;
division means for dividing an amplitude added by said amplitude addition means with a number of amplitudes added; and
means for converting amplitude divided by said division means into a power.

5. The CDMA reception apparatus as claimed in Claim 1 or 2, characterized in that said averaging means is provided with

power addition means for performing power addition;

division means for dividing a power added by said power addition means with a number of powers added.

6. The CDMA reception apparatus as claimed in Claim 1, characterized in that said propagation path variation estimation means estimates a propagation path variation using a channel not performing transmit power control.

7. The CDMA reception apparatus as claimed in Claim 2, characterized in that said transmit power changing amount estimation means estimates a transmit power changing amount using a transmit power control indicator transmitted from own station.

8. The CDMA reception apparatus as claimed in Claim 1 or 2, characterized in that said averaging means further comprises averaging section setting means for setting an averaging section.

9. The CDMA reception apparatus as claimed in Claim 8, characterized in that said averaging section setting means comprises:

means for setting said averaging section to a small section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is high; and
means for setting said averaging section to a large section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is small.

10. The CDMA reception apparatus as claimed in Claim 8, characterized in that said averaging section setting means comprises:

means for setting said averaging section to a large section, when a partner transmit station performs transmit power control, there is a channel other than channel transmitting to said reception station and transmitting a channel not performing transmit power control with the same antenna and directivity, and propagation path variation estimation using said channel not performing transmit power control is possible; and
means for setting said averaging section to a small section, when a partner transmit station performs transmit power control, there is not a channel other than channel transmitting to said reception station and transmitting a channel not performing transmit power control with the same antenna and directivity, or even when transmitting but not performing transmit power control, and propagation path variation estimation using said channel not performing transmit power control is not possible.

11. The CDMA reception apparatus as claimed in Claim 8, characterized in that said averaging section setting means comprises:

traveling speed detection means for detecting a relative traveling speed between a communication partner station and own station; and
means for setting said averaging section to a small section when said detected traveling speed is large, and for setting said averaging section to a large section when said detected traveling speed is small.

12. A received signal power measurement method of a CDMA reception apparatus, characterized by comprising:

a propagation path variation estimation step for estimating a propagation path variation in a present transmit power control section from respective transmit power control sections in the past to obtain a propagation path variation estimation value;
a propagation path variation correction step for correcting at least one of vector, amplitude and/or power of a received signal of said plurality of transmit power control sections with said propagation path variation estimation value obtained by said propagation path variation estimation step; and
an averaging step for averaging at least one of vector, amplitude and/or power of received signal of said plurality of transmit power control sections corrected by said propagation path variation correction step.

13. A received signal power measurement method of a CDMA reception apparatus, characterized by comprising:

a transmit power changing amount estimation step for estimating a changing amount of transmit power of a communication partner station varied by transmit power control in the present transmit power control section from respective transmit power control sections in the past;

a transmit power changing amount correction step for correcting at least one of vector, amplitude and/or power of a received signal of said plurality of transmit power control sections with said transmit power changing amount estimation value obtained by said transmit power changing amount estimation step; and

an averaging step for averaging at least one of vector, amplitude and/or power of received signal of said plurality of transmit power control sections corrected by said transmit power changing amount correction step.

14. The received signal power measurement method as claimed in Claim 12 or 13, characterized in that said averaging step is provided with

a vector addition step for performing vector addition;

a division step for dividing a vector added by said vector addition step with a number of vectors added; and

a step for converting vector divided by said division step into a power.

15. The received signal power measurement method as claimed in Claim 12 or 13, characterized in that said averaging step is provided with

an amplitude addition step for performing amplitude addition;

a division step for dividing an amplitude added by said amplitude addition step with a number of amplitudes added; and

a step for converting amplitude divided by said division step into a power.

16. The received signal power measurement method as claimed in Claim 12 or 13, characterized in that said averaging step is provided with

a step for performing power addition;

a division step for dividing a power added by said power addition step with a number of powers added.

17. The received signal power measurement method as claimed in Claim 12, characterized in that said propagation path variation estimation step estimates a propagation path variation using a channel not performing transmit power control.

18. The received signal power measurement method as claimed in Claim 13, characterized in that said transmit power changing amount estimation step estimates a transmit power changing amount using a transmit power control indicator transmitted from own station.

19. The received signal power measurement method as claimed in Claim 12 or 13, characterized in that said averaging step further comprises an averaging section setting step for setting an averaging section.

20. The received signal power measurement method as claimed in Claim 19, characterized in that said averaging section setting step comprises:

a step for setting said averaging section to a small section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is high; and

a step for setting said averaging section to a large section, when performing communication by a channel of which a power allocated to a signal subjected to received signal power measurement existing in each transmit power control section is small.

21. The received signal power measurement method as claimed in Claim 19, characterized in that said averaging section setting step comprises:

a step for setting said averaging section to a large section, when a partner transmit station performs transmit power control, there is a channel other than channel transmitting to said received station and transmitting a channel not performing transmit power control with the same antenna and directivity, and propagation path variation estimation using said channel not performing transmit power control is possible; and

a step for setting said averaging section to a small section, when a partner transmit station performs transmit power control, there is not a channel other than channel transmitting to said received station and transmitting a channel not performing transmit power control with the same antenna and directivity, or even when transmitting but not performing transmit power control, and propagation path variation estimation using said channel not performing transmit power control is not possible.

22. The received signal power measurement method as claimed in Claim 19, characterized in that said averaging section setting step comprises:

a step for detecting a relative traveling speed between a communication partner station and own station; and a step for setting said averaging section to a small section when said detected traveling speed is large, and for setting said averaging section to a large section when said detected traveling speed is small.

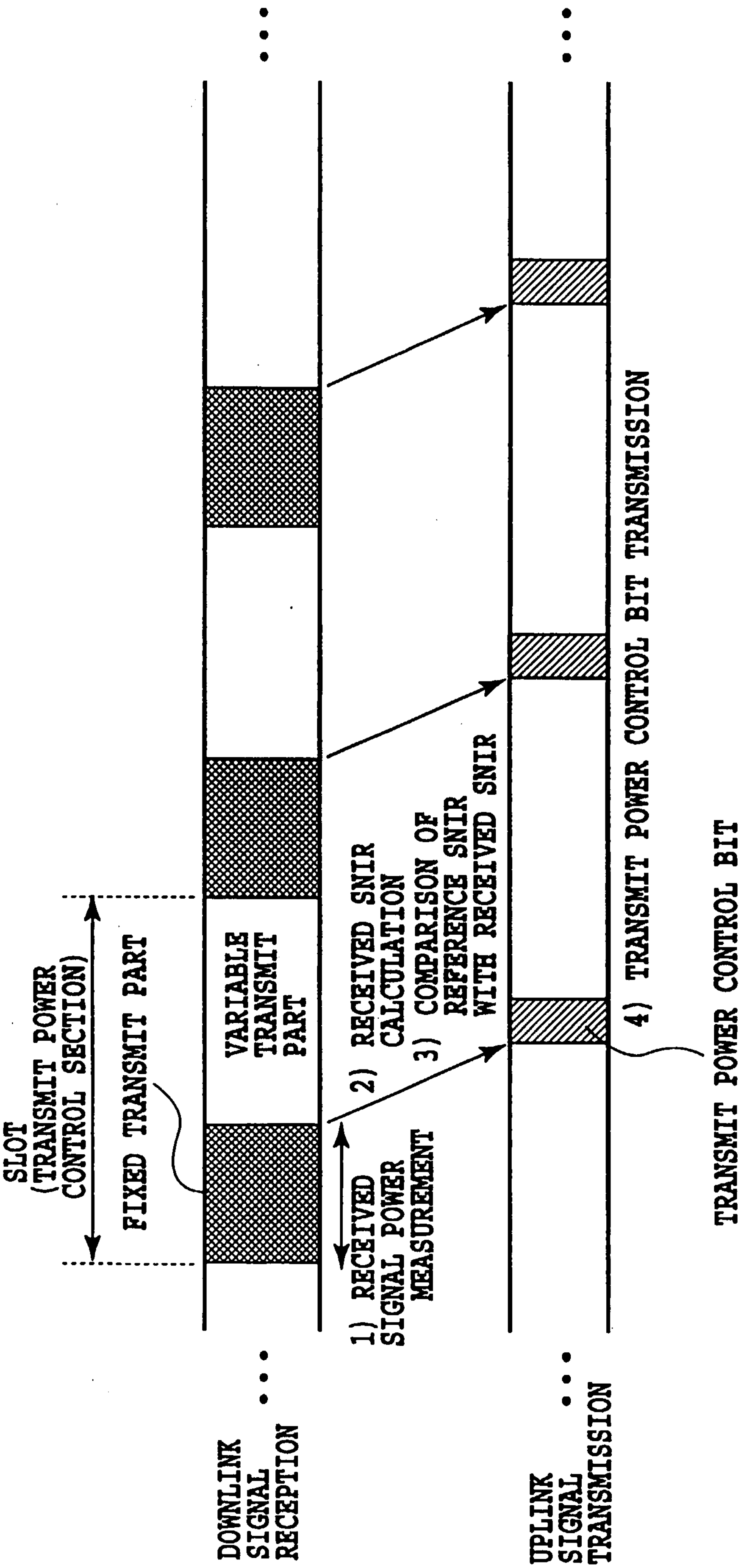
DOWNLINK SIGNAL RECEPTION
UPLINK SIGNAL TRANSMISSION
SLOT (TRANSMIT POWER CONTROL SECTION)
FIXED TRANSMIT PART
VARIABLE TRANSMIT PART
1) RECEIVED SIGNAL POWER MEASUREMENT
2) RECEIVED SNIR CALCULATION
3) COMPARISON OF REFERENCE SNIR WITH RECEIVED SNIR
4) TRANSMIT POWER CONTROL BIT TRANSMISSION
TRANSMIT POWER CONTROL BIT

FIG.1

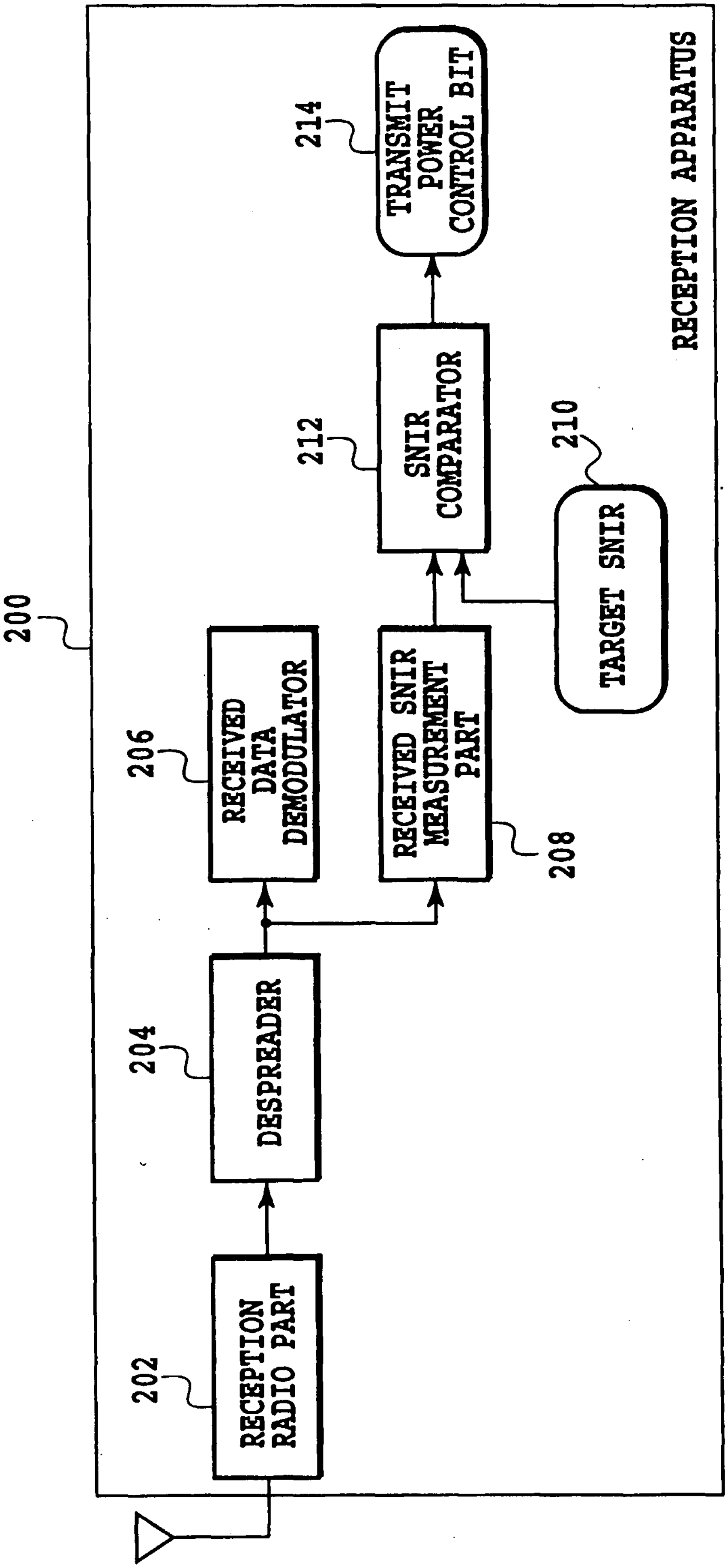
200
202
RECEPTION RADIO PART
204
DESPREADER
206
RECEIVED DATA DEMODULATOR
208
RECEIVED SNIR MEASUREMENT PART
210
TARGET SNIR
212
SNIR COMPARATOR
214
TRANSMIT POWER CONTROL BIT
RECEPTION APPARATUS

FIG.2

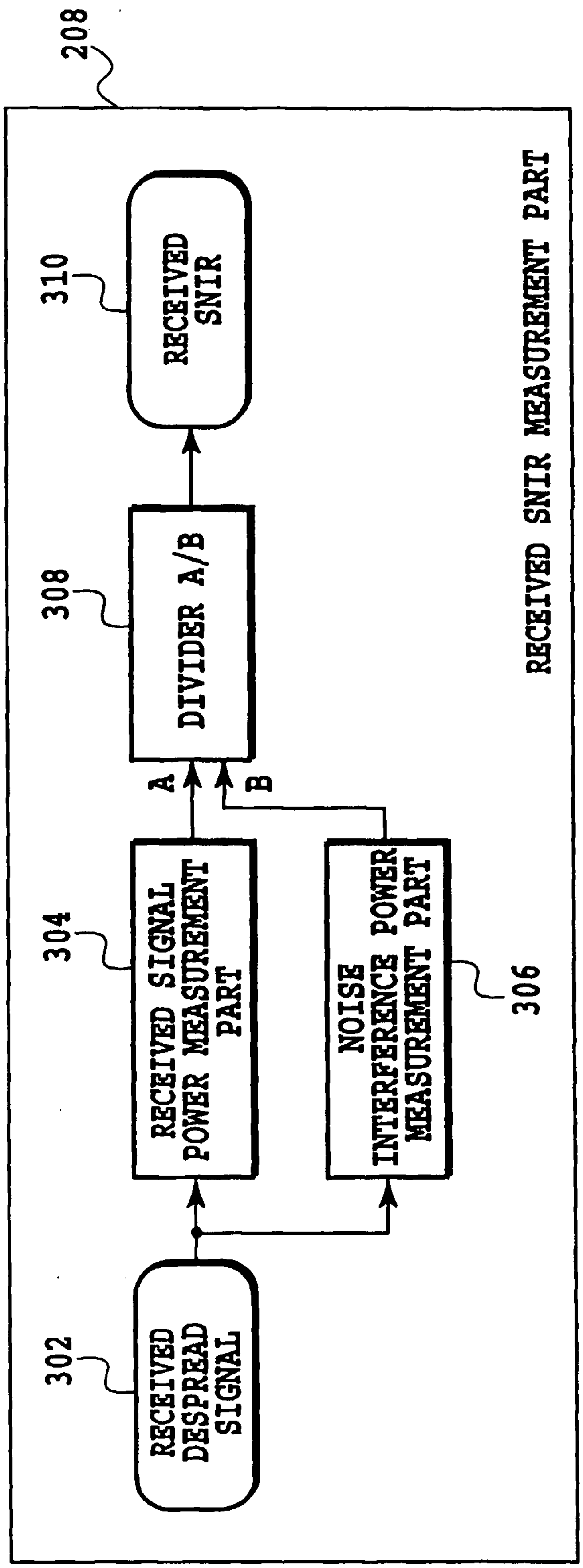
208
RECEIVED SNIR MEASUREMENT PART
302
RECEIVED DESPREAD SIGNAL
304
RECEIVED SIGNAL POWER MEASUREMENT PART
306
NOISE INTERFERENCE POWER MEASUREMENT PART
A
B
308
DIVIDER A/B
310
RECEIVED SNIR

FIG.3

FIG.4

FIG.4A	FIG.4B

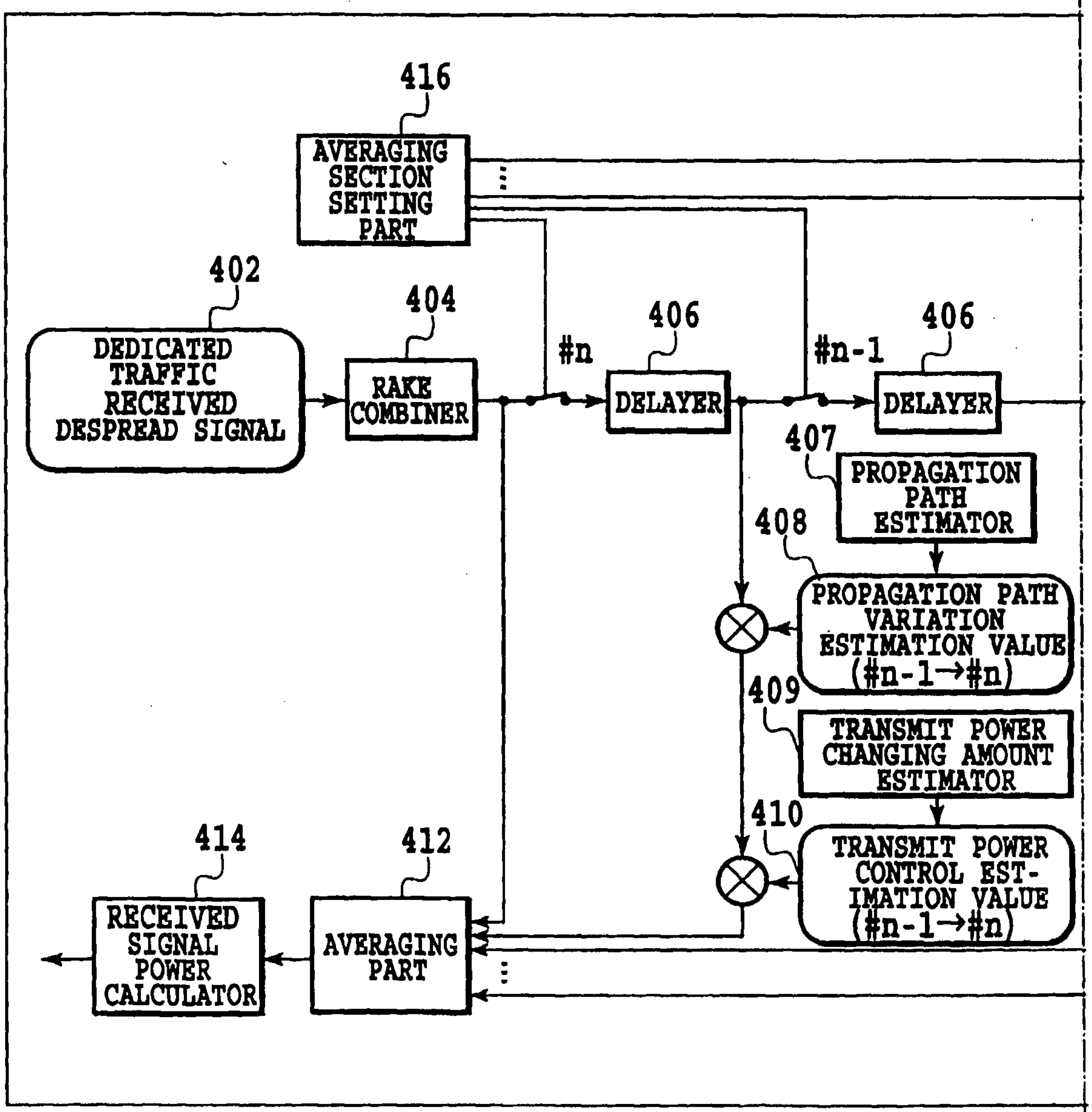

FIG.4A

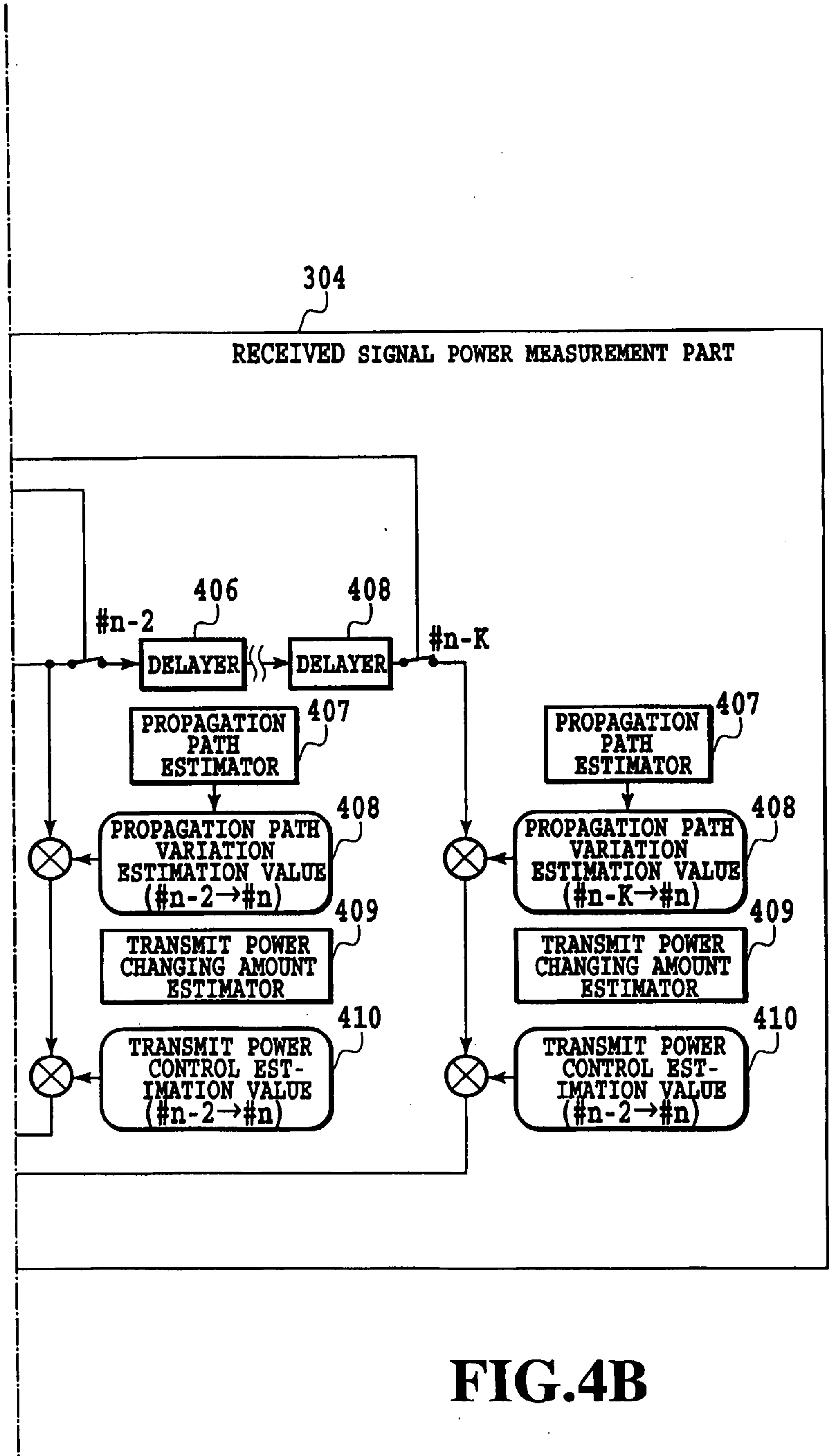
304
RECEIVED SIGNAL POWER MEASUREMENT PART
406
408
#n-2
DELAYER
DELAYER
#n-K
PROPAGATION PATH ESTIMATOR
407
PROPAGATION PATH ESTIMATOR
407
408
PROPAGATION PATH VARIATION ESTIMATION VALUE (#n-2→#n)
408
PROPAGATION PATH VARIATION ESTIMATION VALUE (#n-K→#n)
409
TRANSMIT POWER CHANGING AMOUNT ESTIMATOR
409
TRANSMIT POWER CHANGING AMOUNT ESTIMATOR
410
TRANSMIT POWER CONTROL EST-IMATION VALUE (#n-2→#n)
410
TRANSMIT POWER CONTROL EST-IMATION VALUE (#n-2→#n)

FIG.4B

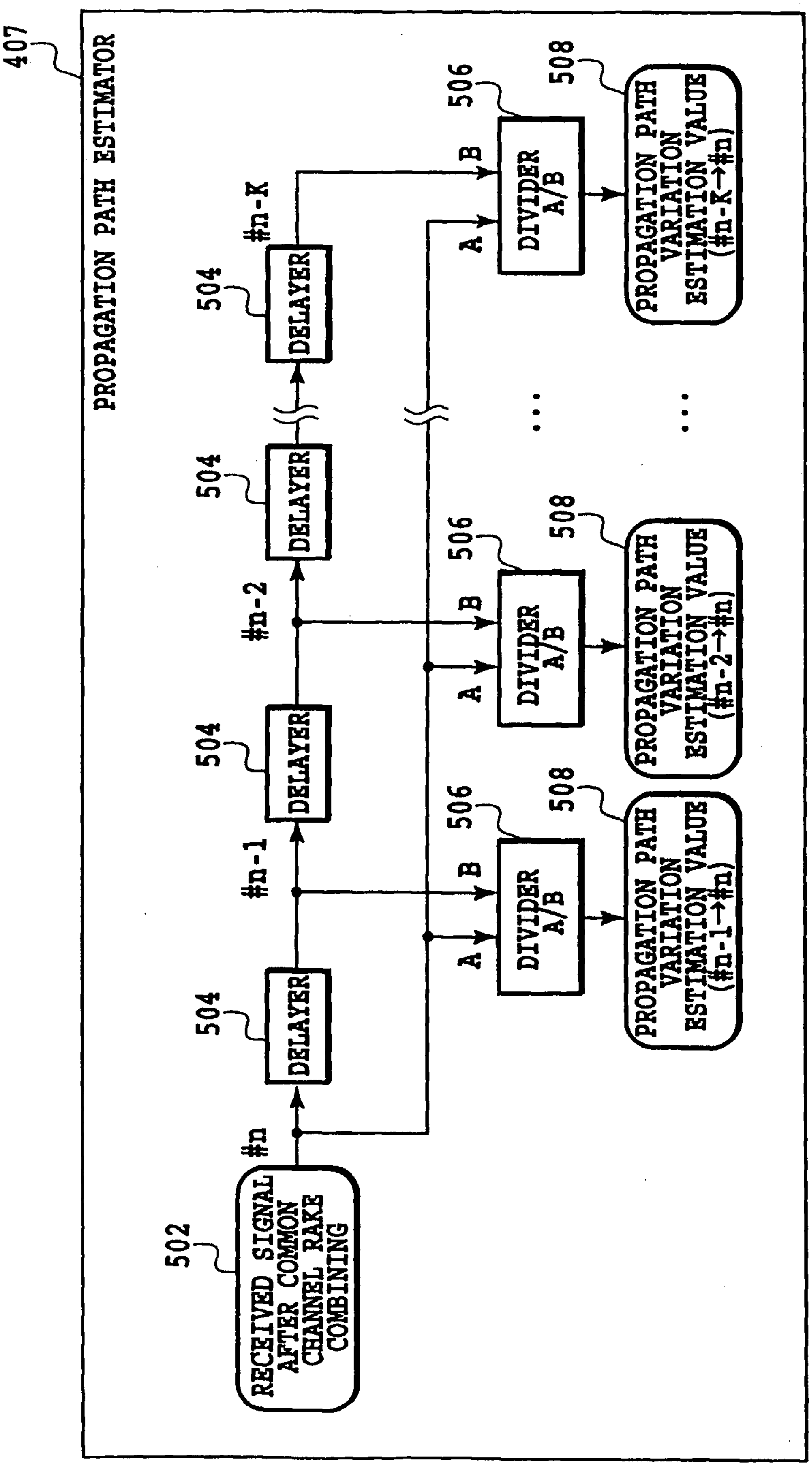
407
PROPAGATION PATH ESTIMATOR
502
RECEIVED SIGNAL AFTER COMMON CHANNEL RAKE COMBINING
#n
504
DELAYER
#n-1
#n-2
#n-K
506
DIVIDER A/B
A
B
508
PROPAGATION PATH VARIATION ESTIMATION VALUE (#n-1→#n)
PROPAGATION PATH VARIATION ESTIMATION VALUE (#n-2→#n)
PROPAGATION PATH VARIATION ESTIMATION VALUE (#n-K→#n)

FIG.5

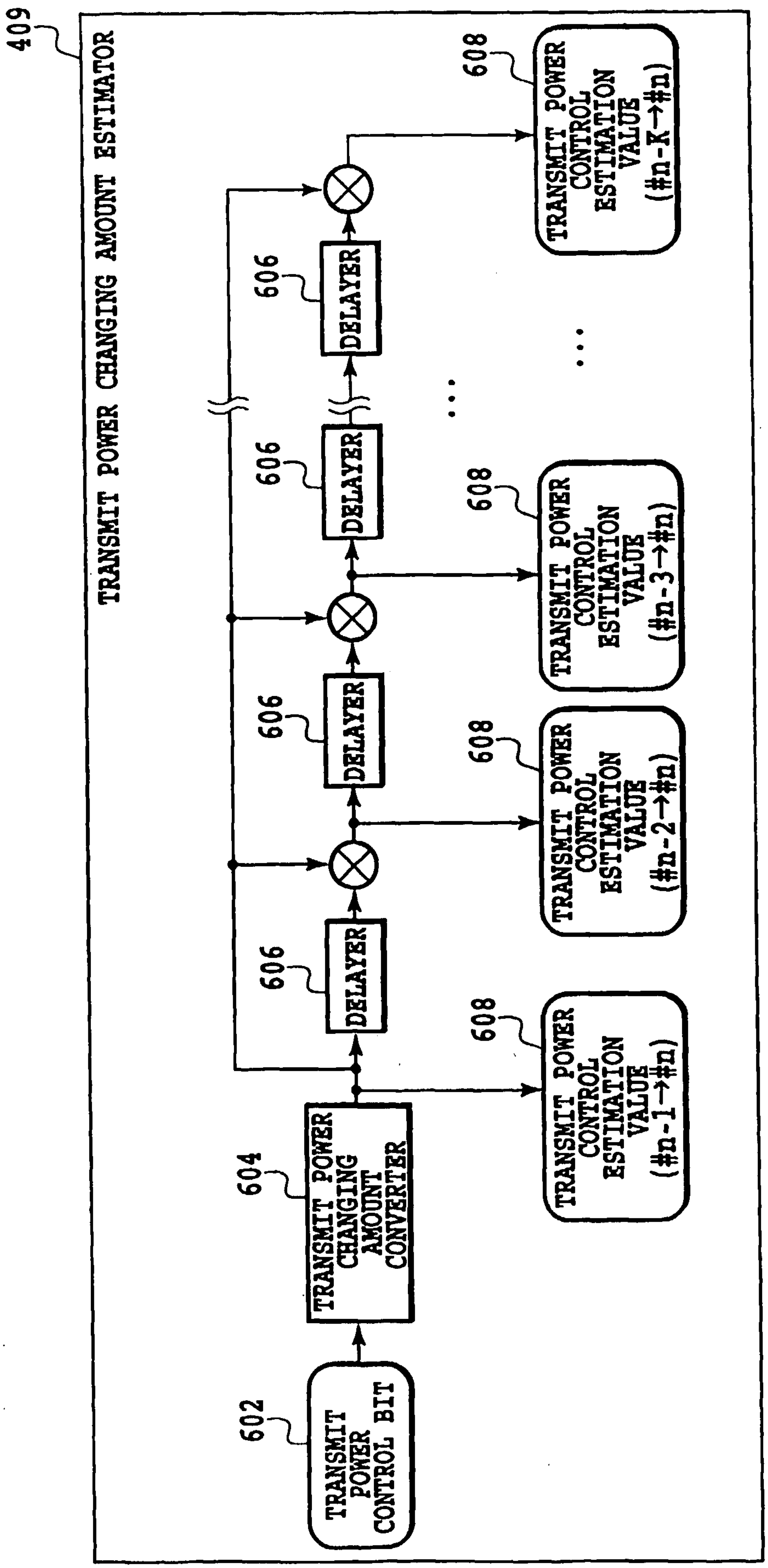
409
TRANSMIT POWER CHANGING AMOUNT ESTIMATOR
602
TRANSMIT POWER CONTROL BIT
604
TRANSMIT POWER CHANGING AMOUNT CONVERTER
606
DELAYER
606
DELAYER
606
DELAYER
606
DELAYER
608
TRANSMIT POWER CONTROL ESTIMATION VALUE (#n-1→#n)
608
TRANSMIT POWER CONTROL ESTIMATION VALUE (#n-2→#n)
608
TRANSMIT POWER CONTROL ESTIMATION VALUE (#n-3→#n)
608
TRANSMIT POWER CONTROL ESTIMATION VALUE (#n-K→#n)

FIG.6

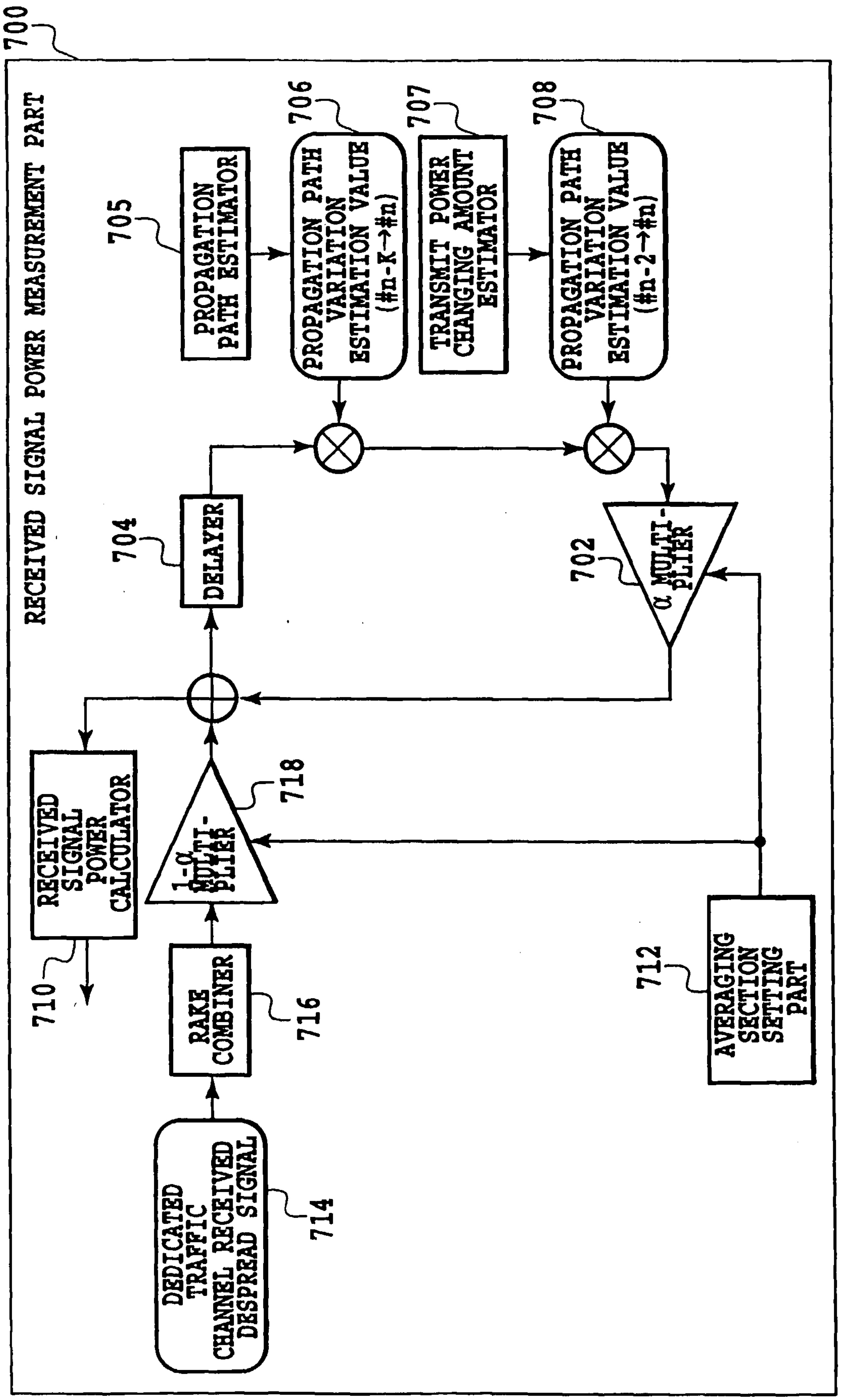
700
RECEIVED SIGNAL POWER MEASUREMENT PART
705
PROPAGATION PATH ESTIMATOR
706
PROPAGATION PATH VARIATION ESTIMATION VALUE (#n-K→#n)
707
TRANSMIT POWER CHANGING AMOUNT ESTIMATOR
708
PROPAGATION PATH VARIATION ESTIMATION VALUE (#n-2→#n)
704
DELAYER
702
α MULTI-PLIER
718
1-α MULTI-PLIER
710
RECEIVED SIGNAL POWER CALCULATOR
716
RAKE COMBINER
714
DEDICATED TRAFFIC CHANNEL RECEIVED DESPREAD SIGNAL
712
AVERAGING SECTION SETTING PART

FIG.7

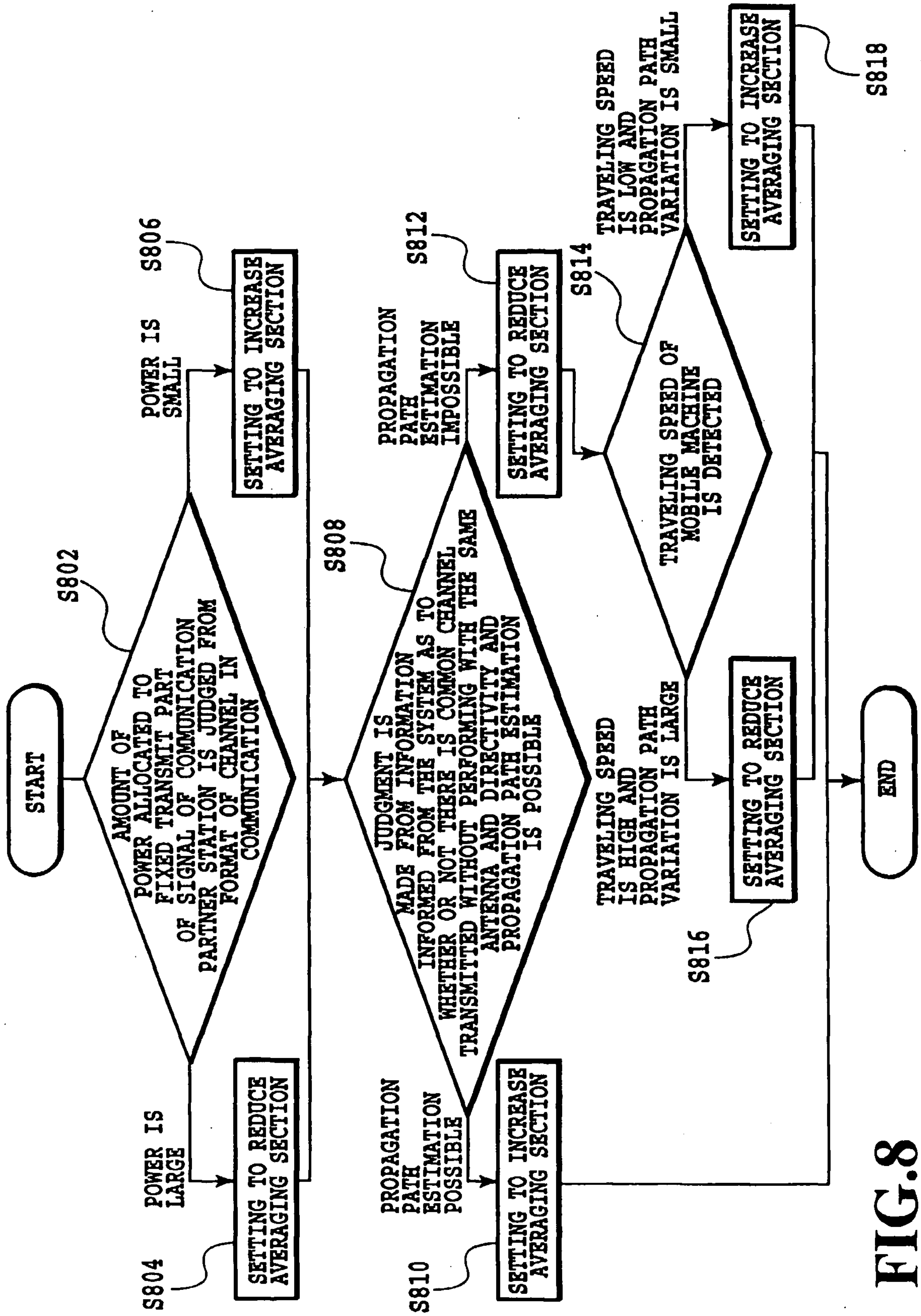
START
AMOUNT OF POWER ALLOCATED TO FIXED TRANSMIT PART OF SIGNAL OF COMMUNICATION PARTNER STATION IS JUDGED FROM FORMAT OF CHANNEL IN COMMUNICATION
S802
POWER IS LARGE
POWER IS SMALL
S804
SETTING TO REDUCE AVERAGING SECTION
S806
SETTING TO INCREASE AVERAGING SECTION
JUDGMENT IS MADE FROM INFORMATION INFORMED FROM THE SYSTEM AS TO WHETHER OR NOT THERE IS COMMON CHANNEL TRANSMITTED WITHOUT PERFORMING WITH THE SAME ANTENNA AND DIRECTIVITY AND PROPAGATION PATH ESTIMATION IS POSSIBLE
S808
PROPAGATION PATH ESTIMATION POSSIBLE
PROPAGATION PATH ESTIMATION IMPOSSIBLE
S810
SETTING TO INCREASE AVERAGING SECTION
S812
SETTING TO REDUCE AVERAGING SECTION
TRAVELING SPEED OF MOBILE MACHINE IS DETECTED
S814
TRAVELING SPEED IS HIGH AND PROPAGATION PATH VARIATION IS LARGE
TRAVELING SPEED IS LOW AND PROPAGATION PATH VARIATION IS SMALL
S816
SETTING TO REDUCE AVERAGING SECTION
S818
SETTING TO INCREASE AVERAGING SECTION
END

FIG.8

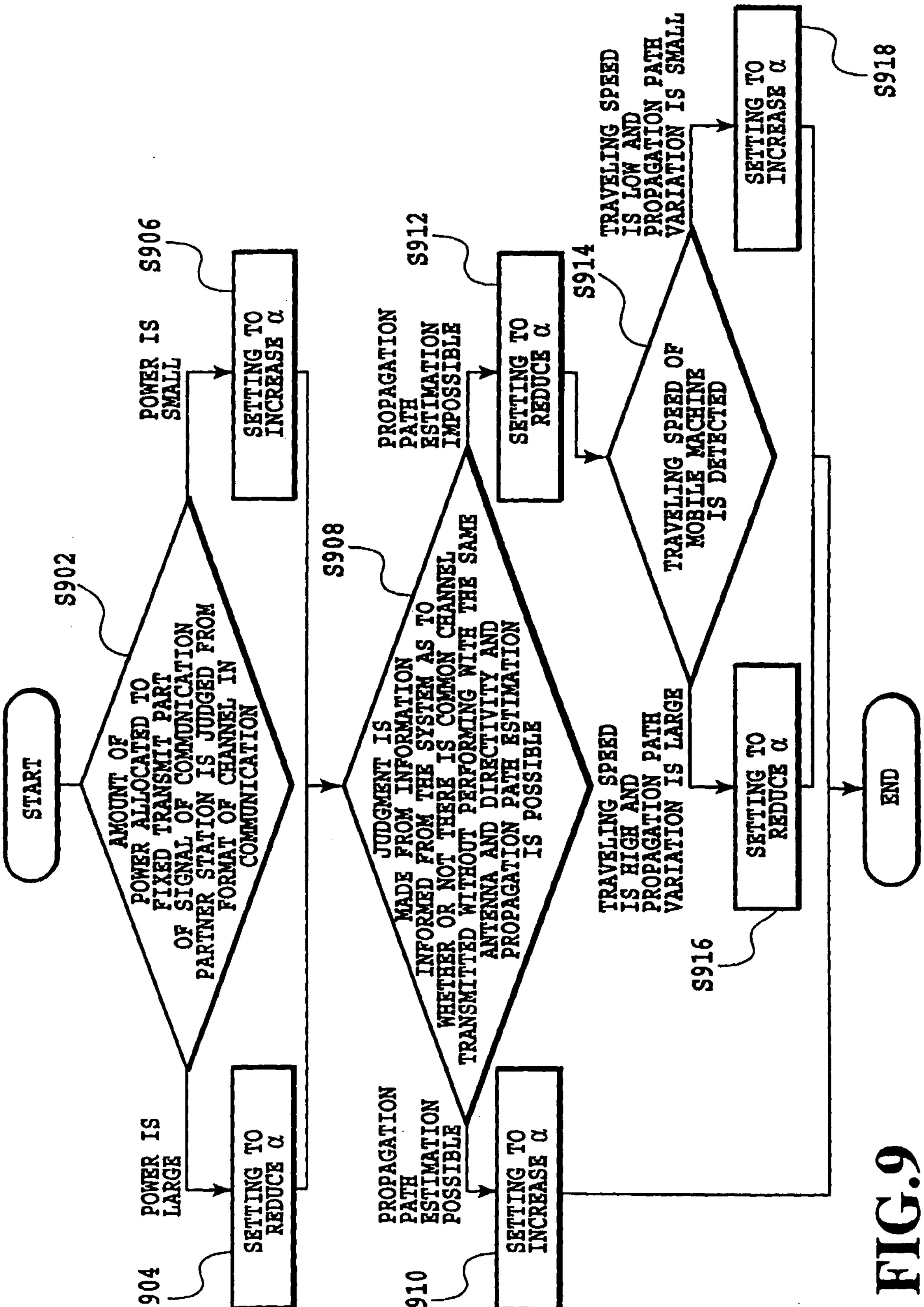
START
AMOUNT OF POWER ALLOCATED TO FIXED TRANSMIT PART OF SIGNAL OF COMMUNICATION PARTNER STATION IS JUDGED FROM FORMAT OF CHANNEL IN COMMUNICATION
S902
POWER IS LARGE
SETTING TO REDUCE α
S904
POWER IS SMALL
SETTING TO INCREASE α
S906
JUDGMENT IS MADE FROM INFORMATION INFORMED FROM THE SYSTEM AS TO WHETHER OR NOT THERE IS COMMON CHANNEL TRANSMITTED WITHOUT PERFORMING WITH THE SAME ANTENNA AND DIRECTIVITY AND PROPAGATION PATH ESTIMATION IS POSSIBLE
S908
PROPAGATION PATH ESTIMATION POSSIBLE
SETTING TO INCREASE α
S910
PROPAGATION PATH ESTIMATION IMPOSSIBLE
SETTING TO REDUCE α
S912
TRAVELING SPEED OF MOBILE MACHINE IS DETECTED
S914
TRAVELING SPEED IS HIGH AND PROPAGATION PATH VARIATION IS LARGE
SETTING TO REDUCE α
S916
TRAVELING SPEED IS LOW AND PROPAGATION PATH VARIATION IS SMALL
SETTING TO INCREASE α
S918
END

FIG.9

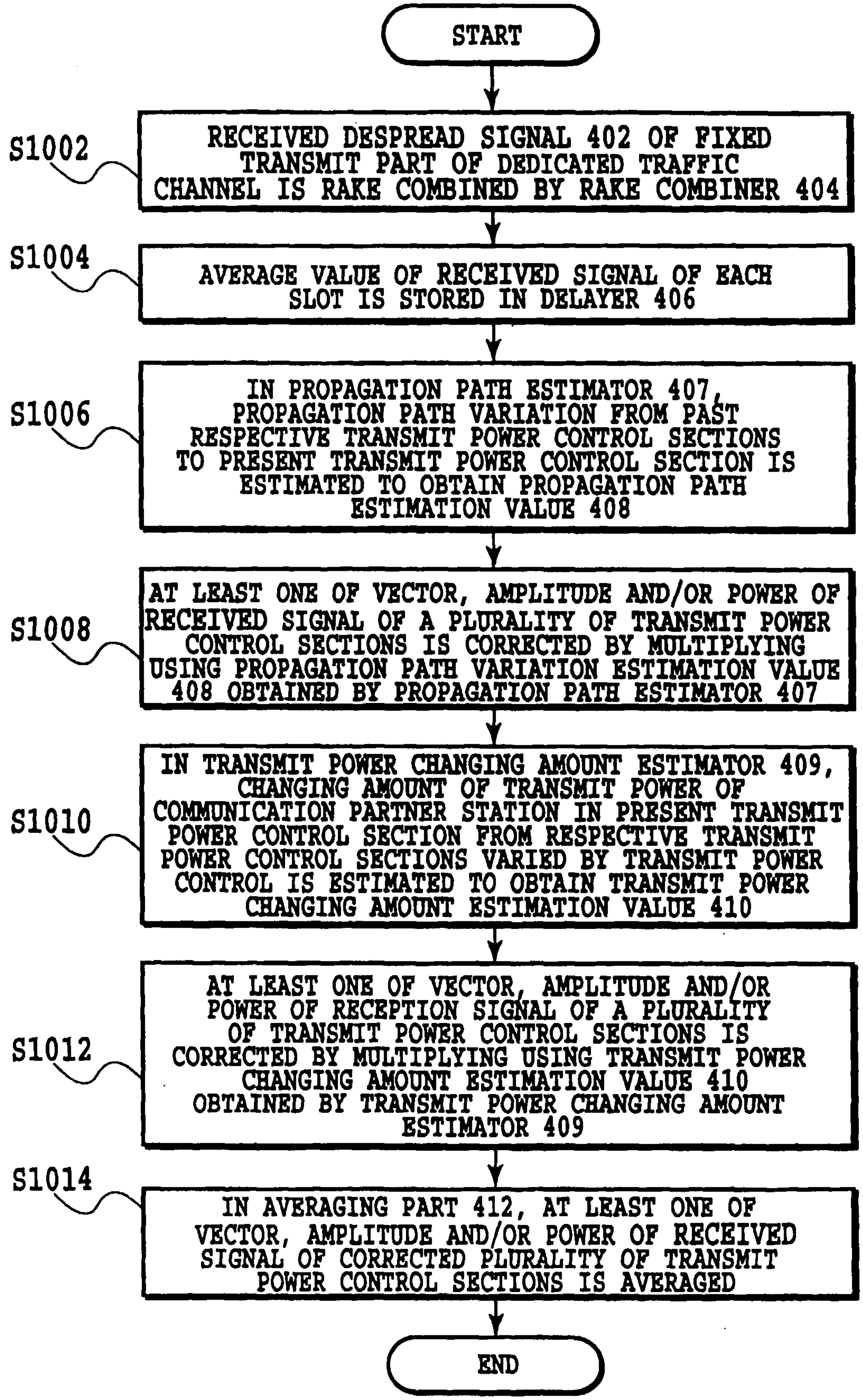
START
S1002
RECEIVED DESPREAD SIGNAL 402 OF FIXED TRANSMIT PART OF DEDICATED TRAFFIC CHANNEL IS RAKE COMBINED BY RAKE COMBINER 404
S1004
AVERAGE VALUE OF RECEIVED SIGNAL OF EACH SLOT IS STORED IN DELAYER 406
S1006
IN PROPAGATION PATH ESTIMATOR 407, PROPAGATION PATH VARIATION FROM PAST RESPECTIVE TRANSMIT POWER CONTROL SECTIONS TO PRESENT TRANSMIT POWER CONTROL SECTION IS ESTIMATED TO OBTAIN PROPAGATION PATH ESTIMATION VALUE 408
S1008
AT LEAST ONE OF VECTOR, AMPLITUDE AND/OR POWER OF RECEIVED SIGNAL OF A PLURALITY OF TRANSMIT POWER CONTROL SECTIONS IS CORRECTED BY MULTIPLYING USING PROPAGATION PATH VARIATION ESTIMATION VALUE 408 OBTAINED BY PROPAGATION PATH ESTIMATOR 407
S1010
IN TRANSMIT POWER CHANGING AMOUNT ESTIMATOR 409, CHANGING AMOUNT OF TRANSMIT POWER OF COMMUNICATION PARTNER STATION IN PRESENT TRANSMIT POWER CONTROL SECTION FROM RESPECTIVE TRANSMIT POWER CONTROL SECTIONS VARIED BY TRANSMIT POWER CONTROL IS ESTIMATED TO OBTAIN TRANSMIT POWER CHANGING AMOUNT ESTIMATION VALUE 410
S1012
AT LEAST ONE OF VECTOR, AMPLITUDE AND/OR POWER OF RECEPTION SIGNAL OF A PLURALITY OF TRANSMIT POWER CONTROL SECTIONS IS CORRECTED BY MULTIPLYING USING TRANSMIT POWER CHANGING AMOUNT ESTIMATION VALUE 410 OBTAINED BY TRANSMIT POWER CHANGING AMOUNT ESTIMATOR 409
S1014
IN AVERAGING PART 412, AT LEAST ONE OF VECTOR, AMPLITUDE AND/OR POWER OF RECEIVED SIGNAL OF CORRECTED PLURALITY OF TRANSMIT POWER CONTROL SECTIONS IS AVERAGED
END

FIG.10

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 071 227 A3

(12) EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
19.02.2003 Bulletin 2003/08

(43) Date of publication A2:
24.01.2001 Bulletin 2001/04

(21) Application number: 00306147.0

(22) Date of filing: 19.07.2000

(51) Int Cl.7: H04B 7/005, H04B 17/00

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 21.07.1999 JP 20678999

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(54) CDMA reception apparatus and received signal power measuring apparatus in CDMA mobile communication system

(57) In a CDMA reception apparatus, averaging means (412) for averaging at least one of vector, amplitude and power of received signal of a plurality of transmit power control sections is provided. Further, propagation path variation estimation means (407) for estimating a propagation path variation of the present transmit power control section from respective transmit power control sections in the past to obtain a propagation path variation estimation value (408) and propagation path variation correction means (multiplier) for correcting by the propagation path variation estimation value (408) are further provided, wherein the averaging means (412) averages at least one of vector, amplitude and power of received signal of the plurality of transmit power control sections corrected by the propagation path variation correction means (multiplier). With this configuration, the measurement accuracy is improved by measuring received signal power using a plurality of slots including past slots, more accurate transmit power control is performed, thereby achieving improved communication quality, a reduced transmit power, and an increased capacity.

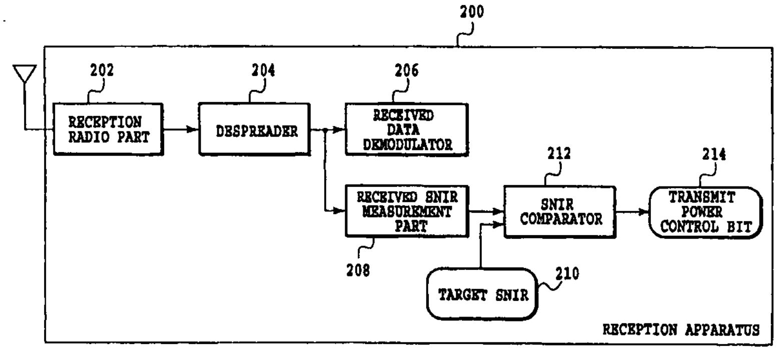

FIG.2

EP 1 071 227 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 30 6147

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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Y	EP 0 854 588 A (NIPPON ELECTRIC CO) 22 July 1998 (1998-07-22) * abstract * * page 4, line 50 - line 58 * ---	1,12	
X	US 5 305 468 A (BRUCKERT EUGENE J ET AL) 19 April 1994 (1994-04-19)	2,13	
Y	* column 4, line 26 - line 28 * ---	6,9	
X	US 5 621 723 A (KETCHUM JOHN W ET AL) 15 April 1997 (1997-04-15) * column 8, line 65 - line 67 * ---	2,13	
Y	EP 0 833 472 A (NIPPON TELEGRAPH & TELEPHONE) 1 April 1998 (1998-04-01) * abstract * * column 13, line 3 - line 4 * ---	6	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
Y	EP 0 798 879 A (NIPPON ELECTRIC CO) 1 October 1997 (1997-10-01) * column 5, line 21 - line 22 * * column 6, line 13 - line 16 * ---	9	H04B
A	JP 06 276053 A (IDOU TSUSHIN SYST KAIHATSU KK) 30 September 1994 (1994-09-30) * abstract * -----	9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	12 December 2002	Mier, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 30 6147

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The members are as contained in the European Patent Office EDP file on
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12-12-2002

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

Appln No. 10/917,968
Docket No. 562492000500

(11) EP 1 367 740 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.12.2003 Bulletin 2003/49

(51) Int Cl.[7]: **H04B 7/005**

(21) Application number: **03019004.5**

(22) Date of filing: **22.03.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **22.03.1999 US 125417 P**
28.05.1999 US 136556 P
28.05.1999 US 136557 P

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
00916600.0 / 1 163 735

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Remarks:
This application was filed on 21 - 08 - 2003 as a divisional application to the application mentioned under INID code 62.

(54) **Outer loop/weighted open loop power control in a time division duplex communication system**

(57) Outer loop/weighted open loop power control controls transmission power levels in a spread spectrum time division duplex communication station. A first communication station (110) transmits a communication to a second communication station including target adjustment information generated at the first station on the basis of measured error rates of communications from the second station to the first station. The second station receives the communication and measures its received power level. Bases on in part the received communication's power level and the communication's transmission power level, a path loss estimate is determined. A quality of the path loss estimate is also determined. The transmission power level for a communication from the second station to the first stations is based on in part weighting the path loss estimate in response to the estimate's quality and based on the receive target adjusted by the target adjustment information transmitted from the first station.

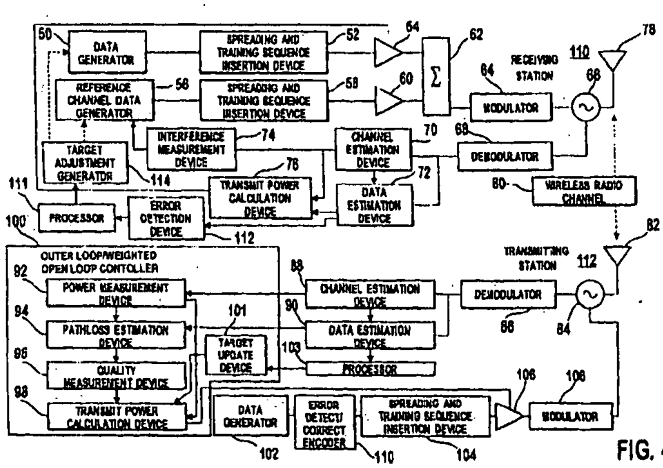


FIG. 4

EP 1 367 740 A1

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND

[0001] This invention generally relates to spread spectrum time division duplex (TDD) communication systems. More particularly; the present invention relates to a system and method for controlling transmission power within TDD communication systems.

[0002] **Figure 1** depicts a wireless spread spectrum time division duplex (TDD) communication system. The system has a plurality of base stations **30_1-30_7**. Each base station **30_1** communicates with user equipment (UEs) **32_1-32_3** in its operating area. Communications transmitted from a base station **30_1** to a UE **32_1** are referred to as downlink communications and communications transmitted from a UE **32_1** to a base station **30_1** are referred to as uplink communications.

[0003] In addition to communicating over different frequency spectrums, spread spectrum TDD systems carry multiple communications over the same spectrum. The multiple signals are distinguished by their respective chip code sequences (codes). Also, to more efficiently use the spread spectrum, TDD systems as illustrated in **Figure 2** use repeating frames **34** divided into a number of time slots **36_1-36_n**, such as sixteen time slots. In such systems, a communication is sent in selected time slots **36_1-36_n** using selected codes. Accordingly, one frame **34** is capable of carrying multiple communications distinguished by both time slot and code. The combination of a single code in a single time slot is referred to as a resource unit. Based on the bandwidth required to support a communication, one or multiple resource units are assigned to that communication.

[0004] Most TDD systems adaptively control transmission power levels. In a TDD system, many communications may share the same time slot and spectrum. When a UE **32_1** or base station **30_1** is receiving a specific communication, all the other communications using the same time slot and spectrum cause interference to the specific communication. Increasing the transmission power level of one communication degrades the signal quality of all other communications within that time slot and spectrum. However, reducing the transmission power level too far results in undesirable signal to noise ratios (SNRs) and bit error rates (BERs) at the receivers. To maintain both the signal quality of communications and low transmission power levels, transmission power control is used.

[0005] One approach using transmission power control in a code division multiple access (CDMA) communication system is described in U.S. Patent No. 5,056,109 (Gilhousen et al.). A transmitter sends a communication to a particular receiver. Upon reception, the received signal power is measured. The received signal power is compared to a desired received signal power. Based on the comparison, a control bit is sent to the transmitter either increasing or decreasing transmission power by a fixed amount. Since the receiver sends a control signal to the transmitter to control the transmitter's power level, such power control techniques are commonly referred to as closed loop.

[0006] Under certain conditions, the performance of closed loop systems degrades. For instance, if communications sent between a UE and a base station are in a highly dynamic environment, such as due to the UE moving, such systems may not be able to adapt fast enough to compensate for the changes. The update rate of closed loop power control in TDD is typically 100 cycles per second which is not sufficient for fast fading channels. Accordingly, there is a need for alternate approaches to maintain signal quality and low transmission power levels.

SUMMARY

[0007] Outer loop/weighted open loop power control controls transmission power levels in a spread spectrum time division duplex communication system. At a first communication station, errors are measured in a received communication from a second communication station. Based on in part the measured errors, an adjustment in a target level is determined. The first station transmits a communication and the target adjustment to the second station. The second station measures the first station's communication's received power level. Based on in part the received power level, a path loss is determined. The target level is adjusted in response to receiving the target adjustment. The quality of the path loss is determined with respect to a subsequent communication to be transmitted from the second station. The second station's transmission power level for the subsequent communication is adjusted based on in part the determined path loss, the determined quality and the adjusted target level.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Figure 1 illustrates a prior art TDD system.
Figure 2 illustrates time slots in repeating frames of a TDD system.
Figure 3 is a flow chart of outer loop/weighted open loop power control.
Figure 4 is a diagram of components of two communication stations using outer loop/weighted open loop power

control.

Figure 5 is a graph of the performance of outer loop/weighted open loop, weighted open loop and closed loop power control systems.

Figure 6 is a graph of the three systems performance in terms of Block Error Rate (BLER).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] The preferred embodiments will be described with reference to the drawing figures where like numerals represent like elements throughout. Outer loop/weighted open loop power control will be explained using the flow chart of **Figure 3** and the components of two simplified communication stations **110,112** as shown in **Figure 4.** For the following discussion, the communication station having its transmitter's power controlled is referred to as the transmitting station **112** and the communication station receiving power controlled communications is referred to as the receiving station **110**. Since outer loop/weighted open loop power control may be used for uplink, downlink or both types of communications, the transmitter having its power controlled may be associated with the base station $\mathbf{30_1}$, UE $\mathbf{32_1}$ or both. Accordingly, if both uplink and downlink power control are used, the receiving and transmitting station's components are associated with both the base station $\mathbf{30_1}$ and UE $\mathbf{32_1}$.

[0010] The receiving station **110** receives various radio frequency signals including communications from the transmitting station **112** using an antenna **78,** or alternately, an antenna array, **step 38**. The received signals are passed thorough an isolator **66** to a demodulator **68** to produce a baseband signal. The baseband signal is processed, such as by a channel estimation device **70** and a data estimation device **72,** in the time slots and with the appropriate codes assigned to the transmitting station's communication. The channel estimation device **70** commonly uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses. The channel information is used by the data estimation device **72,** the interference measurement device **74,** and the transmit power calculation device **76.** The data estimation device **72** recovers data from the channel by estimating soft symbols using the channel information.

[0011] Prior to transmission of the communication from the transmitting station **112,** the data signal of the communication is error encoded using an error detection/correction encoder **110.** The error encoding scheme is typically a circular redundancy code (CRC) followed by a forward error correction encoding, although other types of error encoding schemes may be used.

[0012] Using the soft symbols produced by the data estimation device **72,** an error detection device **112** detects errors in the soft symbols. A processor **111** analyzes the detected error and determines an error rate for the received communication, step 39. Based on the error rate, the processor **111** determines the amount, if any, a target level, such as a target signal to interference ration (SIR_{TARGET}),needs to be changed at the transmitting station **112, step 40.** Based on the determined amount, a target adjustment signal is generated by the target adjustment generator **114.** The target adjustment is subsequently sent to the transmitting station, **step 41**. The target adjustment is signaled to the transmitting station **112**, such as using a dedicated or a reference channel as shown in **Figure 4, step 41.**

[0013] One technique to determine the amount of adjustment in the target level uses an upper and lower threshold. If the determined error rate exceeds an upper threshold, the target level is set at an unacceptably low level and needs to be increased. A target level adjustment signal is sent indicating an increase in the target level. If the determined error rate is below a second threshold, the target level is set at an unnecessarily high level and the target level can be decreased. By reducing the target level, the transmitting station's power level is decreased reducing interference to other communications using the same time slot and spectrum. To improve performance, as soon as the error rate exceeds the upper limit, a target adjustment is sent. As a result, high error rates are improved quickly and lower error rates are adjusted slowly, such as once per 10 seconds. If the error rate is between the thresholds, a target adjustment is not sent maintaining the same target level.

[0014] Applying the above technique to a system using CRC and FEC encoding follows. Each CRC block is checked for an error. Each time a frame is determined to have an error, a counter is incremented. As soon as the counter exceeds an upper threshold, such as 1.5 to 2 times the desired block error rate (BLER), a target adjustment is sent increasing the target level. To adjust the SIR_{TARGET} at the transmitting station **112,** the increase in the SIR_{TARGET} is sent (SIR_{INC}), which is typically in a range of 0.25 dB to 4 dB. If the number of CRC frames encountered exceeds a predetermined limit, such as 1000 blocks, the value of the counter is compared to a lower threshold, such as 0.2 to 0.6 times the desired BLER. If the number of counted block errors is below the lower threshold, a target adjustment signal is sent decreasing the target level, SIR_{DEC}. A typical range of SIR_{DEC} is 0.25 to 4 dB. The value of SIR_{DEC}may be based on $SIR_{INC}$and a target block error rate, $BLER_{TARGET}$.The $BLER_{TARGET}$is based on the type of service. A typical range for the $BLER_{TARGET}$is 0.1% to 10%. **Equation 1** illustrates one such approach for determining SIR_{DEC}.

$$SIR_{DEC} = SIR_{INC} \times BLER_{TARGET}/(1 - BLER_{TARGET})$$ Equation 1

[0015] If the count is between the thresholds for the predetermined block limit, a target adjustment signal is not sent.

[0016] Alternately, a single threshold may be used. If the error rate exceeds the threshold, the target level is increased. If the error rate is below the threshold, the target is decreased. Additionally, the target level adjustment signal may have several adjustment levels, such as from 0 dB to ±4 dB in 0.25 dB increments based on the difference between the determined error rate and the desired error rate.

[0017] The interference measurement device **74** of the receiving station **110** determines the interference level in dB, I_{RS},within the channel, based on either the channel information, or the soft symbols generated by the data estimation device **72**, or both. Using the soft symbols and channel information, the transmit power calculation device **76** controls the receiving station's transmission power level by controlling the gain of an amplifier **54**.

[0018] For use in estimating the pathloss between the receiving and transmitting stations **110,112** and sending data, the receiving station **110** sends a communication to the transmitting station **112, step 41**. The communication may be sent on any one of the various channels. Typically, in a TDD system, the channels used for estimating pathloss are referred to as reference channels, although other channels may be used. If the receiving station **110** is a base station **30$_1$**, the communication is preferably sent over a downlink common channel or a common control physical channel (CCPCH). Data to be communicated to the transmitting station **112** over the reference channel is referred to as reference channel data. The reference data may include, as shown, the interference level, I_{RS}, multiplexed with other reference data, such as the transmission power level, T_{RS}.The interference level, I_{RS},and reference channel power level, I_{RS}, may be sent in other channels, such as a signaling channel.

[0019] The reference channel data is generated by a reference channel data generator **56**. The reference data is assigned one or multiple resource units based on the communication's bandwidth requirements. A spreading and training sequence insertion device **58** spreads the reference channel data and makes the spread reference data time-multiplexed with a training sequence in the appropriate time slots and codes of the assigned resource units. The resulting sequence is referred to as a communication burst. The communication burst is subsequently amplified by an amplifier **60**. The amplified communication burst may be summed by a sum device **62** with any other communication burst created through devices, such as a data generator **50**, spreading and training sequence insertion device **52** and amplifier **54**.

[0020] The summed communication bursts are modulated by a modulator **64**. The modulated signal is passed thorough an isolator **66** and radiated by an antenna **78** as shown or, alternately, through an antenna array. The radiated signal is passed through a wireless radio channel **80** to an antenna **82** of the transmitting station **112**. The type of modulation used for the transmitted communication can be any of those known to those skilled in the art, such as direct phase shift keying (DPSK) or quadrature phase shift keying (QPSK).

[0021] The antenna **82** or, alternately, antenna array of the transmitting station **112** receives various radio frequency signals including the target adjustments. The received signals are passed through an isolator **84** to a demodulator **86** to produce a baseband signal. The baseband signal is processed, such as by a channel estimation device **88** and a data estimation device **90**, in the time slots and with the appropriate codes assigned to the communication burst of the receiving station **110**. The channel estimation device **88** commonly uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses. The channel information is used by the data estimation device **90** and a power measurement device **92**.

[0022] The power level of the processed communication corresponding to the reference channel, R_{TS}, is measured by the power measurement device **92** and sent to a pathloss estimation device **94, step 42**. Both the channel estimation device **88** and the data estimation device **90** are capable of separating the reference channel from all other channels. If an automatic gain control device or amplifier is used for processing the received signals, the measured power level is adjusted to correct for the gain of these devices at either the power measurement device **92** or pathloss estimation device **94**. The power measurement device is a component of an outer loop/weighted open loop controller **100**. As shown in **Figure 4**, the outer loop/weighted open loop controller **100** comprises the power measurement device **92**, pathloss estimation device **94**, quality measurement device **94**, target update device **101**, and transmit power calculation device **98**.

[0023] To determine the path loss, L, the transmitting station **112** also requires the communication's transmitted power level, T_{RS}. The communication's transmitted power level, T_{RS}, may be sent along with the communication's data or in a signaling channel. If the power level, T_{RS}, is sent along with the communication's data, the data estimation device **90** interprets the power level and sends the interpreted power level to the pathloss estimation device **94**. If the receiving station **110** is a base station **30$_1$**, preferably the transmitted power level, T_{RS}, is sent via the broadcast channel (BCH) from the base station **30$_1$**. By subtracting the received communication's power level, R_{TS}, from the sent communication's transmitted power level, T_{RS}, the pathloss estimation device **94** estimates the path loss, L, between the two stations **110,112, step 43**. Additionally, a long term average of the pathloss, L_0, is updated, **step 44.** The long term average of the pathloss, L_0, is an average of the pathloss estimates. In certain situations, instead of transmitting the transmitted power level, T_{RS}, the receiving station **110** may transmit a reference for the transmitted power level. In that case, the pathloss estimation device **94** provides reference levels for the pathloss, L.

[0024] Since TDD systems transmit downlink and uplink communications in the same frequency spectrum, the conditions these communications experience are similar. This phenomenon is referred to as reciprocity. Due to reciprocity, the path loss experienced for the downlink will also be experienced for the uplink and vice versa. By adding the estimated path loss to a target level, a transmission power level for a communication from the transmitting station **112** to the receiving station **110** is determined.

[0025] If a time delay exists between the estimated path loss and the transmitted communication, the path loss experienced by the transmitted communication may differ from the calculated loss. In TDD where communications are sent in differing time slots **36_1-36_n**, the time slot delay between received and transmitted communications may degrade the performance of an open loop power control system. To overcome these drawbacks, weighted open loop power control determines the quality of the estimated path loss using a quality measurement device **96, step 45,** and weights the estimated path loss accordingly, L, and long term average of the pathloss, L_0.

[0026] To enhance performance further in outer loop/weighted open loop, a target level is adjusted. A processor **103** converts the soft symbols produced by the data estimation device **90** to bits and extracts the target adjustment information, such as a SIR_{TARGET} adjustment. A target update device **101** adjusts the target level using the target adjustments, **step 46.** The target level may be a SIR_{TARGET} or a target received power level at the receiving station **110.**

[0027] The transmit power calculation device **98** combines the adjusted target level with the weighted path loss estimate, L, and long term average of the pathloss estimate, L_0, to determine the transmission power level of the transmitting station, **step 47.**

[0028] Data to be transmitted in a communication from the transmitting station **112** is produced by data generator **102.** The data is error detection/correction encoded by error detection/correction encoder **110.** The error encoded data is spread and time-multiplexed with a training sequence by the training sequence insertion device **104** in the appropriate time slots and codes of the assigned resource units producing a communication burst. The spread signal is amplified by an amplifier **106** and modulated by modulator **108** to radio frequency. The gain of the amplifier is controlled by the transmit power calculation device **98** to achieve the determined transmission power level. The power controlled communication burst is passed through the isolator **84** and radiated by the antenna **82.**

[0029] The following is one outer loop/weighted open loop power control algorithm. The transmitting stations's transmission power level in decibels, P_{TS}, is determined using **Equation 2.**

$$P_{TS} = SIR_{TARGET} + I_{RS} + \alpha(L-L_0) + L_0 + \text{CONSTANT VALUE} \qquad \text{Equation 2}$$

[0030] The SIR_{TARGET} has an adjusted value based on the received target adjustment signals. For the downlink, the initial value of SIR_{TARGET} is known at the transmitting station **112.** For uplink power control, SIR_{TARGET} is signaled from the receiving station **110** to the transmitting station **112.** Additionally, a maximum and minimum value for an adjusted SIR_{TARGET} may also be signaled. The adjusted SIR_{TARGET} is limited to the maximum and minimum values. I_{RS} is the measure of the interference power level at the receiving station **110.**

[0031] L is the path loss estimate in decibels, T_{RS} - R_{TS}, for the most recent time slot **36_1-36_n** that the path loss was estimated. L_0, the long term average of the path loss in decibels, is the running average of the pathloss estimate, L. The CONSTANT VALUE is a correction term. The CONSTANT VALUE corrects for differences in the uplink and downlink channels, such as to compensate for differences in uplink and downlink gain. Additionally, the CONSTANT VALUE may provide correction if the transmit power reference level of the receiving station is transmitted, instead of the actual transmit power, T_{RS}. If the receiving station **110** is a base station, the CONSTANT VALUE is preferably sent via a Layer 3 message.

[0032] The weighting value, α, is a measure of the quality of the estimated path loss and is, preferably, based on the number of time slots **36_1-36_n** between the time slot, n, of the last path loss estimate and the first time slot of the communication transmitted by the transmitting station **112.** The value of α is between zero and one. Generally, if the time difference between the time slots is small, the recent path loss estimate will be fairly accurate and α is set at a value close to one. By contrast, if the time difference is large, the path loss estimate may not be accurate and the long term average path loss measurement is most likely a better estimate for the path loss. Accordingly, α is set at a value closer to one.

[0033] **Equations 3** and **4** are equations for determining α.

$$\alpha = 1 - (D - 1)/(D_{max} - 1)$$ Equation 3

$$\alpha = \max\{1 - (D-1)/(D_{max\text{-}allowed} - 1), 0\}$$ Equation 4

The value, D, is the number of time slots **36_1-36_n** between the time slot of the last path loss estimate and the first time slot of the transmitted communication which will be referred to as the time slot delay. If the delay is one time slot, α is one. D_{max} is the maximum possible delay. A typical value for a frame having fifteen time slots is seven. If the delay is D_{max}, α is zero $D_{max\text{-}allowed}$ is the maximum allowed time slot delay for using open loop power control. If the delay exceeds $D_{max\text{-}allowed}$, open loop power control is effectively turned off by setting $\alpha = 0$. Using the transmit power level, P_{TS}, determined by a transmit power calculation device **98** the transmit power of the transmitted communication is set.

[0034] **Figures 5** and **6** compare the performance of the weighted outer loop/open loop, open loop and closed loop systems. The simulations in **Figures 5** and **6** were performed for a slightly different version of the outer loop/weighted open loop algorithm. In this version, the target SIR is updated every block. A SIR_{TARGET} is increased if a block error was detected and decreased if no block error was detected. The outer loop/weighted open loop system used **Equation 2. Equation 3** was used to calculate α. The simulations compared the performance of the systems controlling a UE's **32_1** transmission power level. For the simulations, 16 CRC bits were padded every block. In the simulation, each block was 4 frames. A block error was declared when at least two raw bit errors occur over a block. The uplink communication channel is assigned one time slot per frame. The target for the block error rate is 10%. The SIR_{TARGET} is updated every 4 frames. The simulations address the performance of these systems for a UE **32_1** traveling at 30 kilometers per hour. The simulated base station used two antenna diversity for reception with each antenna having a three finger RAKE receiver. The simulation approximated a realistic channel and SIR estimation based on a midamble sequence of burst type 1 field in the presence of additive white Gaussian noise (AWGN). The simulation used an International Telecommunication Union (ITU) Pedestrian B type channel and QPSK modulation. Interference levels were assumed to have no uncertainty. Channel coding schemes were not considered. L_0 was set at 0 db.

[0035] Graph **120** of **Figure 5** shows the performance as expected in terms of the required E_S/N_O for a BLER of 10^{-1} as a function of time delay between the uplink time slot and the most recent downlink time slot. The delay is expressed by the number of time slots. E_s is the energy of the complex symbol. **Figure 5** demonstrates that, when gain/interference uncertainties are ignored, the performance of the combined system is almost identical to that of weighted open loop system. The combined system outperforms the closed loop system for all delays.

[0036] In the presence of gain and interference uncertainties, the transmitted power level of the open loop system is either too high or too low of the nominal value. In graph **122** of **Figure 6**, a gain uncertainty of -2 dB was used. **Figure 6** shows the BLER as a function of the delay. The initial reference SIR_{TARGET} for each system was set to its corresponding nominal value obtained from **Figure 5**, in order to achieve a BLER of 10^{-1}. **Figure 6** shows that, in the presence of gain uncertainty, both the combined and closed loop systems achieve the desired BLER. The performance of the weighted open loop system severely degrades.

Claims

1. A spread spectrum time division duplex user equipment communicating using frames with time slots for communication, comprising:

   means (82, 88, 92) for receiving, in a first time slot, a first communication having a transmit power level and measuring a power level of said communication;
   means (94) for determining a path loss estimate based in part on said measured power level and said received power level; the user equipment

   characterized by:

   means (96, 98 106) for setting a transmission power level for transmission of a second communication in a second time slot based in part on the path loss estimate weighted by a first factor and a long term path loss estimate weighted by a second factor, said first and second factors being a function of a time separation of the first and second time slots; and
   means (108, 82) for transmitting the second communication in the second time slot at the set transmission power level.

2. The user equipment of claim 1 further **characterized by** comprising:

means (98) for determining the long term path loss estimate based at least in part upon an average of path loss estimates of communications received by the user equipment.

3. The user equipment of claim 2 further **characterized by** comprising:

means (96) for determining a quality, α, of the path loss estimate which is based in part on a number of slots, D, between the first and second time slot; and

wherein the first factor is $\alpha$and teh second factor is 1-α.

4. The user equipment of claim 3 further **characterized by** a maximum time slot delay is D_{max} and $\alpha$is determined by:

$$\alpha = 1 - (D - 1)/(D_{max} - 1).$$

5. The user equipment of claim 3 further **characterized by** maximum allowed time slot delay is $D_{max\text{-}allowed}$and the determined quality, α, is determined by:

$$\alpha = \max\{1-(D-1)/(D_{max\text{-}allowed}-1), 0\}.$$

6. A spread spectrum time division duplex user equipment using frames with time slots for communication, comprising:

an antenna (82) for receiving a first communication in a first time slot and transmitting an amplified second communication in a second time slot;
a channel estimation device (88) having an input receiving said first communication for producing channel information;
a data estimation device (90) responsive to said first communication and said channel information for producing interpreted data;
a power measurement device (92) responsive to said channel information for determining a received power level of the first communication;
a path loss estimation device (94) responsive to said measured power level for producing a path loss estimate of the first communication; the user equipment

characterized by comprising:

a quality measurement device (96) for producing a quality measurement based at least in part upon a time separation of the first time slot and a second time slot;
a transmit power calculation device (98) responsive to said path loss estimate and said quality measurement for producing a power control signal based at least in part upon said path loss estimate weighted by a first factor and a long term path loss estimate weighted by a second factor, wherein the first and second factors are based in part on the quality measurement; and
an amplifier (106) receiving the power control signal and a second communication to be transmitted in the second time slot for amplifying the second communication responsive to the power control signal to produce the amplified second communication for transmission by the antenna.

7. The user equipment of claim 6 further comprising:

a data generator (102) for producing communication data;
a spreading and training sequence insertion device (104) having an input receiving the communication data for producing the second communication in the second time slot; and
a modulator (108) having an input receiving the amplified second communication for modulating the amplified second communication to radio frequency prior to transmission.

8. The user equipment of claim 6 further comprising:

a demodulator (86) having an input receiving the received first communication for producing a baseband signal; and

wherein the channel estimation device (88) and the data estimation device (90) each have an input receiving the baseband signal.

9. The user equipment of claim 6 further **characterized by** the quality measurement is in the range of zero to one and the first factor is the quality measurement and the second factor is one minus the quality measurement.

FIG. 1

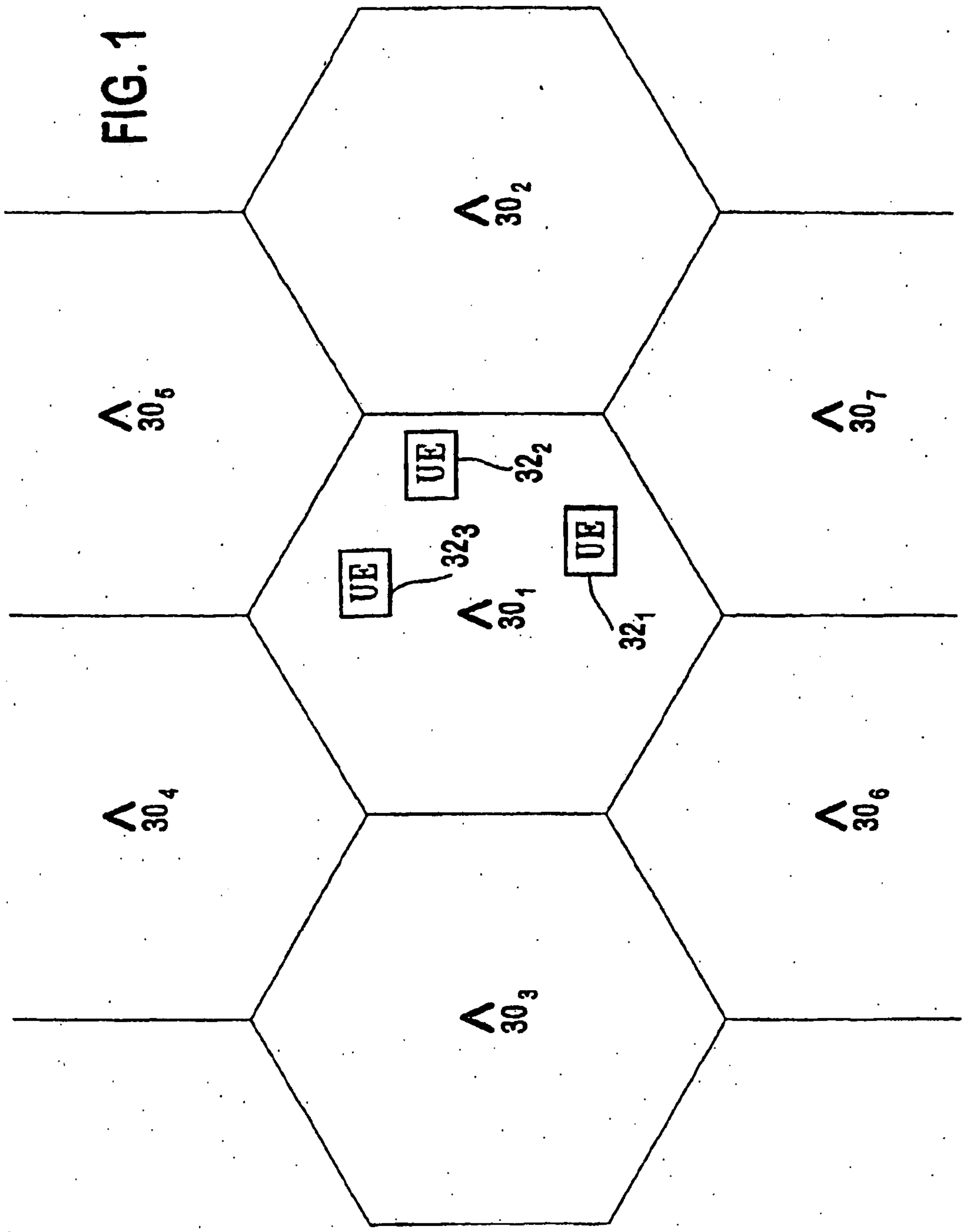


FIG. 2

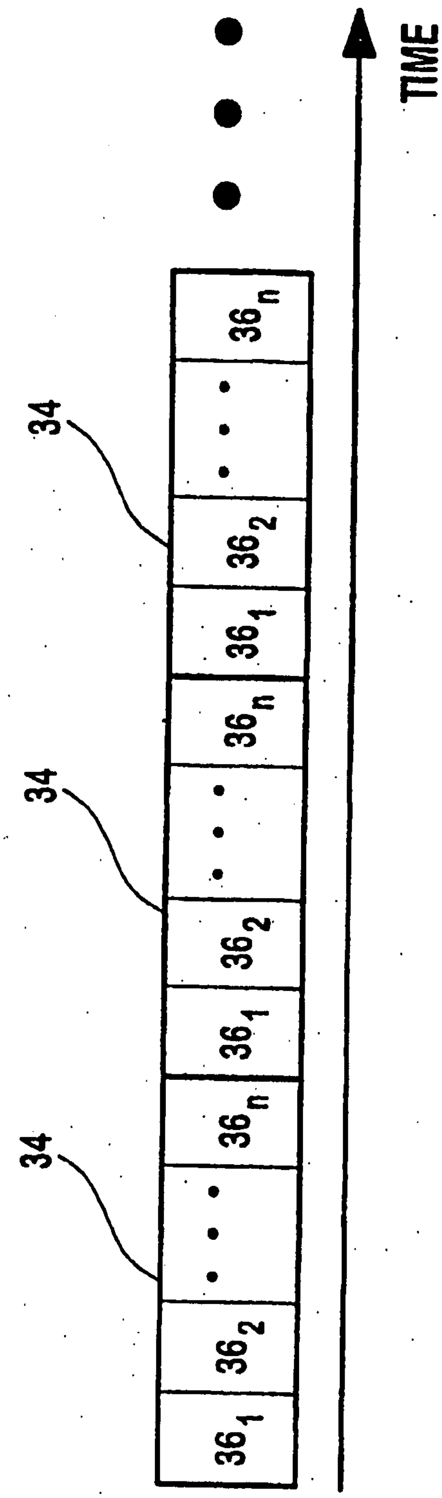
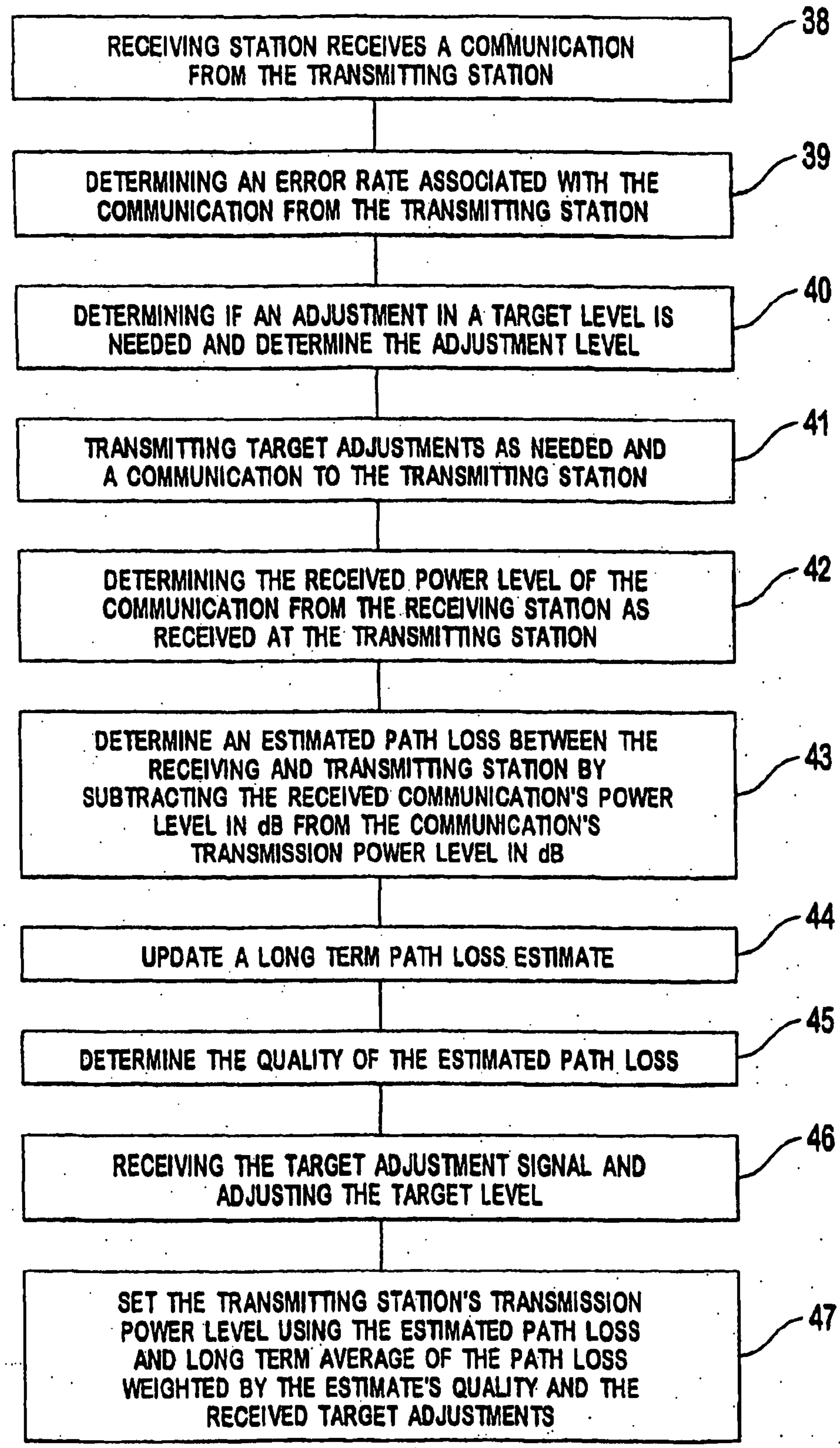


FIG. 3


RECEIVING STATION RECEIVES A COMMUNICATION FROM THE TRANSMITTING STATION
38
DETERMINING AN ERROR RATE ASSOCIATED WITH THE COMMUNICATION FROM THE TRANSMITTING STATION
39
DETERMINING IF AN ADJUSTMENT IN A TARGET LEVEL IS NEEDED AND DETERMINE THE ADJUSTMENT LEVEL
40
TRANSMITTING TARGET ADJUSTMENTS AS NEEDED AND A COMMUNICATION TO THE TRANSMITTING STATION
41
DETERMINING THE RECEIVED POWER LEVEL OF THE COMMUNICATION FROM THE RECEIVING STATION AS RECEIVED AT THE TRANSMITTING STATION
42
DETERMINE AN ESTIMATED PATH LOSS BETWEEN THE RECEIVING AND TRANSMITTING STATION BY SUBTRACTING THE RECEIVED COMMUNICATION'S POWER LEVEL IN dB FROM THE COMMUNICATION'S TRANSMISSION POWER LEVEL IN dB
43
UPDATE A LONG TERM PATH LOSS ESTIMATE
44
DETERMINE THE QUALITY OF THE ESTIMATED PATH LOSS
45
RECEIVING THE TARGET ADJUSTMENT SIGNAL AND ADJUSTING THE TARGET LEVEL
46
SET THE TRANSMITTING STATION'S TRANSMISSION POWER LEVEL USING THE ESTIMATED PATH LOSS AND LONG TERM AVERAGE OF THE PATH LOSS WEIGHTED BY THE ESTIMATE'S QUALITY AND THE RECEIVED TARGET ADJUSTMENTS
47

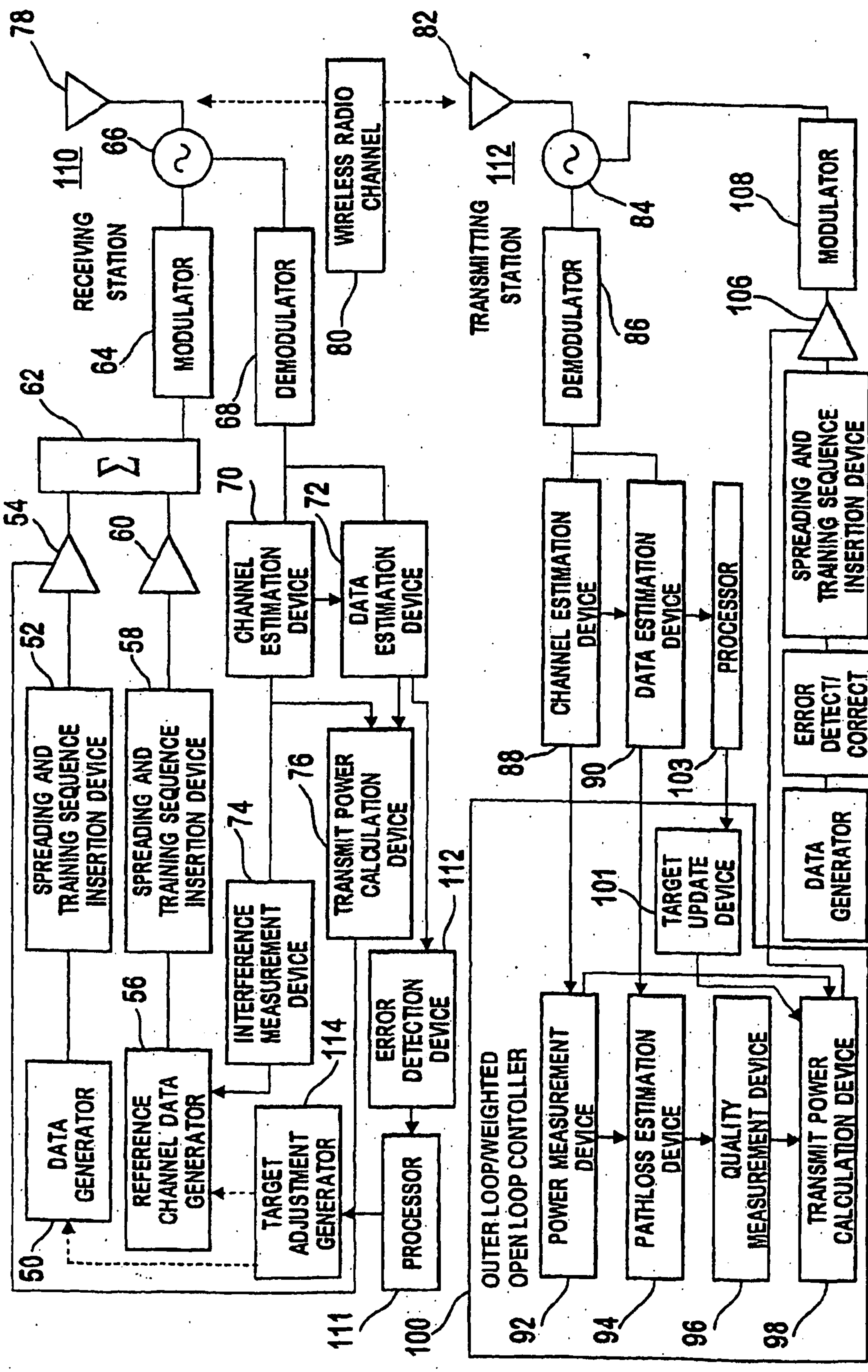

78
110
RECEIVING STATION
66
WIRELESS RADIO CHANNEL
82
112
TRANSMITTING STATION
84
108
MODULATOR
62
64
MODULATOR
68
DEMODULATOR
80
DEMODULATOR
86
106
54
60
Σ
70
72
CHANNEL ESTIMATION DEVICE
DATA ESTIMATION DEVICE
CHANNEL ESTIMATION DEVICE
DATA ESTIMATION DEVICE
PROCESSOR
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
104
52
58
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
74
76
TRANSMIT POWER CALCULATION DEVICE
88
90
103
ERROR DETECT/ CORRECT ENCODER
110
INTERFERENCE MEASUREMENT DEVICE
112
101
TARGET UPDATE DEVICE
DATA GENERATOR
102
56
114
ERROR DETECTION DEVICE
DATA GENERATOR
REFERENCE CHANNEL DATA GENERATOR
TARGET ADJUSTMENT GENERATOR
PROCESSOR
OUTER LOOP/WEIGHTED OPEN LOOP CONTOLLER
POWER MEASUREMENT DEVICE
PATHLOSS ESTIMATION DEVICE
QUALITY MEASUREMENT DEVICE
TRANSMIT POWER CALCULATION DEVICE
50
111
100
92
94
96
98

FIG. 4

FIG. 5

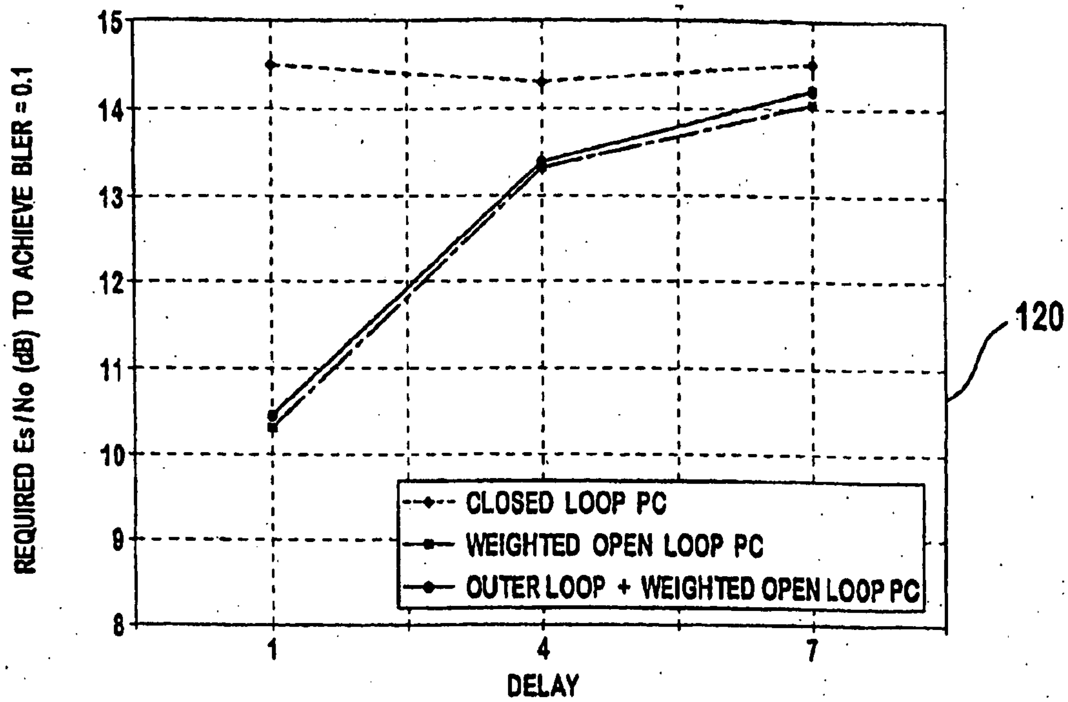
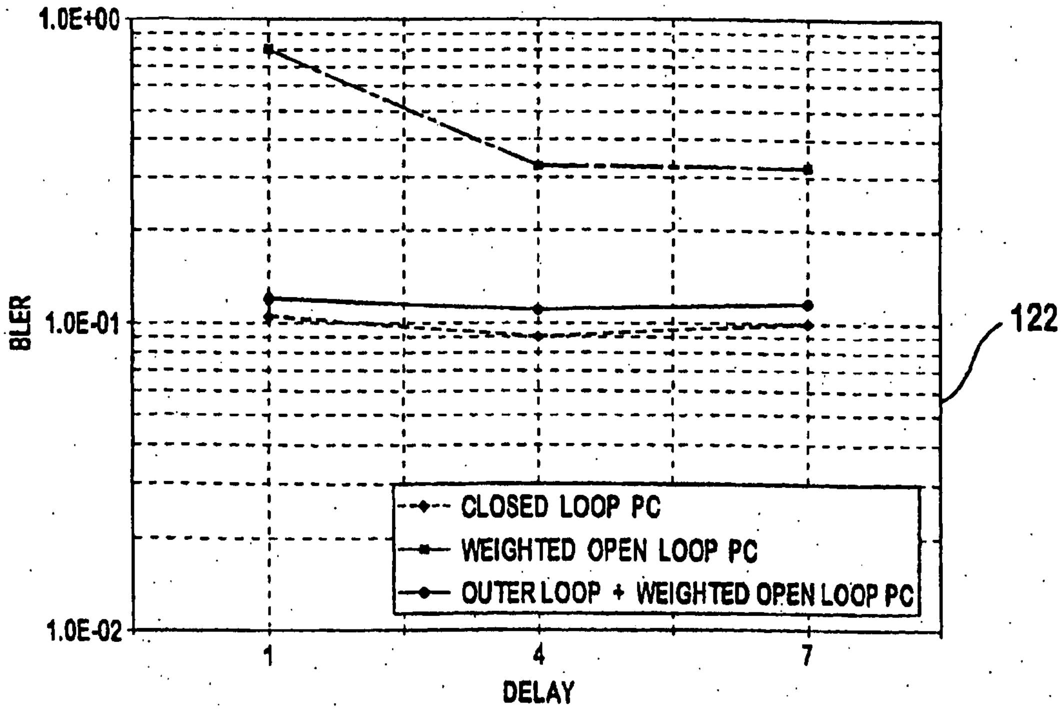

15
14
13
12
11
10
9
8
REQUIRED Es/No (dB) TO ACHIEVE BLER = 0.1
1
4
7
DELAY
CLOSED LOOP PC
WEIGHTED OPEN LOOP PC
OUTER LOOP + WEIGHTED OPEN LOOP PC
120

FIG. 6


1.0E+00
1.0E-01
1.0E-02
BLER
1
4
7
DELAY
CLOSED LOOP PC
WEIGHTED OPEN LOOP PC
OUTER LOOP + WEIGHTED OPEN LOOP PC
122

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 01 9004

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 462 952 A (ERICSSON TELEFON AB L M) 27 December 1991 (1991-12-27) * abstract; figures 4,5 * * column 6, line 6 - column 8, line 15 * ---	1-9	H04B7/005
A	WO 98 45962 A (ERICSSON GE MOBILE INC) 15 October 1998 (1998-10-15) * abstract; figures 5,6,8 * * page 8, line 19 - page 10, line 9 * * page 12, line 14 - page 13, line 10 * * page 14, line 15 - page 15, line 12 * * page 17, line 13 - page 18, line 2 * ---	1-9	
A	WO 97 49197 A (HONKASALO ZHICHUN ;NOKIA MOBILE PHONES LTD (FI); JOKINEN HARRI (FI)) 24 December 1997 (1997-12-24) * abstract; figure 1 * * page 4, line 21 - page 5, line 11 * * page 6, line 13 - page 7, line 3 * * page 7, line 18 - line 29 * * page 11, line 18 - page 12, line 16 * ---	1-9	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 03 01 9004

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
H04B 1/034, 7/26, H04M 11/00

A1

(11) International Publication Number: **WO 96/31009**

(43) International Publication Date: 3 October 1996 (03.10.96)

(21) International Application Number: PCT/US95/03898

(22) International Filing Date: 27 March 1995 (27.03.95)

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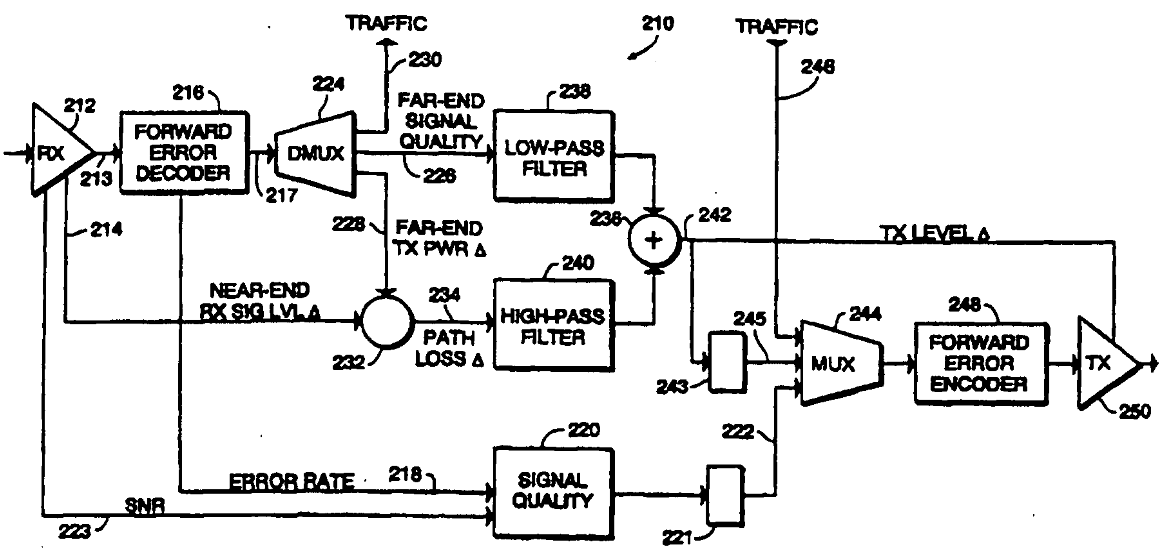
(81) Designated States: CA, CN, JP, RU, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: CELLULAR COMMUNICATIONS POWER CONTROL SYSTEM



(57) Abstract

Two-way adaptive power control and signal quality monitoring and power control responsive thereto are provided for controlling the power output levels of transmitters (210) to the minimum necessary for satisfactory communications. Each transmission includes a code representative of the transmitter output power level. Receivers (212) compare this code to the received signal strength and ajust their associated transmitter power output level accordingly. Bit error rate (218) and SNR (223) are monitored by receivers to develop a measure of signal quality (220). A signal quality code is transmitted (250) to remote units and transmission output power level is adjusted in response.

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CELLULAR COMMUNICATIONS POWER CONTROL SYSTEM

BACKGROUND

The invention relates to communication systems and in particular, to a cellular mobile communications system having integrated satellite and ground nodes.

The cellular communications industry has grown at a fast pace in the United States and even faster in some other countries. It has become an important service of substantial utility and because of the growth rate, saturation of the existing service is of concern. High density regions having high use rates, such as Los Angeles, New York and Chicago are of most immediate concern. Contributing to this concern is the congestion of the electromagnetic frequency spectrum which is becoming increasingly severe as the communication needs of society expand. This congestion is caused not only by cellular communications systems but also by other communications systems. However, in the cellular communications industry alone, it is estimated that the number of mobile subscribers will increase on a world-wide level by an order of magnitude within the next ten years. The radio frequency spectrum is limited and in view of this increasing demand for its use, means to more efficiently use it are continually being explored.

Existing cellular radio is primarily aimed at providing mobile telephone service to automotive users in developed metropolitan areas. For remote area users, airborne users, and marine users, AIRFONE and INMARSAT services exist but coverage is incomplete and service is relatively expensive. Mobile radio satellite systems in an advanced planning stage will probably provide improved direct-broadcast voice channels to mobile subscribers in remote areas but still at significantly higher cost in comparison to existing ground cellular service. The ground cellular and planned satellite technologies complement one another in geographical coverage in that the ground cellular communications service provides voice telephone service in relatively developed urban and suburban areas but not in sparsely populated areas, while the planned earth orbiting satellites will serve the sparsely populated areas.

Cellular communications systems divide the service areas into geographical cells, each served by a base station or node typically located at its center. The central node transmits sufficient power to cover its cell area with adequate field strength. If a mobile user moves to a new cell, the radio link is switched to the new node provided there is an available channel. Present land mobile communication systems typically use a frequency modulation (FM) approach and because of the limited interference rejection capabilities of FM modulation, each radio channel may be used only once over a wide geographical area encompassing many cells. This means that each cell can use only a small fraction of the total allocated radio frequency band, resulting in an inefficient use of the available spectrum. In some cases, the quality of speech is poor because of the phenomena affecting FM transmission known as fading and "dead spots." The subjective effect of fading is repeated submersion of the voice signal in background noise frequently many times per second if the mobile unit is in motion. The problem is exacerbated by interference from co-channel users in distant cells and resultant crosstalk due to the limited interference rejection capability of FM. Additionally, communications privacy is relatively poor; the FM signal may be heard by others who are receiving that frequency.

In the case where one band of frequencies is preferable over others and that one band alone is to be used for mobile communications, efficient communications systems are necessary to assure that the number of users desiring to use the band can be accommodated. For example, there is presently widespread agreement on the choice of L-band as the technically preferred frequency band for the satellite-to-mobile link in mobile communications systems. In the case where this single band is chosen to contain all mobile communications users, improvements in spectral utilization in the area of interference protection and in the ability to function without imposing intolerable interference on other services will be of paramount importance in the considerations of optimal use of the scarce spectrum.

Troubling both terrestrial and satellite communication is channel fading, in which communications channel experiences fading due to numerous factors such as changes in weather conditions, signal propagation, local terrain etc..

Satellite transceivers are generally located in geosynchronous earth orbit, approximately 22,300 miles from earth, and as such, are approximately the same distance from mobile units. Accordingly, path loss in the satellite channel is relatively minor, on the order of only a few dB. Unfortunately, satellite transmissions still experience substantial fading due to the direct component of the satellite signal being summed with multiply reflected components of the satellite signal, thereby inducing channel fading of several dB.

In contrast to satellite transmission, the terrestrial to mobile transmission is substantially effected by the distance between the mobile unit and the cell site. For example, one mobile unit may be located at a distance many miles from the cell site, while another may be only yards away. Accordingly, path loss variations of terrestrial transmissions may be orders of magnitude greater than experienced by satellite transmissions. Further, the terrestrial transmissions typically experience substantial fading due to the signal being reflected from many different features of the physical environment. As a result, a signal may arrive at a mobile unit from many different directions causing both constructive and destructive summation of the signals. Additionally, the transmitted signal may be partially obstructed by buildings, foliage, and the like to produce additional signal fading.

In order to overcome these constraints, the transceivers of typical communications systems commonly radiates at a power level which is 30 to 40 dB greater than is required on the average in order to overcome fading nulls. This results in greatly increased inter-system interference, reduced battery life and a reduction of potential users in the communications system.

The severely limited commodity in the satellite links is satellite prime power, a major component of the weight of a communication satellite and thereby a major factor in satellite cost. Generally in systems such as this, the down links to individual users are the largest power consumers and thus for a limited satellite source power, may provide the limiting factor on the number of users that can be served. Thus it is important to design the system for minimum required power per user.

It would be desirable to provide a power control system to compensate for fading and interference without exceeding the minimum amount of power necessary to overcome such interference. To this end, numerous designs have been developed in an attempt to control transmitter power. A transmitter power control system is disclosed in the patent to Wheatley, III, U.S. Patent No. 5,267,262. Wheatley, III discloses the cell site measuring the signal strength and signal quality, i.e. bit error rate, of a signal transmitted by the mobile unit. The cell site processes the signal strength and signal quality to determine the desired signal strength for that mobile unit and transmits a power adjustment command back to the mobile unit. This power adjustment command is combined with the mobile unit's one way estimate of received signal strength to obtain a final value of the mobile unit transmitter power.

Unfortunately, Wheatley discloses telemetering the transmit power only as a static parameter at call setup time, not for the purpose, nor at a sample rate sufficient to support dynamic compensation of the received signal strength for adaptive power variations in a two-way adaptive power control system where both transmitters continuously adapt their respective transmit power.

A similar concept to control transmitter power is disclosed in Wilson, et al., U.S. Patent No. 5,293,639. Wilson et al. discloses the control of the output power level of a transmitted signal by the mobile unit transmitting a first message on a first communications channel to a repeater station. The repeater station measures the quality of the received first message to produce a quality metric representative of the quality of the first message. The repeater station retransmits the first message back to the mobile unit, appending the quality metric for determination by the mobile unit of its output power. Unfortunately, the retransmission of the first message is unnecessary in many system applications thus requiring additional power, and causing unnecessary signal interference.

It is therefore an object of the present invention to provide an improved method and apparatus for controlling the transmitter power of a transceiver of a cellular communications system including an adaptive two-way power control system which continuously maintains each transmitted signal power at a minimum necessary level, adapting rapidly to, and accommodating signal fade dynamically and only as necessary.

SUMMARY OF THE INVENTION

Briefly and in general terms, the invention, is directed to a cellular communications system having an adaptive transmitter power control system and method compensate for received signal strength variations, such as those caused by buildings, foliage and other obstructions. Each receiver determines the quality of the received signal and provides a local quality signal to its associated transmitter in the respective transceiver indicative of that received signal quality. Each transmitter also transmits the local quality signal provided to it from its associated receiver and the transceiver is additionally responsive to the quality signal received from the other transceiver with which it is in communication to control its own output power in the response to that quality signal.

In yet a further aspect, a path loss measure is derived from the received signal strength and from data included in each transmitted signal which indicates that transmitter's output power level. Based on the derived path loss and the transmitter's power level data, the receiver can then adjust the power output of its own associated transmitter accordingly.

In a more detailed aspect, the error rate of the received signal is determined in providing the quality signal, and in another aspect, the signal-to-noise ratio (SNR) is measured to determine quality. The transceiver receiving the error rate signal or the SNR from the other transceiver controls its own transmitter power output in response.

Other aspects and advantages of the invention will become apparent from the following detailed description and the accompanying drawings, illustrating by way of example the features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing an overview of the principal elements of a communications system in accordance with the principles of the invention;

FIG. 2 is a diagram of the frequency sub-bands of the frequency band allocation for a cellular system;

FIG. 3 is a overview block diagram of a communications system in accordance with the principles of the invention without a network control center;

FIG. 4 is a diagram showing the interrelationship of the cellular hierarchical structure of the ground and satellite nodes in a typical section and presents a cluster comprising more than one satellite cell;

FIG. 5 is a block diagram of a satellite link system showing the user unit and satellite node control center;

FIG. 6 is a block diagram of one embodiment of satellite signal processing in the system of FIG. 5;

FIG. 7 is a functional block diagram of a user transceiver showing an adaptive power control system;

FIGS. 8a through 8h show timing diagrams of an adaptive, two-way power control system; and

FIG 9 is a functional diagram of a two-way power control system incorporating telemetered signal-quality deficiency supervisory control.

FIG 10 is a functional diagram of a power control system combining adaptive signal quality power control and adaptive path loss power control.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As is shown in the exemplary drawings, the invention, though not limited to, is preferredly embodied in a cellular communications system utilizing integrated satellite and ground nodes both of which use the same modulation, coding, and both responding to an identical user unit.

Referring now to FIG. 1, an overview of a preferred communications system 10 is presented showing the functional inter-relationships of the major elements. The system network control center 12 directs the top level allocation of calls to satellite and ground regional resources throughout the system. It also is used to coordinate system-wide operations, to keep track of user locations, to perform optimum allocation of system resources to each call, dispatch facility command codes, and monitor and supervise overall system health. The regional node control centers 14, one of which is shown, are connected to the system network control center 12 and direct the allocation of calls to ground nodes within a major metropolitan region. The regional node control center 14 provides access to and from fixed land communication lines, such as commercial telephone systems known as the public switched telephone network (PSTN). The ground nodes 16 under direction of the respective regional node control center 14 receive calls over the fixed land line network encode them, spread them according to the unique spreading code assigned to each designated user, combine them into a composite signal, modulate that composite signal onto the transmission carrier, and broadcast them over the cellular region covered.

Satellite node control centers 18 are also connected to the system network control center 12 via status and control land lines and similarly handle calls designated for satellite links such as from PSTN, encode them, and multiplex them with other similarly directed calls into an uplink trunk, which is beamed up to the designated satellite 20. Satellite nodes 20 receive the uplink trunks, frequency demultiplex the calls intended for different satellite cells, frequency translate and direct each to its appropriate cell transmitter and cell beam, and broadcast the composite of all such similarly directed calls down to the intended satellite cellular area. As used herein, "backhaul" means the link between a satellite 20 and a satellite node control center 18. In one embodiment, it is a K-band frequency while the link between the satellite 20 and the user unit 22 uses an L-band or an S-band frequency.

As used herein, a "node" is a communication site or a communication relay site capable of direct one- or two-way radio communication with users. Nodes may include moving or stationary surface sites or airborne or satellite sites.

User units 22 respond to signals of either satellite or ground node origin, receive the outbound composite signal, de-modulate, and decode the information and deliver the call to the user. Such user units 22 may be mobile or may be fixed in position. Gateways 24 provide direct trunks, that is, groups of channels, between satellite and the ground public switched telephone system or private trunk users. For example, a gateway may comprise a dedicated satellite terminal for use by a large company or other entity. In the embodiment of FIG. 1, the gateway 24 is also connected to that system network controller 12.

All of the above-discussed centers, nodes, units and gateways are full duplex transmit/receive performing the corresponding inbound (user to system) link functions as well in the inverse manner to the outbound (system to user) link functions just described.

Referring now to FIG. 2, the allocated frequency band 26 of a communications system is shown. The allocated frequency band 26 is divided into 2 main sub-bands, an outgoing sub-band 25 and an incoming sub-band 27. Additionally the main sub-bands are themselves divided into further sub-bands which are designated as follows:

OG: Outbound Ground 28 (ground node to user)

OS: Outbound Satellite 30 (satellite node to user)

OC: Outbound Calling and Command 32 (node to user)

IG: Inbound Ground 34 (user to ground node)

IS: Inbound Satellite 36 (user to satellite node)

IC: Inbound Calling and Tracking 38 (user to node)

All users in all cells use the entire designated sub-band for the described function. Unlike existing ground or satellite mobile systems, there is no necessity for frequency division by cells; all cells may use these same basic six sub-bands. This arrangement results in a higher frequency reuse factor as is discussed in more detail below.

In one embodiment of the communication system, a mobile user's unit 22 will send an occasional burst of an identification signal in the IC sub-band either in response to a poll or autonomously. This may occur when the unit 22 is in standby mode. This identification signal is tracked by the regional node control center 14 as long as the unit is within that respective region, otherwise the signal will be tracked by the satellite node or nodes. In another embodiment, this identification signal is tracked by all ground and satellite nodes capable of receiving it. This information is forwarded to the network control center 12 via status and command lines. By this means, the applicable regional node control center 14 and the system network control center 12 remain constantly aware of the cellular location and link options for each active user 22. An intra-regional call to or from a mobile user 22 will generally be handled solely by the respective regional node control center 14. Inter-regional calls are assigned to satellite or ground regional system resources by the system network control center 12 based on the location of the parties to the call, signal quality on the various link options, resource availability and best utilization of resources.

A user 22 in standby mode constantly monitors the common outbound calling frequency sub-band OC 32 for calling signals addressed to him by means of his unique spreading code. Such calls may be originated from either ground or satellite nodes. Recognition of his unique call code initiates the user unit 22 ring function. When the user goes "off-hook", e.g. by lifting the handset from its cradle, a return signal is broadcast from the user unit 22 to any receiving node in the user calling frequency sub-band IC 38. This initiates a handshaking sequence between the calling node and the user unit which instructs the user unit whether to transition to either satellite, or ground frequency sub-bands, OS 30 and IS 36 or OG 28 and IG 34.

A mobile user wishing to place a call simply takes his unit 22 off hook and dials the number of the desired party, confirms the number and "sends" the call. Thereby an incoming call sequence is initiated in the IC sub-band 38. This call is generally heard by several ground and satellite nodes which forward call and signal quality reports to the appropriate system network control center 12 which in turn designates the call handling to a particular satellite node 20 or regional node control center 14. The call handling element then initiates a handshaking function with the calling unit over the OC 32 and IC 38 sub-bands, leading finally to transition to the appropriate satellite or ground sub-bands for communication.

Referring now to FIG. 3, a block diagram of a communications system 40 which does not include a system network control center is presented. In this system, the satellite node control centers 42 are connected directly into the land line network as are also the regional node control centers 44. Gateway systems 46 are also available as in the system of FIG. 1. and connect the satellite communications to the appropriate land line or other communications systems. The user unit 22 designates satellite node 48 communication or ground node 50 communication by sending a predetermined code.

Referring now to FIG. 4, a hierarchical cellular structure is shown. A pair of clusters 52 of ground cells 54 are shown. Additionally, a plurality of satellite cells 56 are shown. Although numerals 54 and 56 point only to two cells each, this has been done to retain clarity in the drawing. Numeral 54 is meant to indicate all ground cells in the figure and similarly numeral 56 is meant to indicate all satellite cells. The cells are shown as hexagonal in shape, however, this is exemplary only. The ground cells may be from 3 to 15 km across although other sizes are possible depending on user density in the cell. The satellite cells may be approximately 200-500 km across as an example depending on the number of beams used to cover a given area. As shown, some satellite cells may include no ground cells. Such cells may cover undeveloped areas for which ground nodes are not practical. Part of a satellite cluster 58 is also shown. The cell members of such a cluster share a common satellite node control center 60.

Referring again to FIG. 1 as well as to FIG. 4, the satellite nodes 20 make use of large, multiple-feed antennas 62 which in one embodiment provide separate, relatively narrow beamwidth beams and associated separate transmitters for each satellite cell 56. For example, the multiple feed antenna 62 may cover an area such as the United States with, typically, about 100 satellite beams/cells and in one embodiment, with about 200 beams/cells. As used herein, "relatively narrow beamwidth" refers to a beamwidth that results in a cell of 500 km or less across. The combined satellite/ground nodes system provides a hierarchical geographical cellular structure. Thus within a dense metropolitan area, each satellite cell 56 may further contain as many as 100 or more ground cells 54, which ground cells would normally carry the bulk of the traffic originated therein. The number of users of the ground nodes 16 is anticipated to exceed the number of users of the satellite nodes 20 where ground cells exist within satellite cells. Because all of these ground node users would otherwise interfere as background noise with the intended user-satellite links, in one embodiment the frequency band allocation may be separated into separate segments for the ground element and the space element as has been discussed in connection with FIG 2. This combined, hybrid service can be provided in a manner that is smoothly transparent to the user. Calls will be allocated among all available ground and satellite resources in the most efficient manner by the system network control center 12.

An important parameter in most considerations of cellular radio communications systems is the "cluster", defined as the minimal set of cells such that mutual interference between cells reusing a given frequency sub-band is tolerable provided that such "co-channel cells" are in different clusters. Conversely all cells within a cluster must use different frequency sub-bands. The number of cells in such a cluster is called the "cluster size". It will be seen that the "frequency reuse factor", i.e. the number of possible reuses of a frequency sub-band within the system is thus equal to the number of cells in the system divided by the cluster size. The total number of channels that can be supported per cell, and therefore overall bandwidth efficiency of the system is thus inversely proportional to the cluster size.

Referring now to FIG. 5, a block diagram is shown of a typical user unit 22 to satellite 20 to satellite node control 18 communication and the processing involved in the user unit 22 and the satellite node control 18. In placing a call for example, the handset 64 is lifted and the telephone number entered by the user. After confirming a display of the number dialed, the user pushes a "send" button, thus initiating a call request signal. This signal is processed through the transmitter processing circuitry 66 which includes spreading the signal using a calling spread code. The signal is radiated by the omni-directional antenna 68 and received by the satellite 20 through its narrow beamwidth antenna 62. The satellite processes the received signal as will be described below and sends the backhaul to the satellite node control center 18 by way of its backhaul antenna 70. On receive, the antenna 68 of the user unit 22 receives the signal and the receiver processor 72 processes the signal. Processing by the user unit 22 will be described in more detail below in reference to FIG. 7.

The satellite node control center 18 receives the signal at its antenna 71, applies it to a circulator 73, amplifies 74, frequency demultiplexes 76 the signal separating off the composite signal which includes the signal from the user shown in FIG. 5, splits it 78 off to one of a bank of code correlators, each of which comprises a mixer 80 for removing the spreading and identification codes, an AGC amplifier 82, the FECC demodulator 84, a demultiplexer 86 and finally a voice encoder/decoder (CODEC) 88 for converting digital voice information into an analog voice signal. The voice signal is then routed to the appropriate land line, such as a commercial telephone system. Transmission by the satellite node control center 18 is essentially the reverse of the above described reception operation.

Referring now to FIG. 6, the satellite transponder 90 of FIG. 5 is shown in block diagram form. A circulator/diplexer 92 receives the uplink signal and applies it to an L-band or S-band amplifier 94 as appropriate. The signals from all the M satellite cells within a "cluster" are frequency multiplexed 96 into a single composite K-band backhaul signal occupying M times the bandwidth of an individual L-/S-band mobile link channel. The composite signal is then split 98 into N parts, separately amplified 100, and beamed through a second circulator 102 to N separate satellite ground cells. This general configuration supports a number of particular configurations various of which may be best adapted to one or another situation depending on system optimization which for example may include considerations related to regional land line long distance rate structure, frequency allocation and subscriber population. Thus, for a low density rural area, one may utilize an M-to-1 ($M > 1$, $N = 1$) cluster configuration of M contiguous cells served by a single common satellite ground node with M limited by available bandwidth. In order to provide high-value, long distance service between metropolitan areas, already or best covered for local calling by ground cellular technology, an M-to-M configuration would provide an "inter-metropolitan bus" which would tie together all occupants of such M satellite cells as if in a single local calling region. To illustrate, the same cells (for example, Seattle, Los

Angeles, Omaha and others) comprising the cluster of M user cells on the left side of FIG. 6, are each served by corresponding backhaul beams on the right side of FIG. 6.

Referring now to FIG. 7, a functional block diagram of a typical user unit 22 is shown. The user unit 22 comprises a small, light-weight, low-cost, mobile transceiver handset with a small, non-directional antenna 68. The single antenna 68 provides both transmit and receive functions by the use of a circulator/diplexer 104 or other means. It is fully portable and whether stationary or in motion, permits access to a wide range of communication services from one telephone with one call number. It is anticipated that user units will transmit and receive on frequencies in the 1-3 GHz band but can operate in other bands as well.

The user unit 22 shown in FIG. 7 comprises a transmitter section 106 and a receiver section 108. For the transmission of voice communication, a microphone couples the voice signal to a voice encoder 110 which performs analog to digital encoding using one of the various modern speech coding technologies well known to those skilled in the art. The digital voice signal is combined with local status data, and/or other data, facsimile, or video data forming a composite bit stream in digital multiplexer 112. The resulting digital bit stream proceeds sequentially through forward error encoder 114, symbol or bit interleaver 116, symbol or bit, phase, and/or amplitude modulator 118, narrow band IF amplifier 120, wideband multiplier or spreader

122, wide band IF amplifier 124, wide band mixer 126, and final power amplifier 128. Oscillators or equivalent synthesizers derive the bit or baud frequency 130, pseudo-random noise or "chip" frequency 132, and carrier frequency 134. The PRN generator 136 comprises deterministic logic generating a pseudo-random digital bit stream capable of being replicated at the remote receiver. The ring generator 138 on command generates a short pseudo-random sequence functionally equivalent to a "ring.".

The transceiver receive function 108 demodulation operations mirror the corresponding transmit modulation functions in the transmitter section 106. The signal is received by the non-directional antenna 68 and conducted to the circulator 104. An amplifier 142 amplifies the received signal for mixing to an IF at mixer 144. The IF signal is amplified 146 and multiplied or despread 148 and then IF amplified 150 again. The IF signal then is conducted to a bit or symbol detector 152 which decides the polarity or value of each channel bit or symbol, a bit or symbol de-interleaver 154 and then to a forward error decoder 156. the composite bit stream from the FEC decoder 156 is then split into its several voice, data, and command components in the de-multiplexer 158. Finally a voice decoder 160 performs digital to analog converting and results in a voice signal for communication to the user by a speaker or other means. Local oscillator 162 provides the first mixer 144 LO and the bit or symbol detector 152 timing. A PRN oscillator 164 and PRN generator 166 provide the deterministic logic of the spread signal for despreading purposes.

The baud or bit clock oscillator 168 drives the bit in the bit detector 152, forward error decoder 156 and the voice decoder 160.

The bit or symbol interleaver 116 and de-interleaver 154 provide a type of coded time diversity reception which provides an effective power gain against multipath fading to be expected for mobile users. Its function is to spread or diffuse the effect of short bursts of channel bit or symbol errors so that they can more readily be corrected by the error correction code.

As an alternative mode of operation, provision is made for direct data or facsimile or other digital data input 170 to the transmitter chain and output 172 from the receiver chain.

A command decoder 174 and command logic element 176 are coupled to the forward error decoder 156 for receiving commands or information. By means of special coding techniques known to those skilled in the art, the non-voice signal output at the forward error decoder 156 may be ignored by the voice decoder 160 but used by the command decoder 174. An example of the special coding techniques are illustrated in FIG. 7 by the MUX 112 and DEMUX 158.

As shown, acquisition, control and tracking circuitry 178 are provided in the receiver section 108 for the three receive side functional oscillators 162, 164, 168 to acquire and track the phase of their counterpart oscillators in the received signal. Means for so doing are well known to those skilled in the art.

The automatic gain control (AGC) voltage 184 derived from the received signal is used in the conventional way to control the gain of the preceding amplifiers to an optimum value and in addition as an indicator of short term variations of path loss suffered by the received signal. By means to be described more in detail below, this information is combined with simultaneously received digital data 186 in a power level controller 188 indicating the level at which the received signal was originally transmitted to command the local instantaneous transmit power level to a value such that the received value at the satellite node control is approximately constant, independent of fading and shadowing effects. The level commanded to the output power amplifier 128 is also provided 190 to the transmitter multiplexer 112 for transmission to the corresponding unit.

In mobile and other radio applications, fading, shadowing, and interference phenomena result in occasional, potentially significant steep increases of path loss and if severe enough, may result in data loss. In order to insure that the probability that such a fade will be disruptive is acceptably low, conventional design practice is to provide a substantial excess power margin by transmitting at a power level that is normally as much as 10 to 40 dB above the average requirement. But this causes correspondingly increased battery usage, inter-system, and intra-system interference. In a CDMA application, this can drastically reduce the useful circuit capacity of the channel.

In accordance with the principles of the invention is an adaptive two-way power control system which continually maintains each transmitted signal power at a minimum necessary level, adapting rapidly to and accommodating such fades dynamically, and only as necessary. In controlling the transmitted signal power, the adaptive power control system at each end, near-end and far-end, includes a unique hybrid combination of two complementary sensors, the first being a near-end signal strength measure and the second being a far-end signal quality measure, both in operation simultaneously and symmetrically, with respect to each end of the subject two-way communication link.

The signal strength measure is inferred from the near-end measure of received signal strength. In the subject invention, both ends of the link are under adaptive power control depending at least in part on local received signal strength measurement. Thus, the local received strength depends not only on the path loss but also on the instantaneous adapted power level at which the received signal was transmitted from the far end. In order to implement two-way adaptive control, the far-end transmitter continuously telemeters the adapted power at which it is transmitting, multiplexed by any of several available means signal information. Combining the locally measured received signal strength with far end telemetered transmit power level, the transceiver is able to determine the path loss or changes in the path loss of the received signal. Assuming path reciprocity, this provides a first estimate of the path loss of the outgoing path, and in turn, a first estimate of the power or change in power needed by the local transmitter. This determination is fast, in that it responds almost instantaneously to path loss.

Further, the adaptive power control system in accordance with the invention comprises two main adaptive systems, the first being an adaptive signal quality power control system and the second being an adaptive path loss power control system. Each of these systems may be operated independently, but in a preferred embodiment are a combination of the adaptive signal quality power control system and the adaptive path loss power control system.

The adaptive power control system in accordance with the invention considers not only path loss but also a measure of data loss or "signal quality" reported to it from another unit with which it is in communication. Discussing now an embodiment of the adaptive signal quality system, as used herein, "signal quality" refers to the accuracy or fidelity of a received signal in representing the quantity or waveform it is supposed to represent. In a digital data system, this may be measured or expressed in terms of a bit error rate, or, if variable, the likelihood of exceeding a specified maximum bit error rate threshold. Signal quality involves more than just signal strength, depending also on noise and interference level, and on the variability of signal loss over time. Additionally, "grade of service" as used herein is a collective term including the concepts of fidelity, accuracy, fraction of time that communications are satisfactory, etc., any of which may be used to describe the quality objectives or specifications for a communication service. Examples of grade of service objectives would include:

- bit error rate less than one in 10^3;
- ninety percent or better score on the voice diagnostic rhyme test;

and

- less than one-half percent probability of fade below threshold,

although the exact numbers may vary depending on the application. This signal quality measurement, by comparison to a nominal signal quality or grade-of-service objective, provides a second estimate of the power or change required of the near-end transmitter.

To control the transmitter output power of the respective transceiver, each receiver determines the quality of the received signal and provides a local quality signal to its associated transmitter in the respective transceiver indicative of that received signal quality. Each transmitter then transmits the local quality signal provided by the receiver back to the transceiver that transmitted the original transmission. The transceiver is responsive to the local quality signal to control its own transmitter power.

For example, a mobile unit transmits a first signal to a nodal transceiver. The nodal transceiver determines the signal quality of the received signal by analyzing bit error rate, voice diagnostics, fade or the like to provide the local quality signal. The nodal transceiver then transmits the local quality signal back to the mobile unit which processes the local quality signal along with other factors such as received signal strength, or other measurements will known in the art to determine the output power of mobile unit's transmitter. In a preferred embodiment, the local quality signal is appended to the transmission of a second communication signal. In this manner, two way communication provides a carrier signal upon which the local quality signal is transmitted.

Power adjustment based upon path loss reciprocity alone is subject to several sources of error, including, path non-reciprocity (due to frequency difference), staleness due to transit time delay, and local noise or interference anomalies. Compensation for all these effects is provided in the system and method of the invention by a longer term signal quality monitor, which compares recent past actual error rate statistics, (measured in the forward error correction decoder) and compares against prescribed maximum acceptable error rate statistic. In one embodiment, the signal quality monitor includes a history compiler, situated at either the mobile unit or the nodal transceiver, that records and processes additional factors such as past signal quality measurements, position determination of the mobile unit, past measurements of received signal strength, past determinations of the output power of the received signal and other measurements well known to those in the art to provide a more comprehensive determination of actual signal quality. The difference is interpreted as a longer-term signal level deficiency.

This signal level deficiency is then telemetered back to the respondent transceiver as an independent short burst transmission or may be appended to the transmission of a second two-way signal, where it is used to provide a longer term supervisory control over the short term path-reciprocity power adjustment system. Thus, for example, if a mobile terminal passes into an urban area where it suffers deep-fast fades that cannot be fully compensated due to the delay in the path reciprocity sensing power control, the longer term signal quality deficiency estimate will sense this and call for a gradual increase in the reference value calibration of the fast, signal sensing power control.

The two derived estimates of the required near-end transmit power or change in power, (near-end signal strength and far-end signal quality), have complementary error characteristics such that an optimal combination of the two estimates will yield an overall estimate far superior to either one separately. The near-end path loss measurement is fast but error prone. The far-end signal quality measurement is slow but accurate. The invention of the adaptive power control system combines these two available measures into a single control system taking advantage of the better features of each. Several approaches to this combination are possible.

present invention includes an adaptive path loss power control system. In an embodiment of the adaptive path loss power control system, each transmitter telemeters its current signal output level to the counterpart far end receiver by adding a low rate data stream to the composite digital output signal. Using this information along with the measured strength of the received signal and assuming path loss reciprocity, each end can form an estimate of the instantaneous path loss and adjust its current transmit power output to a level which will produce an approximately constant received signal level at the counterpart receiver irrespective of path loss variations.

Referring now to FIGS. 8a through 8h, timing and waveform diagrams of the adaptive path loss system of an adaptive power control system in accordance with the principles of the invention are presented. In this example, the two ends of the communications link are referred to generally as A and B. In the ground cellular application, "A" corresponds to the user and "B" corresponds to the cellular node. In the satellite link, A would be the user and B would be the satellite control node; in this case, the satellite is simply a constant gain repeater and the control of its power output is exercised by the level of the signal sent up to it.

In the example of FIG. 8a, at time 192, the path loss suddenly increases x dB due for example to the mobile user A driving behind a building or other obstruction in the immediate vicinity of A. This causes the signal strength as sensed by A's AGC to decrease x dB as shown in FIG. 8b. The telemetered data at time 192 shown in FIG. 8c indicates that the level at which this signal had been transmitted from B had not been altered, A's power level controller 188 subtracts the telemetered transmitted signal level from the observed received signal level and computes that there has been an increase of x dB in path loss. Accordingly it increases its signal level output by x dB at time 192 as shown in FIG. 8d and at the same time adds this information to its status telemeter channel.

This signal is transmitted to B, arriving after transit time T as shown in FIG. 8e. The B receiver sees a constant received signal strength as shown in FIG. 8f but learns from the telemetered data channel as shown in FIG. 8g that the signal has been sent to him at +x dB. Therefore, B also computes that the path loss has increased x dB, adjusts its output signal level accordingly at FIG. 8h and telemeters that information. That signal increase arrives back at station A at 2T as shown in FIG. 8e thus restoring the nominal signal strength with a delay of two transit times (T). Thus for a path loss variation occurring in the vicinity of A, the path loss compensation at B is seen to be essentially instantaneous while that at A occurs only after a two transit time delay, 2T.

The general hybrid of the adaptive signal quality power control system combined with the adaptive path loss power control system is illustrated in Figure 10. Independent estimates, 250 and 252, of the required power correction are formed based upon the local received signal strength, compensated by telemetered far-end transmit power, and telemetered far-end signal quality as discussed above. These are filtered in filters 256 and 258 and combined in signal summer 260 to provide the best possible power control 260. Based upon estimates or measurements of the true path loss variability power density spectrum, and the power density spectra of the independent estimates 252 and 254, optimal realizable filters 256 and 258 may be designed by well known Wiener methods and specified in terms of their transfer function or impulsive response characteristics.

Alternatively, and more directly relevant to the preferred embodiments, the independent estimates 252 and 254 and the power control output 262 may be in discrete time sampled digital form. The combiner may then be implemented as a finite state machine computer algorithm (constant coefficient digital filter), designed by well known Kalman-Bucy filter estimation methodology based upon the estimated or measured autocorrelation statistics of the true path loss variation and of the estimate errors of 252 and 254. These statistics are directly related to the power density spectral statistics used to describe the analog implementation of the Fourier transforms of one another.

FIG. 9 also shows the operation of an adaptive signal quality power control system acting in concert with the adaptive path loss power control system described above. While FIG. 9 depicts only one of two corresponding transceivers 210 which are in communication with each other, the one not shown functions identically to the one shown in FIG. 9 and described. Receiver 212 receives the signal from the corresponding transceiver and provides a measure indicative of the near-end received signal level deviation from a nominal level 214 by techniques well known to those skilled in the art as a step in determining the path loss. The nominal level is typically calculated to provide a desired minimum acceptable grade of service under average conditions of fading and interference, as is well known to those skilled in the art. The receiver 212 provides a digital output signal 213 based on the received signal. Forward error decoder 216 decodes the digital information in the received signal 213, and in the process provides an error rate measure 218, derived from the fraction of transmitted bits needing correction. The forward error decoded signal 218 is further processed in the signal quality circuit 220 to derive signal quality deficiency; i.e., an estimate of the change in transmit power calculated as that which would be required to just achieve the specified, minimum acceptable error rate under average conditions of fading and interference. The output from the signal quality circuit 220 is provided to an analog-to-digital converter 221 to provide a digital signal to be multiplexed 244. If the error rate is higher than acceptable, the signal quality circuit output 222 will include a power increase command signal and if the error rate is less than acceptable, a transmit power reduction will be output.

The circuit of FIG. 9 also includes a consideration of the signal-to-noise ratio (SNR) in the received signal to determine signal quality. The SNR of the received signal is determined in the receiver 212 by techniques well known to those skilled in the art; for example, the AGC is monitored, and an SNR signal 223 is provided to the signal quality circuit 220. In this embodiment, the signal quality circuit 220 considers both the error rate 218 and the SNR when producing its output control signal 222.

A demultiplexer 224 separates the telemetered data 217 output through the forward error decoder 216 as to far-end signal quality deficiency 226, far-end transmitter power deviation reference 228 from a nominal level, and the traffic signals 230. The far-end transmit power deviation signal 228 is combined 232 with the near-end received signal level deviation 214 to yield a signal 234 representative of the path loss deviation from a nominal reference value. The telemetered far-end signal quality deficiency 226 and the path loss deviation 234 are combined 236 through complementary filters 238 and 240, which may take any of several forms as described above, to yield the transmit power control signal 242 for controlling the output power of the associated transmitter 250. The transmit power control signal 242 is also applied to an analog-to-digital converter 243 to provide a digitized transmit power control signal 245. The resulting transmitter power level deviation from nominal reference 245 and the near-end signal quality 222 deficiency signals are multiplexed 244 with the traffic 246, then forward error encoded 248 and transmitted 250 to the far end transceiver in support of identical functions performed there. In the preferred discrete digitally sampled embodiment, the complementary combining filters 238 and 240 can be designed as optimal estimating filters based upon knowledge of the power requirement signal and measurement error statistics using methods well known to those familiar with estimation theory.

The economic feasibility of a mobile telephone system is related to the number of users that can be supported. Two significant limits on the number of users supported are bandwidth utilization efficiency and power efficiency. In regard to bandwidth utilization efficiency, in either the ground based cellular or mobile satellite elements, radio frequency spectrum allocation is a severely limited commodity. To this end, the power control system of the present invention may be incorporated with other measures to maximize bandwidth utilization efficiency including the use of code division multiple access (CDMA) technology, and spread spectrum communications techniques which provide important spectral utilization efficiency gain and higher spatial frequency reuse, factors made possible by the use of smaller satellite antenna beams.

In regard to power efficiency, which is a major factor for the satellite-mobile links, the power control of the present invention may be combined with the use of forward-error-correcting coding, which in turn is enabled by the above use of spread spectrum code division multiple access (SS/CDMA) technology and by the use of relatively high antenna gain on the satellite. CDMA and forward-error-correction coding are known to those skilled in the art and no further details are given here.

Two-way, adaptive power control and signal quality control system in accordance with the invention provides a flexible capability of providing the following additional special services: high quality, high rate voice and data service; facsimile (the standard group 3 as well as the high speed group 4); two way messaging, i.e. data interchange between mobile terminals at variable rates; automatic position determination and reporting to within several hundred feet; paging rural residential telephone; and private wireless exchange. Additionally, the system obviates the usual practice of continuously transmitting at a power level which is 10 to 40 dB greater than required most of the time in order to provide a margin for accommodating infrequent deep fades.

It is anticipated that the satellite will utilize geostationary orbits but is not restricted to such. The invention permits operating in other orbits as well. While a satellite node has been described above, it is not intended that this be the only means of providing above-ground service. In the case where a satellite has failed or is unable to provide the desired level of service for other reasons, for example, the satellite has been jammed by a hostile entity, an aircraft or other super-surface vehicle may be commissioned to provide the satellite functions described above. The "surface" nodes described above may be located on the ground or in water bodies on the surface of the earth. Additionally, while users have been shown and described as being located in automobiles, other users may exist. For example, a satellite may be a user of the system for communicating signals, just as a ship at sea may or a user on foot.

While several particular forms of the invention have been illustrated and described, it will be apparent that various modifications can be made without departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited, except by the appended claims.

Having described the invention in such terms as to enable those skilled in the art to make and use it and having identified the presently known and preferred best modes thereof, I claim:

1. A cellular communication power control system comprising:

a first transceiver comprising

a first receiver for receiving a first signal,

a quality measurement means for determining the quality of said first signal and for generating a first quality signal representative of the quality of said first signal, and

a first transmitter for transmitting a second signal and said first quality signal;

a second transceiver comprising

a second transmitter for transmitting said first signal,

a second receiver for receiving said second signal and said first quality signal,

a signal strength measurement means for measuring the signal strength of said second signal, a processor means for processing said first quality signal, compiled history data relating to the cellular communication system and said signal strength of said second signal for providing a first path loss signal;

a controller means for controlling the output power level of said first signal in accordance with said first path loss signal; and

a history compilation means for continuously compiling history data relating to the cellular communication system.

2. A cellular communication system as in claim 1 wherein:

said second transceiver further comprises:

a quality means for determining the quality of said second signal and for producing a second quality signal representative of the quality of said second signal, and

said second transmitter for transmitting said first signal and said second quality signal;

said first transceiver further comprises:

said first receiver for receiving said first signal and said second quality signal,

a signal strength measurement means for measuring the signal strength of said first signal,

a processor means for processing said second quality signal, said compiled history data and said signal strength of said first signal for providing a second path loss signal, and a controller means for controlling the output power level of said second signal in accordance with said second path loss signal.

3. A cellular communication system as in claim 1 wherein:

said first transceiver further comprises:

a first level indicator means which generates a first level signal indicative of the output power level of said first transmitter, and

said first transmitter transmits said second signal at a controllable power level and said first level signal;

said second transceiver further comprises:

said processor means further processes said first level signal for comparing said transmitted first level signal to the locally received signal strength of said second signal to provide said first path loss signal.

4. A cellular communication system as in claim 2 wherein:

said first transceiver further comprises:

a first level indicator means which generates a first level signal indicative of the output power level of said first transmitter,

said first transmitter transmits said second signal at a controllable power level and said first level signal, and

said processor means further processes a second level signal for comparing said second level signal to the locally received signal strength of said first signal to provide said second path loss signal;

said second transceiver further comprises:

a second level indicator means which generates said second level signal indicative of the output power level of said second transmitter,

said second transmitter transmits said first signal at a controllable power level and said second level signal, and

said processor means further processes said first level signal for comparing said transmitted first level signal to the locally received signal strength of said second signal to provide said first path loss signal.

5. A method for communicating between first and second transceivers, each transceiver comprising a transmitter and a receiver, the method comprising:

generating a quality signal representative of the quality of a received first signal;

transmitting the quality signal of the respective transceiver and a second signal to the other transceiver;

compiling history data relating to the communication system;

receiving the transmitted quality signal and second signal from the other transceiver;

measuring the signal strength of the received second signal;

processing the quality signal and the signal strength of the second signal to provide a path loss signal; and

controlling the associated transmitter output power level in response to the path loss signal.

6. A cellular communication power control system comprising:

a first transceiver comprising

a first receiver for receiving a first signal,

a quality measurement means for determining the quality of said first signal and for generating a first quality signal representative of the quality of said first signal, and

a first transmitter for transmitting a second signal being different and distinct from said first signal and including said first quality signal;

a second transceiver comprising

a second transmitter for transmitting said first signal,

a second receiver for receiving said second signal and said first quality signal,

a signal strength measurement means for measuring the signal strength of said second signal, a processor means for processing said first quality signal and said signal strength of said second signal for providing a path loss signal, and

controller means for controlling the output power level of said first signal in accordance with said path loss signal.

7. A cellular communication system as in claim 6 wherein:

said second transceiver further comprises:

a quality means for determining the quality of said second signal and for producing a second quality signal representative of the quality of said second signal, and

said second transmitter for transmitting said first signal being different and distinct from said second signal and including said second quality signal;

said first transceiver further comprises:

said first receiver for receiving said first signal and said second quality signal,

a signal strength measurement means for measuring the signal strength of said first signal,

a processor means for processing said second quality signal and said signal strength of said first signal for providing a path loss signal, and a controller means for controlling the output power level of said second signal in accordance with said path loss signal.

8. A cellular communication system as in claim 6 wherein:

said first transceiver further comprises:

a first level indicator means which generates a first level signal indicative of the output power level of said first transmitter, and

said first transmitter transmits said second signal at a controllable power level and said first level signal;

said second transceiver further comprises:

said processor means further processes said first level signal for comparing said transmitted first level signal to the locally received signal strength of said second signal to provide said first path loss signal.

9. A cellular communication system as in claim 7 wherein:

said first transceiver further comprises:

a first level indicator means which generates a first level signal indicative of the output power level of said first transmitter,

said first transmitter transmits said second signal at a controllable power level and said first level signal, and

said processor means further processes a second level signal for comparing said second level signal to the locally received signal strength of said first signal to provide said second path loss signal;

said second transceiver further comprises:

a second level indicator means which generates said second level signal indicative of the output power level of said second transmitter,

said second transmitter transmits said first signal at a controllable power level and said second level signal, and

said processor means further processes said first level signal for comparing said transmitted first level signal to the locally received signal strength of said second signal to provide said first path loss signal.

10. A method for communicating between first and second transceivers, each transceiver comprising a transmitter and a receiver, the method comprising:

generating a quality signal representative of the quality of a received first signal;

transmitting a second signal being different and distinct from said first signal and including the second quality signal to the other transceiver;

receiving the transmitted quality signal and second signal from the other transceiver;

measuring the signal strength of the received second signal;

processing the quality signal and the signal strength of the second signal to provide a path loss signal; and

controlling the associated transmitter output power level in response to the path loss signal.

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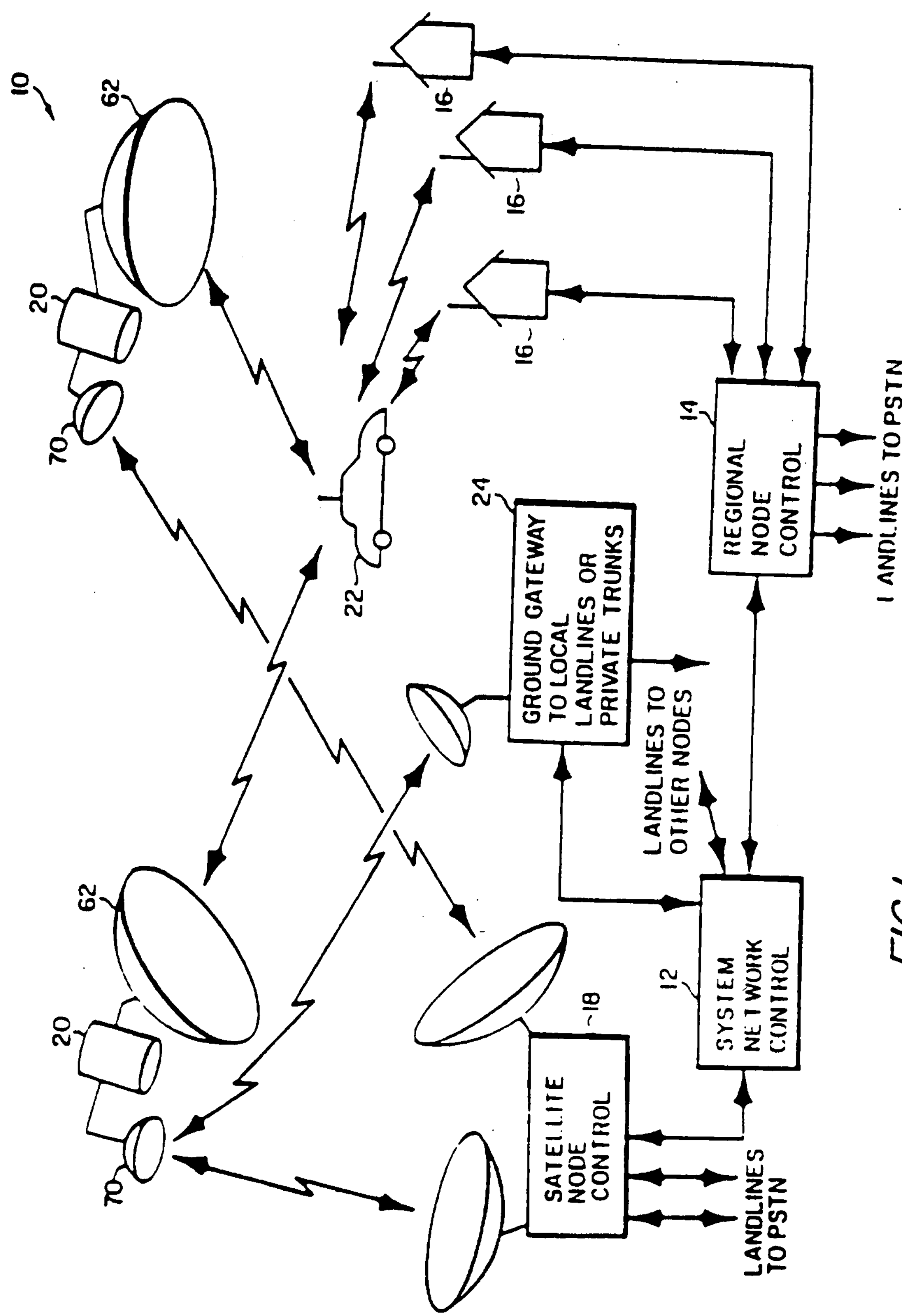
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62
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70
16
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24
GROUND GATEWAY TO LOCAL LANDLINES OR PRIVATE TRUNKS
14
REGIONAL NODE CONTROL
LANDLINES TO PSTN
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18
SATELLITE NODE CONTROL
12
SYSTEM NETWORK CONTROL
LANDLINES TO PSTN

FIG.1

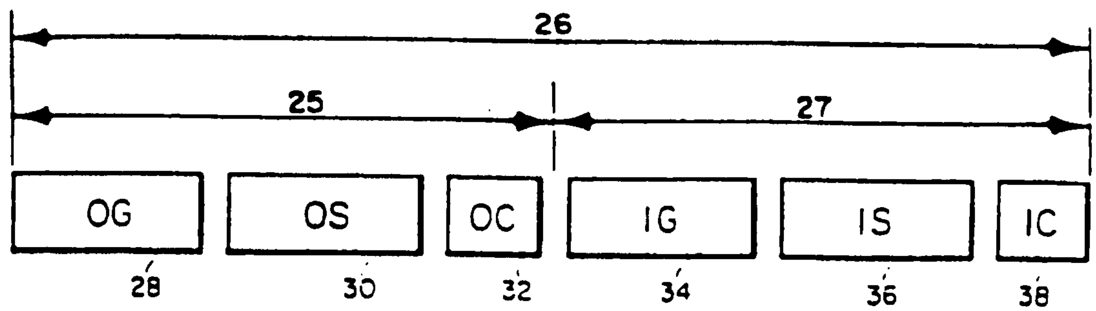

FIG. 2

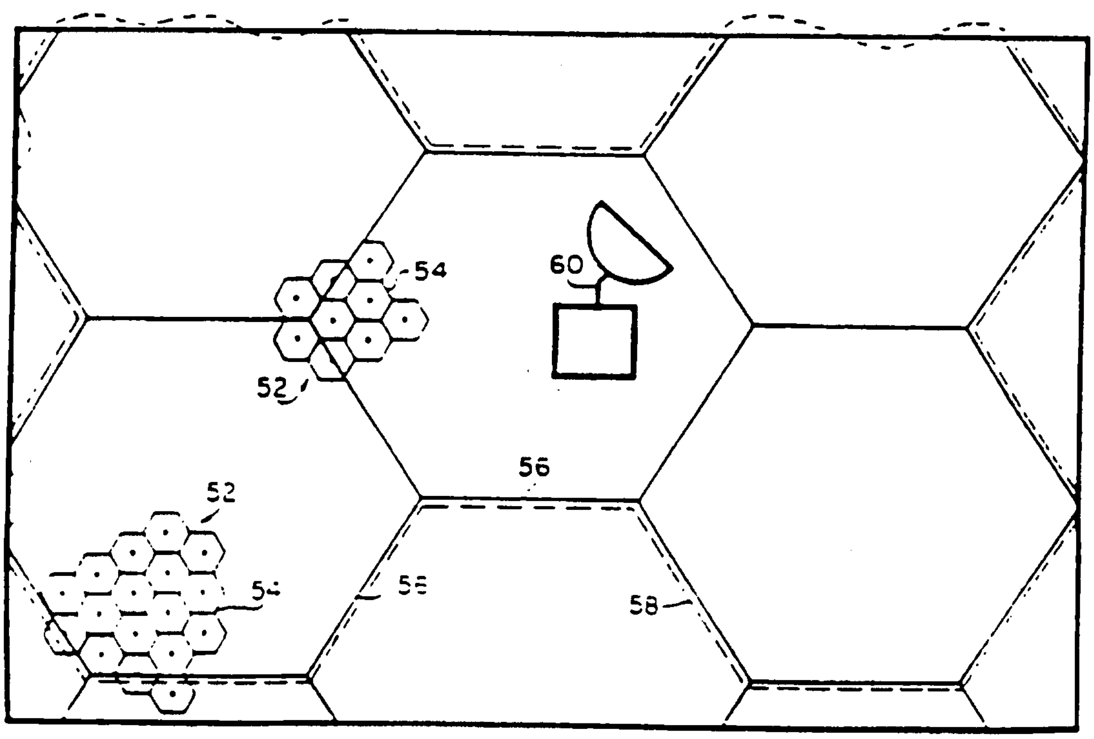

FIG. 4

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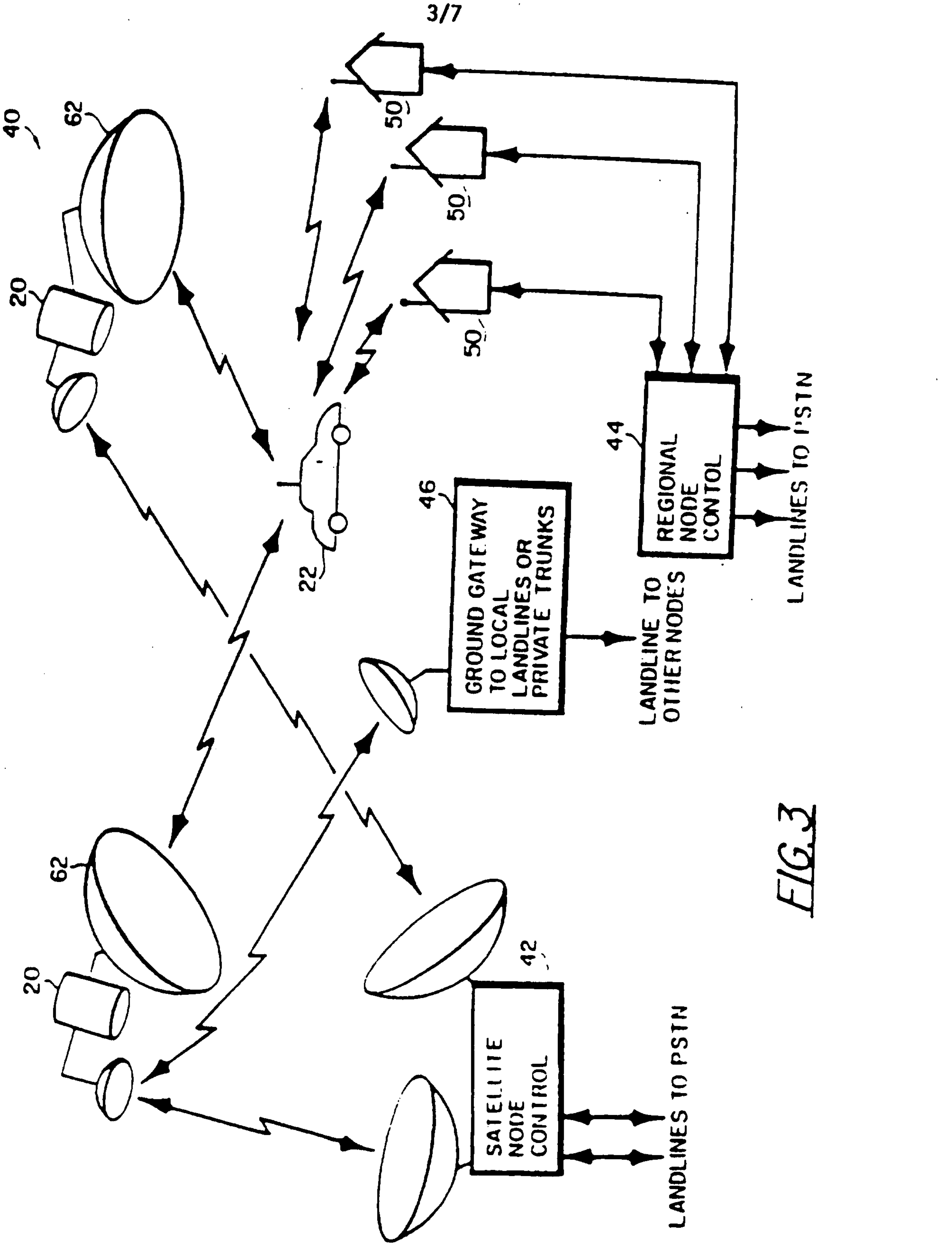
40
62
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50
50
22
46
GROUND GATEWAY TO LOCAL LANDLINES OR PRIVATE TRUNKS
LANDLINE TO OTHER NODES
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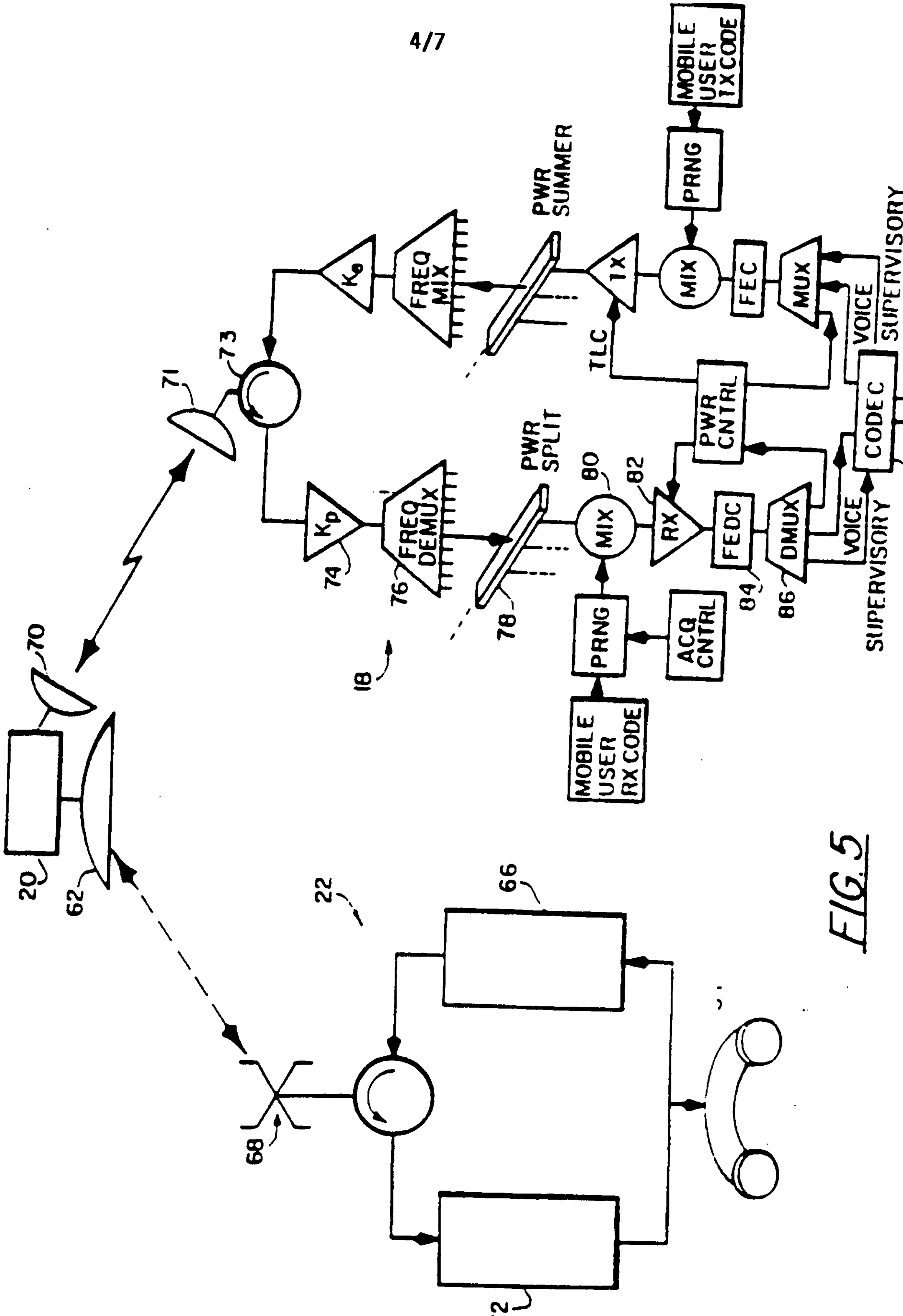
62
20
42
SATELLITE NODE CONTROL
LANDLINES TO PSTN

FIG. 3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MIX
FEC
MUX
VOICE
SUPERVISORY
TX
TLC
PWR CNTRL
CODEC
TO PSTN
PWR SUMMER
FREQ MIX
K_G
73
71
70
20
62
22
66
68
72
K_p
74
FREQ DEMUX
76
PWR SPLIT
78
MIX
80
RX
82
FEDC
84
DMUX
86
88
VOICE
SUPERVISORY
PRNG
ACQ CNTRL
MOBILE USER RX CODE
18

FIG.5

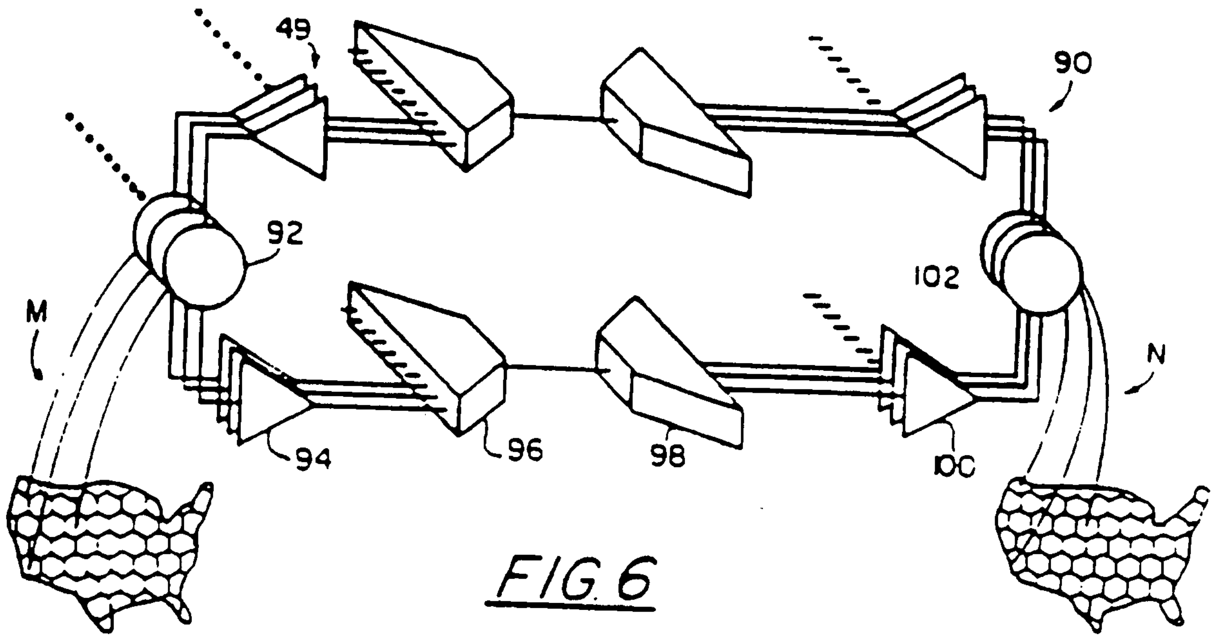
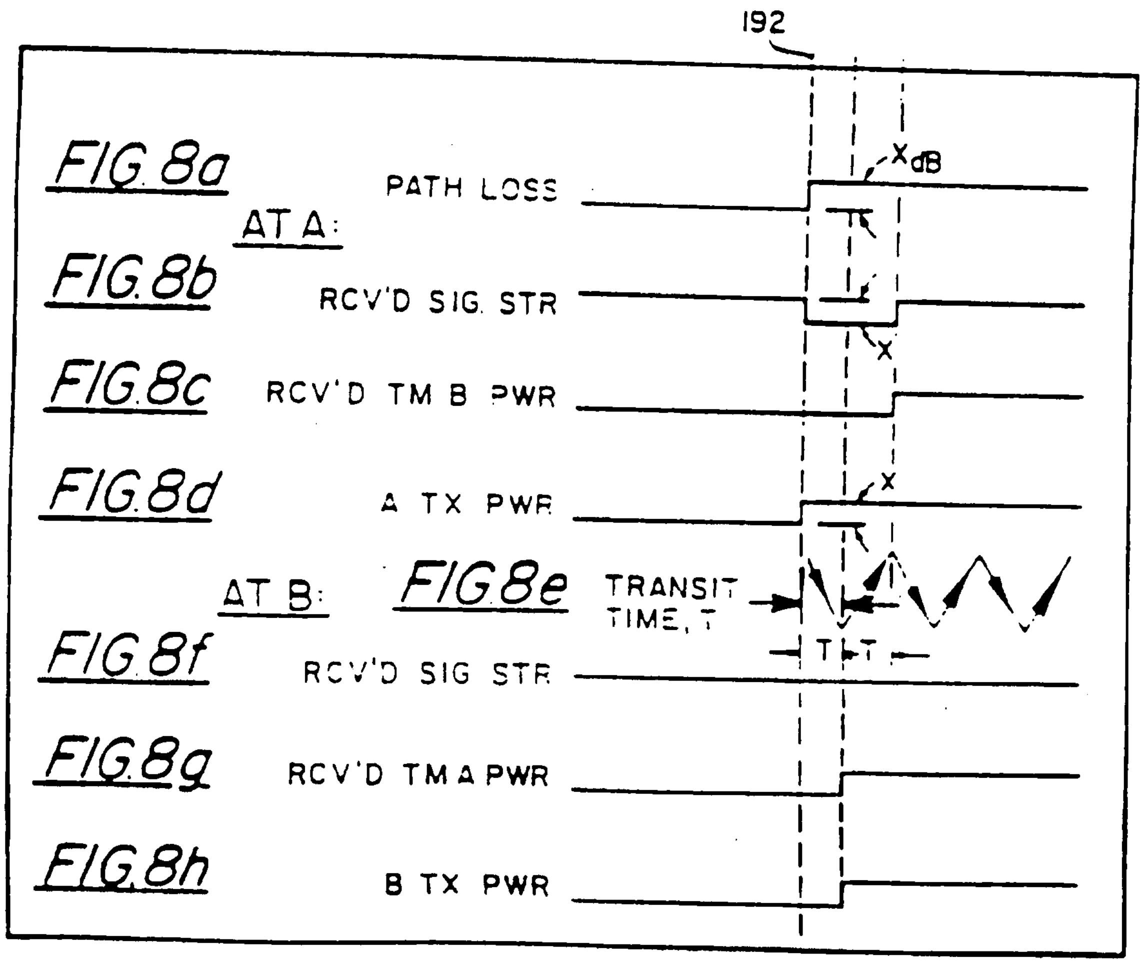
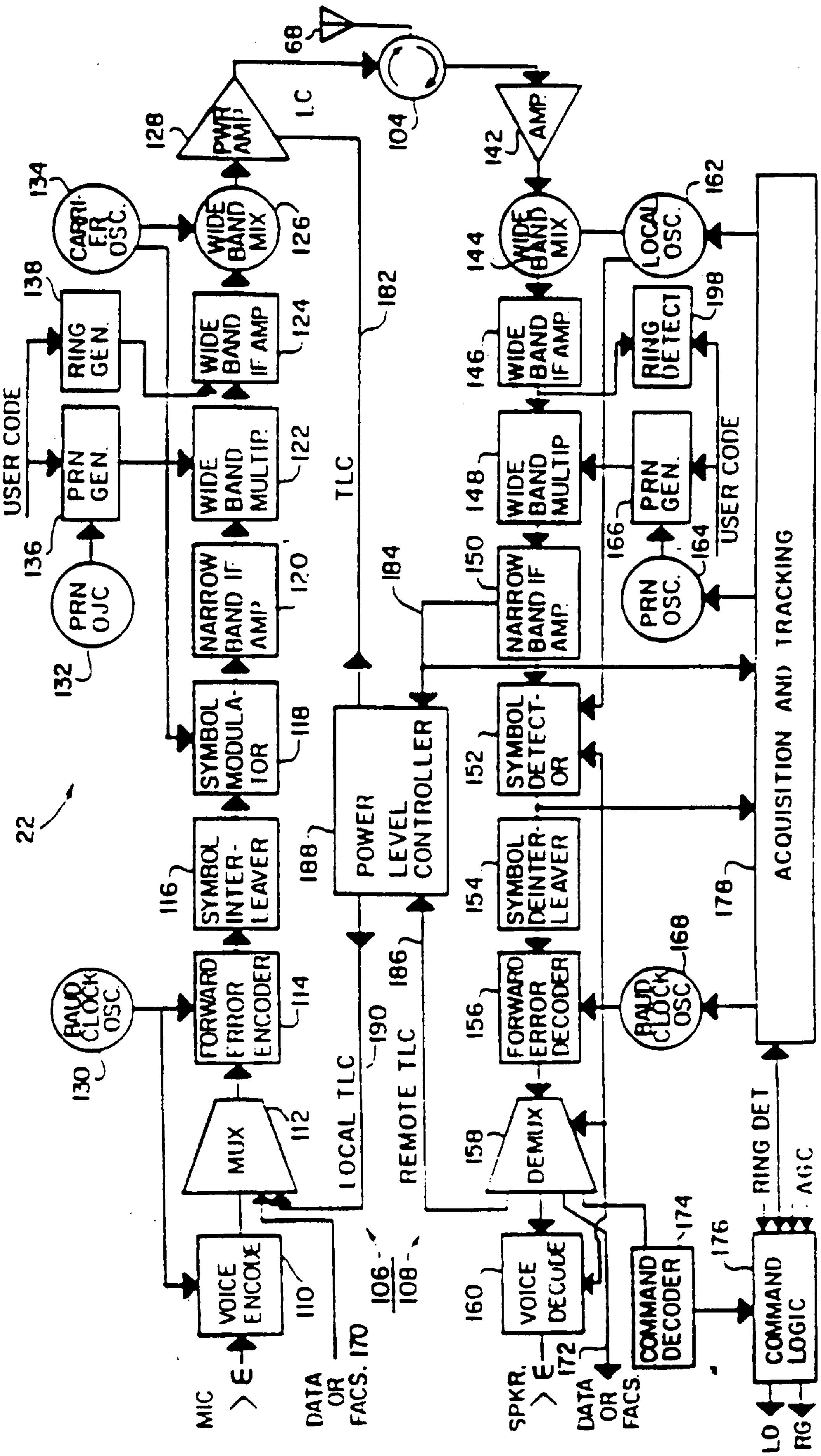


FIG 6



SUBSTITUTE SHEET (RULE 26)

FIG.7


22
MIC
VOICE ENCODE
110
DATA OR FACS. 170
MUX
112
LOCAL TLC
190
BAUD CLOCK OSC.
130
FORWARD ERROR ENCODER
114
SYMBOL INTER-LEAVER
116
SYMBOL MODULA-TOR
118
NARROW BAND IF AMP
120
PRN OSC
132
PRN GEN.
136
USER CODE
WIDE BAND MULTIP.
122
RING GEN.
138
WIDE BAND IF AMP
124
CARRIER OSC.
134
WIDE BAND MIX
126
PWR AMP
128
LC
68
104
182
TLC
POWER LEVEL CONTROLLER
188
186
184
REMOTE TLC
106
108
AMP
142
WIDE BAND MIX
144
WIDE BAND IF AMP
146
WIDE BAND MULTIP
148
NARROW BAND IF AMP
150
SYMBOL DETECT-OR
152
SYMBOL DEINTER-LEAVER
154
FORWARD ERROR DECODER
156
DEMUX
158
VOICE DECODE
160
SPKR.
DATA OR FACS.
172
COMMAND DECODER
174
COMMAND LOGIC
176
LO
RG
RING DET
AGC
BAUD CLOCK OSC
168
PRN OSC.
164
PRN GEN.
166
USER CODE
RING DETECT
198
LOCAL OSC.
162
ACQUISITION AND TRACKING
178

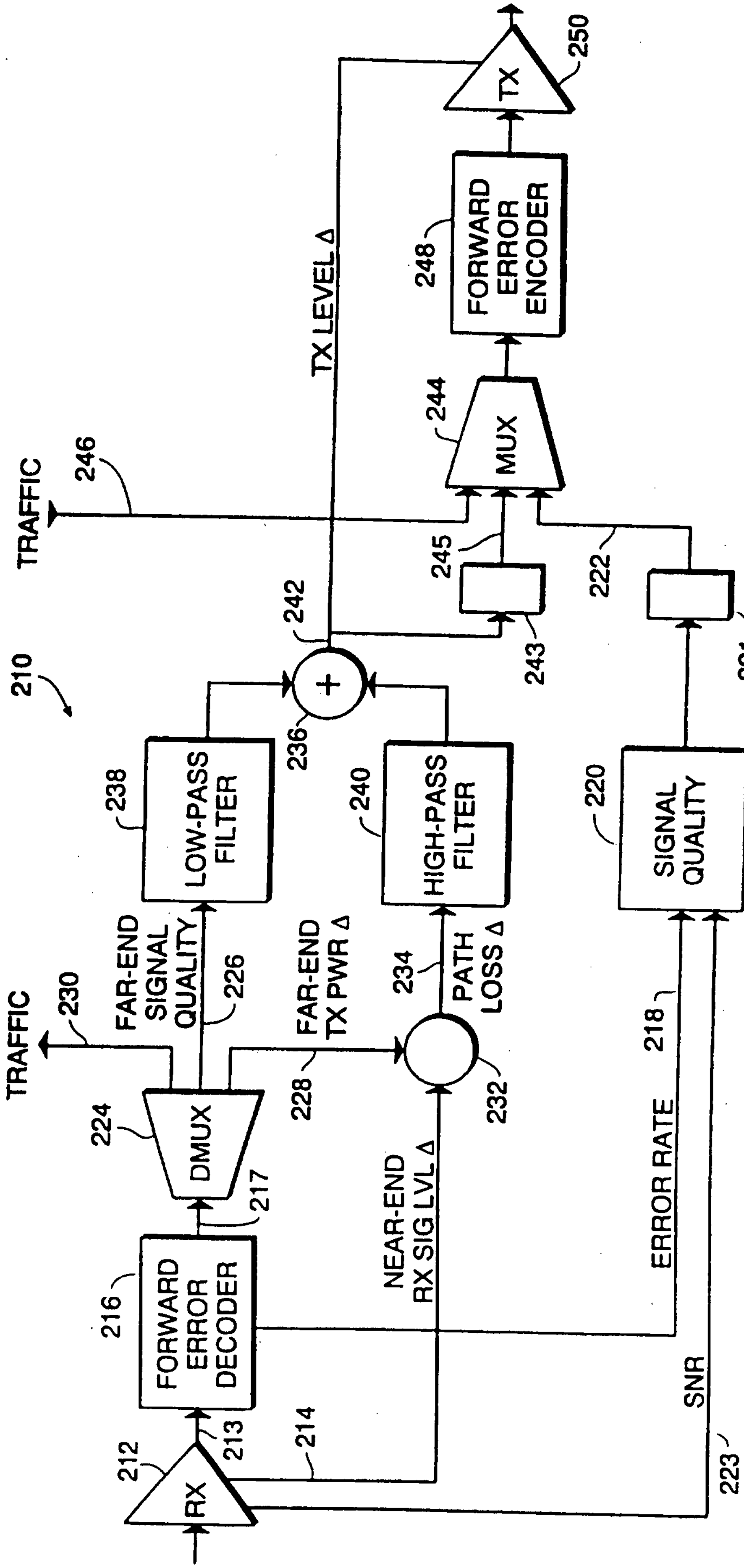

210
RX
212
213
214
FORWARD ERROR DECODER
216
DMUX
217
224
TRAFFIC
230
FAR-END SIGNAL QUALITY
226
FAR-END TX PWR Δ
228
NEAR-END RX SIG LVL Δ
232
234
PATH LOSS Δ
LOW-PASS FILTER
238
HIGH-PASS FILTER
240
236
+
242
243
245
TX LEVEL Δ
TRAFFIC
246
MUX
244
FORWARD ERROR ENCODER
248
TX
250
SIGNAL QUALITY
220
ERROR RATE
218
SNR
223
221
222

FIG. 9

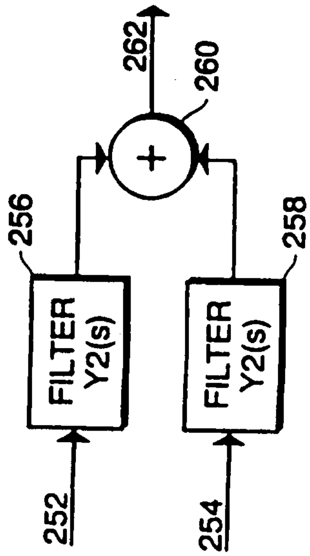

FILTER Y2(s)
FILTER Y2(s)
252
254
256
258
+
260
262

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/03898

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :HO4B 1/034, 7/26; H04M 11/00
US CL :455/38.3
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 455/33.1, 38.3, 52.1, 54.1, 63, 65, 67.1, 69, 88, 89, 115, 126, 127; 379/58,59

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 5,333,175 (Ariyavisitakul et al.) 26 July 1994 see FIGS. 2 and 3	1-10
A	US, A, 4,777,653 (Bonnerot et al.) 11 October 1988 see FIG. 1	1-10
A	US, A, 5,265,119 (Gilhousen et al.) 23 November 1993 see FIGS. 3 and 4	1-10
A	US, A, 5,386, 589 (Kanai) 31 January 1995 see FIG.3	1-10
A	US, A, 5,241,690 (Larsson et al.) 31 August 1993 see FIG. 4	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
16 MAY 1995	16 AUG 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer B. Harold MARSHA D. BANKS-HAROLD for Telephone No. (703) 305-4379

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

Appln No. 10/917,968
Docket No. 562492000500

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04L 12/00, H04B 7/005	A2	(11) International Publication Number: WO 99/07105 (43) International Publication Date: 11 February 1999 (11.02.99)

(21) International Application Number: PCT/GB98/02329

(22) International Filing Date: 3 August 1998 (03.08.98)

(30) Priority Data:
97/6885 1 August 1997 (01.08.97) ZA

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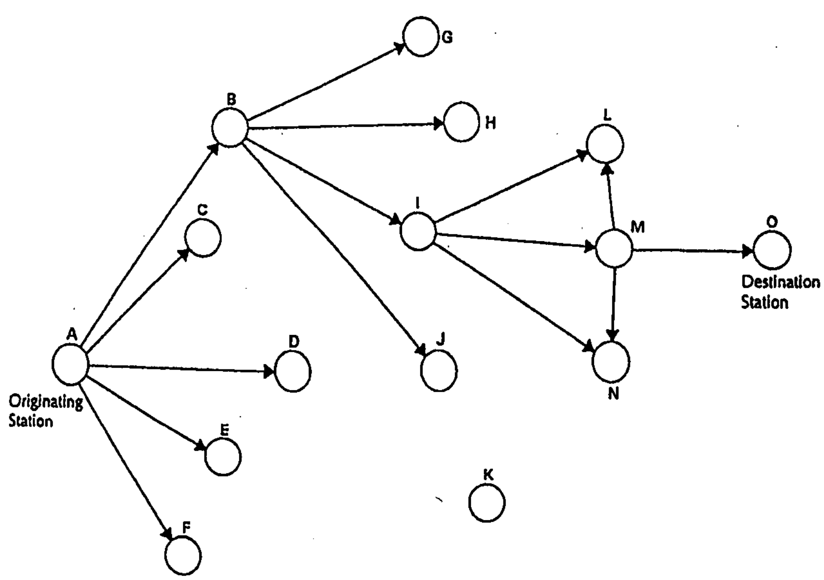
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: POWER ADAPTION IN A MULTI-STATION NETWORK



(57) Abstract

The invention relates to a method of operating a communication network, the network comprising a plurality of stations which are able to transmit data to and receive data from one another. The method comprises monitoring, at each station, the transmission path quality between that station and each other station with which that station can communicate. Data corresponding to the monitored path quality is recorded at each station, thereby permitting a transmission power value based on the relevant path quality data to be selected when transmitting data to another station. Thus, the probability of transmitting data to any selected station at an optimum power level is increased. Each station transmits path quality data in its own transmissions as well as local noise/interference data, so that other stations can obtain path quality data for a particular station even if they are out of range of that particular station. The invention extends to communication apparatus which can be used to implement the method.

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POWER ADAPTION IN A MULTI-STATION NETWORK

BACKGROUND OF THE INVENTION

This invention relates to a method of operating a multi-station communication network and to communication apparatus usable to implement the method.

International patent application no. WO 96/19887 describes a communication network in which individual stations in the network can send messages to other stations by using intermediate stations to relay the message data in an opportunistic manner. In networks of this kind, and in other multi-station networks, it is desirable to control the output power of transmitting stations to a level which is sufficient for successful reception of transmitted data, but which is otherwise as low as possible, to minimise interference with nearby stations or with other users of the radio frequency spectrum.

It is an object of the invention to provide a method of operating a multi-station communication network which addresses the above objective.

SUMMARY OF THE INVENTION

According to the invention there is provided a method of operating a communication network comprising a plurality of stations able to transmit data to and receive data from one another, the method comprising:

> monitoring, at each station, the path quality between that station and each other station with which that station communicates;
>
> recording, at each station, path quality data corresponding to the path quality associated with each said other station; and
>
> setting, at each station, a transmission power value based on the recorded path quality data associated with a selected other station when transmitting data to said selected other station, thereby to increase the probability of transmitting data to said selected other station at an optimum power level.

The monitoring of path quality between stations may include monitoring at least one of the path loss, phase distortion, time delay, Doppler shift and multipath fading characteristics of a channel between the stations.

The method preferably includes transmitting path quality data corresponding to the path quality between a first and a second station when transmitting other data between the stations, so that path quality data recorded at the first station is communicated to the second station for use by the second station and vice versa.

The path quality at a station receiving a data transmission may be calculated by comparing the measured power of the received transmission with data in the transmission indicating the transmission power thereof.

A station receiving such path quality data preferably will compare the received path quality data with respective stored path quality data and calculate a path quality correction value from a difference between the received and stored values, the path quality correction value being utilised to adjust the transmission power when transmitting data to the station which transmitted the path quality data.

The path quality correction factor may be calculated by deriving rate of change data from a plurality of path quality correction factor calculations.

The rate of change data may be utilised to adjust the transmission power predictively when transmitting data to a station whose path quality correction value is detected to be changing over time.

The method may include monitoring, from a station transmitting data, the background noise/interference at a station receiving a data transmission and adjusting the transmission power value at the station transmitting data to the receiving station, thereby to maintain the required signal to noise ratio at the receiving station.

The method may include adjusting the data rate of message data transmitted from a first station to a second station according to the transmission power value set at the first station and the required signal to noise ratio at the second station.

The method may also include adjusting the length of message data packets transmitted from a first station to a second station according to the transmission power value set at the first station and the required signal to noise ratio at the second station.

Each station preferably monitors the transmissions of other stations to obtain path quality and background noise/interference data therefrom, so that a first station monitoring a transmission from a second station within range of the first station to a third station out of range of the first station can obtain path quality and background noise/interference data relating to the third station.

The method preferably includes selecting, opportunistically, a station for transmission of data thereto according to the path quality and/or background noise/interference data associated therewith.

Further according to the invention there is provided communication apparatus operable as a station in a network comprising a plurality of stations which can transmit data to and receive data from one another, the communication apparatus comprising:

transmitter means arranged to transmit data to selected stations;

receiver means arranged to receive data transmitted from other stations;

signal strength measuring means for measuring the power of received transmissions;

processor means for recording path quality data corresponding to the path quality associated with other stations; and

control means for adjusting the output power of the transmitter according to the path quality between the apparatus and a destination station.

The processor means is preferably arranged to calculate the path quality by comparing data in received transmissions relating to their transmission power and/or a previously measured path quality with the measurements made by the signal strength measuring means.

The processor means is preferably arranged to monitor at least one of the path loss, phase distortion, time delay, Doppler shift and multipath fading characteristics of a channel between the apparatus and other stations.

The processor means is preferably arranged to extract path quality data from received transmissions, to compare the path quality data with the measured power of received transmissions, and to calculate a path quality correction factor from the difference therebetween, the path quality correction factor being utilised by the control means to adjust the output power of the transmitter.

The processor means may be adapted to derive rate of change data from a plurality of path quality correction factor calculations, thereby to compensate for variations in the path quality between stations.

The processor means is preferably arranged to utilise the rate of change data to adjust the transmission power predictively when transmitting data to a station whose path quality correction value is detected to be changing over time.

Preferably, the processor means is arranged to store path quality data for each of a plurality of stations and to set an initial transmission power value when initiating communication with any of said plurality of stations according to the respective stored path quality data.

The processor means is preferably adapted to monitor transmissions of other stations to obtain path quality and background noise/interference data therefrom, so that the apparatus can select, opportunistically, another station for transmission of data thereto according to the path quality and/or background noise/interference data associated therewith.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a multi-station communication network, indicating how an originating station can transmit data via a plurality of intermediate stations to a destination station;

Figures 2A to 2E	comprise together a simplified flow diagram indicating graphically the operation of the method of the invention;
Figures 3 to 6	are schematic block diagrams of apparatus suitable for implementing the invention; and
Figures 7 to 9	are flow diagrams showing the power, modem data rate and packet size adaption processes of the invention, respectively.

DESCRIPTION OF EMBODIMENTS

The network illustrated schematically in Figure 1 comprises a plurality of stations, each comprising a transceiver able to receive and transmit data from any other station within range. A communication network of this kind is described in international patent application no. WO 96/19887, the contents of which are incorporated herein by reference. The stations of the network maintain contact with one another using the probing methodology described in international patent application no. PCT/GB98/01651, the contents of which are also incorporated herein by reference.

Although the method and apparatus of the present invention were designed for use in the above referenced communication network, it should be understood that the application of the present invention is not limited to such a network and can be employed in other networks, including conventional cellular or star networks, or even in a two-way communication situation between first and second stations.

In Figure 1, an originating station A is able to communicate with five "nearby" stations B to F, and is transmitting data to a destination station O via intermediate stations B, I and M.

When any of the stations transmit data to any other station, it is necessary that the transmit power used be sufficient to enable successful reception of the transmitted data at the receiving station. At the same time, to avoid unnecessary energy consumption and interference with other stations in the network, or other communications systems in general, it is desirable to minimise the transmission power utilised.

The problem of setting an optimum transmission power is complicated by variations in the path quality between stations, which may be severe in the case of stations which are moving relative to one another.

In this specification, the expression "path quality" includes path loss (also referred to by those skilled in the art as transmission loss or path attenuation) which is a measure of the power lost in transmitting a signal from one point to another through a particular medium. However, the expression also includes other parameters of the transmission path between any two stations, such as phase distortion, time delay spread, Doppler shift and multipath fading characteristics, which would affect the transmission power required for successful transmission between any two stations.

The present invention addresses this problem by providing a method and apparatus for continually monitoring the path quality between stations and adjusting the transmission power used when transmitting data, so as to use just enough power to ensure successful reception of the transmitted data, without transmitting at a higher power than is required. In addition, other transmission parameters, such as the equalisation and coding applied to the transmitted signals, can be adjusted to improve the likelihood of successful reception.

When a station receives a data package from a remote station it measures the power or strength of the received transmission. This is known as the Received Signal Strength Indicator (RSSI) value of the received transmission. In the data packet from the remote station there is included data corresponding to the transmission power used by the remote station. The local station can therefore calculate the path loss (ie. transmission loss or path attenuation) between the two stations by subtracting the locally measured RSSI value from the transmission power value in any data packet. Whenever a local station responds to a probe signal from a remote station, it will always indicate the path loss it has calculated in the response data packet. Likewise, the local station knows that any data packets addressed to itself will contain data corresponding to the path loss measured by the remote station from the most recent probe signal received by that remote station from the local station.

The local station will compare its calculated path loss with the path loss data received from the remote station, and will use the difference in the path loss values to determine a correction factor to use when transmitting data to the remote station, thereby to adapt its output power to an optimum level, or as close to it as possible.

The first time the local station hears from the remote station it will use a correction factor of:

$Path_{Cor}$ = Remote Path Loss - Local Path Loss

Thereafter:

$Path_{Cor}$ = $Path_{Cor}$+(((Remote Path Loss - Local Path Loss)+$Path_{Cor}$)/2)-$Path_{Cor}$)

where the maximum adjustment made to $Path_{Cor}$ in both cases is 5 dB up or down.

$Path_{Cor}$ may only be a maximum of ± 30dB.

The local station adds the correction factor $Path_{Cor}$ to its measured path loss, thus generating a Corrected Path Loss value when determining what power to use when responding to the remote station. However, the Path Loss value it places in the packet header is its measured Path Loss without correction.

If the local station does not get a direct response from the remote station after ten transmissions then it must increase its $Path_{Cor}$ value by 5dB to a maximum of +10dB. The reason for doing this is to avoid going below the noise threshold of the remote station. (The $Path_{Cor}$ value is added to the measured

Path Loss. The adjusted Path Loss is then used to determine the required transmission power. A smaller value for $Path_{Cor}$ will correspond to a lower transmission power. Therefore, if the $Path_{Cor}$ value is made too small or even negative then the transmission power may be too low to reach the remote station. It is therefore necessary to increase the $Path_{Cor}$ value in 5dB steps until a response from the remote station is detected).

The local station will also not increase its transmission power more than 10dB above normal. This is to avoid swamping other stations if there is an error with the remote station's receiver. However, if the local station does receive a response then the maximum adjustment may go as high as 30dB above normal.

If the RSSI of the remote station is pegged it will set its Path Loss value in the data packet header as 0 (zero). A station will not make any adjustment to its path quality correction factor if either the remote Path Loss in the header is at zero, or if its local RSSI is pegged.

Having calculated the Path Loss and the correction factor $Path_{Cor}$, the local station can now determine the power required to transmit back to the remote station. The remote station also includes in every packet it sends the background RSSI values for the current, previous, and next modem. The local station will use the Corrected Path Loss and the remote background RSSI value to determine what power to use when responding.

Each station has a minimum Signal to Noise (S/N) ratio level that it will try to maintain for each modem. It is assumed that the required Signal to Noise ratio of all the stations in the network is the same. The local station will set the power level for its transmissions such that the remote station will receive them at the correct S/N ratio. If the local station has additional data to send, or if it can operate at a higher data rate, then the required S/N ratio required may vary.

Example 1

Remote station Tx Power	: 40 dBm
Remote Station Background RSSI	: -120 dBm
Remote Station Path Loss	: 140 dB
Local station Required S/N	: 25 dB
Local station Path Loss	: 130 dB

$Path_{Cor}$	= Remote Path Loss - Local Path Loss (Assume first time)
	= 140 - 130
	= 10 dB
Corrected Path Loss	= Local Path Loss + $Path_{Cor}$
	= 130 + 10
	= 140 dB
Local Tx Power	= Remote RSSI + Required S/N + Corrected Path Loss
	= -120 + 25 + 140
	= 45 dBm

From the above example it can be seen that the local station must use a Tx Power of 45 dBm to obtain a remote S/N ratio of 25 dB. If the local station can only set its power in 10 dB steps then it must adjust its power up to the next step, ie. 50 dBm.

The power adaption process described above is summarised graphically in the flow chart of Figure 7.

A station may have one or more modems. Each modem operates at a different data rate. However, they all operate in the same channel, ie. frequency and/or medium. Therefore when a station changes channels all the modems will be available on the new channel. A channel may however have a minimum and/or maximum data rate associated with it. For example if a station is on a 80 kbps probing channel it may not use data rates lower than 80 kbps. Therefore it may not use the 8 kbps modem on that channel. In the same way the 8 kbps probing channel may have a maximum bandwidth of 80 kbps, therefore not allowing the use of the 800 kbps modem on that channel.

When a station is probing on a probing channel, it will use the data rate associated with the channel. It will always probe on the channel and at the power required to maintain 5 neighbours.

When a local station responds to the probe of a remote station, or if it responds to a data packet of a remote station, it will always try to use the optimum modem for its response.

A station will always try to respond at the highest data rate possible. The highest data rate will be determined by the maximum data rate allowed for the channel and by, the remote S/N ratio on the modem associated with that data rate.

If a station can use a higher data rate on the channel, it will determine the remote S/N for that data rate. If it can achieve that required S/N ratio it will use the higher data rate. On the other hand, if the conditions are poor and the station can't achieve the required S/N ratio then it will remain at the current data rate. When condition are very poor and the station can't maintain the current data rate, it may even choose to respond at a lower data rate, if the channel allows. It will only use a lower data rate if the S/N ratio of the lower data rate is achieved. If the station cannot use a lower data rate, and if it is on the lowest data rate available then the station will try anyway. However, if there is a lower data rate available, but the station may not use it on the current channel, then the station will not respond to the remote station. This will force the remote station to find a lower data rate channel.

In summary:

- A station will switch to the next modem if the S/N ratio of the next modem meets the required S/N ratio and the maximum modem rate of the channel allows the next modem to be used.

- A station will switch to the previous modem if the S/N ratio of the current modem is below the required S/N ratio and the S/N ratio of the previous modem meets the required S/N ratio and the minimum modem rate of the channel allows the previous modem to be used.

The modem data rate adaption process described above is summarised graphically in the flow chart of Figure 8.

When a station responds to another station it will always try to send as much data as it can. The factors which limit the packet size are: spacing between probes, maximum transmission power, and the allowed transmission duration on a data channel.

In the prototype system, the base packet size is 127 bytes. This is the smallest packet size that will allow data to be reliably transmitted between two stations. (This assumes there is data to send. If a station has no data to send then the packet will always be smaller than 127 bytes.)

A station will use the base packet size under very bad conditions even when it has more data to send. Thus if it is sending to a remote station which has bad background noise, or is very far away, it will only be able to respond at the lowest data rate (8 kbps), and at maximum power.

If a station can achieve a remote S/N ratio better than the base value (i.e. Required S/N for 8 kbps), it may start using larger packets based on the following equations:

For a 10x baud rate increase it will multiply the packet size by a factor

Z. (Typically Z = 4)

Multiplier for packet size = $Z^{\log(X)}$, where X is Baud 2 / Baud 1.

For a 10dB S/N increase, multiply packet size by Y (Typically Y = 2)

Multiplier for packet size = $Y^{W/10}$, where W is additional S/N available.

The values for Z and Y are fixed for the entire network. Typical values for Z and Y are 4 and 2 respectively.

Example 2

If a station can respond at 80 kbps at the required S/N ratio for 80 kbps, it will then use a maximum packet size of $127 * 4^{\log(80000/8000)} = 127 * 4 = 508$ bytes. If the station cannot fill the packet, it will still use the power required to achieve the required S/N ratio.

Example 3

If a station can respond at 15 dB above the required S/N ratio for 80 kbps, it will then use a maximum packet size of $127 * 4^{\log(80000/8000)} * 2^{15/10} = 127 * 4 * 2.83 = 1437$ bytes. If the station cannot fill the packet it will drop its transmission power to the level required for the packet size it will actually use. For example, even though it could use a packet size of 1437 bytes, if it only has 600 bytes to send to the other station it will adjust its Tx power to a level between the required S/N and 15dB above the required S/N by using the inverse of the equation $Y^{W/10}$ to determine how much additional power it needs above the required S/N ratio.

It is important to note that even though a station may use a larger packet size based on the available S/N ratio and data rate, the packet size may be limited by the probe interval. For example, if the probe interval on the 8 kbps channel is 300 milliseconds, and the maximum packet size based on the available S/N ratio is 600 bytes (which translates to 600 milliseconds at 8 kbps), it can be seen that a packet size of less than 300 bytes must be used, otherwise other stations may corrupt the packet when they probe.

A number of factors must be taken into account when trying to determine the maximum packet size based on the probing rate. These factors include: Tx on delay (the time for the transmitter power amplifier to settle, and for the remote receiver to settle), modem training delay (length of modem training sequence), turnaround delay (time for processor to switch from Rx to Tx, ie. to process data), and propagation delay (time for signal to travel through medium).

To determine the maximum packet size based on the probing rate the following equation is used:

Max Length (ms) = Probe interval - Tx on delay - modem training delay - turnaround delay - propagation delay

The length in bytes can then be determined by:

Max Length (bytes) = Data Rate / 8 * Max Length (seconds)

Example 4

Probe interval is 300 milliseconds on 8 kbps channel. Tx on delay 2 milliseconds, modem training delay is 2 milliseconds, turnaround delay 3 milliseconds, propagation delay 8 milliseconds (worse case for station 1200 km away).

Max Length (ms) = Probe interval - Tx on delay - modem training delay - turnaround delay -propagation delay
= 300 - 2 - 2 - 3 - 8
= 285 ms

Max Length (bytes) = Data Rate / 8 * Max Length (seconds)
= 8000 / 8 * 0.285
= 285 bytes

The packet size adaption process described above is summarised graphically in the flow chart of Figure 9.

Below is a table giving details of the format of Probe and Data packets used in the network of the invention.

Format of Probe and Data packets

Variable	Bit Len	Allows
Preamble	64	Modem training sequence (101010101010 etc ...)
Sync1	8	First Sync Character used to lock Zilog
Sync2	8	Second Sync Character used to lock Zilog
Sync3	8	Third Sync character checked by software
Packet Size	16	Size of packet from Sync3 until last CRC
Size Check	8	Packet Size Check = Packet Size MSB XOR LSB
Protocol Version	8	Protocol Version
Packet Type	8	Packet Type (E.g. Probe, Data, Key, etc.)
Sending ID	32	Sending Station ID
Receiving ID	32	Receiving Station ID (0 = Broadcast)
Packet Number	16	Packet number
Adp Tx Power	8	Sending station current power in dBm
Adp Tx Path Loss	8	Path Loss measured at sending station in dB
Adp Tx Activity	4	Sending station current Activity Level
Adp Tx Antenna	8	Sending station current antenna configuration
Adp Tx Bkg RSSI -1	8	Sending station RSSI in dBm -> Current Modem -1
Adp Tx Bkg RSSI	8	Sending station RSSI in dBm -> Current Modem
Adp Tx Bkg RSSI +1	8	Sending station RSSI in dBm -> Current Modem +1
Adp Tx Spike Noise	8	Spike Frequency & Level at sending station
Adp Rx Activity	4	Required Activity Level for receiving station
Adp Rx Channel	8	Required Rx & Tx Channel for receiving station
Header CRC	16	16 bit CRC for header data
Neigh Routing Flags	8	Bit 0 - In Traffic, Bit 1 - Gateway, Bit 2 - Cert Auth
Neighbour Data Size	16	Size of routing data in bytes = 3 + 4 (Update) + IDs * 6
Neigh Soft Update	32	Software Update Version (16) and Block Number (16)
Neighbour Data	x	Neigh * (32 (ID) + 8 (TxPowerReq) + 4 (ModemReq) + 4 (Flags))
Packet Data	x	
CRC	32	32 bit CRC for whole packet, including header

Preamble:

This is a modem training sequence consisting of alternating 1's and 0's.

Sync1 – Sync3:

These are the three Sync characters that are used to detect the start of a valid packet.

Packet Size:

This is the total size of the packet from Sync3 up to and including the last CRC byte. The maximum packet size that is allowed on a probing channel is determined by the probing rate, ie. a station may not send a packet that is longer (measured in time) than the spacing between probes on the probing channel. The maximum packet size that is allowed on a data channel is determined by the amount of time a station is allowed to remain on a data channel.

Size Check:

This is used to check the Packet Size variable to avoid any invalid long packet receptions.

Protocol Version:

This is used to check which protocol version is being used. If the software can not support the version the packet will be ignored.

Packet Type:

This defines the type of packet being sent. Another packet will directly follow the current packet, if the most significant bit is set.

Receiving ID:

This is the ID of the station to which the packet is addressed.

Sending ID:

This is the ID of the station currently sending the packet.

Packet Number:

Each packet that is transmitted is given a new sequential number. The number is not used in any way by the protocol. It is merely there to provide information to a systems engineer. Each time the station is reset, the packet number starts at a random number. This prevents confusion with older packets.

Adp Tx Power:

The sending station's current power is given as the absolute power in dBm, in the range -80dBm to +70dBm. (Field allows values from -128 dBm to +127 dBm)

Tx Path Loss:

This is the path quality as measured at the sending station. Path Loss = (Remote Tx Power - Local RSSI) of receiving station's previous transmission. A value of 0 is used to indicate that the sending station's RSSI was pegged. The Path Quality is used as a correction factor at the receiving station, for the next time the receiving station transmits to the sending station.

Adp Tx Activity:

This is the activity level of the sending station, measured as: Activity = Watts * Time / (Bandwidth * Success) averaged over time.

Adp Tx Antenna:

This indicates the current antenna configuration being used by the sending station. Each of the 255 possible configurations describes a complete antenna system, i.e. Tx and Rx antenna.

Adp Tx Bkg RSSI:

This is the current background RSSI at the sending station for the modem that it is currently transmitting on. It allows for values from -255 to -1 dBm. The value sent is the absolute value of the RSSI, and the receiving station must multiply the value with -1 to get the correct value in dBm. A value of 0 is used to indicate that the channel is not available or is greater than or equal to 0 dBm. A value of 0 dBm cannot be used for adaptation purposes.

Adp Tx Bkg RSSI –1:

Same as above except for the previous modem.

Adp Tx Bkg RSSI +1:

Same as above except for the next modem.

Tx Spike Noise:

The lower 3 bits for spike frequency in Hz, 0 = none, 1,5,10,50,100,500, & > 500, and the next 5 bits for spike amplitude in dB.

Adp Rx Activity:

If a station has a high activity level and is interfering with other stations, they will use this field to force the active station to drop its activity level. If a number of stations request a drop in activity then the interfering station will respond and drop its activity. If no stations request that such a drop, the active station will slowly start to increase its activity level. Thus if a station is in a very remote area it will keep increasing it activity level trying to generate connectivity. If it is in a very busy area, other stations will keep its activity at a lower level.

In preferred embodiments of the invention, a station will always try to maintain five neighbours, so that other stations should not need to request that the station reduce its activity. However the feature has been provided for cases where stations cannot reduce their power, or increase their data rate any further, yet they still interfere with too many other stations.

Adp Rx Channel:

Allows 255 predefined channels. These channels are set for the entire network. Each channel will have a probing rate associated with it (it may be turned off, which makes it a data channel). Each channel will also have a minimum data rate associated with it. The channels will have the Tx and Tx Frequencies defined. The channels may also be defined as other media, e.g. Satellite, Diginet, ISDN, etc.

A sending station will request that another station move to a data channel (ie. where probing has been disabled) when it has more data to send to the receiving station than can fit in the packet size allowed for the probing channel.

Header CRC:

This is a 16-bit CRC check for the header data. It is the sum of all the bytes in the header. It is only checked if the packet CRC fails. This is provided as a means of determining which station sent the packet. If the packet CRC fails and the header CRC passes, the data provided in the header should be used with caution, since the Header CRC is not a very strong means of error detection.

The Neighbour routing fields given below are not included in the Header CRC since they may not be used unless the packet CRC is passed. This makes the routing less prone to errors.

Neigh Routing Flags:

These flags are used to enhance routing. They provide additional information about the current station. Currently defined bits are:

Bit 0 – Set if current station is busy in traffic.

Bit 1 - Set if current station is an Internet Gateway.

Bit 2 – Set if current station is Certification Authority.

Bit 3 – Reserved.

Another byte of 8 bits could be added should more flags be required.

Neighbour Data Size:

Size of routing data in bytes. This includes the Neigh Routing Flags and Neighbour Data Size (ie. 3 bytes). Another 4 bytes are added if the Neigh Soft Update field is included. An additional 6 bytes are added for each neighbour included in the Neighbour Data section. Neigh Soft Update must be included if any Neighbour Data is included.

Neigh Soft Update:

This is the current version of update software available at the current station (Upper 16 bits of field) and the current block number available (Lower 16 bits of field).

Neighbour Data:

This is the list of neighbours that the current station has routing data for. Every time the current station receives updated routing data for a station that is better than the data it had, it will update its own data and include the station in this list in its next probe. The data section has four sub fields for each station in the list:

Station ID: 32 bit field with the ID of the neighbour station.

Tx Power Req: 8 bit field indicating the combined or direct Tx power required to reach the Station ID from the current station.

Modem Req: Modem required by current station to reach destination station.

Flags: Flags giving additional routing information for destination station. Bit 0 – In Traffic, Bit 1 – Gateway, Bit 3 – Cert Auth, Bit 4 – Direct Neighbour. The last bit indicates that the station in the list is a direct neighbour of the current station.

Packet Data:

This is the data of the packet. It is made up of 1 or more segments. The segments may be of any type, and may have originated or be destined for any ID.

CRC:

This is a 32 bit CRC check for the entire packet. If this CRC fails the packet data is discarded, however the header data may still be salvaged if the header CRC passes.

Enhanced method

The flow diagram of Figures 2A to 2D shows the process of measurement and power control and calibration carried out in the network of Figure 1. The originating station A measures the signal strength it receives from station B. In addition, station A identifies station B from its transmission headers and identifies which station it is addressing and what information is being sent. Station A then reads the transmit power and noise/interference level embedded in station B's header, thereby deriving from it the power level that Station B is using to reach the station it is addressing as well as its local noise/interference floor. Station A can then compute the path quality from station B to station A by using its measured signal strength and the declared power level of station B.

If station B is responding to another station such as station C, station A can read from station B's header its declared path quality to station C, thereby deriving information as to fluctuating path qualities between stations B and C , by simply monitoring the transmission of station B. In addition, since station B declares its transmitted power in responding to station C in conjunction with the path loss declared by station B to station C, it is possible for station A to compute the noise/interference floor at station C even though it cannot hear the transmissions of station C.

By monitoring the transmissions of station B at station A when station B transmits to station C, the path quality, required power level and noise/interference floor of both stations B and C may be derived, even though station C is "out of range" of station A.

If station B is probing and is not responding to any other station, no other information as to path quality or required path quality can be derived from its transmissions apart from calculating the effective path quality from A to B. If station A monitors station B responding to station A and reads the calculated path quality to station A embedded in station B's header, station A can then compare this calculated path quality to that read from station B and calculates a differential. Station A uses the differential to update its average path quality differential. This is done by comparing the path quality it computes to that which station B computes, and that differential is as a result of differences in the methods of measurement and other inaccuracies of the two stations.

However, since there is a fluctuation in path quality between transmissions it is possible that the path quality changes from the time that station B calculated the path quality from station A to station B, to the time that station A calculated the path quality from station B to station A. Therefore, a rate of change can be calculated over and above the differential long-term averaging which is a result of measurement inaccuracy. This rate of change will be due to the rate of change of the actual path quality due to propagation changes between transmissions.

Station A may also use a noise/interference level declared by station B to update its database to indicate the slow rate of change of noise/interference, based upon past records at station B and also fast fluctuations that may be in the noise/interference floor of B. Station A may then use the predicted fluctuations in the path quality from station A to station B and the predicted fluctuations in the rate of change of noise/interference in order to predict an opportunity to transmit to station B. This is done so as to choose periods of minimum path quality or minimum noise floor between stations A and B. Since station A is gathering data from other stations, for example stations B, C, D, E and F, it can decide whether station B provides the best opportunity, or whether it should choose one of the other stations. In addition, it can choose its data rate, packet duration and transmitter power based upon the rate of change and duration of the fluctuations of path quality and noise/interference that exist between stations A and B.

If station A chooses station B to transmit data to, it receives an acknowledgement back from station B, and the information is then forwarded on from station B opportunistically to the other stations. It is important to note that by monitoring the transmissions from station B, station A also has an idea of the path quality from station B to stations G, H, I, J, K, etc., and other stations to which station B can transmit. By monitoring those transmissions, it picks up the fluctuations in path quality between station B and the other stations and an indication of the noise/interference floor fluctuations of the other stations even if those other stations are not directly monitored by station A. Using this technique an opportunistic relay station can be chosen, taking not just the first hop but two hops into account and, providing overall routing information is available, data can be routed effectively towards the destination station O.

Hardware

Figures 3, 4, 5 and 6 show the basic hardware used to implement the invention. These Figures correspond to Figures 8, 9, 10 and 11 of the abovementioned international patent application no. WO 96/19887.

Based upon its "decision" to transmit, the main processor 149 will decide on a power level data rate and packet duration to use and will send this packet to the serial controller 131 and simultaneously through the peripheral interface 147 switch the transmit/receive switch 103 into transmit mode and switch the transmitter on after a suitable delay. The Zilog chip 131 will send the packet data together with a suitable header and CRC check via the PN sequence encoders in block 128 or 130, depending on the data rate chosen.

The main processor 149 will embed in the data packet, as one of the fields of information, data corresponding to the transmit power it is using, which will be the same transmit power as sent to the power control PIC block 132, which in turn is used to drive the power control circuit 141, which in turn controls the gain control and low pass filter block 143. This block in turn uses feedback from the power amplifier 145 to control the drivers 144 and 142.

The sensing and gain feedback method allows a reasonably accurate power level to be derived based upon the instruction from the power control circuit 141.

Prior to switching the power amplifier on, the transmission frequency is selected by the synthesizer 138, after which the power amplifier 145 is instructed via the driver block 141 and the amplifier is switched on.

If power levels below the minimum power level provided by the power amplifier 145 are required, the switched attenuator block 102 may be switched in, in order to provide up to an additional 40 dB of attenuation. Therefore the processor can instruct the power amplifier to switch in an attenuator combination to provide an output power level ranging from minus 40 dBm to plus 50 dBm. When the amplifier is switched on, the processor obtains information from the low power sensing circuit 101 as to the forward and reverse power, which is sent via the analogue to digital converter 146 and is used by the main processor 149 in order to monitor the level of power being transmitted. This information is then stored in the dynamic RAM 150 to provide information as to forward and reflected power levels actually generated by comparison to the level requested.

The amount of output transmit power will be affected by the efficiency of the transmit power control loop (blocks 145, 144, 142 and 143) and the switched attenuator block 102. In addition, any mismatch in the antenna 100 will also result in variations in reflected and forward power. The relative power actually output for various levels required can be stored by the processor in the RAM providing a table giving requested against actual power output levels. This can be used to allow the processor to use a more accurate power level field in the information it provides on future transmissions, within messages or probe signals. Since the power level is varied from between minus 40 dBm to plus 50 dBm there are effectively ten different power levels spaced 10 dB apart that may be transmitted. Therefore, the table stored by the processor will have these ten power levels, with the requested power level and actual power level being in this range.

Any other station in the network will then receive this transmission via its antenna 100. The received signal will then pass through the low power sensing circuit 101 and the switched attenuator 102, which initially is set for 0 dB attenuation. It will then pass through the 2 MHz bandpass filter 104, which will remove out of band interference, and then passes into the preamplifier 105, which amplifies the signal before it is mixed down via the mixer 106 to a 10.7 MHz IF signal. This signal is filtered by the bandpass filler 107, and amplified in the IF amplifier 108 and further filtered and amplified in blocks 109, 110, 111 and 112.

The final filtering occurs at blocks 114 and 115, at which stage the signal is measured at block 116 using the narrowband RSSI function, the output of which is used via the main processor to determine the signal strength of the incoming transmission. This then allows the processor, if necessary, to request the power control PIC circuit 132 to switch in additional receiver attenuation up to 40 dB. The switching in of additional attenuation in will only be necessary if the signal exceeds the measurement range of the NE615 of block 116. Otherwise, the attenuator is left at 0 dB attenuation, allowing the full sensitivity of the receiver to be available for receiving small signals. The incoming transmission is measured in two bandwidths simultaneously, namely 8 kHz and 80 kHz. The 80 kHz bandwidth is measured by tapping off the 10.7 MHz IF signal after the 150 kHz ceramic filter 109 and using a 150 kHz ceramic filter 121 and an NE604 IC 120. This, too, has an RSSI output which is received via the interface by the main processor 149.

The broadband and narrowband RSSI are measured via the analogue to digital converter 146, which then passes the data on to the main processor 149. The main processor has a lookup table, and takes the information from the A to D converter and derives from previously calibrated data a receive signal strength. This data is calibrated in dBm, typically from minus 140 dBm to 0 dBm. This information is typically generated using the output of a calibrated signal generator, injecting this into the input of the receiver, and then dialling up various signal strength levels and instructing the processor via the keyboard 209 as to what power levels are being injected. This information is then stored permanently in static RAM or flash RAM 150.

Therefore, the receiving station can accurately record the power level of any incoming transmission. It then reads the address of the incoming transmission and its embedded transmit power level. By comparing these, for example, a plus 40 dBm transmit power level may be measured in the receiver as minus 90 dBm and this is then used to compute a path loss of 130 dB. Path losses may vary from 0 dB up to a maximum of 190 dB (+50 - (-140) = 190). The minimum path loss that can be measured is dependent on the transmission power of the transmitting station and the maximum signal that can be measured by the receiving station. Since with this design the maximum receiving signal is 0 dBm at the antenna port 100, a 0 dB path loss can be measured, providing the transmit power is less than 0 dBm. Otherwise, for example, at a transmit power of 50 dBm the minimum path loss that can be measured is 50 dB. This could be improved by adding additional steps in the switched attenuator or through using a different arrangement in the receiver. If the switched attenuator is fully switched in and the output of the A to D converter indicates that the RSSI is at its highest level, the receiving processor will tag the data associated with the transmission as being "pegged". This means that the path loss is less than is measurable.

The processor on receive will continually measure the background signal and interference, and providing that no transmissions are detected on either modem at either data rate, will monitor and measure the noise and interference in dBm and generate an average which will be stored in the static RAM. When a transmission is detected, the most recent noise measurement is compared to the signal strength to derive a signal to noise ratio. On each transmission, the background noise picked up prior to transmission is advertised inside the transmission message or probe as another field together with the transmitted power. Other stations in the network can pick up and derive from transmission not only the path quality but also the distant station's noise floor just prior to its transmission. The receiving station, since it knows the path quality and has the noise floor of the distant station, will then know at what power to transmit to achieve any desired signal to noise ratio at the distant station.

The required signal to noise ratio is typically based upon the performance of the modem and a figure based upon packet duration and probability of success. This required signal to noise ratio is stored in the database by the processor and is continually updated, based upon the success of transmissions to various destinations. If a station, for example, picks up a transmission and calculates the path loss to be 100 dB and the distant station to have a declared noise floor of minus 120 dBm, to meet the required signal to noise ratio of for example, 20 dB for 8 kilobits per second, it will then transmit at a power level of minus 20 dBm. This required signal to noise ratio will be different for 80 kilobits per second in that the noise floor would be higher in the wider bandwidth of 150 kHz by comparison to 15kHz and in that the performance of the 80 kilobits per second modem may be different from that of the 8 kilobits per second modem.

Therefore, the receiving station would know that if, for example, the declared noise floor in the wideband is minus 110 dBm and the path loss is still 100 dB, but the required signal to noise ratio is, for example, 15 dB, it would require a transmission power of plus 5 dBm. The station receiving the transmission will know what power level to use to respond to the originating station.

Monitoring other communicating stations, the receiving station will see the path quality variation and the noise floor declared by various other stations it is monitoring varying as well, and through choosing a moment of minimum path quality and minimum noise floor will transmit at the appropriate power level to achieve the required signal to noise ratio to the station or stations that it is monitoring. In responding to a transmission, the responding station will switch on its transmitter, control the power amplifier via the power control PIC 132 to meet the required power level and then the main processor 149 will embed the fields of its own transmit power, its own receive noise prior to transmission and the path quality that it has just received from the station to which it is responding.

Depending on the signal to noise ratio and the power level required, the main processor will elect to switch in either the 80 kilobit per second or 8 kilobit per second modem and make the transmission. On making this transmission, it will embed its own transmit power level, its own background noise floor measured in both the 150 kHz and 15 kHz bandwidth and the path quality it has just calculated for the transmission to which it is responding. The originating station, on receiving the transmission, will again measure the RSSI in the two bandwidths and via the A to D converter 146, and using the lookup table in the static RAM 150, calculate the received signal strength. By examining the received packet passed from the Zilog synchronous serial chip 131, it will calculate the received path loss using the transmitter power declared and the measured RSSI and compare the path loss value sent to it by the other station.

In comparing these two path losses, since only a short period of time has elapsed between transmission and reception, these two path losses should be quite similar unless the path loss is fluctuating, caused perhaps by a moving vehicle environment. In successive transmissions, the difference between the two path loss values is averaged and stored since this number represents the difference due to measurement error in signal strength or error in the declared power level being transmitted. The averaging process is used to average out, say, the effects of moving vehicles and path loss fluctuation. The main processor will use this averaged number and retain one for every station in the network. It will have a path loss correction factor or delta ranging from a few dB to tens of dB for each station in the network which it will store in RAM. On detecting any station transmitting and measuring the path loss, the correction factor is then used to correct the transmit power level before responding to the station, ie. predictively . A typical process is as follows:

Station A measures the incoming path loss from Station B, of say 100 dB. Station A looks at Station B's address which is then compared to a lookup table to determine a correction factor or delta, for example 10 dB plus. This means that the path loss as measured by Station A is on average 10 dB higher than that measured by Station B. Based upon the path loss just measured by Station A and Station B's, noise, the power level required is calculated by Station A to meet the required signal to noise ratio at Station B. The difference allowed between the declared path loss by Station B and the measured path loss by Station A is stored by Station A. If a strong variation is detected, this is in all probability due to fluctuating path loss between transmissions, and therefore the receive signal strength is used to determine the path loss by Station A. The difference between the path loss values is used to update the average differential number, which over a number of transmissions will average any fluctuations in path loss between transmission and response.

Having the differential number is also useful, in that on hearing a station probing or communicating to any other station, a path loss can be calculated using the correction factor and an estimation can be made of the required transmit power to use to reach the distant station with sufficient signal to noise ratio. The path loss delta or correction factor is only updated when stations are interacting with each other and this field will only be present in a transmission when a station is responding to another, and will not be present when another station is simply probing, when this field is left empty.

Although embodiments of the invention have been described above with specific reference to the measurement of path loss in the sense of path attenuation or transmission loss, it will be understood that additional path quality parameters such as those referred to above can be measured to provide a more accurate path quality value for use in adjusting the transmission power used when transmitting data between stations.

CLAIMS:

1. A method of operating a communication network comprising a plurality of stations able to transmit data to and receive data from one another, the method comprising:

   monitoring, at each station, the path quality between that station and each other station with which that station communicates;

   recording, at each station, path quality data corresponding to the path quality associated with each said other station; and

   setting, at each station, a transmission power value based on the recorded path quality data associated with a selected other station when transmitting data to said selected other station, thereby to increase the probability of transmitting data to said selected other station at an optimum power level.

2. A method according to claim 1 wherein the monitoring of path quality between stations includes monitoring at least one of the path loss, phase distortion, time delay, Doppler shift and multipath fading characteristics of a channel between the stations.

3. A method according to claim 1 or claim 2 including transmitting path quality data corresponding to the path quality between a first and a second station when transmitting other data between the stations, so that path quality data recorded at the first station is communicated to the second station for use by the second station and vice versa.

4. A method according to any one of claims 1 to 3 wherein the path quality at a station receiving a data transmission is calculated by comparing the measured power of the received transmission with data in the transmission indicating the transmission power thereof.

5. A method according to claim 4 wherein a station receiving such path quality data compares the received path quality data with respective stored path quality data and calculates a path quality correction value from a difference between the received and stored values, the path quality correction value being utilised to adjust the transmission power when transmitting data to the station which transmitted the path quality data.

6. A method according to claim 5 wherein the path quality correction factor is calculated by deriving rate of change data from a plurality of path quality correction factor calculations.

7. A method according to claim 6 wherein the rate of change data is utilised to adjust the transmission power predictively when transmitting data to a station whose path quality correction value is detected to be changing over time.

8. A method according to any one of claims 4 to 7 including monitoring, from a station transmitting data, the background noise/interference at a station receiving a data transmission and adjusting the transmission power value at the station transmitting data to the receiving station, thereby to maintain the required signal to noise ratio at the receiving station.

9. A method according to claim 8 including adjusting the data rate of message data transmitted from a first station to a second station according to the transmission power value set at the first station and the required signal to noise ratio at the second station.

10. A method according to claim 8 or claim 9 including adjusting the length of message data packets transmitted from a first station to a second station according to the transmission power value set at the first station and the required signal to noise ratio at the second station.

11. A method according to any one of claims 1 to 10 wherein each station monitors the transmissions of other stations to obtain path quality and background noise/interference data therefrom, so that a first station monitoring a transmission from a second station within range of the first station to a third station out of range of the first station can obtain path quality and background noise/interference data relating to the third station.

12. A method according to any one of claims 1 to 11 including selecting, opportunistically, a station for transmission of data thereto according to the path quality and/or background noise/interference data associated therewith.

13. Communication apparatus operable as a station in a network comprising a plurality of stations which can transmit data to and receive data from one another, the communication apparatus comprising:

transmitter means arranged to transmit data to selected stations;

receiver means arranged to receive data transmitted from other stations;

signal strength measuring means for measuring the power of received transmissions;

processor means for recording path quality data corresponding to the path quality associated with other stations; and

control means for adjusting the output power of the transmitter according to the path quality between the apparatus and a destination station.

14. Communication apparatus according to claim 13 wherein the processor means is arranged to calculate the path quality by comparing data in received transmissions relating to their transmission power and/or a previously measured path quality with the measurements made by the signal strength measuring means.

15. Communication apparatus according to claim 14 wherein the processor means is arranged to monitor at least one of the path loss, phase distortion, time delay, Doppler shift and multipath fading characteristics of a channel between the apparatus and other stations.

16. Communication apparatus according to claim 14 or claim 15 wherein the processor means is arranged to extract path quality data from received transmissions, to compare the path quality data with the measured power of received transmissions, and to calculate a path quality correction factor from the difference therebetween, the path quality correction factor being utilised by the control means to adjust the output power of the transmitter.

17. Communication apparatus according to claim 16 wherein the processor means is adapted to derive rate of change data from a plurality of path quality correction factor calculations, thereby to compensate for variations in the path quality between stations.

18. Communication apparatus according to claim 17 wherein the processor means is arranged to utilise the rate of change data to adjust the transmission power predictively when transmitting data to a station whose path quality correction value is detected to be changing over time.

19. Communication apparatus according to claim 17 or claim 18 wherein the processor means is arranged to store path quality data for each of a plurality of stations and to set an initial transmission power value when initiating communication with any of said plurality of stations according to the respective stored path quality data.

20. Communication apparatus according to any one of claims 13 to 19 wherein the processor means is adapted to monitor transmissions of other stations to obtain path quality and background noise/interference data therefrom, so that the apparatus can select, opportunistically, another station for transmission of data thereto according to the path quality and/or background noise/interference data associated therewith.

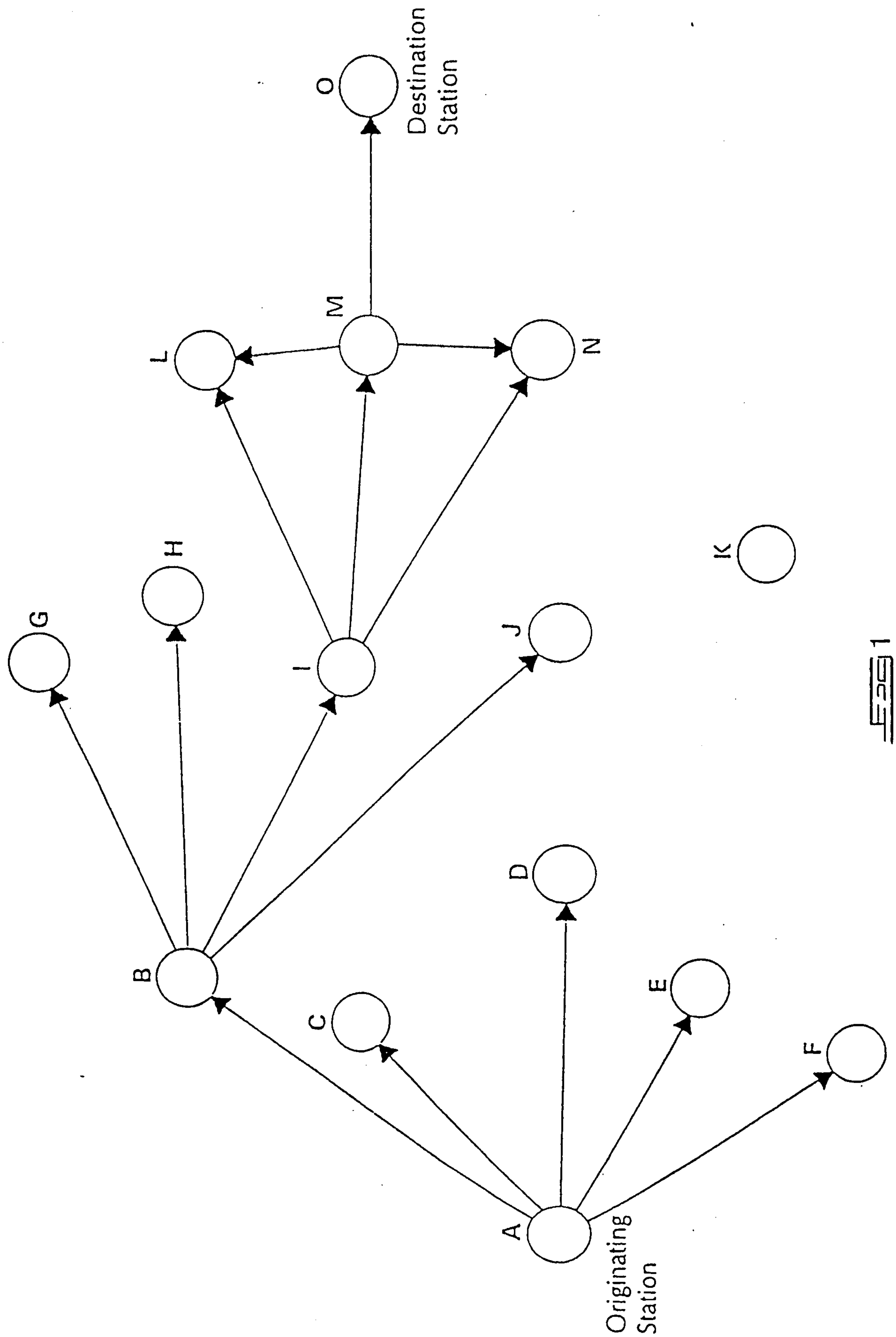

O
Destination Station
L
M
N
G
H
I
J
K
B
C
D
E
F
A
Originating Station

FIG 1

Fig 2A

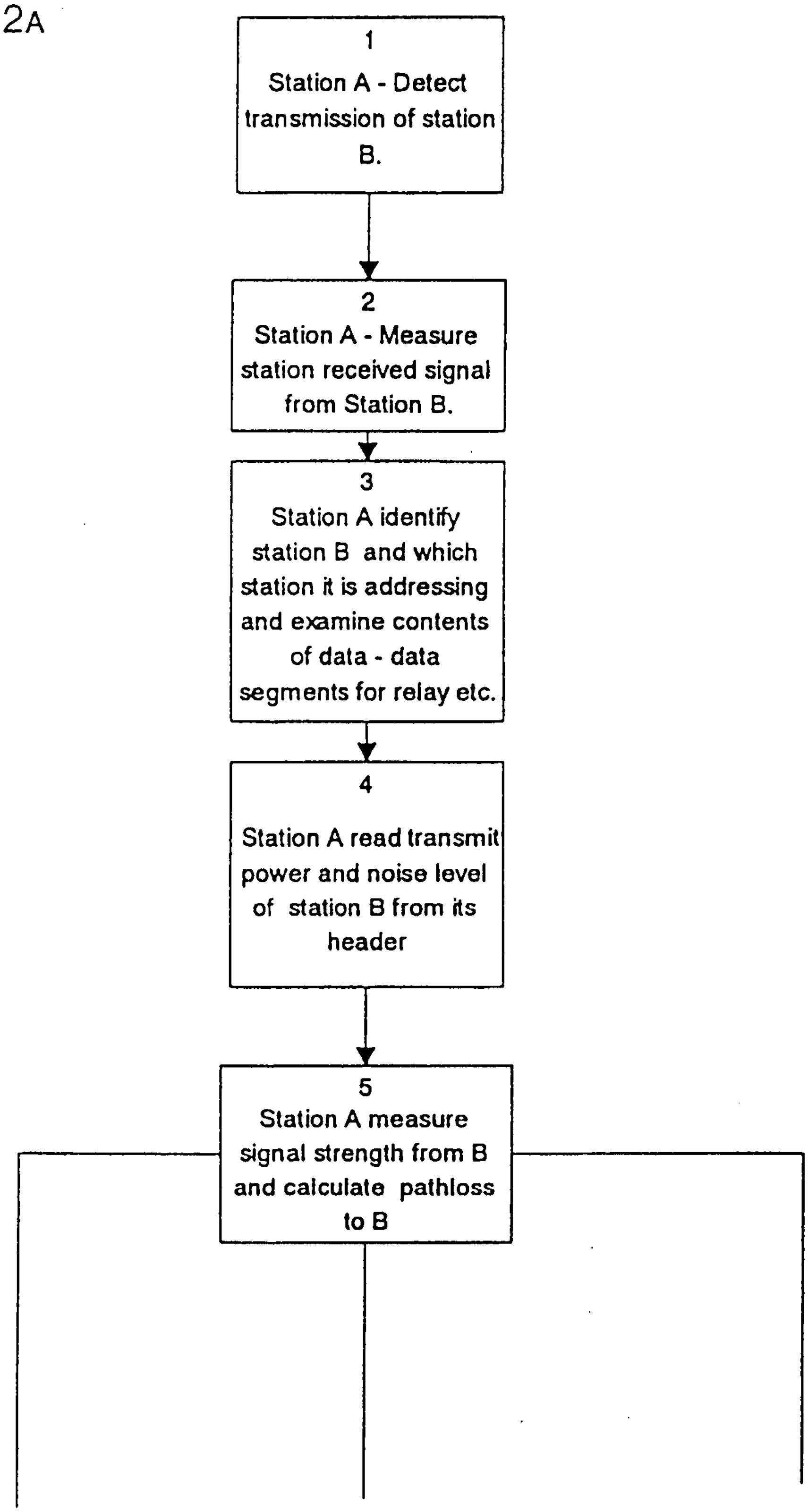
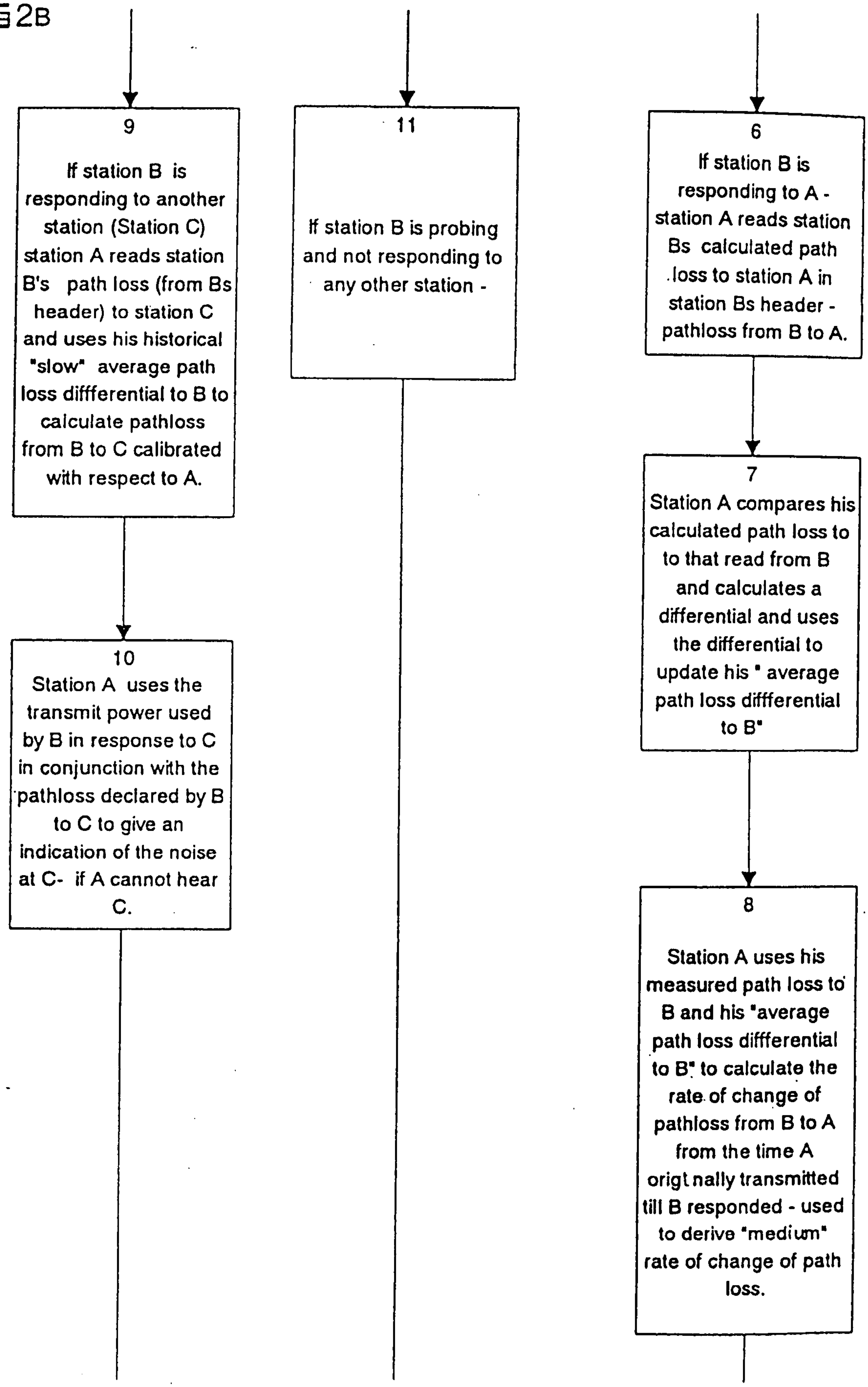
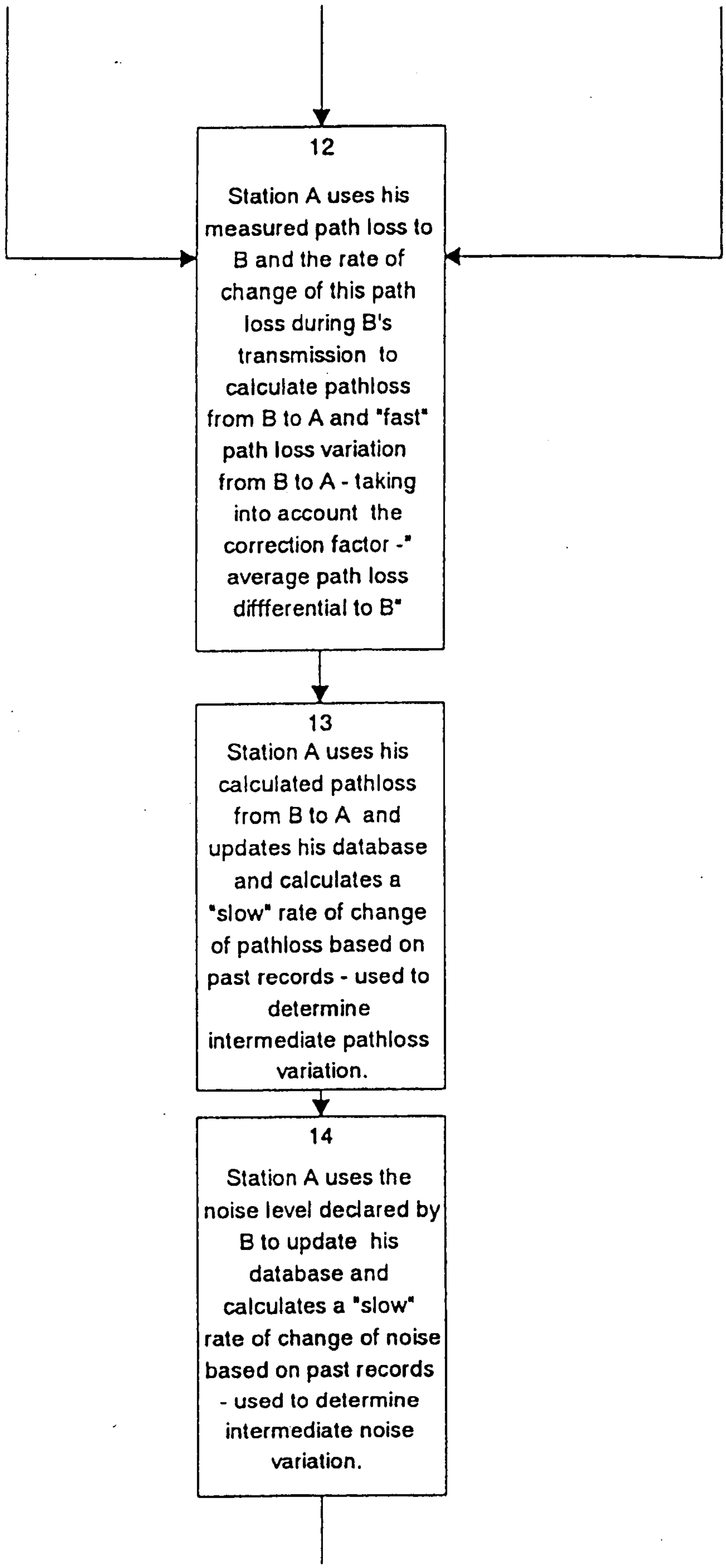

1
Station A - Detect transmission of station B.
2
Station A - Measure station received signal from Station B.
3
Station A identify station B and which station it is addressing and examine contents of data - data segments for relay etc.
4
Station A read transmit power and noise level of station B from its header
5
Station A measure signal strength from B and calculate pathloss to B

FIG 2B


9
If station B is responding to another station (Station C) station A reads station B's path loss (from Bs header) to station C and uses his historical "slow" average path loss diffferential to B to calculate pathloss from B to C calibrated with respect to A.
10
Station A uses the transmit power used by B in response to C in conjunction with the pathloss declared by B to C to give an indication of the noise at C- if A cannot hear C.
11
If station B is probing and not responding to any other station -
6
If station B is responding to A - station A reads station Bs calculated path loss to station A in station Bs header - pathloss from B to A.
7
Station A compares his calculated path loss to to that read from B and calculates a differential and uses the differential to update his " average path loss diffferential to B"
8
Station A uses his measured path loss to B and his "average path loss diffferential to B" to calculate the rate of change of pathloss from B to A from the time A origtnally transmitted till B responded - used to derive "medium" rate of change of path loss.


12
Station A uses his measured path loss to B and the rate of change of this path loss during B's transmission to calculate pathloss from B to A and "fast" path loss variation from B to A - taking into account the correction factor -" average path loss diffferential to B"
13
Station A uses his calculated pathloss from B to A and updates his database and calculates a "slow" rate of change of pathloss based on past records - used to determine intermediate pathloss variation.
14
Station A uses the noise level declared by B to update his database and calculates a "slow" rate of change of noise based on past records - used to determine intermediate noise variation.

2C

FIG 2D

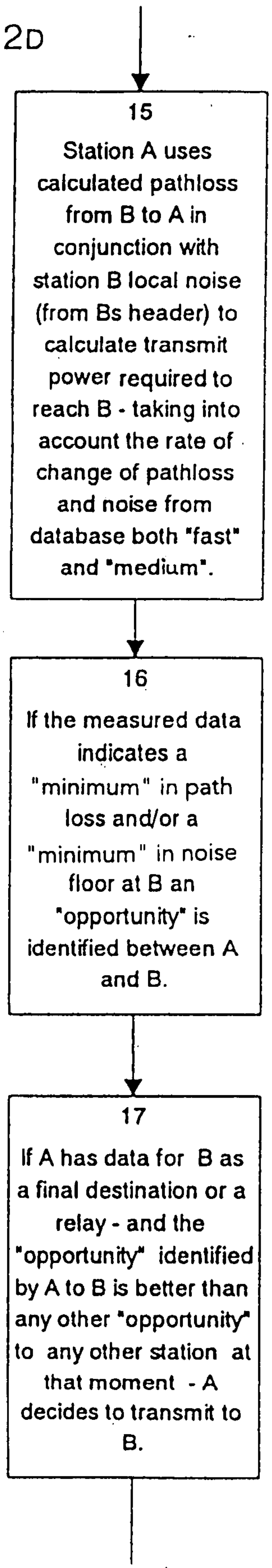

15
Station A uses calculated pathloss from B to A in conjunction with station B local noise (from Bs header) to calculate transmit power required to reach B - taking into account the rate of change of pathloss and noise from database both "fast" and "medium".
16
If the measured data indicates a "minimum" in path loss and/or a "minimum" in noise floor at B an "opportunity" is identified between A and B.
17
If A has data for B as a final destination or a relay - and the "opportunity" identified by A to B is better than any other "opportunity" to any other station at that moment - A decides to transmit to B.

FIG 2E

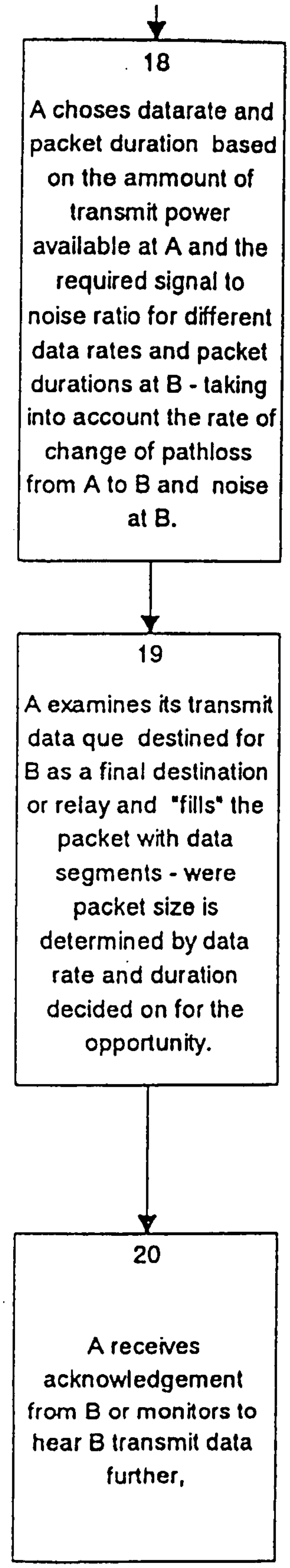
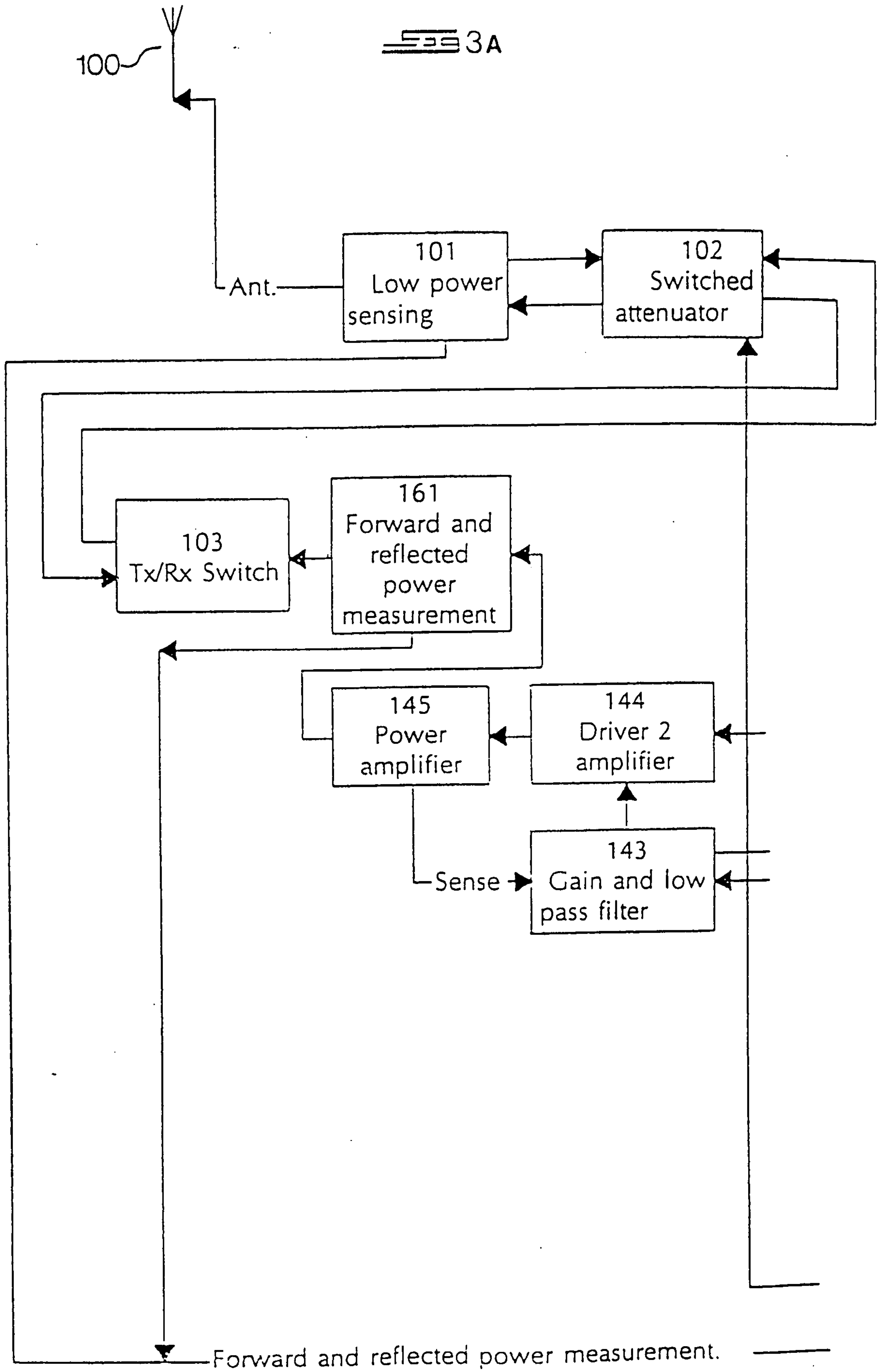

18
A choses datarate and packet duration based on the ammount of transmit power available at A and the required signal to noise ratio for different data rates and packet durations at B - taking into account the rate of change of pathloss from A to B and noise at B.
19
A examines its transmit data que destined for B as a final destination or relay and "fills" the packet with data segments - were packet size is determined by data rate and duration decided on for the opportunity.
20
A receives acknowledgement from B or monitors to hear B transmit data further,

FIG. 3A



100
101
Low power
sensing
Ant.
102
Switched
attenuator
161
Forward and
reflected
power
measurement
103
Tx/Rx Switch
145
Power
amplifier
144
Driver 2
amplifier
143
Gain and low
pass filter
Sense
Forward and reflected power measurement.

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FIG. 3B

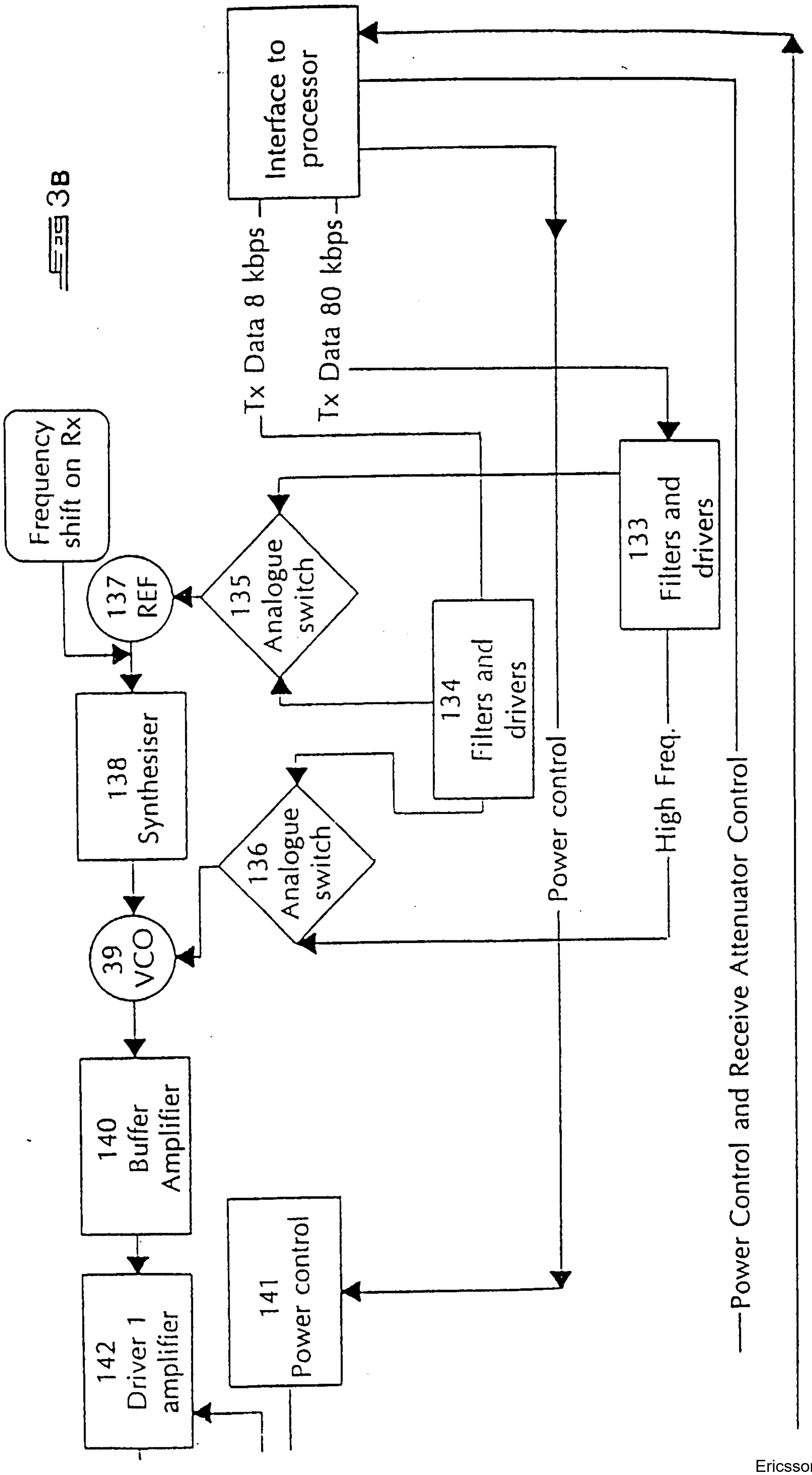

Interface to processor
Tx Data 8 kbps
Tx Data 80 kbps
Power control
Power Control and Receive Attenuator Control
133 Filters and drivers
134 Filters and drivers
High Freq.
135 Analogue switch
136 Analogue switch
Frequency shift on Rx
137 REF
138 Synthesiser
39 VCO
140 Buffer Amplifier
141 Power control
142 Driver 1 amplifier

FIG 4A

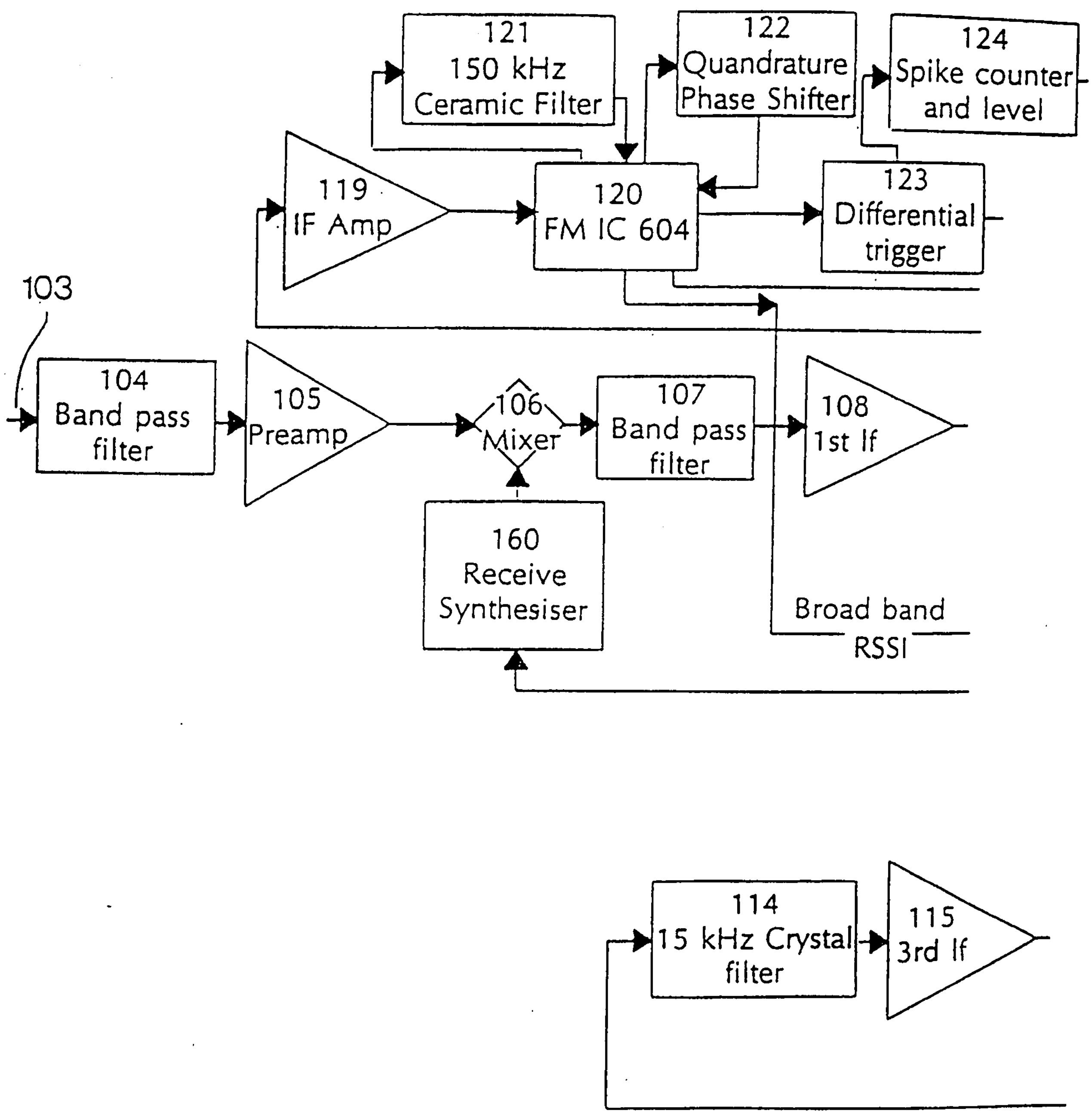

121
150 kHz
Ceramic Filter
122
Quandrature
Phase Shifter
124
Spike counter
and level
119
IF Amp
120
FM IC 604
123
Differential
trigger
103
104
Band pass
filter
105
Preamp
106
Mixer
107
Band pass
filter
108
1st If
160
Receive
Synthesiser
Broad band
RSSI
114
15 kHz Crystal
filter
115
3rd If

FIG. 4B

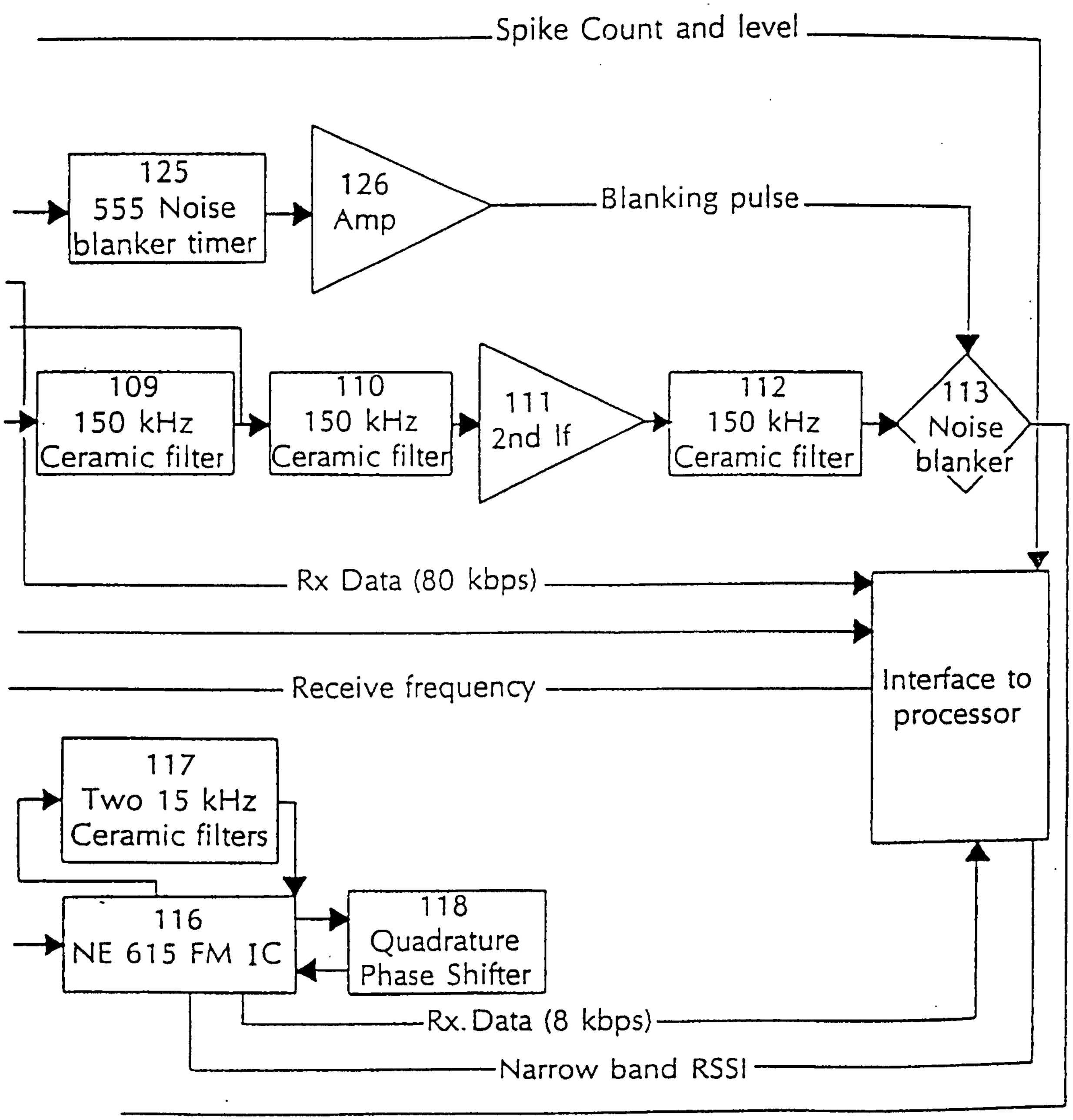

Spike Count and level
125
555 Noise
blanker timer
126
Amp
Blanking pulse
109
150 kHz
Ceramic filter
110
150 kHz
Ceramic filter
111
2nd If
112
150 kHz
Ceramic filter
113
Noise
blanker
Rx Data (80 kbps)
Receive frequency
Interface to
processor
117
Two 15 kHz
Ceramic filters
116
NE 615 FM IC
118
Quadrature
Phase Shifter
Rx. Data (8 kbps)
Narrow band RSSI

FIG 5A

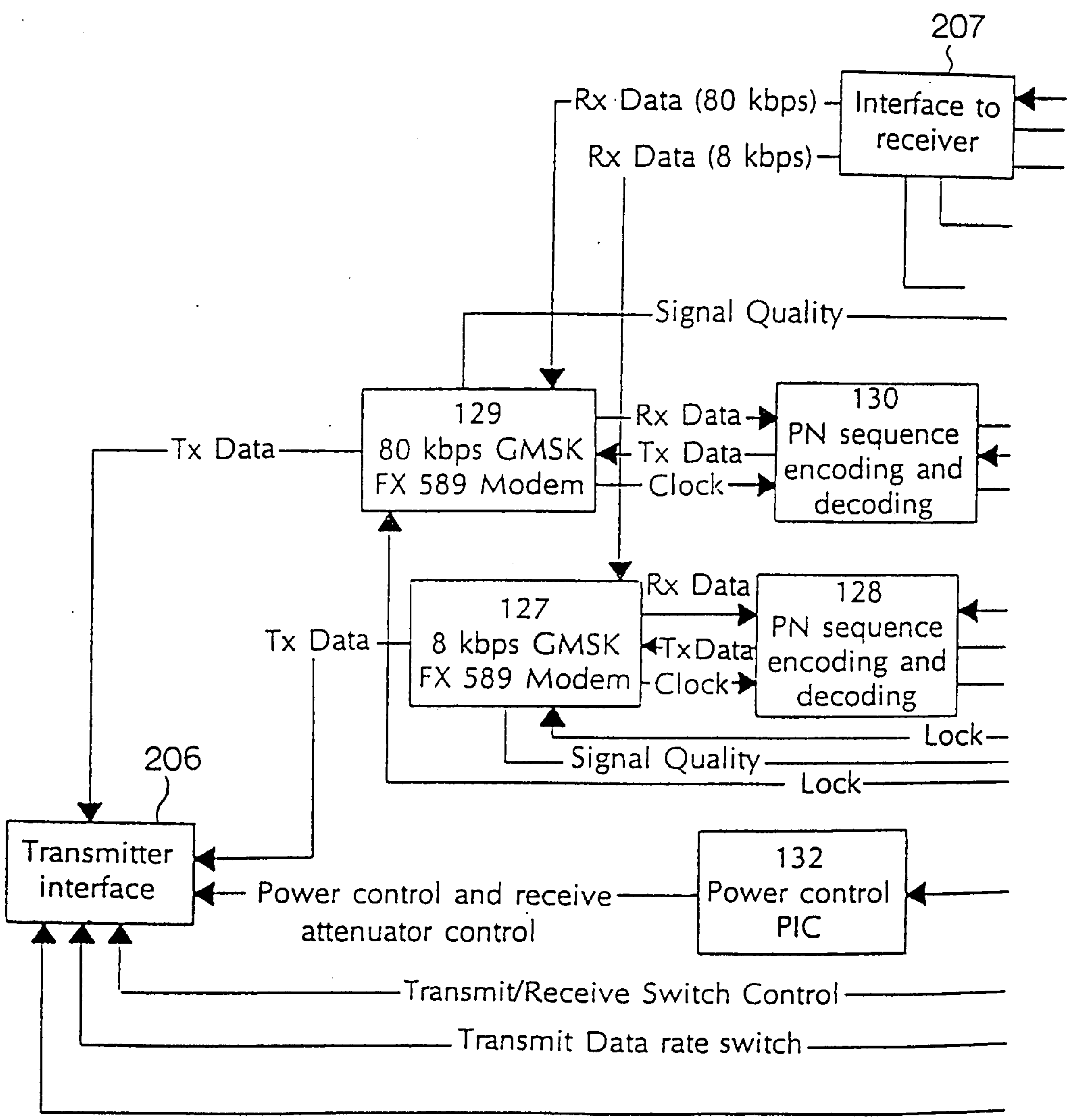
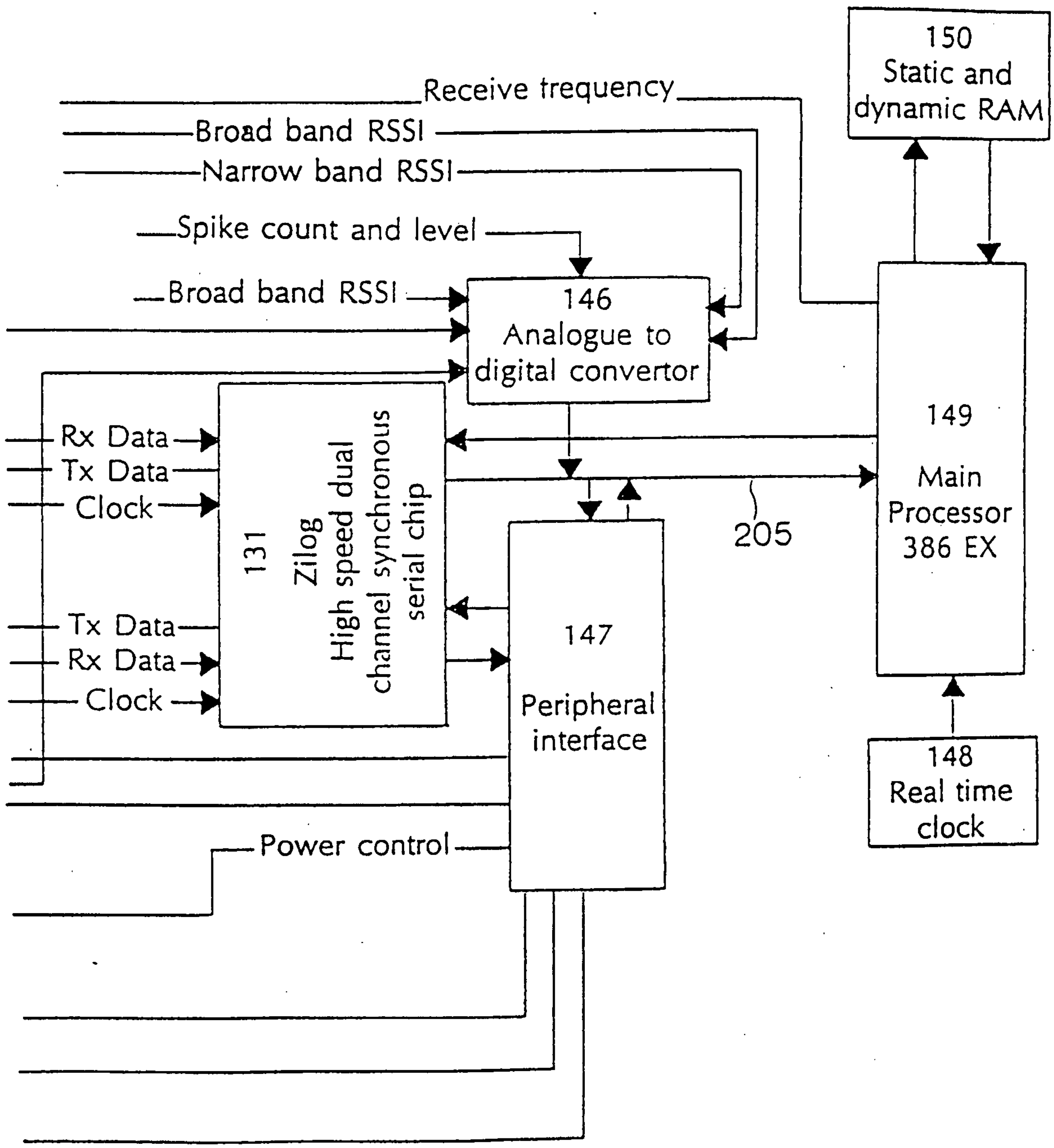

207
Interface to receiver
Rx Data (80 kbps)
Rx Data (8 kbps)
Signal Quality
129
80 kbps GMSK
FX 589 Modem
Tx Data
Rx Data
Tx Data
Clock
130
PN sequence encoding and decoding
127
8 kbps GMSK
FX 589 Modem
Tx Data
Rx Data
TxData
Clock
128
PN sequence encoding and decoding
Lock
Signal Quality
Lock
206
Transmitter interface
Power control and receive attenuator control
132
Power control PIC
Transmit/Receive Switch Control
Transmit Data rate switch

FIG. 5B



Receive frequency
Broad band RSSI
Narrow band RSSI
Spike count and level
Broad band RSSI
146
Analogue to
digital convertor
150
Static and
dynamic RAM
Rx Data
Tx Data
Clock
131
Zilog
High speed dual
channel synchronous
serial chip
Tx Data
Rx Data
Clock
205
149
Main
Processor
386 EX
147
Peripheral
interface
148
Real time
clock
Power control

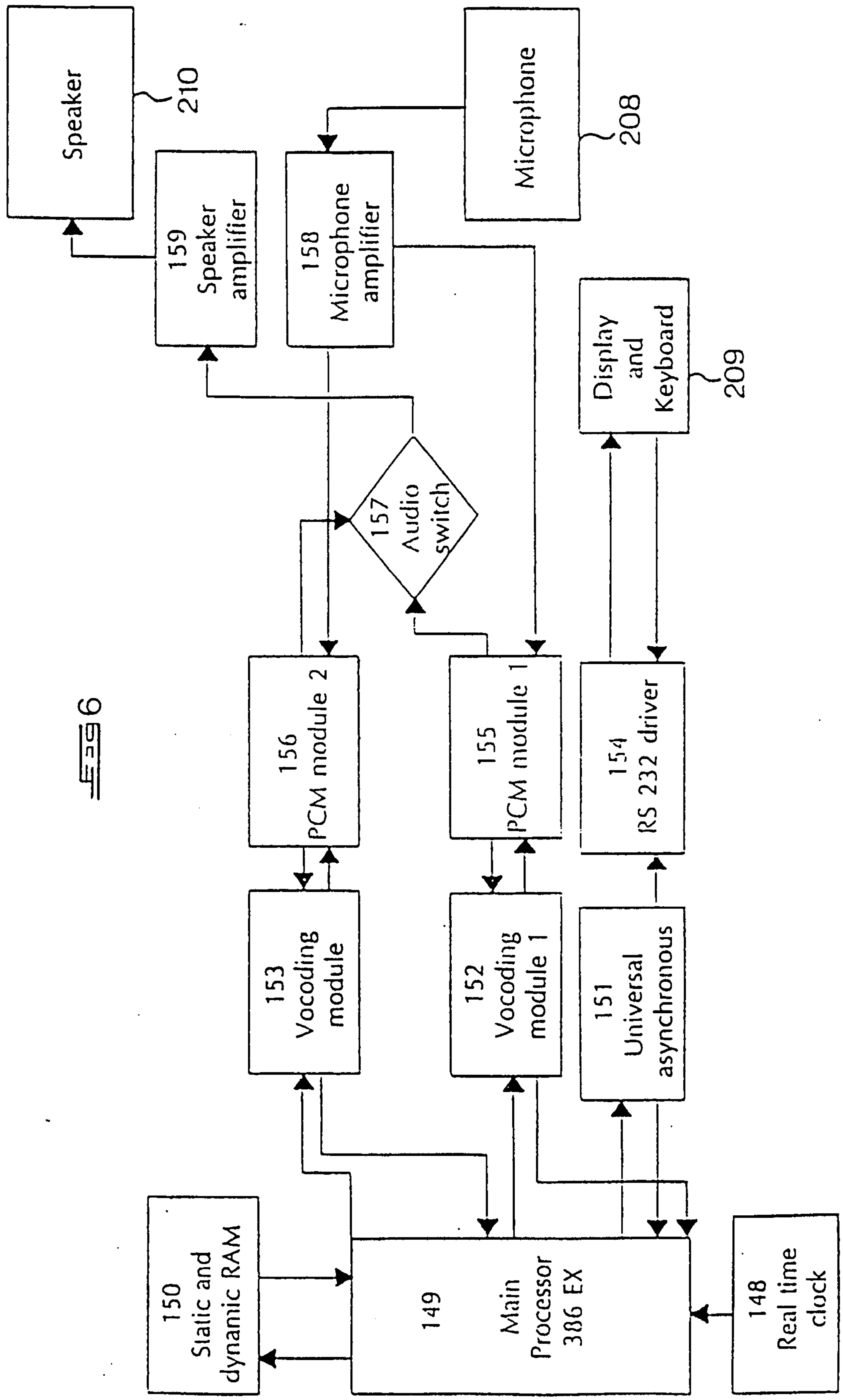

Speaker
210
Microphone
208
159 Speaker amplifier
158 Microphone amplifier
Display and Keyboard
209
157 Audio switch
156 PCM module 2
155 PCM module 1
154 RS 232 driver
153 Vocoding module
152 Vocoding module 1
151 Universal asynchronous
150 Static and dynamic RAM
149 Main Processor 386 EX
148 Real time clock

Fig 6

FIG 7A

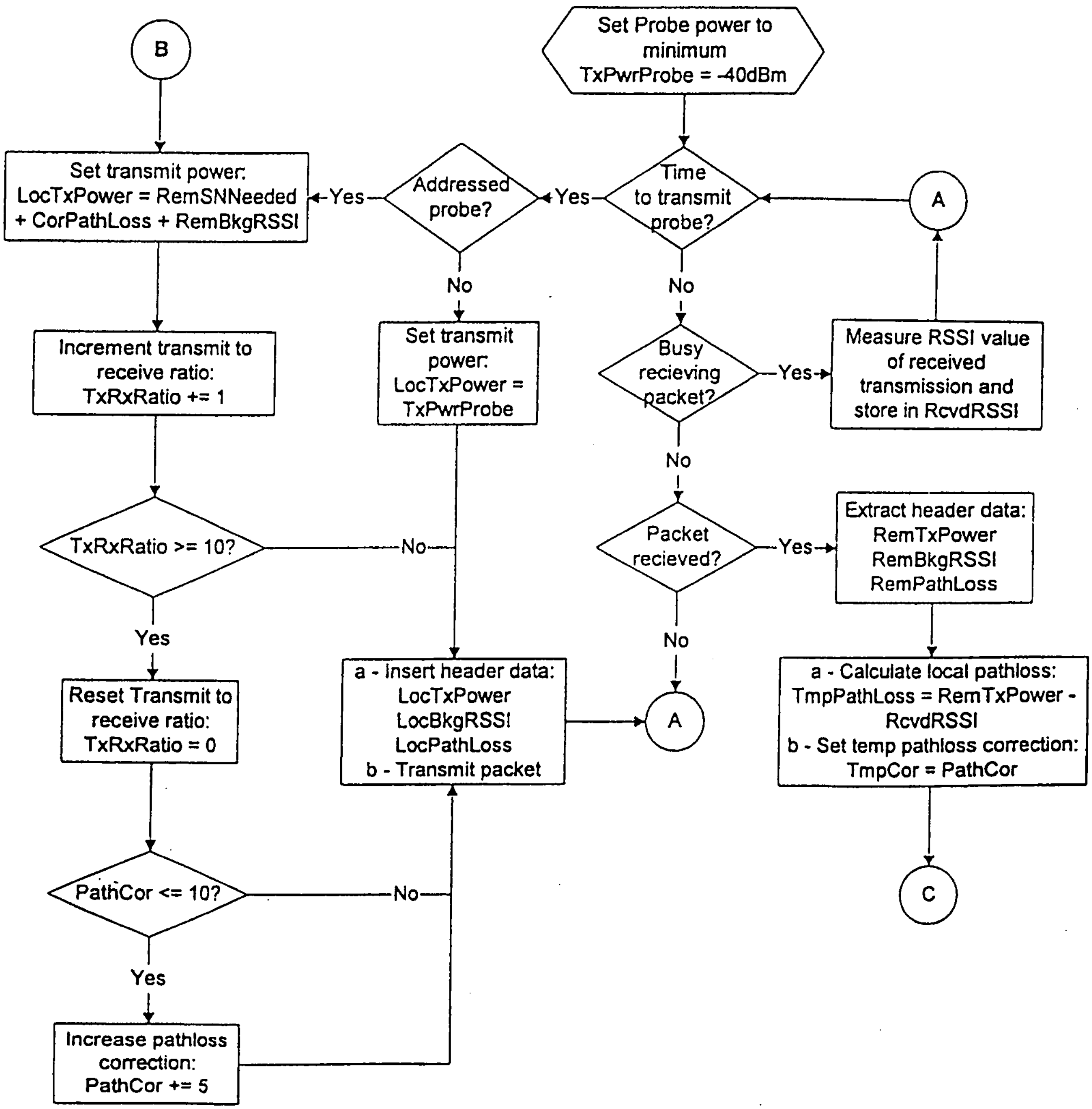
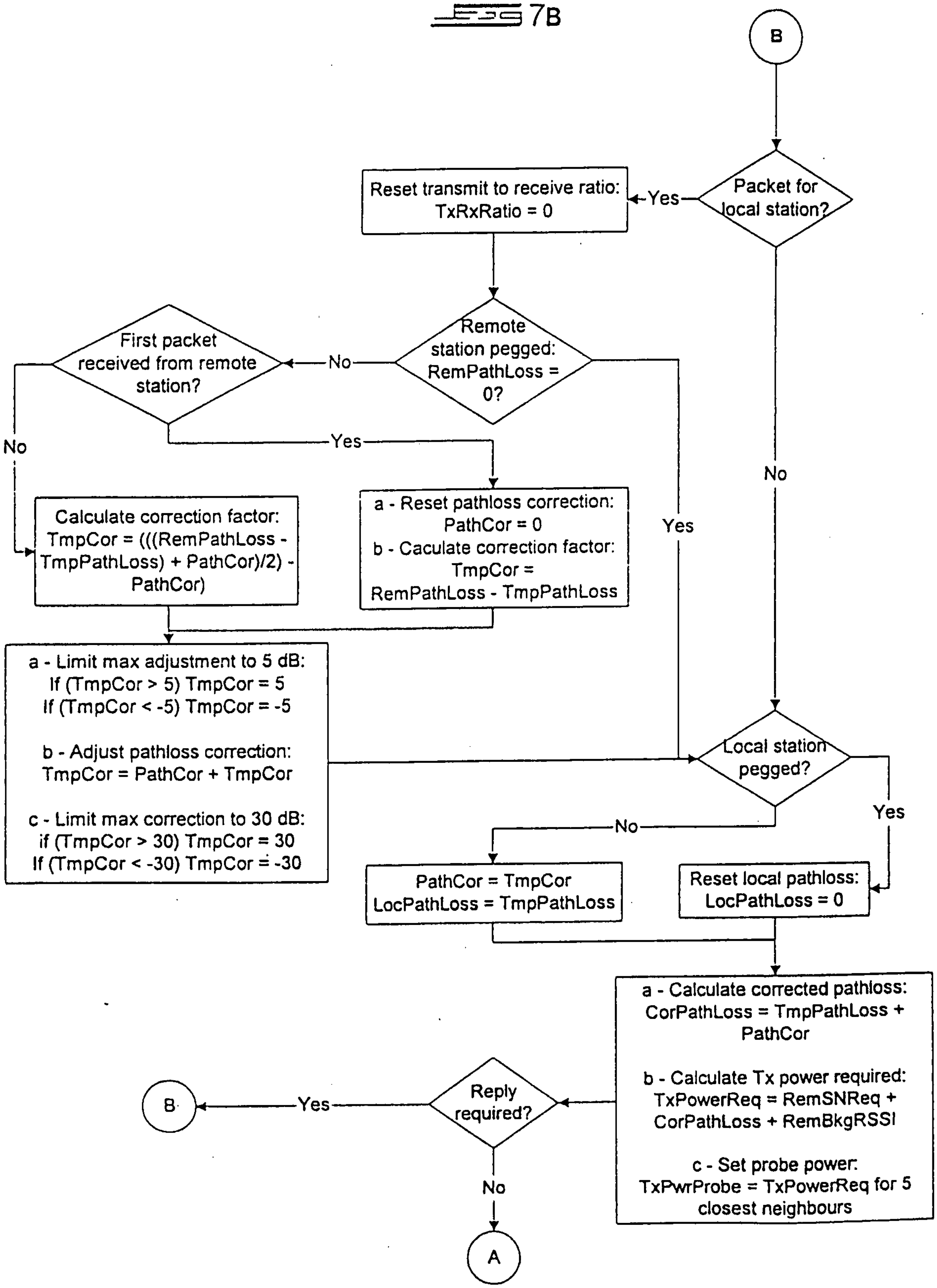

Set Probe power to minimum TxPwrProbe = -40dBm
B
Set transmit power: LocTxPower = RemSNNeeded + CorPathLoss + RemBkgRSSI
Yes
Addressed probe?
Yes
Time to transmit probe?
A
No
No
Increment transmit to receive ratio: TxRxRatio += 1
Set transmit power: LocTxPower = TxPwrProbe
Busy recieving packet?
Yes
Measure RSSI value of received transmission and store in RcvdRSSI
No
TxRxRatio >= 10?
No
Packet recieved?
Yes
Extract header data: RemTxPower RemBkgRSSI RemPathLoss
Yes
No
Reset Transmit to receive ratio: TxRxRatio = 0
a - Insert header data: LocTxPower LocBkgRSSI LocPathLoss b - Transmit packet
A
a - Calculate local pathloss: TmpPathLoss = RemTxPower - RcvdRSSI b - Set temp pathloss correction: TmpCor = PathCor
PathCor <= 10?
No
C
Yes
Increase pathloss correction: PathCor += 5

FIG 7B



B
Packet for local station?
Yes
Reset transmit to receive ratio: TxRxRatio = 0
Remote station pegged: RemPathLoss = 0?
No
First packet received from remote station?
Yes
No
Calculate correction factor: TmpCor = (((RemPathLoss - TmpPathLoss) + PathCor)/2) - PathCor)
a - Reset pathloss correction: PathCor = 0
b - Caculate correction factor: TmpCor = RemPathLoss - TmpPathLoss
Yes
No
a - Limit max adjustment to 5 dB: If (TmpCor > 5) TmpCor = 5 If (TmpCor < -5) TmpCor = -5
b - Adjust pathloss correction: TmpCor = PathCor + TmpCor
c - Limit max correction to 30 dB: if (TmpCor > 30) TmpCor = 30 If (TmpCor < -30) TmpCor = -30
Local station pegged?
No
Yes
PathCor = TmpCor LocPathLoss = TmpPathLoss
Reset local pathloss: LocPathLoss = 0
a - Calculate corrected pathloss: CorPathLoss = TmpPathLoss + PathCor
b - Calculate Tx power required: TxPowerReq = RemSNReq + CorPathLoss + RemBkgRSSI
c - Set probe power: TxPwrProbe = TxPowerReq for 5 closest neighbours
Reply required?
Yes
B
No
A

FIG 8A

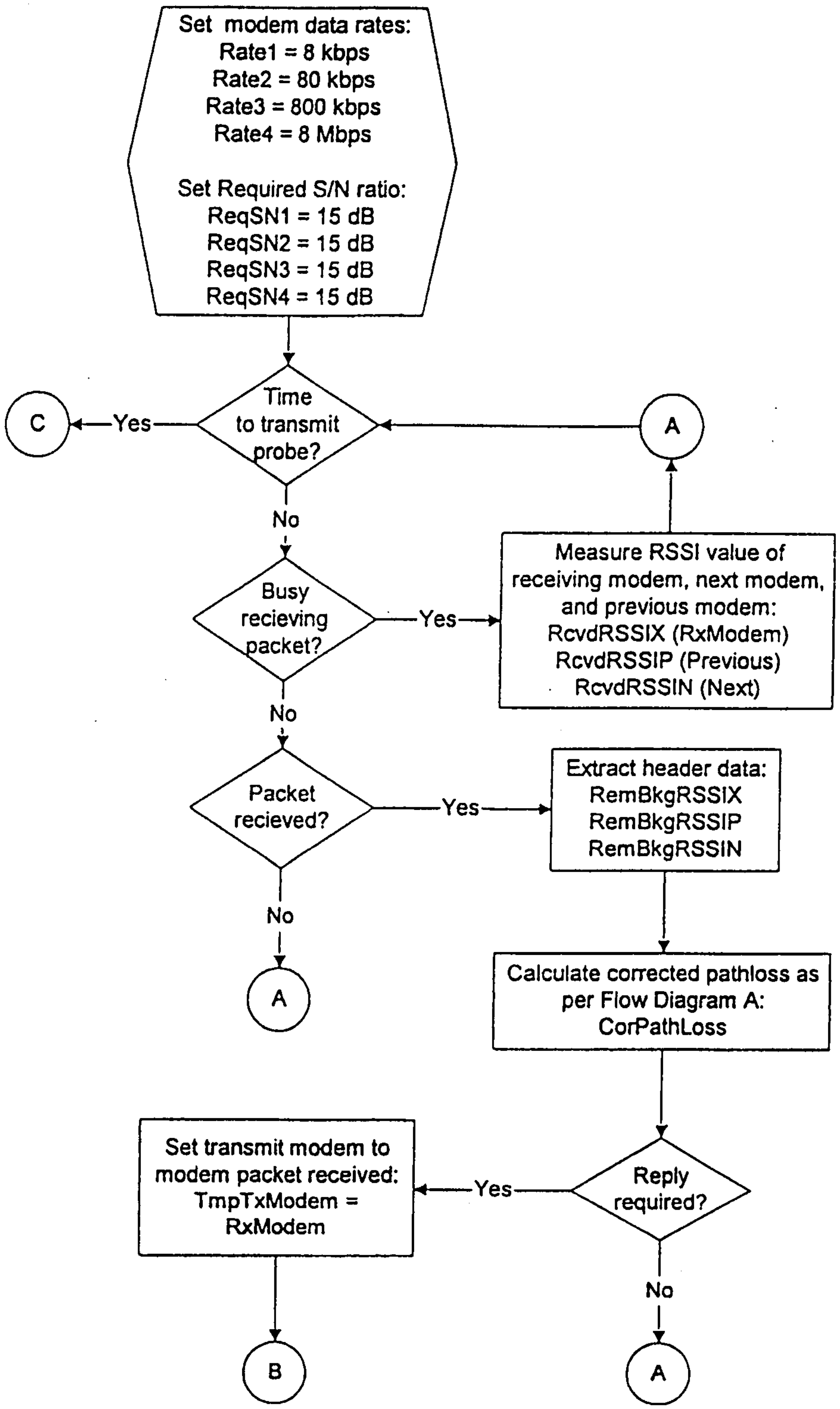

Set modem data rates:
Rate1 = 8 kbps
Rate2 = 80 kbps
Rate3 = 800 kbps
Rate4 = 8 Mbps
Set Required S/N ratio:
ReqSN1 = 15 dB
ReqSN2 = 15 dB
ReqSN3 = 15 dB
ReqSN4 = 15 dB
C
Yes
Time to transmit probe?
A
No
Busy recieving packet?
Yes
Measure RSSI value of receiving modem, next modem, and previous modem:
RcvdRSSIX (RxModem)
RcvdRSSIP (Previous)
RcvdRSSIN (Next)
No
Packet recieved?
Yes
Extract header data:
RemBkgRSSIX
RemBkgRSSIP
RemBkgRSSIN
No
A
Calculate corrected pathloss as per Flow Diagram A:
CorPathLoss
Set transmit modem to modem packet received:
TmpTxModem = RxModem
Yes
Reply required?
No
B
A

FIG. 8B

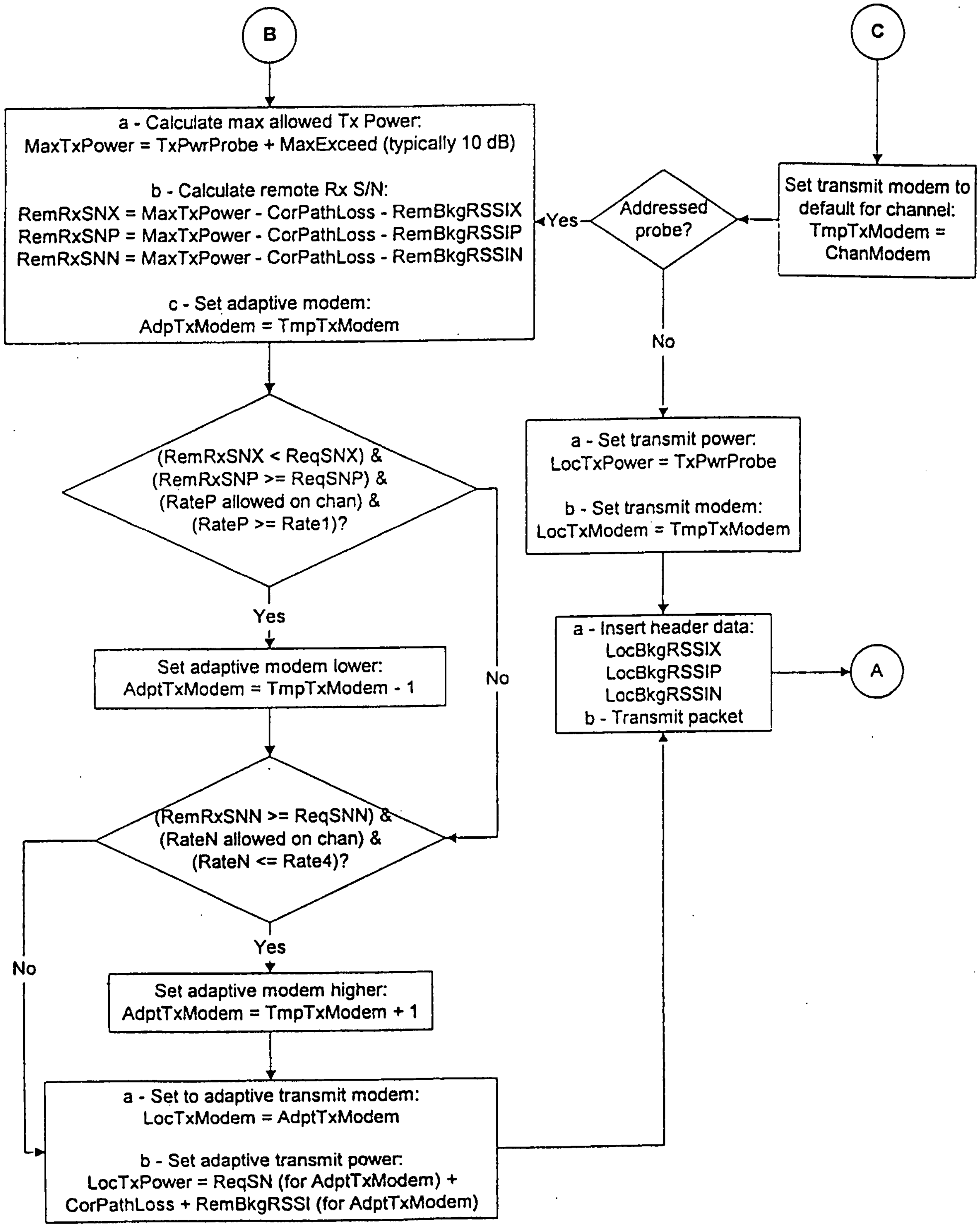

B
C
a - Calculate max allowed Tx Power:
MaxTxPower = TxPwrProbe + MaxExceed (typically 10 dB)
b - Calculate remote Rx S/N:
RemRxSNX = MaxTxPower - CorPathLoss - RemBkgRSSIX
RemRxSNP = MaxTxPower - CorPathLoss - RemBkgRSSIP
RemRxSNN = MaxTxPower - CorPathLoss - RemBkgRSSIN
c - Set adaptive modem:
AdpTxModem = TmpTxModem
Set transmit modem to default for channel:
TmpTxModem = ChanModem
Addressed probe?
Yes
No
a - Set transmit power:
LocTxPower = TxPwrProbe
b - Set transmit modem:
LocTxModem = TmpTxModem
(RemRxSNX < ReqSNX) &
(RemRxSNP >= ReqSNP) &
(RateP allowed on chan) &
(RateP >= Rate1)?
Yes
No
Set adaptive modem lower:
AdptTxModem = TmpTxModem - 1
a - Insert header data:
LocBkgRSSIX
LocBkgRSSIP
LocBkgRSSIN
b - Transmit packet
A
(RemRxSNN >= ReqSNN) &
(RateN allowed on chan) &
(RateN <= Rate4)?
Yes
No
Set adaptive modem higher:
AdptTxModem = TmpTxModem + 1
a - Set to adaptive transmit modem:
LocTxModem = AdptTxModem
b - Set adaptive transmit power:
LocTxPower = ReqSN (for AdptTxModem) +
CorPathLoss + RemBkgRSSI (for AdptTxModem)

FIG 9A

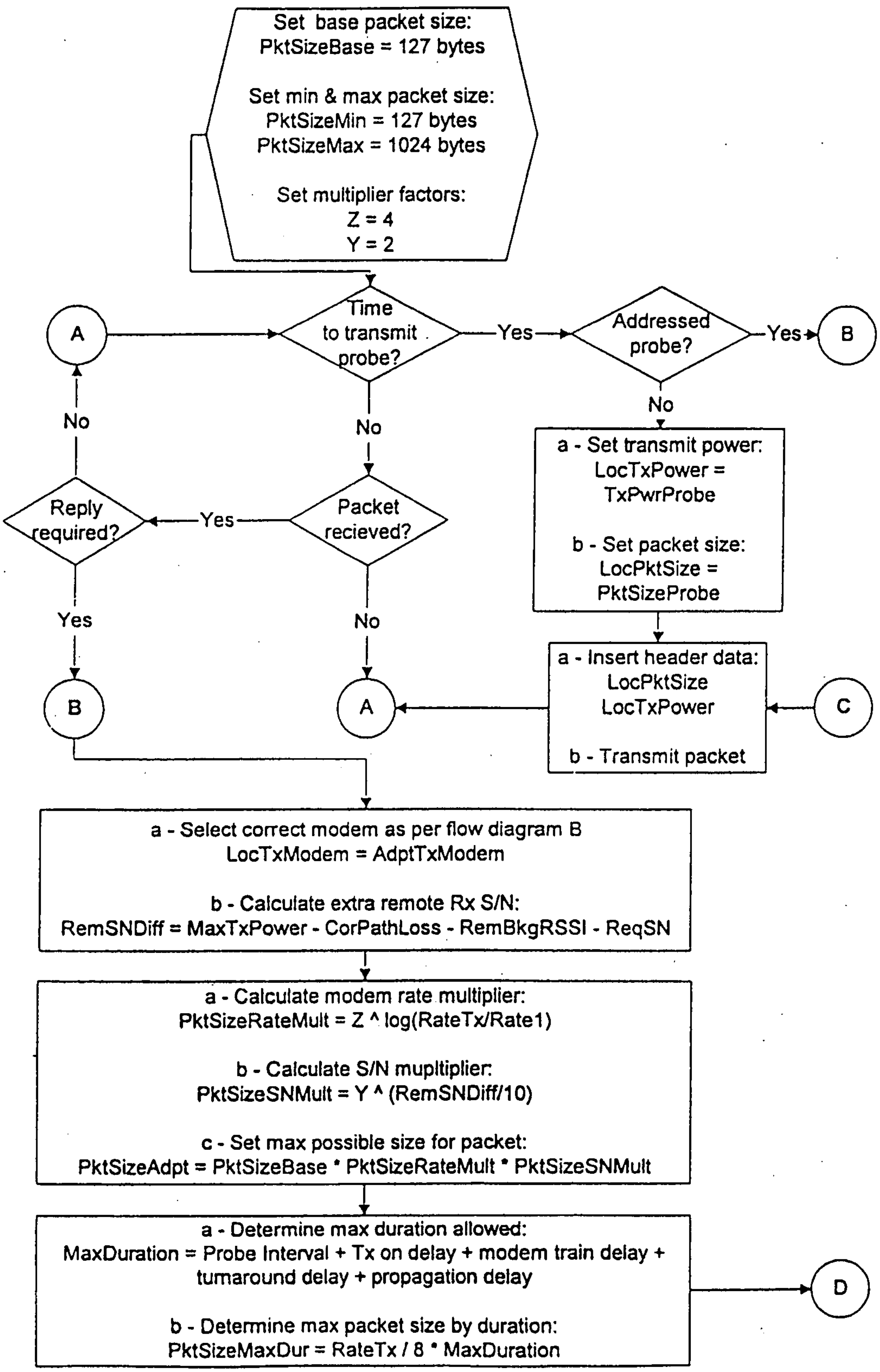
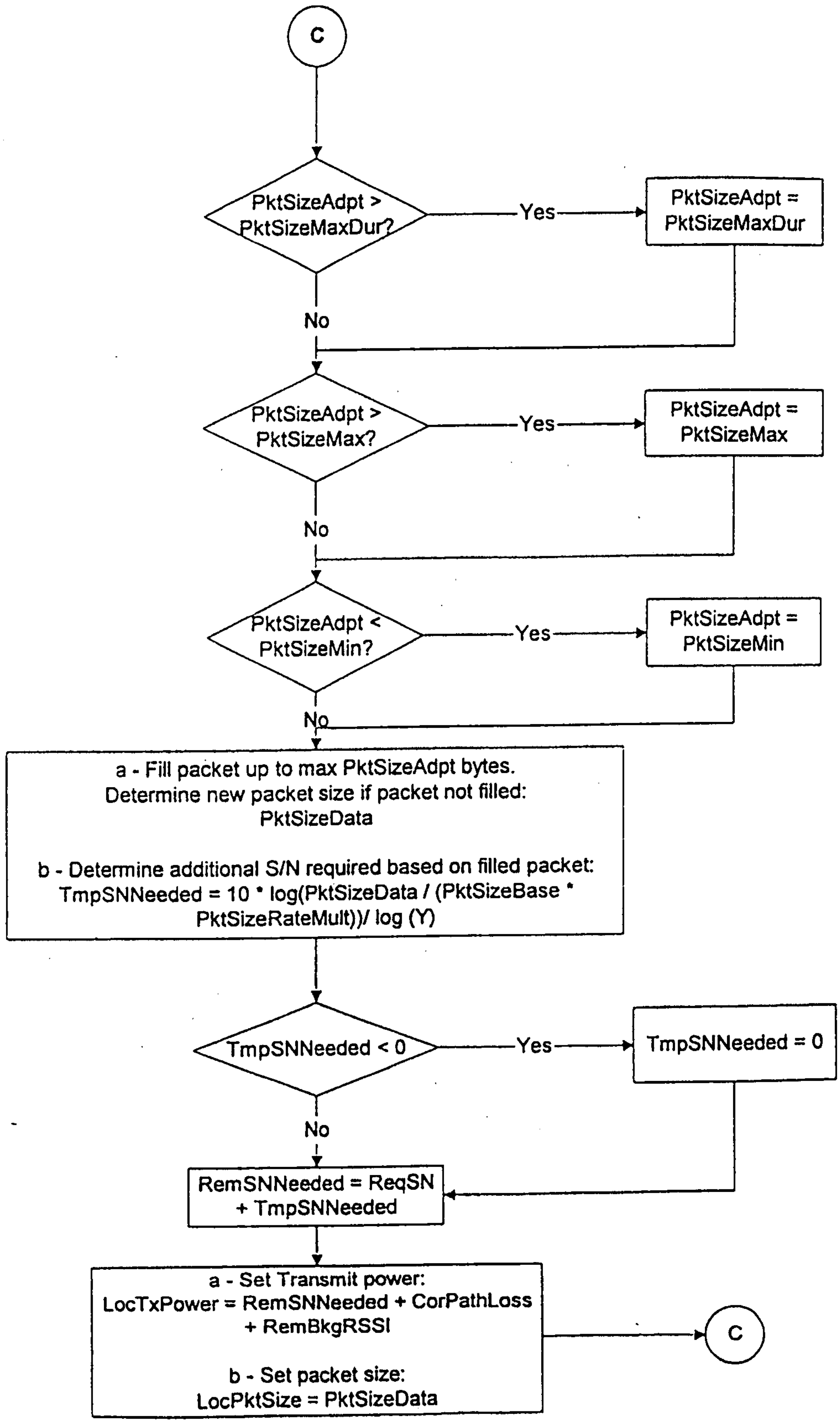

Set base packet size:
PktSizeBase = 127 bytes
Set min & max packet size:
PktSizeMin = 127 bytes
PktSizeMax = 1024 bytes
Set multiplier factors:
Z = 4
Y = 2
A
Time to transmit probe?
Yes
Addressed probe?
Yes
B
No
No
a - Set transmit power:
LocTxPower = TxPwrProbe
b - Set packet size:
LocPktSize = PktSizeProbe
No
Reply required?
Yes
Packet recieved?
Yes
No
a - Insert header data:
LocPktSize
LocTxPower
b - Transmit packet
B
A
C
a - Select correct modem as per flow diagram B
LocTxModem = AdptTxModem
b - Calculate extra remote Rx S/N:
RemSNDiff = MaxTxPower - CorPathLoss - RemBkgRSSI - ReqSN
a - Calculate modem rate multiplier:
PktSizeRateMult = Z ^ log(RateTx/Rate1)
b - Calculate S/N mupltiplier:
PktSizeSNMult = Y ^ (RemSNDiff/10)
c - Set max possible size for packet:
PktSizeAdpt = PktSizeBase * PktSizeRateMult * PktSizeSNMult
a - Determine max duration allowed:
MaxDuration = Probe Interval + Tx on delay + modem train delay + turnaround delay + propagation delay
b - Determine max packet size by duration:
PktSizeMaxDur = RateTx / 8 * MaxDuration
D

FIG 9B


C
PktSizeAdpt > PktSizeMaxDur?
Yes
PktSizeAdpt = PktSizeMaxDur
No
PktSizeAdpt > PktSizeMax?
Yes
PktSizeAdpt = PktSizeMax
No
PktSizeAdpt < PktSizeMin?
Yes
PktSizeAdpt = PktSizeMin
No
a - Fill packet up to max PktSizeAdpt bytes.
Determine new packet size if packet not filled:
PktSizeData
b - Determine additional S/N required based on filled packet:
TmpSNNeeded = 10 * log(PktSizeData / (PktSizeBase * PktSizeRateMult))/ log (Y)
TmpSNNeeded < 0
Yes
TmpSNNeeded = 0
No
RemSNNeeded = ReqSN + TmpSNNeeded
a - Set Transmit power:
LocTxPower = RemSNNeeded + CorPathLoss + RemBkgRSSI
b - Set packet size:
LocPktSize = PktSizeData
C

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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04B 7/005, H04L 12/56 | A3

(11) International Publication Number: WO 99/07105

(43) International Publication Date: 11 February 1999 (11.02.99)

(21) International Application Number: PCT/GB98/02329

(22) International Filing Date: 3 August 1998 (03.08.98)

(30) Priority Data:
97/6885 1 August 1997 (01.08.97) ZA

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(71) Applicant *(for IS only)*: TOMLINSON, Kerry, John [GB/GB]; 79 Hove Park Road, Hove, East Sussex BN3 6LL (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: LARSEN, Mark, Sievert [ZA/ZA]; 49 Kirkia Avenue, Val-de-Grace 0184 (ZA). LARSEN, James, David [ZA/ZA]; Portion 86–87 of Farm Doornkloof, Pretoria 0002 (ZA).

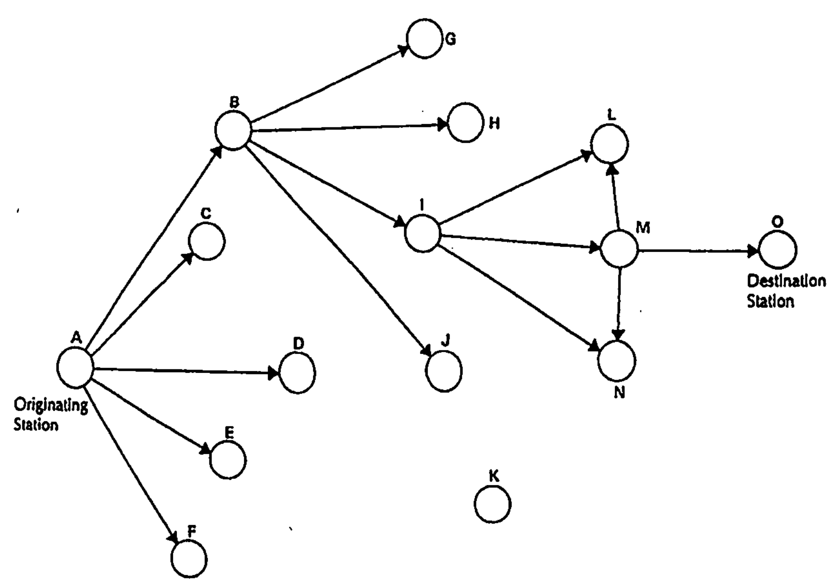
(74) Agent: TOMLINSON, Kerry, John; Frank B. Dehn & Co., 179 Queen Victoria Street, London EC4V 4EL (GB).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(88) Date of publication of the international search report: 1 July 1999 (01.07.99)

(54) Title: POWER ADAPTION IN A MULTI–STATION NETWORK



(57) Abstract

The invention relates to a method of operating a communication network, the network comprising a plurality of stations which are able to transmit data to and receive data from one another. The method comprises monitoring, at each station, the transmission path quality between that station and each other station with which that station can communicate. Data corresponding to the monitored path quality is recorded at each station, thereby permitting a transmission power value based on the relevant path quality data to be selected when transmitting data to another station. Thus, the probability of transmitting data to any selected station at an optimum power level is increased. Each station transmits path quality data in its own transmissions as well as local noise/interference data, so that other stations can obtain path quality data for a particular station even if they are out of range of that particular station. The invention extends to communication apparatus which can be used to implement the method.

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INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/GB 98/02329

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/005 H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 31009 A (CELSAT AMERICA INC) 3 October 1996 see abstract see page 2, line 13 - page 8, line 2 see page 9, line 14 - page 13, line 17 see page 23, line 3 - page 28, line 9 see page 31, line 19 - page 32, line 2	1-5,8, 12-16,20
Y		6,9-11, 17
A		7,18,19

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
27 April 1999	12/05/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Vaskimo, K

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INTERNATIONAL SEARCH REPORT

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PCT/GB 98/02329

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X	WO 96 19887 A (SALBU RES AND DEV PTY LTD ;BROWN KEITH EDWIN FRANK (ZA); LARSEN DA) 27 June 1996 cited in the application see abstract see page 1, line 14 - page 5, line 16 see page 6, line 16 - page 9, line 6 see page 12, line 15 - page 14, line 26 see page 16, line 21 - page 18, line 2 see page 20, line 5 - page 22, line 21 see page 24, line 14 - page 26, line 7 see page 30, line 17 - page 32, line 16	1-3,12, 13
Y		4,9,11, 14
A		5,8,20
Y	US 5 564 075 A (GOURGUE FREDERIC) 8 October 1996 see abstract see column 1, line 9 - line 12 see column 1, line 64 - column 2, line 39 see column 3, line 3 - column 4, line 33 see column 5, line 24 - line 41	4,14
A		1-3, 11-13
Y	WO 95 12295 A (NOKIA TELECOMMUNICATIONS OY ;KESKITALO ILKKA (FI); KIEMA ARTO (FI)) 4 May 1995 see page 1, line 20 - page 2, line 11 see page 3, line 11 - page 4, line 32 see page 8, line 7 - line 26 see claims 1,2	6,17
A		1,4,5,7, 13-16, 18,19
Y	EP 0 602 340 A (MOTOROLA LTD) 22 June 1994 see column 1, line 9 - column 3, line 24 see column 4, line 11 - line 41 see column 5, line 15 - column 7, line 34 see column 8, line 8 - column 9, line 57	6,17
A		1,4,5,7, 13-16, 18,19
Y	EP 0 767 548 A (AT & T CORP) 9 April 1997 see column 3, line 13 - column 4, line 41 see column 6, line 13 - column 10, line 27	9
A		1,4,8

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2

INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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2

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PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

Appln No. 10/917,968
Docket No. 562492000500

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04B 7/005 — A1

(11) International Publication Number: WO 00/57574

(43) International Publication Date: 28 September 2000 (28.09.00)

(21) International Application Number: PCT/US00/07476

(22) International Filing Date: 22 March 2000 (22.03.00)

(30) Priority Data:

60/125,417	22 March 1999 (22.03.99)	US
60/136,556	28 May 1999 (28.05.99)	US
60/136,557	28 May 1999 (28.05.99)	US

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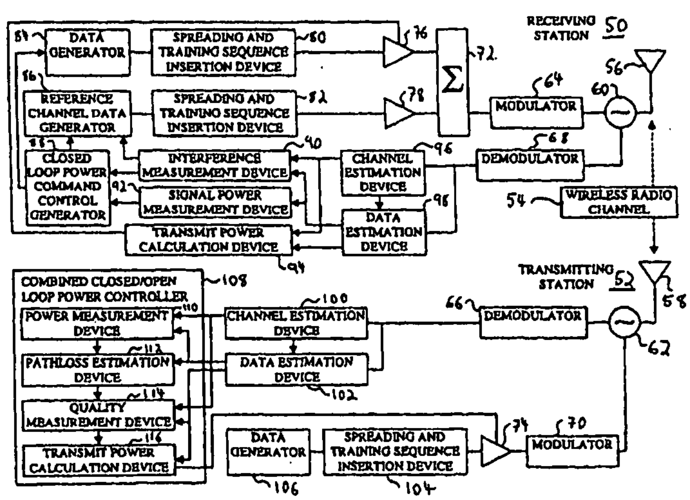
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: COMBINED CLOSED LOOP/OPEN LOOP POWER CONTROL IN A TIME DIVISION DUPLEX COMMUNICATION SYSTEM



(57) Abstract

Combined closed loop/open loop power control controls transmission power levels in a spread spectrum time division duplex communication station. A first communication station (50) receives communications from a second communication station (52). The first station transmits power commands based on in part a reception quality of the received communications. The first station transmits a second communication having a transmission power level in a first time slot. The second station receives the second communication and the power commands. A power level of the second communication as received is measured. A path loss estimate is determined based on in part the measured received second communication power level and the first communication transmission power level. The second station transmits a second communication to the first station in a second time slot. The second communication transmission power level is set based on in part the path loss estimate weighted by a factor and the power commands. The factor is a function of a time separation of the first and second time slots.

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COMBINED CLOSED LOOP/OPEN LOOP POWER CONTROL IN A TIME DIVISION DUPLEX COMMUNICATION SYSTEM

BACKGROUND

This invention generally relates to spread spectrum time division duplex (TDD) communication systems. More particularly, the present invention relates to a system and method for controlling transmission power within TDD communication systems.

Figure 1 depicts a wireless spread spectrum time division duplex (TDD) communication system. The system has a plurality of base stations **30_1-30_7**. Each base station **30_1** communicates with user equipments (UEs) **32_1-32_3** in its operating area. Communications transmitted from a base station **30_1** to a UE **32_1** are referred to as downlink communications and communications transmitted from a UE **32_1** to a base station **30_1** are referred to as uplink communications.

In addition to communicating over different frequency spectrums, spread spectrum TDD systems carry multiple communications over the same spectrum. The multiple signals are distinguished by their respective chip code sequences (codes). Also, to more efficiently use the spread spectrum, TDD systems as illustrated in **Figure 2** use repeating frames **34** divided into a number of time slots **36_1-$36_{n,}$**, such as fifteen time slots. In such systems, a communication is sent in selected time slots **36_1-36_n** using selected codes. Accordingly, one frame **34** is capable of carrying multiple communications distinguished by both time slot **36_1-36_n** and code. The combination of a single code in a single time slot is referred to as a resource unit. Based on the bandwidth required to support a communication, one or multiple resource units are assigned to that communication.

Most TDD systems adaptively control transmission power levels. In a TDD system, many communications may share the same time slot and spectrum. When a UE 32_1 or base station 30_1 is receiving a specific communication, all the other communications using the same time slot and spectrum cause interference to the specific communication. Increasing the transmission power level of one communication degrades the signal quality of all other communications within that time slot and spectrum. However, reducing the transmission power level too far results in undesirable signal to noise ratios (SNRs) and bit error rates (BERs) at the receivers. To maintain both the signal quality of communications and low transmission power levels, transmission power control is used.

One approach to control transmission power levels is open loop power control. In open loop power control, typically a base station 30_1 transmits to a UE 32_1 a reference downlink communication and the transmission power level of that communication. The UE 32_1 receives the reference communication and measures its received power level. By subtracting the received power level from the transmission power level, a pathloss for the reference communication is determined. To determine a transmission power level for the uplink, the downlink pathloss is added to a desired received power level at the base station 30_1. The UE's transmission power level is set to the determined uplink transmission power level.

Another approach to control transmission power level is closed loop power control. In closed loop power control, typically the base station **30_1** determines the signal to interference ratio (SIR) of a communication received from the UE **32_1**. The determined SIR is compared to a target SIR (SIR_{TARGET}). Based on the comparison, the base station **30_1** transmits a power command, b_{TPC}. After receiving the power command, the UE **32_1** increases or decreases its transmission power level based on the received power command.

Both closed loop and open loop power control have disadvantages. Under certain conditions, the performance of closed loop systems degrades. For instance, if communications sent between a UE and a base station are in a highly dynamic environment, such as due to the UE moving, such systems may not be able to adapt fast enough to compensate for the changes. The update rate of closed loop power control in TDD is 100 cycles per second which is not sufficient for fast fading channels. Open loop power control is sensitive to uncertainties in the uplink and downlink gain chains and interference levels.

One approach to combining closed loop and open loop power control was proposed by the Association of Radio Industries and Business (ARIB) and uses **Equations 1**, **2**, and **3**.

$$T_{UE} = P_{BS}(n) + L$$ **Equation 1**

$$P_{BS}(n) = P_{BS}(n-1) + b_{TPC}\,\Delta_{TPC}$$ **Equation 2**

$$b_{TPC} = \begin{cases} 1: \text{if } SIR_{BS} < SIR_{TARGET} \\ -1: \text{if } SIR_{BS} > SIR_{TARGET} \end{cases}$$ **Equation 3**

T_{UE} is the determined transmission power level of the UE **32**$_1$. L is the estimated downlink pathloss. $P_{BS}(n)$ is the desired received power level of the base station **30**$_1$ as adjusted by **Equation 2**. For each received power command, b_{TPC}, the desired received power level is increased or decreased by Δ_{TPC}. Δ_{TPC} is typically one decibel (dB). The power command, b_{TPC}, is one, when the SIR of the UE's uplink communication as measured at the base station **30**, SIR_{BS}, is less than a target SIR, SIR_{TARGET}. Conversely, the power command is minus one, when SIR_{BS} is larger than SIR_{TARGET}.

Under certain conditions, the performance of these systems degrades. For instance, if communications sent between a UE **32** and a base station **30** are in a highly dynamic environment, such as due to the UE **32** moving, the path loss estimate for open loop severely degrades the overall system's performance. Accordingly, there is a need for alternate approaches to maintain signal quality and low transmission power levels for all environments and scenarios.

SUMMARY

Combined closed loop/open loop power control controls transmission power levels in a spread spectrum time division duplex communication station. A first communication station receives communications from a second communication station. The first station transmits power commands based on in part a reception quality of the received communications. The first station transmits a second communication having a transmission power level in a first time slot. The second station receives the second communication and the power commands. A power level of the second communication as received is measured. A path loss estimate is determined based on in part the measured received second communication power level and the first communication transmission power level. The second station transmits a second communication to the first station in a second time slot. The second communication transmission power level is set based on in part the path loss estimate weighted by a factor and the power commands. The factor is a function of a time separation of the first and second time slots.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a prior art TDD system.

Figure 2 illustrates time slots in repeating frames of a TDD system.

Figure 3 is a flow chart of combine closed loop/open loop power control.

Figure 4 is a diagram of components of two communication stations using combined closed loop/open loop power control.

Figures 5-10 depict graphs of the performance of a closed loop, ARIB's proposal and two (2) schemes of combined closed loop/open loop power control.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments will be described with reference to the drawing figures where like numerals represent like elements throughout. Combined closed loop/open loop power control will be explained using the flow chart of **Figure 3** and the components of two simplified communication stations **50**, **52** as shown in **Figure 4**. For the following discussion, the communication station having its transmitter's power controlled is referred to as the transmitting station **52** and the communication station receiving power controlled communications is referred to as the receiving station **50**. Since combined closed loop/open loop power control may be used for uplink, downlink or both types of communications, the transmitter having its power controlled may be located at a base station $\mathbf{30_1}$, UE $\mathbf{32_1}$ or both. Accordingly, if both uplink and downlink power control are used, the receiving and transmitting station's components are located at both the base station $\mathbf{30_1}$ and UE $\mathbf{32_1}$.

The receiving station **50** receives various radio frequency signals including communications from the transmitting station **52** using an antenna **56**, or alternately, an antenna array. The received signals are passed through an isolator **60** to a demodulator **68** to produce a baseband signal. The baseband signal is processed, such as by a channel estimation device **96** and a data estimation device **98**, in the time slots and with the appropriate codes assigned to the transmitting station's communication. The channel estimation device **96** commonly uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses. The channel information is used by the data estimation device **98**, the interference measurement device **90**, the signal power measurement device **92** and the transmit power calculation device **94**. The data estimation device **98** recovers data from the channel by estimating soft symbols using the channel information. Using the soft symbols and channel information, the transmit power calculation device **94** controls the receiving station's transmission power level by controlling the gain of an amplifier **76**.

The signal power measurement device **92** uses either the soft symbols or the channel information, or both, to determine the received signal power of the communication in decibels (dB). The interference measurement device **90** determines the interference level in dB, I_{RS}, within the channel, based on either the channel information, or the soft symbols generated by the data estimation device **102**, or both.

The closed loop power command generator **88** uses the measured communication's received power level and the interference level, I_{RS}, to determine the Signal to Interference Ratio (SIR) of the received communication. Based on a comparison of the determined SIR with a target SIR (SIR_{TARGET}), a closed loop power command is generated, b_{TPC}, such as a power command bit, b_{TPC}, **step 38**. Alternately, the power command may be based on any quality measurement of the received signal.

For use in estimating the path loss between the receiving and transmitting stations **50, 52** and sending data, the receiving station **50** sends a communication to the transmitting station **58, step 40**. The communication may be sent on any one of various channels. Typically, in a TDD system, the channels used for estimating path loss are referred to as reference channels, although other channels may be used. If the receiving station **50** is a base station 30_1, the communication is preferably sent over a downlink common channel or a common control physical channel (CCPCH).

Data to be communicated to the transmitting station **52** over the reference channel is referred to as reference channel data. The reference data may include, as shown, the interference level, I_{RS}, multiplexed with other reference data, such as the transmission power level of the reference channel, T_{RS}. The interference level, I_{RS}, and reference channel power level, T_{RS}, may be sent in other channels, such as a signaling channel, **step 40**. The closed loop power control command, b_{TPC}, is typically sent in a dedicated channel, dedicated to the communication between the receiving station **50** and transmitting station **52**.

The reference channel data is generated by a reference channel data generator **86**. The reference data is assigned one or multiple resource units based on the communication's bandwidth requirements. A spreading and training sequence insertion device **82** spreads the reference channel data and makes the spread reference data time-multiplexed with a training sequence in the appropriate time slots and codes of the assigned resource units. The resulting sequence is referred to as a communication burst. The communication burst is subsequently amplified by an amplifier **78**. The amplified communication burst may be summed by a sum device **72** with any other communication burst created through devices, such as a data generator **84**, spreading and training sequence insertion device **80** and amplifier **76**.

The summed communication bursts are modulated by a modulator **64**. The modulated signal is passed through an isolator **60** and radiated by an antenna **56** as shown or, alternately, through an antenna array. The radiated signal is passed through a wireless radio channel **54** to an antenna **58** of the transmitting station **52**.

The type of modulation used for the transmitted communication can be any of the those known to those skilled in the art, such as direct phase shift keying (DPSK) or quadrature phase shift keying (QPSK).

The antenna **58** or, alternately, antenna array of the transmitting station **52** receives various radio frequency signals. The received signals are passed through an isolator **62** to a demodulator **66** to produce a baseband signal. The baseband signal is processed, such as by a channel estimation device **100** and a data estimation device **102**, in the time slots and with the appropriate codes assigned to the communication burst of the receiving station **50**. The channel estimation device **100** commonly uses the training sequence component in the baseband signal to provide channel information, such as channel impulse responses. The channel information is used by the data estimation device **102** and a power measurement device **110**.

The power level of the processed communication corresponding to the reference channel, R_{TS}, is measured by the power measurement device **110** and sent to a pathloss estimation device **112, step 42**. Both the channel estimation device **100** and the data estimation device **102** are capable of separating the reference channel from all other channels. If an automatic gain control device or amplifier is used for processing the received signals, the measured power level is adjusted to correct for the gain of these devices at either the power measurement device **110** or the pathloss estimation device **112**. The power measurement device **110** is a component of the combined closed loop/open loop controller **108**. As illustrated in **Figure 4**, the combined closed loop/open loop power controller **108** consists of the power measurement device **110**, pathloss estimation device **112**, quality measurement device **114**, and transmit power calculation device **116**.

To determine the path loss, L, the transmitting station **52** also requires the communication's transmitted power level, T_{RS}. The transmitted power level, T_{RS}, may be sent along with the communication's data or in a signaling channel. If the power level, T_{RS}, is sent along with the communication's data, the data estimation device **102** interprets the power level and sends the interpreted power level to the pathloss estimation device **112**. If the receiving station **50** is a base station **30_1**, preferably the transmitted power level, T_{RS}, is sent via the broadcast channel (BCH) from the base station **30_1**. By subtracting the received communication's power level, R_{TS} in dB, from the sent communication's transmitted power level, T_{RS} in dB, the pathloss estimation device **112** estimates the path loss, L, between the two stations **50**, **52**, **step 42**. In certain situations, instead of transmitting the transmitted power level, T_{RS}, the receiving station **50** may transmit a reference for the transmitted power level. In that case, the pathloss estimation device **112** provides reference levels for the path loss, L.

If a time delay exists between the estimated path loss and the transmitted communication, the path loss experienced by the transmitted communication may differ from the calculated loss. In TDD systems where communications are sent in differing time slots **36_1-36_n**, the time slot delay between received and transmitted communications may degrade the performance of an open loop power control system. Combined closed loop/open loop power control utilizes both closed loop and open loop power control aspects. If the quality of the path loss measurement is high, the system primarily acts as an open loop system. If the quality of the path loss measurement is low, the system primarily acts as a closed loop system. To combine the two power control aspects, the system weights the open loop aspect based on the quality of the path loss measurement.

A quality measurement device **114** in a weighted open loop power controller **108** determines the quality of the estimated path loss, **step 46**. The quality may be determined using the channel information generated by the channel estimation device **100**, the soft symbols generated by the data estimation device **102** or other quality measurement techniques. The estimated path loss quality is used to weight the path loss estimate by the transmit power calculation device **116**. If the power command, b_{TPC}, was sent in the communication's data, the data estimation device **102** interprets the closed loop power command, b_{TPC}. Using the closed loop power command, b_{TPC}, and the weighted path loss, the transmit power calculation device **116** sets the transmit power level of the receiving station **50**, **step 48**.

The following is one of the preferred combined closed loop/open loop power control algorithms. The transmitting station's power level in decibels, P_{TS}, is determined using **Equations 4** and **6**.

$$P_{TS} = P_0 + G(n) + \alpha L \qquad \textbf{Equation 4}$$

P_0 is the power level that the receiving station **50** desires to receive the transmitting station's communication in dB. P_0 is determined by the desired SIR at the receiving station **50**, SIR_{TARGET}, and the interference level, I_{RS}, at the receiving station **50** using **Equation 5**.

$$P_0 = SIR_{TARGET} + I_{RS}$$ **Equation 5**

I_{RS} is either signaled or broadcasted from the receiving station **50** to the transmitting station **52**. For downlink power control, SIR_{TARGET} is known at the transmitting station **52**. For uplink power control, SIR_{TARGET} is signaled from the receiving station **50** to the transmitting station **52**. G(n) is the closed loop power control factor. **Equation 6** is one equation for determining G(n).

$$G(n) = G(n-1) + b_{TPC} \Delta_{TPC}$$ **Equation 6**

G(n-1) is the previous closed loop power control factor. The power command, b_{TPC}, for use in **Equation 6** is either +1 or -1. One technique for determining the power command, b_{TPC}, is **Equation 3**. The power command, b_{TPC}, is typically updated at a rate of 100 ms in a TDD system, although other update rates may be used. Δ_{TPC} is the change in power level. The change in power level is typically 1 dB although other values may be used. As a result, the closed loop factor increases by 1 dB if b_{TPC} is +1 and decreases by 1 dB if b_{TPC} is -1.

The weighting value, α, is determined by the quality measurement device **114**. α is a measure of the quality of the estimated path loss and is, preferably, based on the number of time slots, D, between the time slot of the last path loss estimate and the first time slot of the communication transmitted by the transmitting station **52**. The value of α is from zero to one. Generally, if the time difference, D, between the time slots is small, the recent path loss estimate will be fairly accurate and α is set at a value close to one. By contrast, if the time difference is large, the path loss estimate may not be accurate and the closed loop aspect is most likely more accurate. Accordingly, α is set at a value closer to zero.

Equation 7 is one equation for determining α, although others may be used.

$$\alpha = 1 - (D - 1)/D_{max} \qquad \textbf{Equation 7}$$

D_{max} is the maximum possible delay. A typical value for a frame having fifteen time slots is six. If the delay is D_{max} or greater, α approaches zero. Using the calculated transmit power level, P_{TS}, determined by a transmit power calculation device **116**, the combined closed loop/open loop power controller **108** sets the transmit power of the transmitted communication.

Data to be transmitted in a communication from the transmitting station **52** is produced by a data generator **106**. The communication data is spread and time-multiplexed with a training sequence by the spreading and training sequence insertion device **104** in the appropriate time slots and codes of the assigned resource units producing a communication burst. The spread signal is amplified by the amplifier **74** and modulated by the modulator **70** to radio frequency.

The combined closed loop/open loop power controller **108** controls the gain of the amplifier **74** to achieve the determined transmit power level, P_{TS}, for the communication. The power controlled communication is passed through the isolator **62** and radiated by the antenna **58**.

Equations 8 and **9** are another preferred combined closed loop/open loop power control algorithm.

$$P_{TS} = P_0 + K(n) \qquad \textbf{Equation 8}$$

$$K(n) = K(n-1) + b_{TPC}\,\Delta_{TPC} + \alpha L \qquad \textbf{Equation 9}$$

K(n) is the combined closed loop/open loop factor. As shown, this factor includes both the closed loop and open loop power control aspects. **Equations 4** and **5** segregate the two aspects.

Although the two above algorithms only weighted the open loop factor, the weighting may be applied to the closed loop factor or both the open and closed loop factors. Under certain conditions, the network operator may desire to use solely open loop or solely closed loop power control. For example, the operator may use solely closed loop power control by setting α to zero.

Figures 5-10 depict graphs **118-128** illustrating the performance of a combined closed-loop/open-loop power control system. These graphs **118-128** depict the results of simulations comparing the performance of the ARIB proposed system, a closed loop, a combined open loop/closed loop system using **Equations 4** and **6** (scheme I) and a combined system using **Equations 8** and **9** (scheme II). The simulations were performed at the symbol rate. A spreading factor of sixteen was used for both the uplink and downlink channels. The uplink and downlink channels are International Telecommunication Union (ITU) Channel model [ITU-R M.1225, vehicular, type B]. Additive noises were simulated as being independent of white Gaussian noises with unity variance. The path loss is estimated at the transmitting station **52** which is a UE $\mathbf{32_1}$ and in particular a mobile station. The BCH channel was used for the path loss estimate. The path loss was estimated two times per frame at a rate of 200 cycles per second. The receiving station **50**, which was a base station 30_1, sent the BCH transmission power level over the BCH. RAKE combining was used for both the UE 32_1 and base station 30_1. Antenna diversity combining was used at the base station 30_1.

Graphs **118, 122, 126** depict the standard deviation of the received signal to noise ratio (SNR) at the base station 30_1 of the UE's power controlled communication as a function of the time slot delay, D. Graphs **120, 124, 128** depict the normalized bias of the received SNR as a function of the delay, D. The normalization was performed with respect to the desired SNR. Each point in the graphs **118-128** represents the average of 3000 Monte-Carlo runs.

Graphs **118, 120** depict the results for an α set at one. For low time slot delays ($D<4$), scheme I and II outperform closed loop power control. For larger delays ($D \geq 4$), closed loop outperforms both scheme I and II which demonstrates the importance of weighting the open loop and closed loop aspects.

Graphs **122, 124** depict the results for an α set at 0.5. As shown, for all delays excluding the maximum, schemes I and II outperform closed loop power control. The ARIB proposal only outperforms the others at the lowest delay ($D=1$).

Graphs **126, 128** depict the results for an α set using **Equation 7** with D_{max} equal to six. As shown, schemes I and II outperform both closed loop and the ARIB proposal at all delays, D.

* * *

CLAIMS

1. A method for controlling transmission power levels in a spread spectrum time division duplex communication system having frames with time slots for communication, the method comprising:

receiving at a first communication station communications from a second communication station and transmitting from the first station power commands based on in part a reception quality of the received communications;

transmitting from the first communication station a first communication having a transmission power level in a first time slot;

receiving at the second communication station the first communication and the power commands;

measuring a power level of the first communication as received;

determining a pathloss estimate based on in part the measured received first communication power level and the first communication transmission power level; and

setting a transmission power level for a second communication in a second time slot from the second station to the first station based on in part the pathloss estimate weighted by a quality factor and the power commands, wherein the quality factor is a function of a time separation of the first and second time slots.

2. The method of claim 1 further comprising:

determining a quality, α, of the pathloss estimate based on in part a number of time slots, D, between the first and second time slot; and

wherein the quality factor is α.

3. The method of claim 1 wherein a maximum time slot delay is D_{max} and the determined quality, α, is determined by

$\alpha = 1 - (D-1) / D_{max}$.

4. The method of claim 1 wherein the set transmission power level is based on in part a desired received power level at the first station, a closed loop factor and an open loop factor; wherein the closed loop factor is based on in part the received power commands and the open loop factor is based on in part the pathloss estimate weighted by the quality factor.

5. The method of claim 1 wherein the set transmission power level is based on in part a desired received power level at the first station and a combined closed loop/open loop factor; wherein the combined closed loop/open loop factor is based on in part the received power commands and the pathloss estimate weighted by the quality factor.

6. The method of claim 4 wherein the closed loop factor is updated for each received power command.

7. The method of claim 5 wherein the combined factor is updated for each received power command.

8. The method of claim 4 wherein the desired received power level is based on in part a target signal to interference ratio and a measured interference level at the first station.

9. The method of claim 5 wherein the desired received power level is based on in part a target signal to interference ratio and a measured interference level at the first station.

10. The method of claim 1 wherein the first station is a base station and the second station is a user equipment.

11. The method of claim 1 wherein the first station is a user equipment and the second station is a base station.

12. A spread spectrum time division duplex communication system having a first and second communication station, the system using frames with time slots for communication, the system comprising:

the first station comprising:

means for receiving communications from the second communication station and transmitting power commands based on in part a reception quality of the received communications; and

means for transmitting a first communication having a transmission power level in a first time slot; and

the second station comprising:

means for receiving the first communication and the power commands;

means for measuring a power level of the first communication as received;

means for determining a pathloss estimate based on in part the measured received first communication power level and the first communication transmission power level; and

means for setting a transmission power level for a second communication in a second time slot from the second station to the first station based on in part the pathloss estimate weighted by a quality factor and the power commands, wherein the quality factor is a function of a time separation of the first and second time slots.

13. The system of claim 12 wherein:

the second station further comprises means for determining a quality, α, of the pathloss estimate based on in part a number of time slots, D, between the first and second time slot; and

the quality factor is α.

14. The system of claim 12 wherein a maximum time slot delay is D_{max} and the determined quality, α, is determined by

$$\alpha = 1 - (D-1) / D_{max}.$$

15. The system of claim 1 wherein the setting means sets the transmission power level based on in part a desired received power level at the first station, a closed loop factor and an open loop factor, the closed loop factor is based on in part the received power commands and the open loop factor is based on in part the pathloss estimate weighted by the quality factor.

16. The system of claim 1 wherein the setting means sets the transmission power level based on in part a desired received power level at the first station and a combined closed loop/open loop factor, the combined closed loop/open loop factor is based on in part the received power commands and the path loss estimate weighted by the quality factor.

17. The system of claim 15 wherein the closed loop factor is updated for each received power command.

18. The system of claim 16 wherein the combined factor is updated for each received power command.

19. The system of claim 15 wherein the desired received power level is based on in part a target signal to interference ratio and a measured interference level at the first station.

20. The system of claim 16 wherein the desired received power level is based on in part a target signal to interference ratio and a measured interference level at the first station.

21. The system of claim 12 wherein the first station is a base station and the second station is a user equipment.

22. The system of claim 12 wherein the first station is a user equipment and the second station is a base station.

23. A communication station having its transmission power level controlled in a spread spectrum time division duplex communication system, the system using frames with time slots for communication and having a second communication station transmitting a first communication in a first time slot and power commands, the communication station comprising:

at least one antenna for receiving the first communication and the power commands and transmitting an amplified second communication in a second time slot;

a channel estimation device having an input configured to receive the received first communication for producing channel information;

a data estimation device having inputs configured to receive the received first communication, the power commands and the channel information for producing soft symbols and recovering the power commands;

a power measurement device having an input configured to receive the channel information for producing a measurement of a received power level for producing a pathloss estimate for the first communication;

a quality measurement device for producing a quality measurement based at least in part upon a time separation of the first time slot and a second time slot;

a transmit power calculation device having inputs configured to receive the pathloss estimation, the recovered power commands and the quality measurement for producing a power control signal based on in part the pathloss estimate weighted by the quality measurement and the recovered power commands; and

an amplifier having inputs configured to receive the power control signal and a second communication to be transmitted in the second time slot for amplifying the second communication in response to the power control signal to produce the amplified second communication.

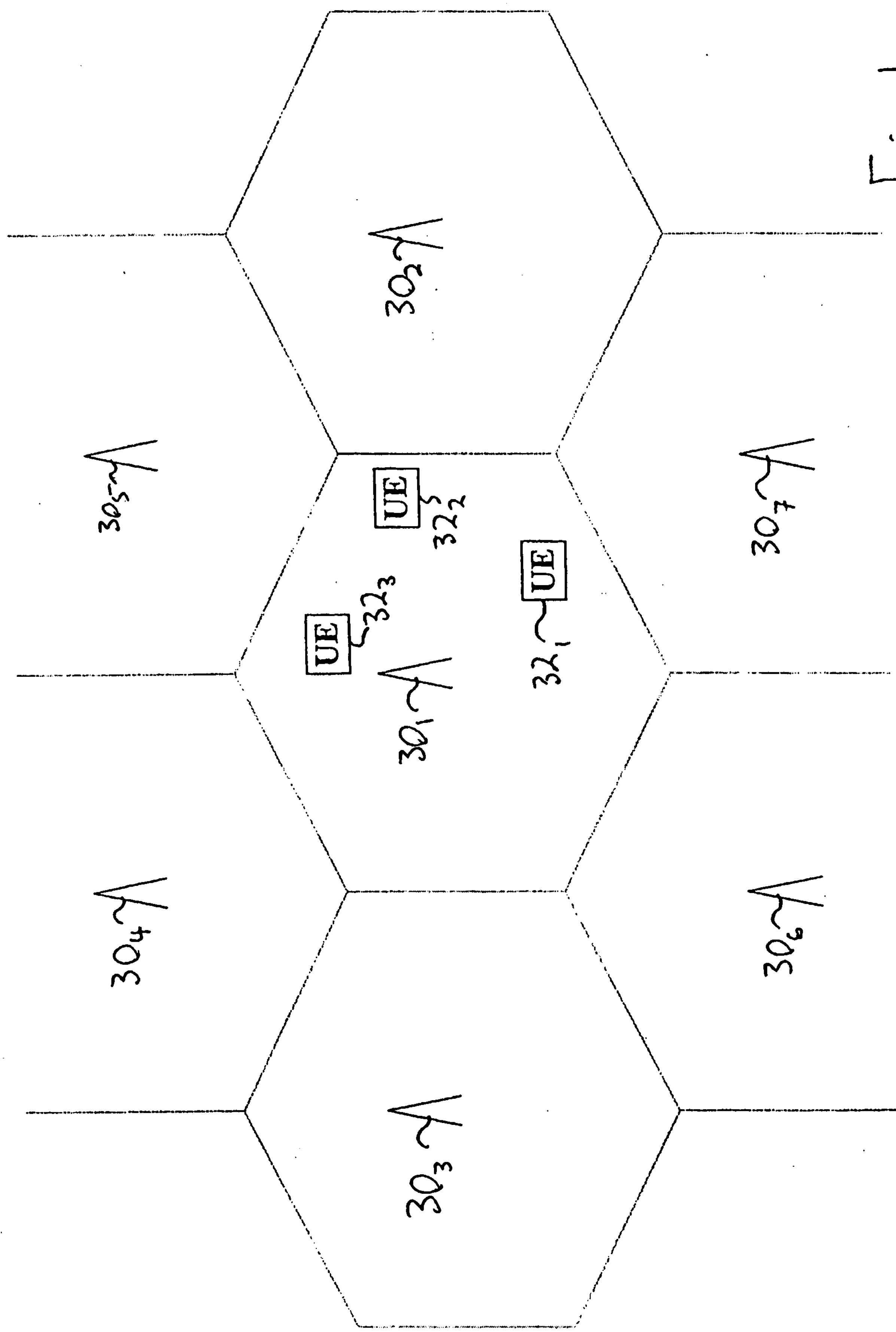

Fig. 1

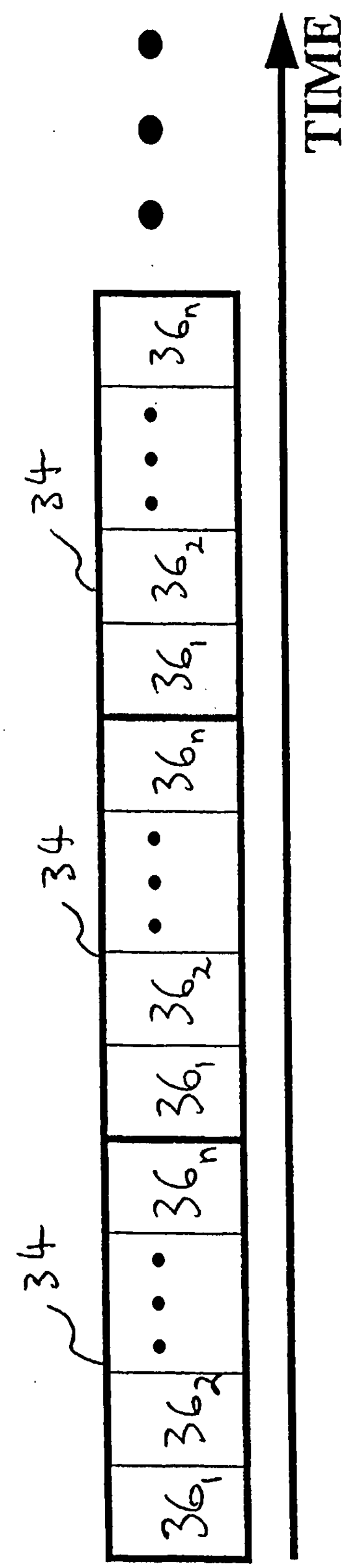

Fig. 2

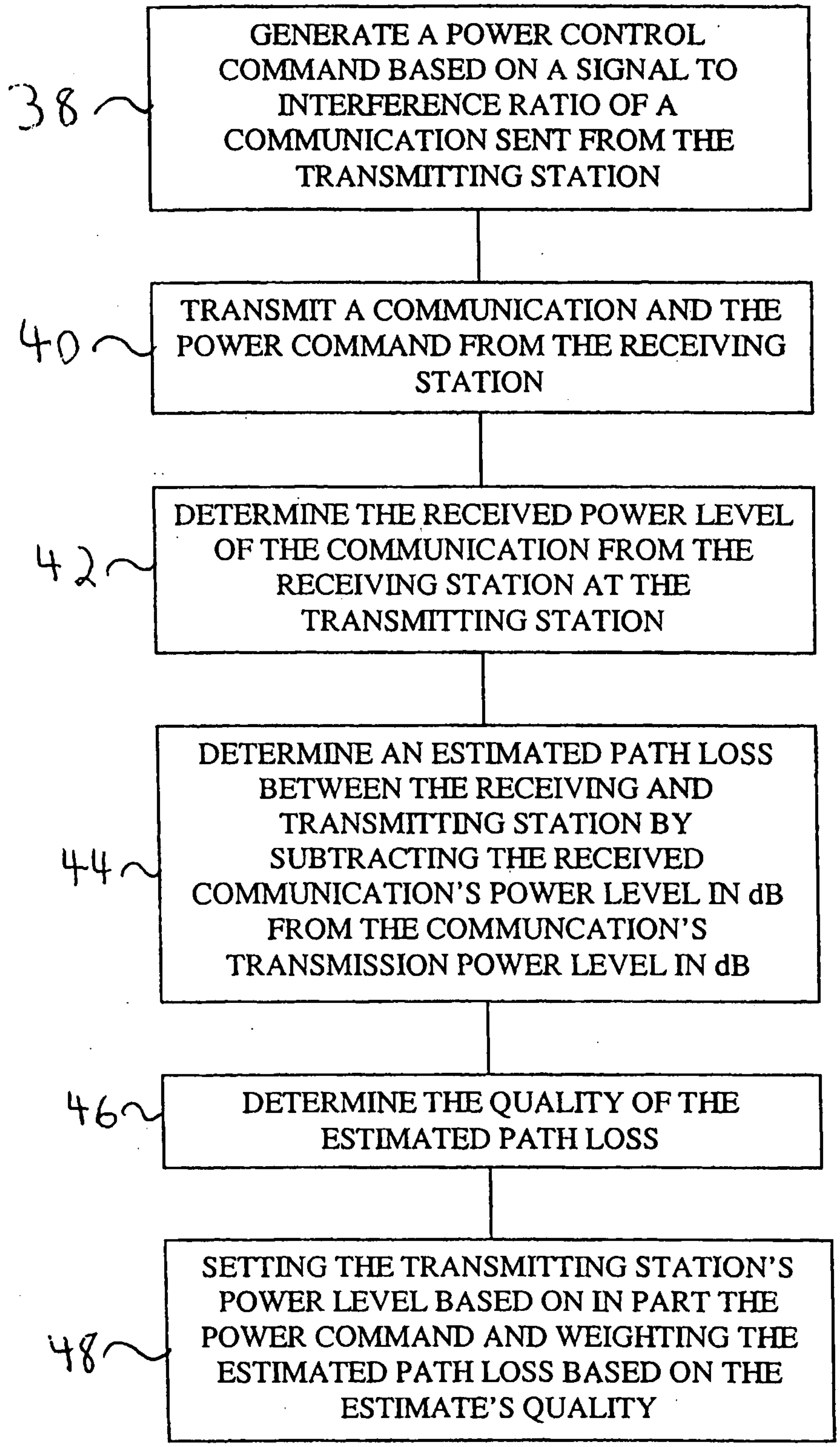
38
GENERATE A POWER CONTROL COMMAND BASED ON A SIGNAL TO INTERFERENCE RATIO OF A COMMUNICATION SENT FROM THE TRANSMITTING STATION
40
TRANSMIT A COMMUNICATION AND THE POWER COMMAND FROM THE RECEIVING STATION
42
DETERMINE THE RECEIVED POWER LEVEL OF THE COMMUNICATION FROM THE RECEIVING STATION AT THE TRANSMITTING STATION
44
DETERMINE AN ESTIMATED PATH LOSS BETWEEN THE RECEIVING AND TRANSMITTING STATION BY SUBTRACTING THE RECEIVED COMMUNICATION'S POWER LEVEL IN dB FROM THE COMMUNCATION'S TRANSMISSION POWER LEVEL IN dB
46
DETERMINE THE QUALITY OF THE ESTIMATED PATH LOSS
48
SETTING THE TRANSMITTING STATION'S POWER LEVEL BASED ON IN PART THE POWER COMMAND AND WEIGHTING THE ESTIMATED PATH LOSS BASED ON THE ESTIMATE'S QUALITY

Fig. 3

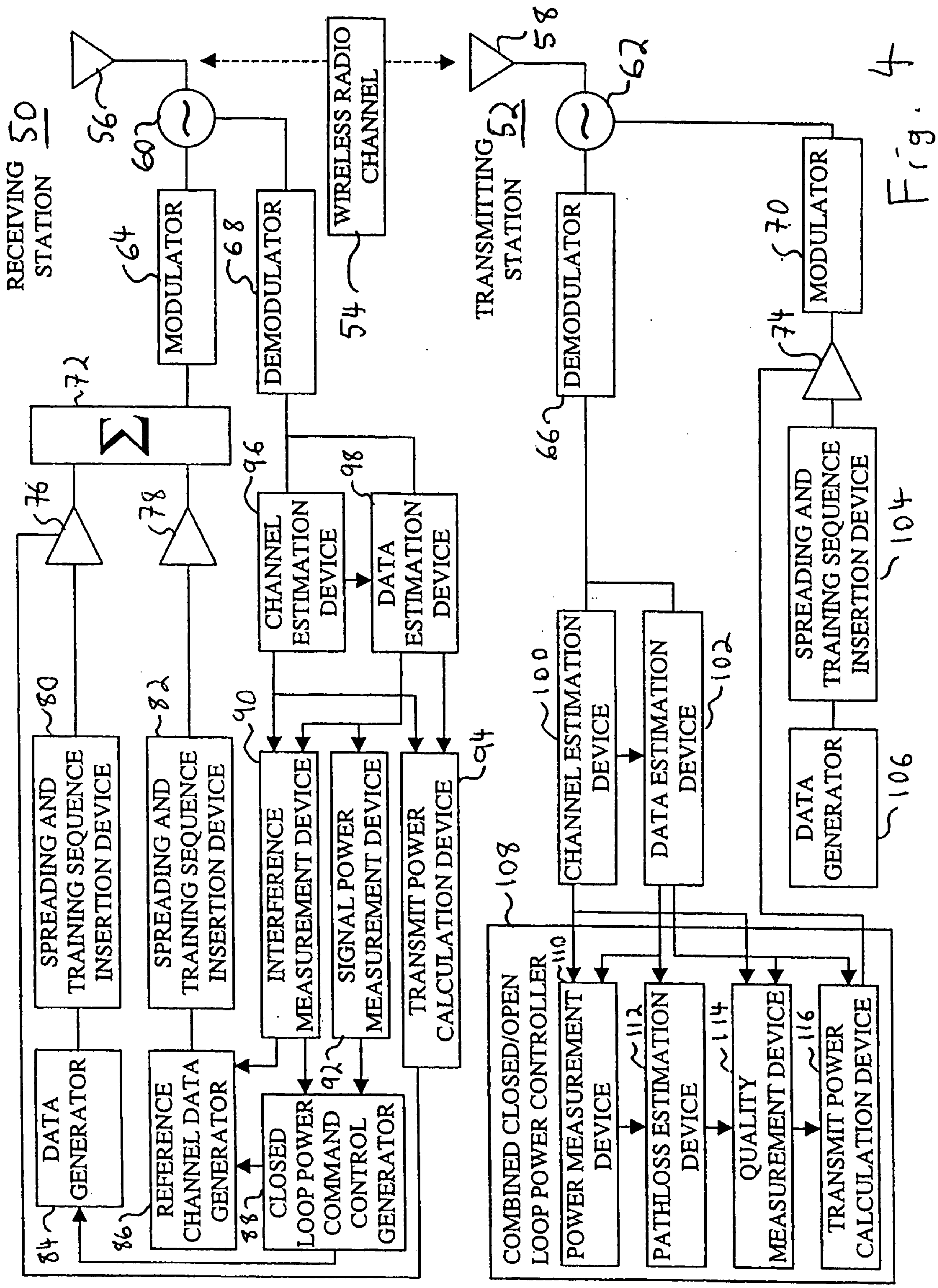
RECEIVING STATION 50
56
58
60
62
WIRELESS RADIO CHANNEL
54
TRANSMITTING STATION 52
MODULATOR
64
DEMODULATOR
68
DEMODULATOR
66
MODULATOR
70
72
74
76
78
CHANNEL ESTIMATION DEVICE
96
DATA ESTIMATION DEVICE
98
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
80
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
82
INTERFERENCE MEASUREMENT DEVICE
90
SIGNAL POWER MEASUREMENT DEVICE
92
TRANSMIT POWER CALCULATION DEVICE
94
DATA GENERATOR
84
REFERENCE CHANNEL DATA GENERATOR
86
CLOSED LOOP POWER COMMAND CONTROL GENERATOR
88
CHANNEL ESTIMATION DEVICE
100
DATA ESTIMATION DEVICE
102
SPREADING AND TRAINING SEQUENCE INSERTION DEVICE
104
DATA GENERATOR
106
COMBINED CLOSED/OPEN LOOP POWER CONTROLLER
108
POWER MEASUREMENT DEVICE
110
PATHLOSS ESTIMATION DEVICE
112
QUALITY MEASUREMENT DEVICE
114
TRANSMIT POWER CALCULATION DEVICE
116

Fig. 4

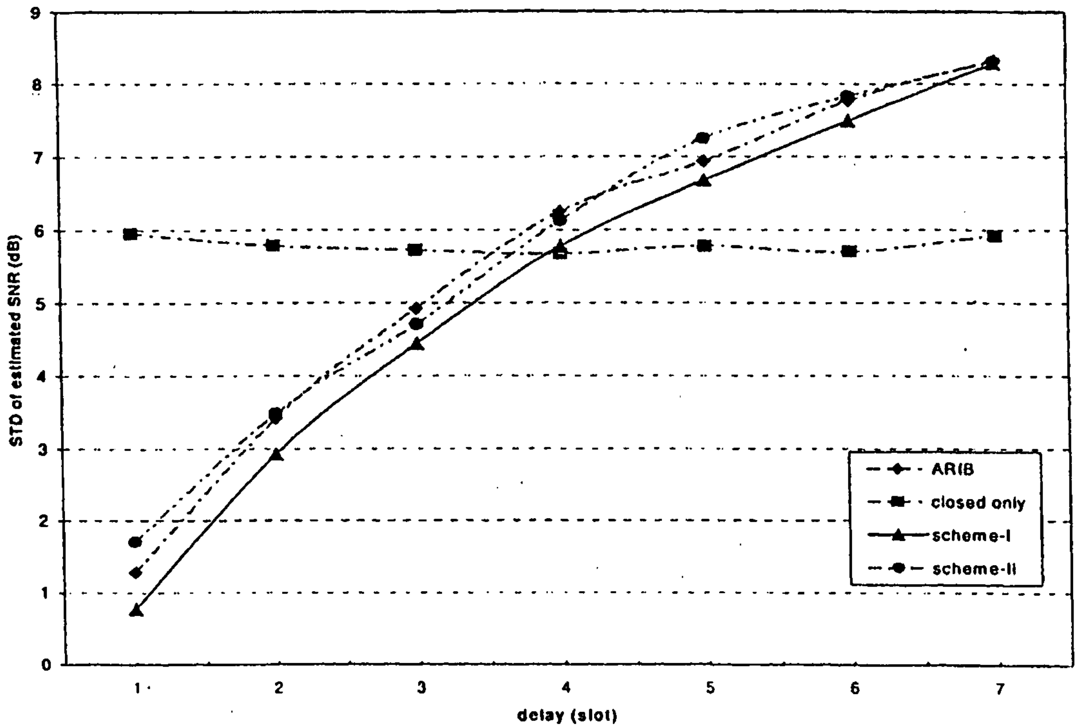
9
8
7
6
5
4
3
2
1
0
STD of estimated SNR (dB)
1
2
3
4
5
6
7
delay (slot)
ARIB
closed only
scheme-I
scheme-II

Fig. 5

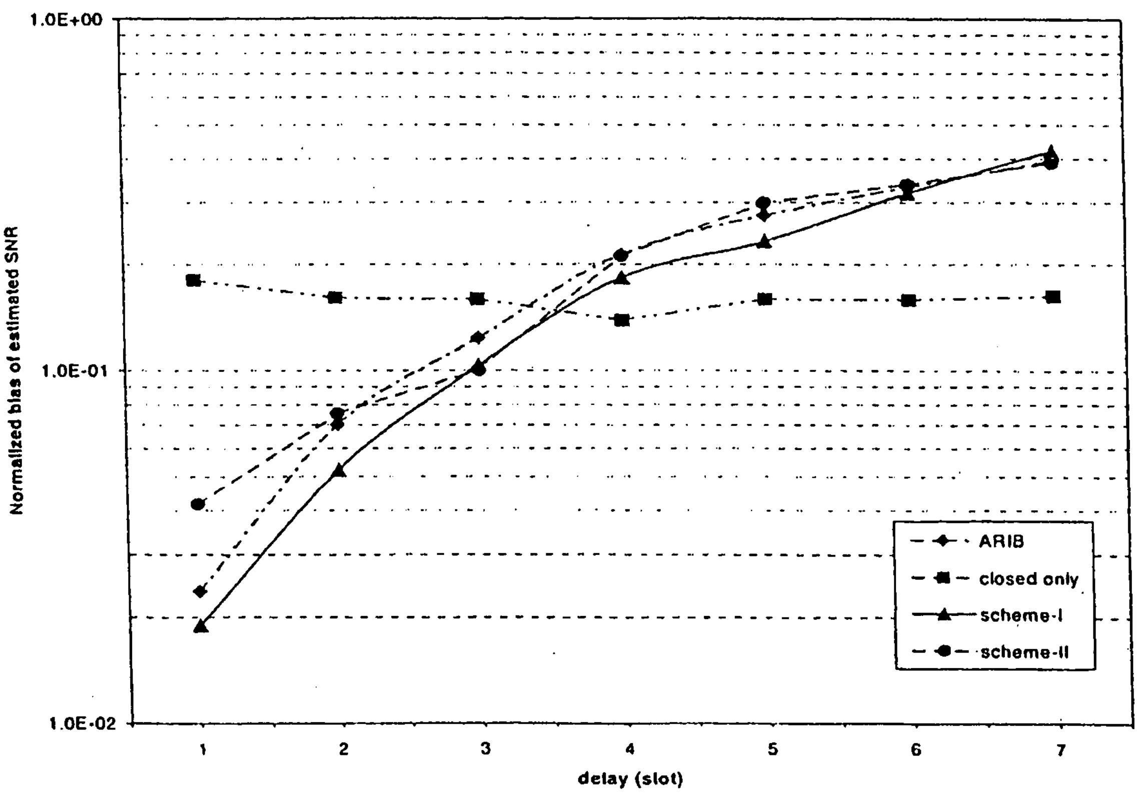
1.0E+00
1.0E-01
1.0E-02
Normalized bias of estimated SNR
1
2
3
4
5
6
7
delay (slot)
ARIB
closed only
scheme-I
scheme-II

Fig. 6

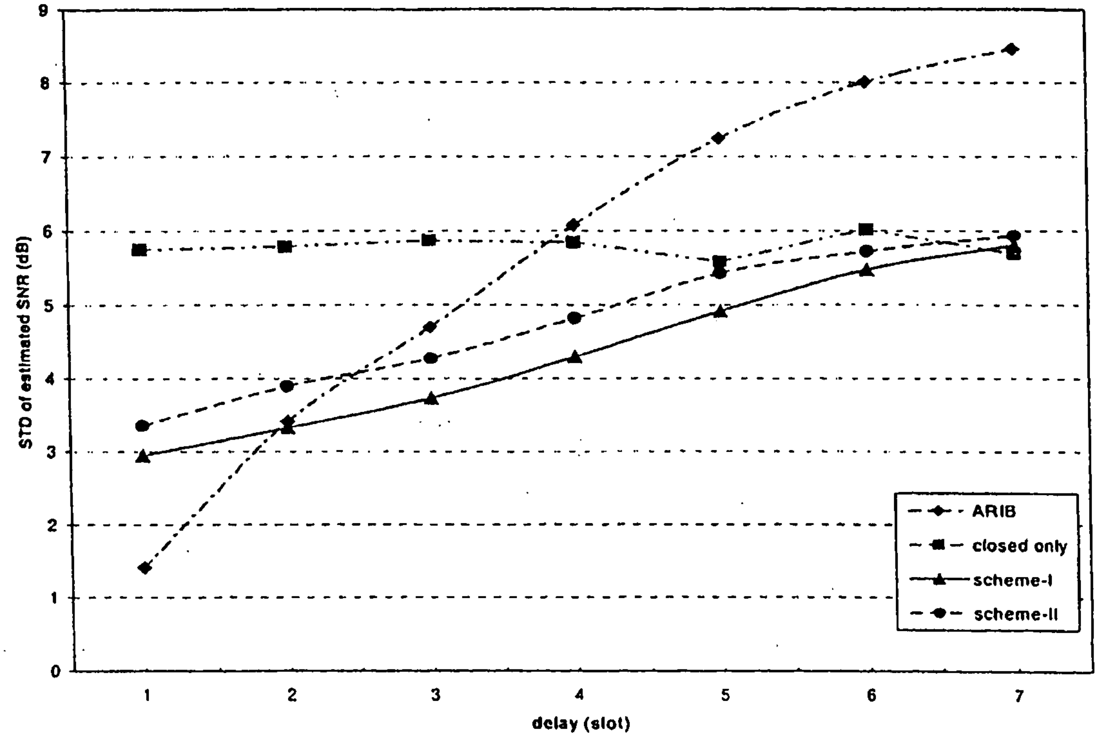
9
8
7
6
5
4
3
2
1
0
STD of estimated SNR (dB)
1
2
3
4
5
6
7
delay (slot)
ARIB
closed only
scheme-I
scheme-II

Fig. 7

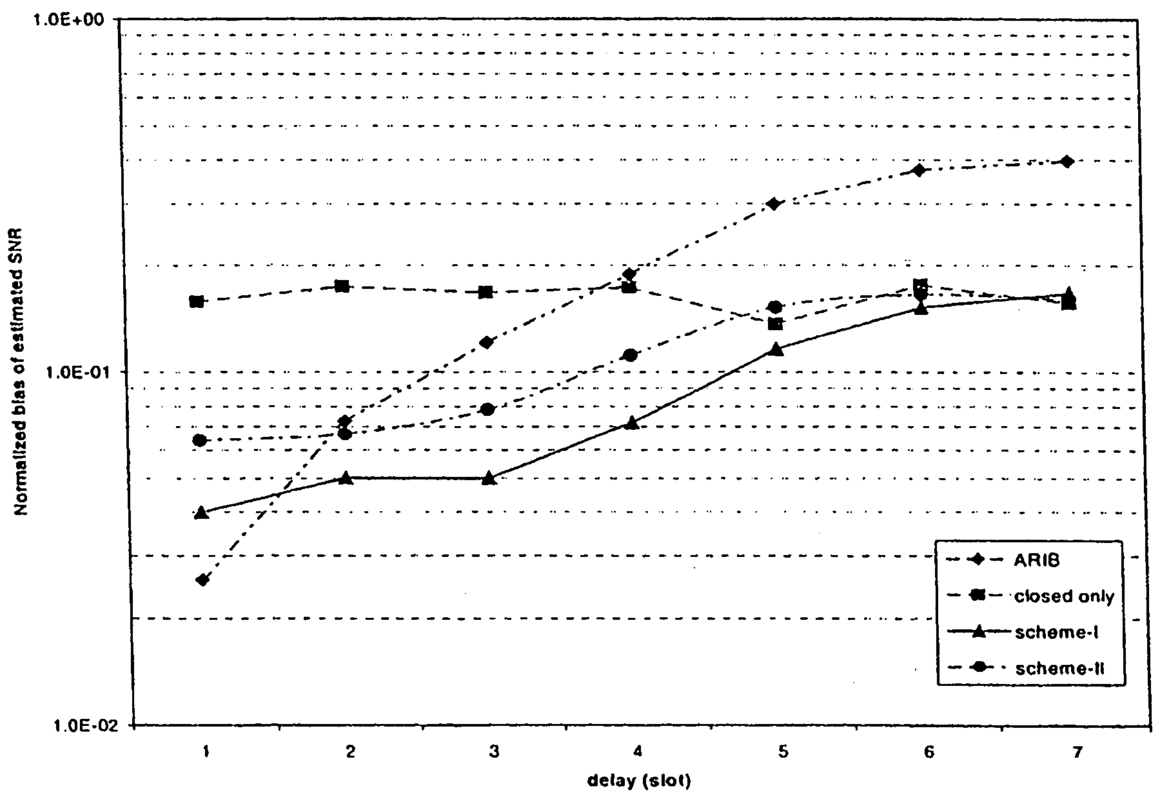
1.0E+00
1.0E-01
1.0E-02
Normalized bias of estimated SNR
1
2
3
4
5
6
7
delay (slot)
ARIB
closed only
scheme-I
scheme-II

Fig. 8

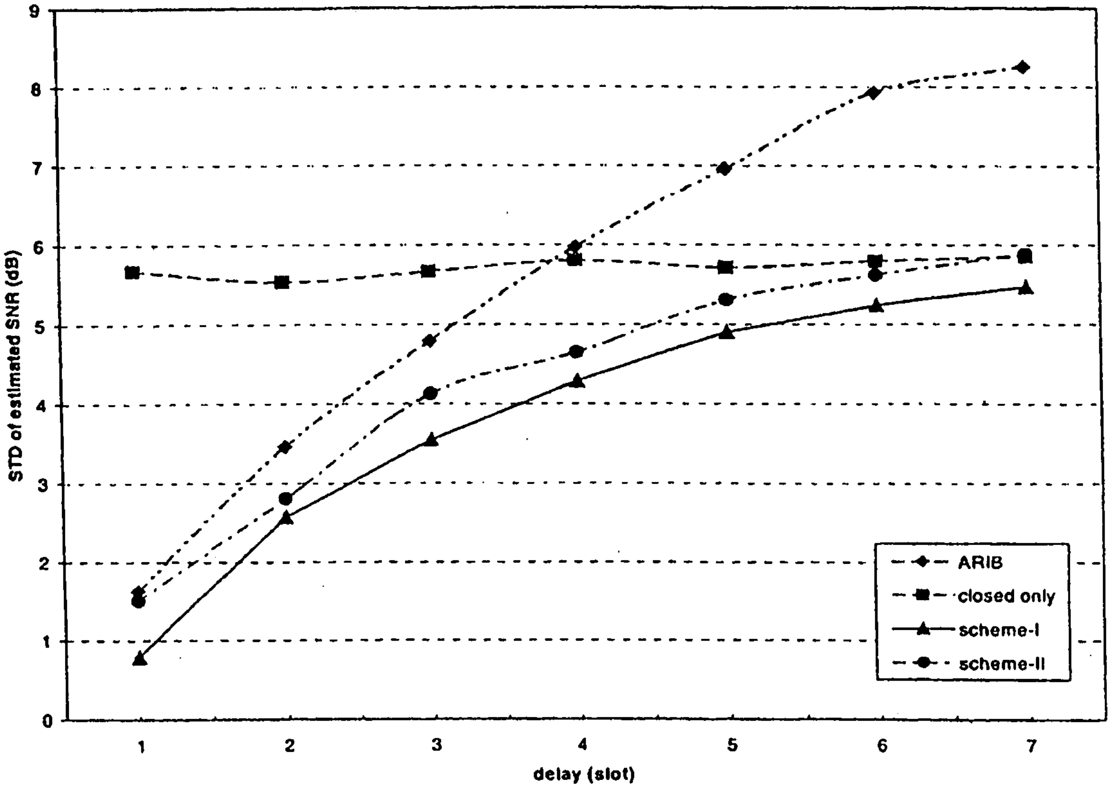
9
8
7
6
5
4
3
2
1
0
STD of estimated SNR (dB)
1
2
3
4
5
6
7
delay (slot)
ARIB
closed only
scheme-I
scheme-II

Fig. 9

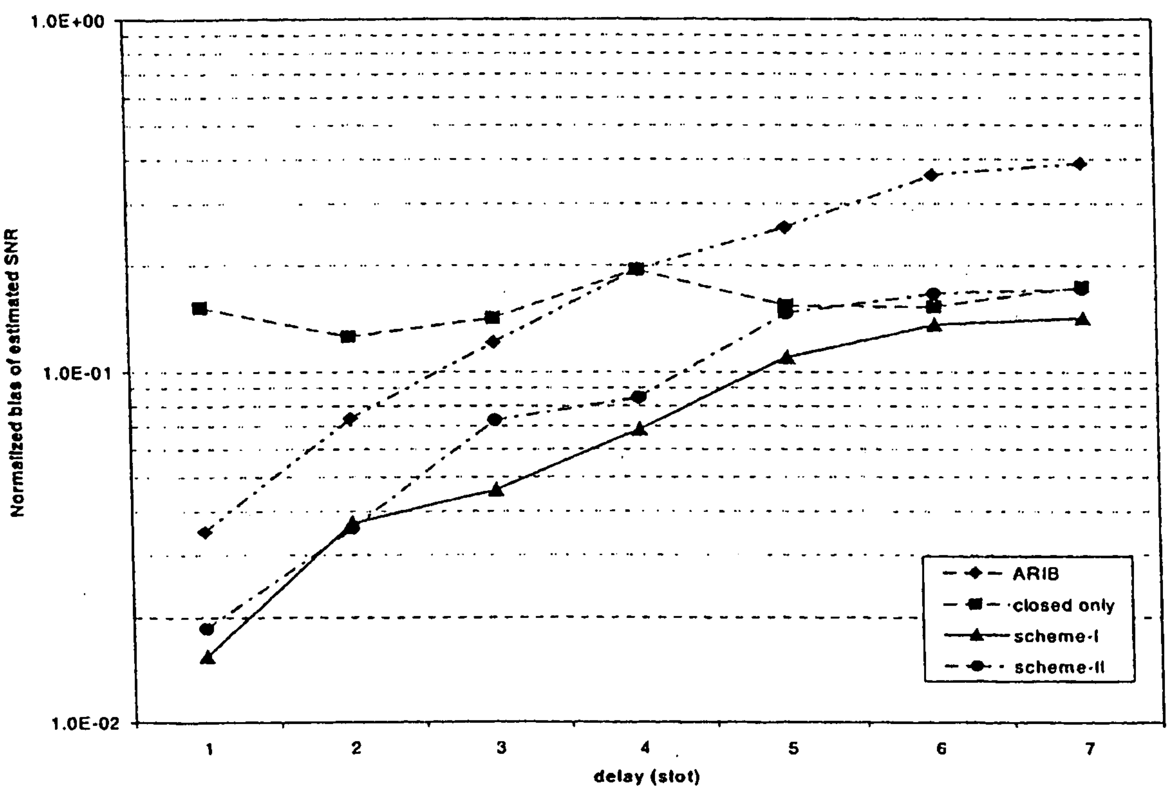
1.0E+00
1.0E-01
1.0E-02
Normalized bias of estimated SNR
1
2
3
4
5
6
7
delay (slot)
ARIB
closed only
scheme-I
scheme-II

Fig. 10

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/07476

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/005

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 49197 A (HONKASALO ZHICHUN ;NOKIA MOBILE PHONES LTD (FI); JOKINEN HARRI (FI) 24 December 1997 (1997-12-24) abstract; figure 1 page 4, line 21 -page 5, line 11 page 6, line 13 -page 7, line 3 page 7, line 18 - line 29 page 11, line 18 -page 12, line 16 ---	1,2, 4-13, 15-23
A	EP 0 682 419 A (NIPPON TELEGRAPH & TELEPHONE) 15 November 1995 (1995-11-15) abstract; figures 4,6,7 column 8, line 13 - line 44 ---	1,4-12, 15-23

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
4 July 2000	13/07/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Inte. ional Application No
PCT/US 00/07476

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	US 5 542 111 A (IVANOV KOLIO ET AL) 30 July 1996 (1996-07-30) abstract; figures 1,2 column 2, line 20 - line 43 column 2, line 58 - line 64 column 3, line 24 -column 4, line 61 ---	1,4-12, 15-23
A	US 5 859 838 A (SOLIMAN SAMIR S) 12 January 1999 (1999-01-12) column 5, line 4 - line 19 column 8, line 1 - line 23; figure 2 -----	1,4-12, 15-23

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/07476

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TR

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 February 2001 (01.02.2001)

PCT

(10) International Publication Number
WO 01/08322 A1

(51) International Patent Classification[7]: H04B 7/005, H04Q 7/20

(21) International Application Number: PCT/SE00/01460

(22) International Filing Date: 7 July 2000 (07.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/359,859 26 July 1999 (26.07.1999) US

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(74) Agent: NORIN, Klas; Ericsson Radio Systems AB, Common Patent Department, S-164 80 Stockholm (SE).

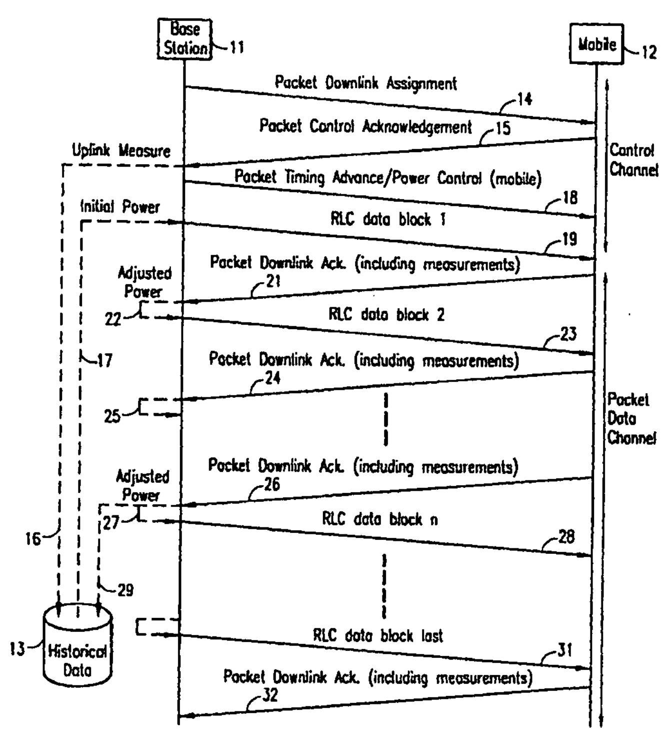
(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

[Continued on next page]

(54) Title: INITIAL UPLINK AND DOWNLINK POWER LEVEL ASSIGNMENT IN A RADIO TELECOMMUNICATIONS NETWORK



(57) Abstract: A method of assigning initial uplink and downlink power levels for a transaction of a data package between a mobile station (12) and a base station (11) in a radio telecommunications network. A historical database (13) of signal strength measurements, interference measurements, and uplink and downlink power level settings in the network is maintained. To set downlink power, an uplink signal strength (16) of an initial access signal (15) sent from the mobile station to the base station is measured at the base station. The measured uplink signal strength (16) is sent to the historical database where it is correlated with an associated downlink power level setting. The correlated downlink power level setting (17) is sent to the base station where it is utilized as the initial downlink power level setting for a first transmission (19) from the base station to the mobile station. To set uplink power, the signal strength (42) of an initial packet channel request (41) on the control channel is sent to the historical database along with an interference measurement (43) on the packet date channel. An associated mobile station uplink power level setting (44) is retrieved from the database and sent to the mobile station where it is utilized for the first data transmission (46). A closed loop power control method may be utilized to adjust either the uplink or the downlink power level to an optimum level.

WO 01/08322 A1

— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INITIAL UPLINK AND DOWNLINK POWER LEVEL ASSIGNMENT IN A RADIO TELECOMMUNICATIONS NETWORK

BACKGROUND OF THE INVENTION

Technical Field of the Invention

This invention relates to telecommunication systems and, more particularly, to a method of setting initial uplink and downlink power levels in a mobile station and a radio base station in a radio telecommunications network.

Description of Related Art

U.S. Patent No. 4,696,027 to Bonta (Bonta) discloses a two-way radio system which employs power control of a mobile station to provide a predetermined received signal strength at a radio base station following a handoff. During the locating function, Bonta measures the uplink signal strength of signals transmitted by the mobile station to the target base station, and after accounting for path loss, etc., the post-handoff power level of the mobile station is determined. Thus, the methodology utilized in Bonta is applicable to the uplink power level when a call is ongoing and there has been plenty of opportunity to make signal strength measurements for use in analyzing what mobile station power level is required in the target cell. However, Bonta does not teach or suggest a method of setting an initial uplink (mobile station to base station) or downlink (base station to mobile station) power level at times such as system access when multiple signal strength measurements have not been made.

In some existing Time Division Multiple Access (TDMA) radio telecommunications networks, a Base-Station Power Control (BSPC) function sets the initial downlink power level to its highest level when a mobile station first accesses the network and a call is being set up on a digital traffic channel. After uplink and downlink signal strength measurements have been reported, the BSPC function adjusts the downlink power level to a more optimum level. In most cases, this process ensures adequate downlink signal strength for call setup, but causes unnecessary peaks of energy in the downlink with a resultant increase in the interference level in the network. Therefore, some calls in co-channel cells may experience degraded radio quality performance, or may even be disconnected.

In other existing radio telecommunications networks such as wideband Code Division Multiple Access (CDMA) systems, the initial downlink power level is set at its lowest level, and is then incrementally increased until the mobile station can receive it. After the initial downlink signal is sent to the mobile station, the system must wait for an acknowledgment from the MS. If an acknowledgment is not received, the downlink power is increased, and the signal is sent again. This process may be repeated several times before an acknowledgment is received from the mobile station. Thus, this approach reduces interference levels in the network, but requires additional time for call setup.

In order to overcome the disadvantage of existing solutions, it would be advantageous to have a method of assigning more optimum initial uplink and downlink power levels at system access on the control channel (for a circuit-switched call) or at acknowledgment on the packet channel (for a packet-switched call). Such a method would also provide a more efficient way to optimize initial power settings following handoff or at the beginning of a data transaction during an ongoing call. The present invention provides such a method.

SUMMARY OF THE INVENTION

In one aspect, the present invention is a method of assigning an initial downlink power level from a base station to a mobile station. The method assigns the initial downlink power level based on historical data. Rather than calculating the power level directly from signal strength measurements taken after the call has begun, the invention builds a historical database of signal strength measurements and path loss offsets in the system. These path loss offsets are then correlated with the downlink power used by the power control algorithm in the base station, and a statistical relationship between the two is determined. When it is time to assign the initial downlink power, the uplink signal strength is measured, and then the downlink power corresponding to that measured signal strength is assigned. The method may be applied at initial system access or at intercell handoff, and is applicable to both circuit-switched calls and packet-switched data transactions.

In particular, the method of the present invention maintains a historical database of signal strength measurements and downlink power level settings in the telecommunication system. The uplink signal strength of an initial signal sent from the mobile station to the base station is measured at the base station. The measured uplink signal strength is sent to the historical database where it is correlated with an associated downlink power level setting. The correlated downlink power level setting is sent to the base station where it is utilized as the initial downlink power level setting for a first transmission from the base station to the mobile station. A closed loop power control method may then be used to adjust the downlink power level to achieve an optimum received signal strength at the mobile station. After the initial phase of the closed loop method, the historical database is updated by sending the adjusted downlink power level to the historical database, and associating the adjusted downlink power level setting with the uplink signal strength of the initial signal sent from the mobile station to the base station.

In another aspect, the present invention is a method of assigning an initial downlink power level at intercell handoff between a target base station and a mobile station in a radio telecommunication system. The method includes the steps of building a historical database which correlates measurements of radio quality parameters with downlink power level settings, measuring at the target base station a radio quality parameter from an initial signal sent from the mobile station to the target base station, and sending the measured radio quality parameter to the historical database. The method also includes correlating in the historical database the measured radio quality parameter with an associated downlink power level setting, sending the correlated downlink power level setting to the target base station, and utilizing the correlated downlink power level setting as the initial downlink power level setting for a first transmission from the target base station to the mobile station.

In yet another aspect, the present invention is method of assigning an initial uplink power level from a mobile station to a base station in a radio telecommunication system. The method includes building a historical database which correlates measurements of radio quality parameters such as signal strength and interference measurements with uplink mobile station power level settings. The radio quality parameters are then measured at the base station. For example, the method may measure a signal strength of an initial access signal sent from the mobile station to the base station, assign a packet data channel to the mobile station, and then measure an interference level on the assigned packet data channel. This is followed by sending the measured parameters to the historical database, correlating the measured parameters with an optimum uplink mobile station power level setting, sending the correlated optimum uplink mobile station power level setting to the mobile station, and utilizing the correlated optimum uplink power level setting as the initial mobile station power level setting for a first data transmission from the mobile station to the base station.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be better understood and its numerous objects and advantages will become more apparent to those skilled in the art by reference to the following drawing, in conjunction with the accompanying specification, in which:

FIG. 1 is a signal flow diagram illustrating how the method of the present invention is utilized with the General Packet Radio Service (GPRS) and the Global System for Mobile Communications (GSM) to determine an initial downlink power level and to maintain the historical database;

FIG. 2 is a signal flow diagram illustrating how the method of the present invention is utilized with GPRS and GSM to determine an initial uplink power level and to maintain the historical database; and

FIG. 3 is an exemplary data structure for the historical database.

DETAILED DESCRIPTION OF EMBODIMENTS

The present invention is a method of assigning initial uplink and downlink power levels at times such as system access when multiple signal strength measurements between a mobile station and a base station have not been made. The invention assigns the initial power levels based on historical data. Rather than calculating a power level directly from signal strength measurements taken after the call has begun, the invention builds a historical database of signal strength measurements and path loss offsets in the system. These path loss offsets are then correlated, for example, with the downlink power used by the power control algorithm in the base station, and a statistical relationship between the two is determined. When it is time to assign the initial downlink power, the uplink path loss is estimated, and then the downlink power corresponding to that path loss is assigned.

In a typical scenario in which initial downlink power is to be determined, a speech cell exists, and it is desired to begin the access at a near-optimum power level. The system may know only a single uplink signal strength measurement. The needed downlink power must be calculated from that single uplink measurement. A classical approach is to establish some fixed offset. To do so, however, the system must calculate path losses using a number of varying parameters which are not known. In addition, the uplink control signaling may be of very short duration, resulting in an unreliable measurement. Also, if interference is present, signal strength is not a good measure of radio quality.

Alternatively, if the cell is programmed to learn its environment, historical uplink and downlink path loss information can be stored as historical data. This historical data can then be associated with uplink signal strength measurements. Then, when a mobile station accesses the network, its uplink signal strength is measured, and the system can select a near-optimum initial uplink or downlink power level. A historical database may be built for each cell, transceiver, or mobile station type, depending on the level of accuracy desired. The database may also be built for each mobile individual or data transaction. This method can be applied to system access as well as handoff and data packet transfer.

The present invention is useful for assigning initial power level in a variety of networks, and is particularly useful for packet data applications. For packet data being transmitted from the base station to the mobile station, the system may assign the initial downlink power based only on an uplink packet control acknowledgment. This saves additional signaling now utilized by the BSPC function. For packet data being transmitted from the mobile station to the base station, the system may assign an initial uplink power based on the signal strength of the packet channel request signal which the mobile station sends on the control channel, and an interference measurement on the assigned packet data channel. The historical database correlates these measurements with an optimum initial mobile station power level for the data transmission.

In many cases, it is more important to make an accurate determination of the initial power level in packet data transmissions because packet data transmissions may be of shorter duration than typical circuit-switched voice calls. Thus, the period of time utilized by existing BSPC functions to determine an optimum uplink or downlink power level may equate to a large percentage of the total transmission. For example, in a speech call, at least 20-30 seconds may be spent in one cell, and the interference caused by the initial peak transmitter power lasts for only 1 or 2 seconds of that period. A packet transmission may only last a few seconds, and therefore using existing techniques, a larger percentage of the call may be utilized trying to find a good power level.

Other methods may also be used for initial power level assignment for packet data transactions. For example, a certain mobile station may have conducted a recent packet data transaction, and by retaining signal strength and power level information, the system can better estimate the initial power level required in a later transaction. During a packet data call, the mobile station requests packets or acknowledges packets on the uplink signal channel. These requests or acknowledgments may be very short bursts. The signal strength of these requests or acknowledgments is measured, and a relationship is then built between the signal strength measurements and the power that is currently being used to eventually derive an optimum power level for packet transmission.

Several radio quality parameters may be measured and stored in the historical database for later correlation. Then, at a later system access, pairs of parameters, or combinations of additional parameters may be utilized to determine a most likely best initial power level. Examples of available radio quality measurements that can be utilized for the historical database are:

- Signal strength of control signaling during access;
- Signal strength on the idle traffic channel, indicating interference;
- Energy-per-bit/Noise (Eb/No) or Carrier-to-Interference (C/I)

measurements;

• Bit errors, indicating radio quality (Eb/No or C/I); and

• Cell-load or sum of used power in a CDMA system, indicating interference.

Since uplink and downlink offsets are measured and compensated for, either uplink or downlink measurements can be used and correlated with the desired power. Therefore, uplink measurements can be utilized to set initial downlink power.

As noted above, the historical database can be built for each cell, transceiver, mobile station type, mobile individual, or data transaction. The database may be built on a per-cell basis to adapt to each cell radio environment, to measurement devices inaccuracy, and to the uplink/downlink link budget difference. The database may be built on a per-transceiver basis to adapt to equipment differences and to channel reuse/interference differences between channels. The database may be built on the basis of mobile station type in order to adapt to different mobile station design characteristics. The database may be built on a per-mobile individual basis to adapt to each mobile station. The database may be built on a per-data transaction basis to retain and reuse data gathered about a particular radio environment during a packet data association.

FIG. 1 is a signal flow diagram illustrating how the method of the present invention is utilized with the General Packet Radio Service (GPRS) and the Global System for Mobile Communications (GSM) to determine an initial downlink power level and to maintain the historical database. Illustrated in the figure are a base station 11, a mobile station 12, and a historical database 13 which stores signal strength measurements, path loss offsets, and associated power level settings in the network. The signal flow illustrates a Temporary Block Flow (TBF) process in which one data packet is sent downlink using GPRS. The data packet has been split into a number of Radio Link Control (RLC) blocks, each of which is four GSM bursts. This equates to between 22 and 54 bytes payload depending on channel coding.

When it is desired to transmit a packet to the mobile station 12, the base station 11 assigns a packet data channel and notifies the mobile station with a Packet Downlink Assignment signal 14 on the control channel. Upon receipt of this signal, the mobile station sends a Packet Control Acknowledgment 15 as a response. The uplink signal strength of this acknowledgment is measured by the base station, and at 16, the measurement is passed to the historical database 13. The database utilizes the measured uplink signal strength and associated historical path loss offsets to select a near-optimum initial power level setting. At 17, the initial power level setting is returned to the base station. Meanwhile, the base station has sent a Packet Timing Advance/Power Control signal 18 to the mobile station on the control channel. The mobile station is then switched to the assigned packet data channel.

The first RLC data block 19 is then sent from the base station 11 to the mobile station 12 with the initial power based on the selected initial power level setting from the historical database 13. The mobile station receives the first RLC data block and measures the downlink signal strength and C/I. The mobile station then sends a Packet Downlink Acknowledgment signal 21 to the base station and includes the downlink measurement results. At 22, the base station filters the received downlink measurements, and uses a closed loop power control process to adjust the power level of the second RLC data block based on the received downlink measurements. The adjusted power level is calculated to result in a more optimum received signal strength at the mobile station. At 23, the second RLC data block is then sent from the base station to the mobile station at the adjusted power level. Once again, the mobile station receives the RLC data block and measures the downlink signal strength and C/I. The mobile station then sends a second Packet Downlink Acknowledgment signal 24 to the base station and includes the downlink measurements from the second RLC data block. At 25, the base station again adjusts the power level of the transmitted RLC data blocks based on the received downlink measurements.

This process continues until the closed loop power control has passed its initial phase, which is dependent on filter times. This is shown in FIG. 1 after "n" iterations where the mobile station 12 sends a Packet Downlink Acknowledgment signal 26 to the base station and includes the downlink measurement results from the n-1th RLC data block. At 27, the base station adjusts the power level of the nth RLC data block based on the received downlink measurements, and sends the data block to the mobile station at 28. At 29, the base station also passes the adjusted power level setting to the historical database 13 which stores this value along with the uplink measurement recorded at step 16. This can be done with filters, a look-up table, or any other suitable method. As noted above, the value may be associated with one parameter or with others on a per-cell, per-data transfer, etc. basis.

The closed loop power control function may then continue until the last RLC data block is transmitted at 31, and the last Packet Downlink Acknowledgment signal 32 is sent to the base station with downlink signal strength and C/I measurements.

FIG. 2 is a signal flow diagram illustrating how the method of the present invention is utilized with GPRS and GSM to determine an initial uplink power level and to maintain the historical database. When it is desired to transmit a packet from the mobile station 12, the mobile station sends a Packet Channel Request signal 41 on the control channel to the base station 11. The base station measures the uplink signal strength of the signal and sends a signal strength measurement 42 to the historical database 13. The base station also assigns a packet data channel to the mobile station and measures the idle signal strength on the assigned channel as an interference measurement 43 which is also sent to the historical database. Alternatively, the interference may be continuously measured on all packet data channels and recorded in the historical database so that the information is readily available and does not delay allocation when requested.

The combination of signal strength of the Packet Channel Request signal 41 and interference on the assigned packet data channel 43 is then used in the historical database to look up an optimum initial mobile uplink power setting 44. The base station then sends a Packet Uplink Assignment signal 45 to the mobile station and includes the initial mobile uplink power setting.

Upon receipt of the Packet Uplink Assignment signal 45, the mobile station 12 sends a first RLC data block 46 to the base station 11 utilizing the initial mobile uplink power setting 44 from the historical database 13. The base station receives the first RLC data block, analyzes the quality of the received block, and uses a closed loop power control process at 47 to compute an adjusted uplink power setting for the mobile station. The adjusted uplink power setting is sent to the mobile station in a Packet Uplink Acknowledgment signal 48. The mobile station then uses the adjusted uplink power setting to send the second RLC data block 49.

Once again, the base station receives the RLC data block (in this case RLC data block 2), analyzes the quality of the received block, and uses a closed loop power control process at 51 to compute an adjusted uplink power setting for the mobile station. The adjusted uplink power setting is sent to the mobile station in a Packet Uplink Acknowledgment signal 52.

This process continues until the closed loop power control has passed its initial phase, which is dependent on filter times. This is shown in FIG. 2 after "n" iterations where the mobile station 12 sends the nth RLC data block 53 to the base station 11. At 54, the base station computes an adjusted uplink power setting for the mobile station, and sends a Packet Uplink Acknowledgment signal 55 to the mobile station with the adjusted power level setting. At 56, the base station also passes the adjusted power level setting to the historical database 13 which stores this value along with the uplink signal strength measurement 42 and the uplink interference measurement 43 previously recorded. This can be done with filters, a look-up table, or any other suitable method.

The closed loop power control function may then continue until the last RLC data block 57 is transmitted from the mobile station 12, and the last Packet Uplink Acknowledgment signal 58 is sent from the base station 11.

FIG. 3 is an exemplary data structure for the historical database 13 in which the database is built for each cell 61. As noted above, the historical database may be built for each cell, transceiver, or mobile station type, depending on the level of accuracy desired. The database may also be built for each mobile individual or data transaction. Essentially, a database can be built for each entity which has individual behavior for initial data, and for which enough data can be collected. In each database, a probability density function (PDF) is built for each combination of measurement values. In this example, the combination of signal strength measurements 62 and interference measurements 63 results in a PDF 64 for each combination 65. The values can be rounded and truncated to limit the size of the database.

The PDF may be programmed in several ways to identify a power level setting associated with the signal strength/interference combination. For example, the PDF may identify the most common resulting adjusted power level computed by the closed loop power control function and reported to the historical database. Alternatively, the PDF may identify a median value rather than the most common power level setting.

It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description. While the method shown and described has been characterized as being preferred, it will be readily apparent that various changes and modifications could be made therein without departing from the scope of the invention as defined in the following claims.

WHAT IS CLAIMED IS:

1. A method of assigning an initial downlink power level from a base station to a mobile station in a radio telecommunication system, comprising the steps of:

building a historical database which correlates measurements of radio quality parameters with downlink power level settings;

measuring at the base station, a radio quality parameter from an initial signal sent from the mobile station to the base station;

sending the measured radio quality parameter to the historical database;

correlating in the historical database, the measured radio quality parameter with an associated downlink power level setting;

sending the correlated downlink power level setting to the base station; and

utilizing the correlated downlink power level setting as the initial downlink power level setting for a first transmission from the base station to the mobile station.

2. The method of assigning an initial downlink power level of claim 1 wherein the step of building a historical database includes building a historical database in which measurements are grouped for each transceiver in the base station.

3. The method of assigning an initial downlink power level of claim 1 wherein the step of building a historical database includes building a historical database in which measurements are grouped for each cell in the system.

4. The method of assigning an initial downlink power level of claim 1 wherein the step of building a historical database includes building a historical database in which measurements are grouped for each mobile station type operating in the system

5. The method of assigning an initial downlink power level of claim 1 wherein the step of building a historical database includes building a historical

database in which measurements are grouped for each mobile individual in the system.

6. The method of assigning an initial downlink power level of claim 1 wherein the step of building a historical database includes building a historical database in which measurements are grouped for each data transaction conducted in the system.

7. The method of assigning an initial downlink power level of claim 1 wherein the measured radio quality parameter is selected from a group consisting of:

an uplink signal strength of an initial access signal sent from the mobile station to the base station;

signal strength of control signaling during access;

signal strength on an idle traffic channel;

Energy-per-bit/Noise (Eb/No) measurements;

Carrier-to-Interference (C/I) ratio measurements;

bit errors;

cell-load in the system; and

sum of used power in the system.

8. The method of assigning an initial downlink power level of claim 1 further comprising a closed loop power control step, the closed loop step including:

measuring at the mobile station, at least one radio quality parameter of a transmission from the base station;

sending the measured radio quality parameter from the mobile station to the base station; and

adjusting the downlink power level at the base station to a more optimum level.

9. The method of assigning an initial downlink power level of claim 8 further comprising the step of updating the historical database, the updating step including:

sending the adjusted downlink power level to the historical database; and

associating the adjusted downlink power level setting with the uplink signal strength of the initial signal sent from the mobile station to the base station.

10. The method of assigning an initial downlink power level of claim 9 wherein the updating step is performed after a number of iterations in which the received radio quality parameter is measured at the mobile station, the received radio quality measurements are reported to the base station, and the downlink power level is adjusted to a more optimum level.

11. The method of assigning an initial downlink power level of claim 10 wherein the number of iterations is determined when the closed loop power control step has passed its initial phase, as determined by filter times.

12. The method of assigning an initial downlink power level of claim 1 wherein the step of measuring at the base station, a radio quality parameter from an initial signal sent from the mobile station to the base station includes measuring the signal strength of control signaling at initial system access on a control channel for a circuit-switched call.

13. The method of assigning an initial downlink power level of claim 1 wherein the initial downlink power level is being set at intercell handoff of the mobile station from a serving base station to a target base station, and the step of measuring at the base station, a radio quality parameter from an initial signal sent from the mobile station to the base station includes measuring at the target base station, a radio quality parameter from an initial signal sent from the mobile station to the target base station.

14. The method of assigning an initial downlink power level of claim 1 wherein the initial downlink power level is being set for a transaction of a data package between the base station and the mobile station, and the step of building a historical database includes storing in the historical database, measurements of radio quality parameters and power level information from previous data package transactions between the base station and the mobile station.

15. The method of assigning an initial downlink power level of claim 14 wherein the step of measuring at the base station, a radio quality parameter from an initial signal sent from the mobile station to the base station includes measuring the signal strength of control signaling at packet control acknowledgment on a packet channel.

16. A method of assigning an initial downlink power level from a base station to a mobile station in a radio telecommunication system, comprising the steps of:

building a historical database which correlates measurements of radio quality parameters with downlink power level settings;

measuring at the mobile station, a radio quality parameter from an initial signal sent from the base station to the mobile station;

sending the measured radio quality parameter to the historical database;

correlating in the historical database, the measured radio quality parameter with an associated downlink power level setting;

sending the correlated downlink power level setting to the base station; and

utilizing the correlated downlink power level setting as the initial downlink power level setting for a first transmission from the base station to the mobile station.

17. The method of assigning an initial downlink power level of claim 16 wherein the measured radio quality parameter is selected from a group consisting of:

an uplink signal strength of an initial access signal sent from the mobile station to the base station;

signal strength of control signaling during access;

signal strength on an idle traffic channel;

Energy-per-bit/Noise (Eb/No) measurements;

Carrier-to-Interference (C/I) ratio measurements; and

bit errors.

18. The method of assigning an initial downlink power level of claim 16

wherein the step of measuring at the mobile station, a radio quality parameter from an initial signal sent from the base station to the mobile station includes measuring the signal strength of control signaling at initial system access on a control channel for a circuit-switched call.

19. The method of assigning an initial downlink power level of claim 16 wherein the initial downlink power level is being set at intercell handoff of the mobile station from a serving base station to a target base station, and the step of measuring at the mobile station, a radio quality parameter from an initial signal sent from the base station to the mobile station includes measuring at the mobile station, a radio quality parameter from an initial signal sent from the target base station to the mobile station.

20. The method of assigning an initial downlink power level of claim 16 wherein the initial downlink power level is being set for a transaction of a data package between the base station and the mobile station, and the step of building a historical database includes storing in the historical database, measurements of radio quality parameters and power level information from previous data package transactions between the base station and the mobile station.

21. A method of assigning an initial uplink power level from a mobile station to a base station in a radio telecommunication system, comprising the steps of:

building a historical database which correlates measurements of radio quality parameters with optimum uplink mobile station power level settings;

measuring at the base station, at least one radio quality parameter from signals sent from the mobile station to the base station;

sending the measured radio quality parameter to the historical database;

correlating in the historical database, the measured radio quality parameter with an optimum uplink mobile station power level setting;

sending the correlated optimum uplink power level setting to the mobile station; and

utilizing the correlated optimum uplink power level setting as the initial mobile station power level setting for a first transmission from the mobile station to the base station.

22. The method of assigning an initial uplink power level of claim 21 wherein the measured radio quality parameter is selected from a group consisting of:

an uplink signal strength of an initial access signal sent from the mobile station to the base station;

signal strength of control signaling during access;

signal strength on an idle traffic channel;

Energy-per-bit/Noise (Eb/No) measurements;

Carrier-to-Interference (C/I) ratio measurements;

bit errors;

cell-load in the system; and

sum of used power in the system.

23. The method of assigning an initial uplink power level of claim 21 wherein the transmission from the mobile station to the base station is a data transmission, and the step of measuring at least one radio quality parameter from signals sent from the mobile station to the base station includes:

measuring at the base station, a signal strength of an initial access signal sent from the mobile station to the base station on a control channel; and

measuring at the base station, an interference level on an assigned packet data channel.

24. The method of assigning an initial uplink power level of claim 21 further comprising a closed loop power control step, the closed loop step including:

measuring at the base station, at least one radio quality parameter of the first data transmission from the mobile station;

utilizing the measured radio quality parameter to compute an adjusted mobile station power level; and

sending the adjusted mobile station power level from the base station to the mobile station.

25. The method of assigning an initial uplink power level of claim 21 wherein the step of building a historical database includes the steps of:

establishing an association of signal strength measurements on a control channel and interference measurements on a packet data channel; and

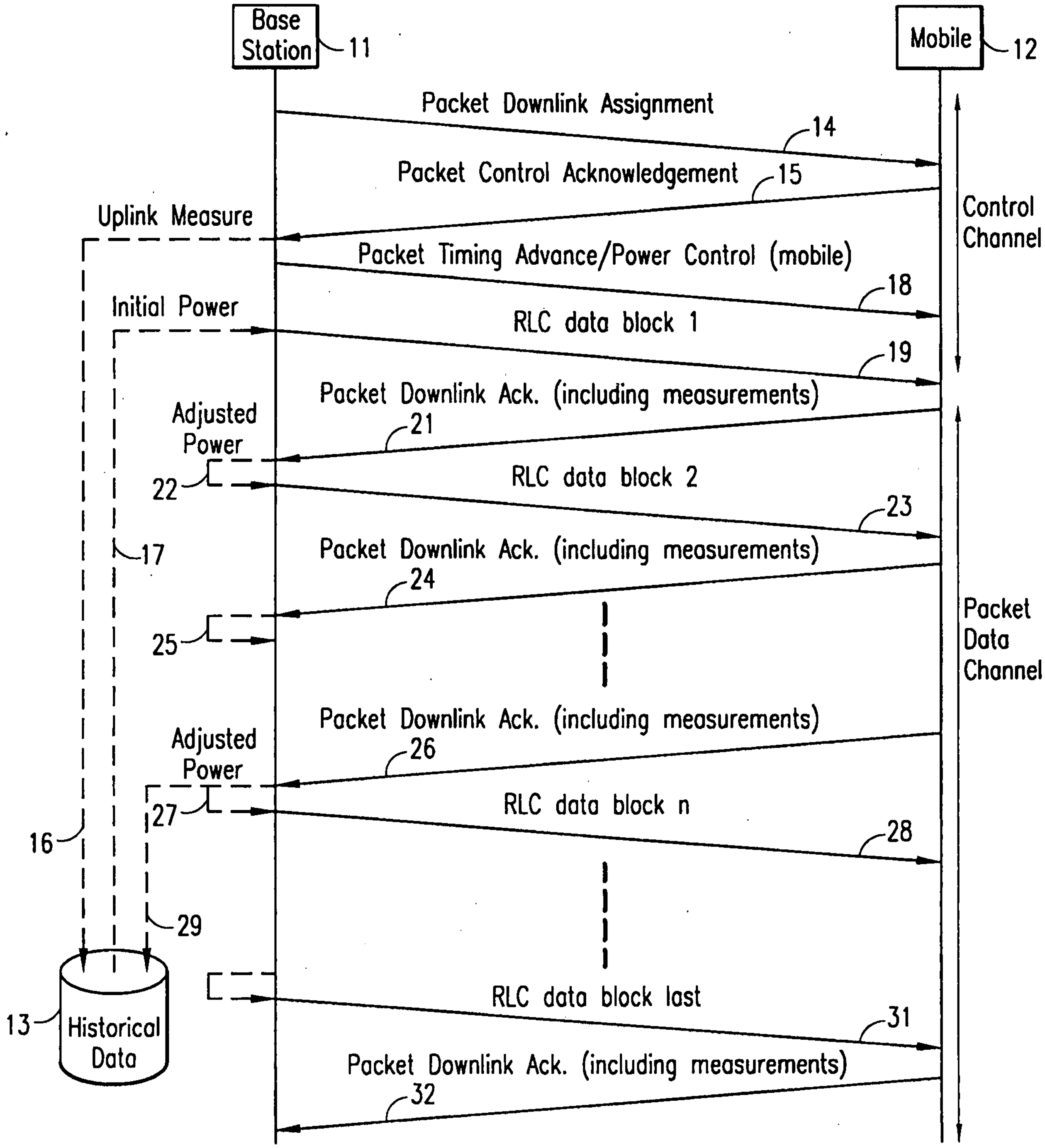
building a probability density function (PDF) of uplink power level settings for each combination of measured control channel signal strength and packet data channel interference.

26. The method of assigning an initial uplink power level of claim 25 wherein the PDF identifies the most common resulting adjusted mobile station power level computed by the closed loop power control step.

27. The method of assigning an initial uplink power level of claim 25 wherein the PDF identifies a median adjusted mobile station power level computed by the closed loop power control step.

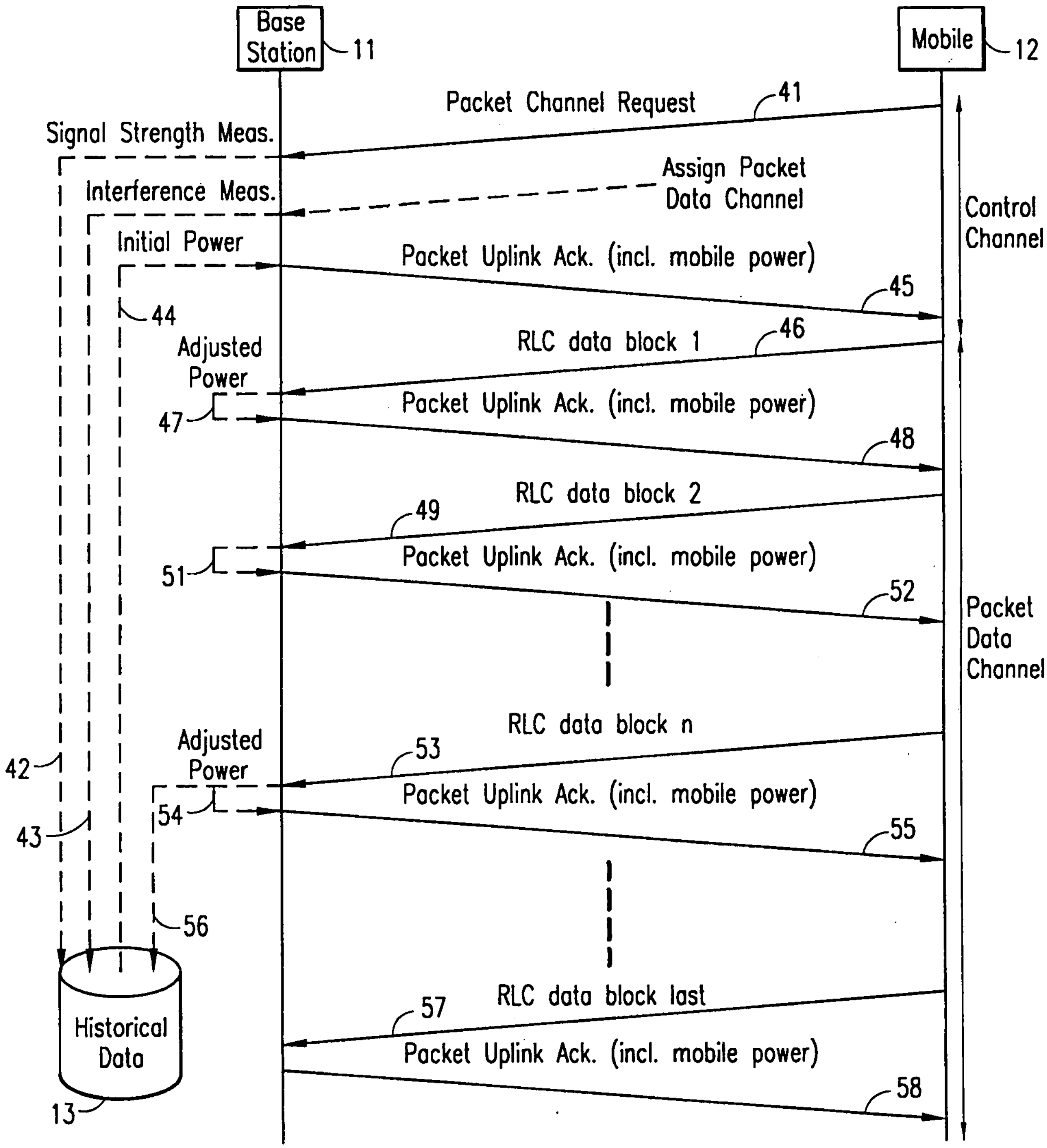
28. The method of assigning an initial uplink power level of claim 21 wherein the step of measuring at the base station, at least one radio quality parameter from a signals sent from the mobile station to the base station includes measuring the signal strength of control signaling at initial system access on a control channel for a circuit-switched call.

29. The method of assigning an initial uplink power level of claim 21 wherein the initial uplink power level is being set at intercell handoff of the mobile station from a serving base station to a target base station, and the step of measuring at the base station, at least one radio quality parameter from signals sent from the mobile station to the base station includes measuring at the target base station, a radio quality parameter from an initial signal sent from the mobile station to the target base station.



Base Station
11
Mobile
12
Packet Downlink Assignment
14
Packet Control Acknowledgement
15
Uplink Measure
Control Channel
Packet Timing Advance/Power Control (mobile)
18
Initial Power
RLC data block 1
19
Packet Downlink Ack. (including measurements)
Adjusted Power
21
22
RLC data block 2
23
17
Packet Downlink Ack. (including measurements)
24
25
Packet Data Channel
Packet Downlink Ack. (including measurements)
Adjusted Power
26
27
RLC data block n
28
16
29
13
Historical Data
RLC data block last
31
Packet Downlink Ack. (including measurements)
32

FIG. 1



Base Station
11
Mobile
12
Packet Channel Request
41
Signal Strength Meas.
Assign Packet Data Channel
Interference Meas.
Control Channel
Initial Power
Packet Uplink Ack. (incl. mobile power)
45
44
RLC data block 1
46
Adjusted Power
47
Packet Uplink Ack. (incl. mobile power)
48
RLC data block 2
49
51
Packet Uplink Ack. (incl. mobile power)
52
Packet Data Channel
RLC data block n
Adjusted Power
53
42
54
Packet Uplink Ack. (incl. mobile power)
43
55
56
RLC data block last
57
Historical Data
Packet Uplink Ack. (incl. mobile power)
58
13

FIG. 2

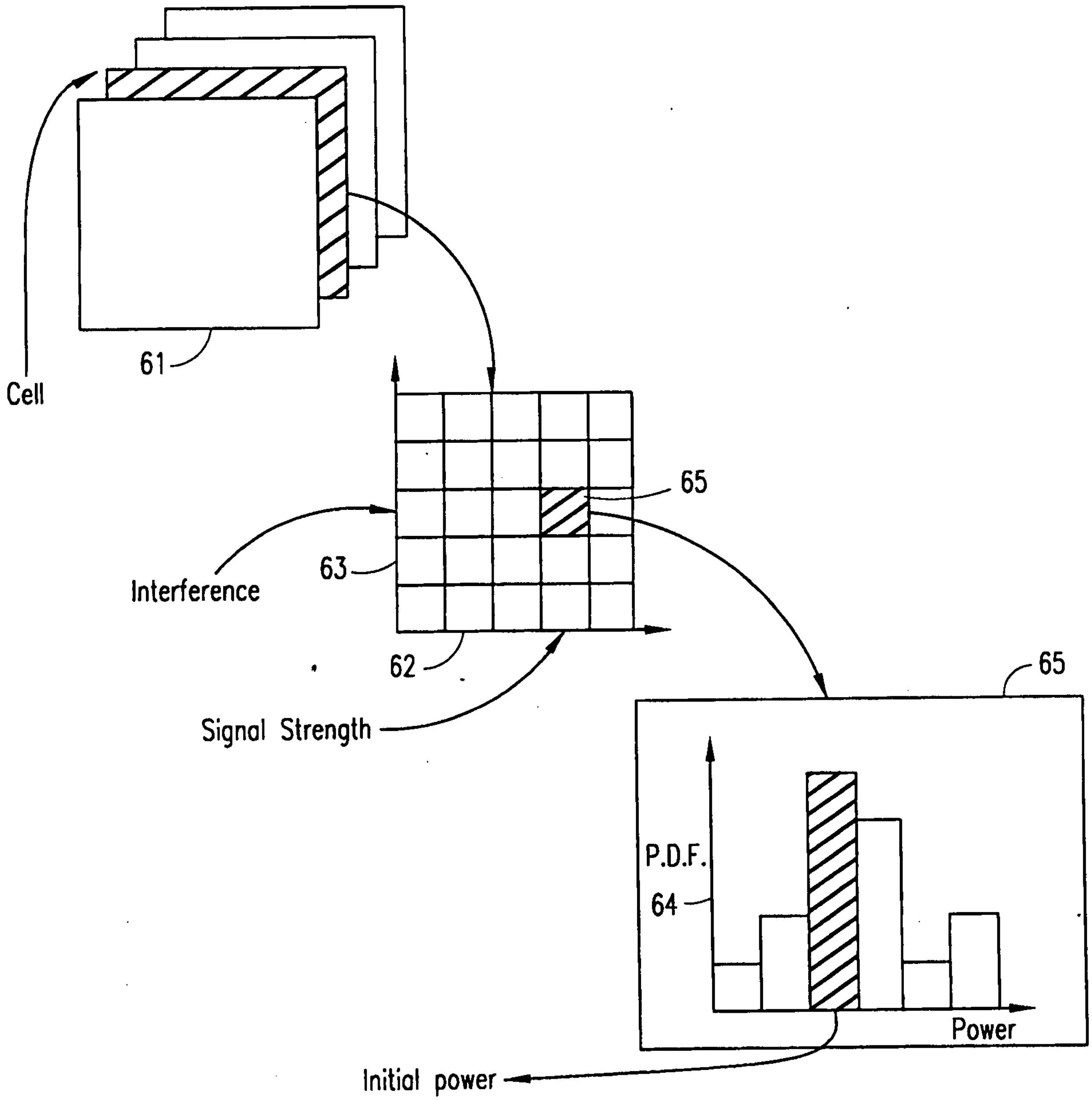

Cell
61
Interference
63
62
65
Signal Strength
65
P.D.F.
64
Power
Initial power

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01460

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 7/005, H04Q 7/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04B, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9934531 A1 (TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)), 8 July 1999 (08.07.99), page 2, line 24 - page 4, line 24 --	1-29
A	WO 9849785 A1 (QUALCOMM INCORPORATED), 5 November 1998 (05.11.98), page 6, line 8 - page 8, line 26 --	1-29
A	WO 9406217 A1 (MILLICOM HOLDINGS (UK)), 17 March 1994 (17.03.94), page 2, line 16 - page 6, line 37 --	1-29

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 November 2000	11. 12. 2000

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel(+31-70)340-2040, Tx 31 651 epo nl, Fax(+31-70)340-3016	Antonio Farieta/mj Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01460

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5873028 A (ETSUHIRO NAKANO ET AL), 16 February 1999 (16.02.99), column 2, line 34 - column 3, line 51 --	1-29
A	US 5884147 A (DOUGLAS O. REUDINK ET AL), 16 March 1999 (16.03.99), column 2, line 39 - column 6, line 7 -- --------	1-29

INTERNATIONAL SEARCH REPORT
Information on patent family members

03/10/00

International application No.
PCT/SE 00/01460

WO	9934531	A1	08/07/99	AU	2193199	A	19/07/99
WO	9849785	A1	05/11/98	AU	7099498	A	24/11/98
				CN	1254460	T	24/05/00
				EP	0978170	A	09/02/00
				NO	995180	A	22/12/99
				ZA	9803400	A	27/10/98
WO	9406217	A1	17/03/94	EP	0611498	A	24/08/94
				GB	9218876	D	00/00/00
US	5873028	A	16/02/99	CN	1054013	B	28/06/00
				CN	1123976	A	05/06/96
				EP	0709973	A	01/05/96
				JP	3014308	B	28/02/00
				JP	8181653	A	12/07/96
US	5884147	A	16/03/99	AU	1569597	A	28/07/97
				CA	2241971	A	10/07/97
				IL	125275	D	00/00/00
				WO	9724895	A	10/07/97

Appln No. 10/917,968
Docket No. 562492000500

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

(43) **International Publication Date**
1 May 2003 (01.05.2003)

PCT

(10) **International Publication Number**
WO 03/036816 A1

(51) **International Patent Classification**[7]: **H04B 7/005**

(21) **International Application Number:** PCT/GB02/04811

(22) **International Filing Date:** 24 October 2002 (24.10.2002)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
0125504.1 24 October 2001 (24.10.2001) GB

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(81) **Designated States** *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) **Designated States** *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,*

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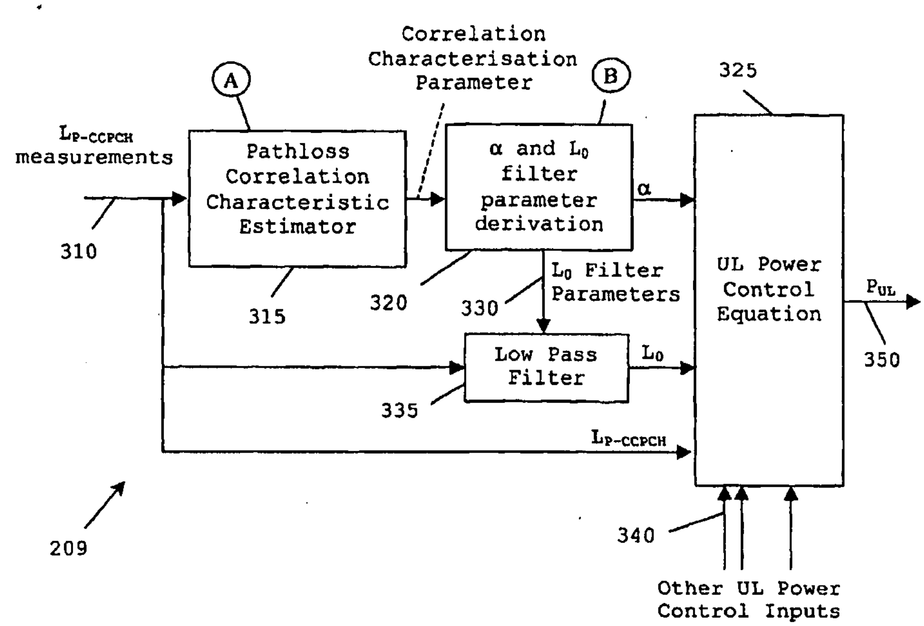
(54) **Title:** METHOD AND ARRANGEMENT FOR POWER USING PATH LOSS METRICS



(57) **Abstract:** A method for performing power control in a wireless communication unit (112) operating in a wireless communication system (100), includes the steps of: determining (315) a path loss correlation metric to derive one or more parameters pertaining to a wireless transmission; and adjusting an output power level of said wireless communication unit in response to said one or more parameters.Basing power control calculations on a path loss correlation metric provides the advantage of improved power control performance particularly for slow moving subscriber equipment without compromising power control performance at high speed.

WO 03/036816 A1

KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

METHOD AND ARRANGEMENT FOR POWER USING PATH LOSS METRICS

Field of the Invention

This invention relates to power control in a wireless communication system. The invention is applicable to, but not limited to, open loop power control in a UMTS terrestrial radio access (UTRA) time division duplex (TDD), code division multiple access (CDMA) communication system.

Background of the Invention

Wireless communication systems, for example cellular telephony or private mobile radio communication systems, typically provide for radio telecommunication links to be arranged between a plurality of base transceiver stations (BTS), referred to as Node Bs with regard to universal mobile telecommunication system (UMTS) systems, and a plurality of subscriber units, often referred to as user equipment (UE) in UMTS systems.

The communication link from a Node B to a UE is generally referred to as a down-link communication channel. Conversely, the communication link from a UE to a Node B is generally referred to as an up-link communication channel.

In a UTRA wireless communication system, each Node B has associated with it a particular geographical coverage area (or cell). The coverage area is defined by a particular range over which the Node B can maintain acceptable communications with UEs operating within its serving cell. Often these cells combine to produce an extensive coverage area.

In such wireless communication systems, methods for communicating information simultaneously exist where communication resources in a communication network are shared by a number of users. Such methods are termed multiple access techniques. A number of multiple access techniques exist, whereby a finite communication resource is divided into any number of physical parameters, such as:

(i) Frequency division multiple access (FDMA) whereby frequencies used in the communication system are shared,

(ii) Time division multiple access (TDMA) whereby each frequency used in the communication system, is shared amongst users by dividing the communication resource (each frequency) into a number of distinct time periods (time-slots, frames, etc.), and

(iii) Code division multiple access (CDMA) whereby communication is performed by using all of the respective frequencies, in all of the time periods, and the resource is shared by allocating each communication a particular code, to differentiate desired signals from undesired signals.

Within such multiple access techniques, different duplex (substantially simultaneous two-way communication) paths are arranged. Such paths can be arranged in a frequency division duplex (FDD) configuration, whereby a first frequency is dedicated for up-link communication and a second frequency is dedicated for down-link communication.

Alternatively, the paths can be arranged in a time division duplex (TDD) configuration, whereby a first time period is dedicated for up-link communication and a second time period is dedicated for down-link communication within the same frequency channel. In addition, some communication channels are used for carrying traffic and other channels are used for transferring control information, such as call paging, between the base station and the subscriber units.

Wireless communication systems are distinguished over fixed communication systems, such as the public switched telephone network (PSTN), principally in that mobile stations/subscriber equipment move between coverage areas served by different Node B (and/or different service providers). In doing so, the mobile stations/subscriber equipment encounter varying radio propagation environments. In particular, in a mobile context, a received signal level can vary rapidly due to multipath and fading effects.

The present invention will be described with respect to a 3rd generation partnership project (3GPP) communication system based on the universal mobile telecommunications standard (UMTS). UMTS is a CDMA-based system. A CDMA system employs spread spectrum signaling. Two categories of spread spectrum communications are direct sequence spread spectrum (DSSS) and frequency hopping spread spectrum (FHSS).

In the case of a DSSS communication system, for example, the spectrum of a signal can be most easily spread by multiplying it with a wide-band pseudo-random code generated signal. It is essential that the spreading signal be precisely known so that the receiver can de-spread the signal. A cellular communication system using DSSS is commonly known as a Direct Sequence Code Division Multiple Access (DS-CDMA) system, one example of which is defined in the TIA-EAI standard IS-95. Individual users in the system use the same radio frequencies (RF) and time slots but they are distinguishable from each other by the use of individual spreading codes. Hence, multiple communications channels are allocated using a number of spreading codes within a portion of the radio spectrum. Each code is uniquely assigned to a UE, except for common channels.

One feature associated with most wireless communication systems, which is particularly needed in a UTRA system, allows the transceivers in the Node B and UE to adjust their transmission output power to take into account the geographical distance between them. The closer the UE is to the Node B's transceiver, the less power the UE and Node B's transceivers are required to transmit, for the transmitted signal to be adequately received by the other unit. This 'power control' feature saves battery power in the UE and also helps to reduce interference effects. Initial power settings for the UE, along with other control information, are set by the information provided on a beacon physical channel for a particular cell.

In the context of the present invention, both up-link and down-link power settings can be controlled independently, although the present invention is described primarily with regard to up-link power control.

Precise reverse link power control is a vital element of CDMA systems as the spreading codes are not orthogonal on the reverse link. Hence, any error in the power control (PC) levels introduces interference that directly reduces system capacity.

Furthermore, it is known that the 3GPP standard is particularly sensitive to power control mismatches in the up-link because of fast fading effects in the communication channel. Fast fading is a known and generally undesirable phenomenon caused by the signal arriving at a receiver via a number of different paths. Therefore, in order to achieve maximum up-link capacity in a CDMA system, fast power control loops are required.

An inner power control (PC) loop is provided to adjust a UE's transmission power to counter the so-called "near-far" problem. The inner power control loop adjusts the transmission power of each connection such that the received signal power observed at the Node B is sufficient to meet a particular quality of service (QoS) requirement of each particular connection; thereby reducing interference to others in the system. The inner PC loop adjusts the UE's transmission power in order to keep the received reverse link signal-to-interference ratio (SIR) as close to constant as possible.

The predetermined threshold, to which the inner loop SIR measure is compared, is generated by the outer, quality-driven, power control loop. This loop sets a target SIR threshold that is proportionate with the required quality of service (QoS) for a given connection (usually defined in terms of target bit error rate (BER) or frame error rate (FER)). This target will vary as propagation conditions change, for example as a function of each UE's speed and its specific propagation environment, as both have an impact on the SIR required at the Node B to maintain the desired QoS.

The inner loop simply adjusts the transmit power from a UE to achieve the desired received SIR observed at the Node B. The actual transmit power of a UE generally has a fixed dynamic range that is primarily dictated by practical size and cost constraints. This means that the transmit power of the UE is constrained to lie somewhere within this range. If the UE is situated close to a Node B that it is communicating with, then the path loss between the UE and the Node B will, in general, be low, meaning that the transmission power of the UE to achieve a given SIR can also be low.

In the context of the present invention, an open-loop power control scheme is used in UTRA TDD-CDMA whereby user equipment (UE) adapts its transmit output level in accordance with measured path loss variations. These path loss variations are determined by regular measurements of the received signal code power (RSCP) of a downlink beacon physical channel. In the RSCP, the UE is provided with the reference power at which the beacon channel was transmitted. Hence, when this value is compared to the measured level of the received signal, the path loss can be calculated.

The UE then compensates for changes in the path loss by transmitting more or less power depending on whether the path loss has increased or decreased respectively.

Nominally, the open loop scheme runs at the radio frame rate of 10 msec., although an option exists within the UTRA standard to run at twice this rate by utilising two beacon physical channels per frame, i.e. spaced eight timeslots (8/15ths of a frame) apart.

Due to the update rate limitations of the scheme, the effectiveness of the loop at combating the aforementioned fast fading problem decreases with increasing UE speed. Hence, as PC is a critical issue in CDMA systems, a solution to the implementation of effective PC at high subscriber unit speeds is required.

The technical specification 'TS25.224' of the 3rd Generation Partnership Project (3GPP) specifies that a weighting parameter α can be used to weight the path loss towards the long-term-averaged path loss (L_0) and the instantaneous path loss $L_{P\text{-}CCPCH}$ as required. The equation that is used to implement the open loop power control scheme, is:

$$P_{UL} = \alpha L_{P\text{-}CCPCH} + (1-\alpha) L_0 + I_{BTS} + SIR_{TARGET} + Const. \quad [1]$$

Where:

P_{UL}: Power setting in dBm. This value corresponds to a particular CCTrCH (due to CCTrCH-specific SIR_{TARGET}) and a particular timeslot (due to possibly timeslot-specific α and I_{BTS}).

$L_{P\text{-}CCPCH}$: Measure representing path loss in dB (reference transmit power is broadcast on a broadcast channel (BCH)).

L_0: Long term average of path loss in dB.

I_{BTS}: Interference signal power level at cell's receiver in dBm, which is broadcast on a BCH.

α: α is a weighting parameter that represents the quality of path loss measurements. The

UTRA standard states: (i) α may be a function of the time delay between the up-link time slot and the most recent down link time slot containing a beacon channel; (ii) α shall be calculated autonomously at the UE, subject to a maximum allowed value which shall be signalled by higher layers.

SIR_{TARGET}: Target SIR in dB. A higher layer outer loop adjusts the target SIR.

Const.: This 'constant' value shall be set by higher Layer (defined by respective operators) and is broadcast on BCH.

In an annex of TS25.224 it is suggested that α could be made a function of the "delay" between the instantaneous path loss measurement $L_{P\text{-}CCPCH}$ (where CCPCH is the Common Control Physical Channel) and the up-link timeslot for which the power control calculation is being made.

However, although α could be set to be a function of the delay, or the up-link timeslot position in the frame, it is up to each equipment manufacturer how exactly to configure this set up. Furthermore, it is not apparent how power control performance can be usefully employed when configuring α in this manner.

A need therefore exists, in general, for an improved power control arrangement and method of operation, and in particular, an arrangement and method for open-loop power control for an UTRA-TDD system, wherein the abovementioned disadvantages may be alleviated.

Statement of Invention

In accordance with a first aspect of the present invention, there is provided a method for performing power control in a wireless communication unit, as claimed in claim 1.

In accordance with a second aspect of the present invention, there is provided a wireless communication unit, as claimed in claim 16.

In accordance with a third aspect of the present invention, there is provided wireless communication system, as claimed in claim 19.

In accordance with a fourth aspect of the present invention, there is provided a wireless communication unit, as claimed in claim 21.

In accordance with a fifth aspect of the present invention, there is provided a storage medium storing processor-implementable instructions, as claimed in claim 39.

In accordance with a sixth aspect of the present invention, there is provided a differentiator, as claimed in claim 40.

Brief Description of the Drawings

Exemplary embodiments of the present invention will now be described, with reference to the accompanying drawings, in which:

FIG. 1 shows a block diagram of a communication system that can be adapted to support the various inventive concepts of a preferred embodiment of the present invention;

FIG. 2 shows a functional block diagram of a UE, adapted in accordance with various inventive concepts of a preferred embodiment of the present invention;

FIG. 3 shows a flowchart/functional block diagram of a power control processing operation of a UE adapted to incorporating the present invention;

FIG. 4 shows a block schematic diagram illustrating the open-loop power control scheme on which the arrangement of FIG. 3 is based;

FIG. 5 shows an alternative manner of illustrating the power control processing function 209 of the embodiment of FIG. 4; and

FIG. 6 shows a block schematic diagram illustrating an alternative embodiment for implementing the open-loop power control scheme of FIG. 3.

Description of Preferred Embodiments

Referring now to FIG. 1, a cellular-based telephone communication system 100 is shown in outline, in accordance with a preferred embodiment of the invention. In the preferred embodiment of the invention, the cellular-based telephone communication system 100 is compliant with, and contains network elements capable of operating over, a UMTS air-interface. In particular, the invention relates to the Third Generation Partnership Project (3GPP) specification for wide-band code-division multiple access (WCDMA) standard relating to the UTRAN radio Interface (described in the 3G TS 25.xxx series of specifications).

A plurality of subscriber terminals (or user equipment (UE) in UMTS nomenclature) 112, 114, 116 communicate over radio links 118, 119, 120 with a plurality of base transceiver stations, referred to under UMTS terminology as Node-Bs, 122, 124, 126, 128, 130, 132. The system comprises many other UEs and Node Bs, which for clarity purposes are not shown.

The wireless communication system, sometimes referred to as a Network Operator's Network Domain, is connected to an external network 134, for example the Internet. The Network Operator's Network Domain (described with reference to both a 3rd generation UMTS and a 2nd generation GSM system) includes:

(i) A core network, namely at least one Gateway GPRS Support Node (GGSN) 144 and or at least one Serving GPRS Support Nodes (SGSN); and

(ii) An access network, namely:

(ai) a GPRS (or UMTS) Radio network controller (RNC) 136-140; or

(aii) Base Site Controller (BSC) in a GSM system and/or

(bi) a GPRS (or UMTS) Node B 122-132; or

(bii) a Base Transceiver Station (BTS) in a GSM system.

The GGSN/SGSN 144 is responsible for GPRS (or UMTS) interfacing with a Public Switched Data Network (PSDN) such as the Internet 134 or a Public Switched Telephone Network (PSTN) 134. A SGSN 144 performs a routing and tunnelling function for traffic within say, a GPRS core network, whilst a GGSN 144 links to external packet networks, in this case ones accessing the GPRS mode of the system

The Node-Bs 122-132 are connected to external networks, through base station controllers, referred to under UMTS terminology as Radio Network Controller stations (RNC), including the RNCs 136, 138, 140 and mobile switching centres (MSCs), such as MSC 142 (the others are, for clarity purposes, not shown) and SGSN 144 (the others are, for clarity purposes, not shown).

Each Node-B 122-132 contains one or more transceiver units and communicates with the rest of the cell-based system infrastructure via an I_{ub} interface, as defined in the UMTS specification.

Each RNC 136-140 may control one or more Node-Bs 122-132. Each MSC 142 provides a gateway to the external network 134. The Operations and Management Centre (OMC) 146 is operably connected to RNCs 136-140 and Node-Bs 122-132 (shown only with respect to Node-B 126 for clarity). The OMC 146 administers and manages sections of the cellular telephone communication system 100, as is understood by those skilled in the art.

In the preferred embodiment of the invention, a number of UEs 112-116 and/or corresponding Node-Bs 122-132 have been adapted, to offer, and provide for, adapted power controlled transmission, reception and processing of power control related information. In particular, the preferred embodiment of the present invention describes a feature that bases power control calculations on a good correlation of path loss across a received frame. In this manner, the feature can be added to the operation of the up-link inner-loop power control loop running at a layer-1 physical layer in the UE, in order to improve power control performance at low UE speed, whilst maintaining appropriate power control at high UE speed.

Advantageously, implementation of this invention allows standards compliance to be retained.

More particularly, in this embodiment the above UE elements have been adapted to implement the present invention in either or both up-link or down-link modes of operation. Although the preferred embodiment of the present invention is further described with respect to FIGs 3 to 6 for UE open loop power control in an up-link channel, it is envisaged that a Node B can in general, use the same inventive concepts in the down-link channel.

In such a closed-loop configuration, the Node B (or BTS) transmits a signal to the UE, which is processed to determine path loss correlated information. This information is transmitted from the UE back to the Node B, where it is received, processed, and PC settings used/assigned based on the path loss correlated information. In this manner, the use of a feature that bases power control calculations on a good correlation of path loss across a received frame can also improve the accuracy in setting down-link power control levels, albeit not in an open loop configuration. Such improved accuracy can help minimise system interference.

It is also envisaged that for other wireless communication systems, other criteria and/or equations could be employed in determining an appropriate power control scheme. Such schemes would still benefit from the concept of using path loss correlation parameters, as described herein.

It is also within the contemplation of the invention that such adaptation of the physical layer (air-interface) elements may be alternatively controlled, implemented in full or implemented in part by adapting any other suitable part of the communication system 100. For example, equivalent elements such as intermediate fixed communication units (for example repeaters) in other types of systems may, in appropriate circumstances, be adapted to provide or facilitate the power control features as described herein.

Referring now to FIG. 2, a block diagram of a UE 112 adapted to support the inventive concepts of the preferred embodiments of the present invention, is shown.

The UE 112 contains an antenna 202 preferably coupled to a duplex filter or circulator 204 that provides isolation between receive and transmit chains within UE 112.

The receiver chain includes receiver front-end circuitry 206 (effectively providing reception, filtering and intermediate or base-band frequency conversion). The front-end circuit 206 receives signal transmissions from its associated Node B. The front-end circuit 206 is serially coupled to a signal processing function (processor, generally realised by a DSP) 208. The processing function 208 performs signal demodulation, error correction and formatting. Recovered information from the signal processing function 208 is serially coupled to a power control processing function 209, which extracts pertinent power control information from the received (RSCP) signal and interprets the information to determine an appropriate transmit output level for the UE's transmissions.

The power control processing function 209 has been adapted in the following manner. In operation, as mentioned earlier, the up-link (UL) inner loop is updated at the radio frame rate of 10 msec. as each consecutive beacon-function RSCP is measured by the power control processing function 209 UE. For pedestrian and slow mobile conditions, where the UE is travelling at up to say, four Km/hr, the loop is capable of compensating for any fast fading present. Beyond these speeds, the radio channel becomes uncorrelated across the 10 msec. frame, and any instantaneous path loss measurement inferred from timeslot '0' can no longer be used as a good indicator of the path loss that will be experienced on any other timeslot in the same frame.

The inventor of the present invention has determined that, when there is good correlation of path loss across a radio frame period, it is better to use the 'instantaneous' measurement of RSCP in the power control processing function 209 for use in the UL open-loop PC calculations.

Conversely, when there is little or no correlation of path loss across the radio frame, the inventor of the present invention has determined that it is better to use, in the power control processing function 209 for UL open-loop PC, either (or both of):

(i) an adjusted 'filtered' (mean) RSCP signal/measurement;

(ii) an adjusted "α" parameter.

In particular, the power control processing function 209 of the preferred embodiment of the present invention involves setting the α value between a logical '1' and a logical '0' dependent upon the frame-to-frame path loss correlation seen in the radio channel. The operation of the power control processing function 209 is further described with respect to FIG. 3 to FIG. 6.

A timer 218 is preferably operably coupled to the processing function 208 and power control processing function 209 to provide synchronisation in the signal recovery process, including recovering the RSCP signal.

In different embodiments of the invention, the signal processing function 208 and baseband processing function 211 may be provided within the same physical device. The power control processing function 209 may also be provided within the same physical device with either the signal processing function 208 or the baseband processing function 211, or both.

As known in the art, received signals that have been processed by the power control processing function 209 are typically input to a baseband-processing device 210. The baseband processing device 210 takes the received information formatted in a suitable manner and sends it to an output device 211, such as an audio speaker or liquid crystal display or visual display unit (VDU). A controller 214 controls the information flow and operational state of each circuit/element/function.

As regards the transmit chain, this essentially includes an input device 220, such as a microphone, coupled in series through a baseband processor 210, a power control processing function 209, signal processing function 208, transmitter/modulation circuitry 222 and a power amplifier 224. The processor 208, transmitter/modulation circuitry 222 and the power amplifier 224 are operationally responsive to the controller, with an output from the power amplifier coupled to the duplex filter or circulator 204, as known in the art.

The transmit chain in UE 112 takes the baseband signal from input device 220 and converts this into a signal whose level can be baseband adjusted by the power control processor 209. The power control processor forwards the amplitude-adjusted signal to the signal processor 208, where it is encoded for transmission by transmit/ modulation circuitry 222, thereafter amplified by power amplifier 224, and radiated from antenna 202. Clearly, the adjustment of the transmit output power can be effected by any amplitude or attenuation means in the transmit chain, and the above baseband adjustment is described as one example only.

The signal processor function 208 in the transmit chain may be implemented as distinct from the processor in the receive chain. Alternatively, a single processor 208 may be used to implement processing of both transmit and receive signals, as shown in FIG. 2. Furthermore, the various components within the UE 112 can be realised in discrete or integrated component form.

Referring now to FIG. 3, a flowchart/functional block diagram of the power control processing operation 209 of a UE, adapted to incorporate the present invention, is shown in more detail.

In accordance with the UTRA recommendation, instantaneous path loss measurements $L_{P\text{-}CCPCH}$ 310 are performed for each received frame. Notably, in accordance with the preferred embodiment of the invention, the historical results of these measurements are used to derive a path loss correlation metric 315. The path loss correlation metric 315 is then used to derive any adjustment to the path loss weighting function α, in the parameter derivation function 320.

It is also envisaged that spectral analysis could be performed on the aforementioned path loss correlation over time of $L_{P\text{-}CCPCH}$ measurements. In this case, it is envisaged that a decision on α (or indeed one or more filter parameter(s) to be adapted as described below) could be based on such spectral analysis.

In addition, or as an alternative, to an adjustment of α, the inventor of the present invention has recognised that an adjustment of the filter bandwidth of the low-pass filter (LPF) 335, used to derive L_0 from $L_{P\text{-}CCPCH}$, can also be used for power control level adjustment in response to the path loss correlation information. Such a (L_0) filter-adjusted signal can be used instead of the direct instantaneous path loss measurements $L_{P\text{-}CCPCH}$ 310 in the power control calculation. It is envisaged that the L_0 filter parameters 330 may also be derived from the path loss correlation metric 315, in parameter derivation function 320.

The characteristics of this LPF 335 are not specified in the UTRA standard. Thus, as an alternative to changing α, or in addition to changing α, the filter bandwidth may be widened or narrowed in response to the observed correlation in the radio channel path loss. The LPF will likely be implemented as a digital filter and, as such, its frequency response parameters can be adjusted by appropriate adjustment of filter taps, as known to those skilled in the art.

In the preferred embodiment of the present invention, the parameter derivation function 320 therefore includes an algorithm to derive the parameter changes of α and/or L_0 for use in the UL power control equation 325.

Hence, as shown in FIG. 3, the UL power control equation 325 can be calculated using the current direct instantaneous path loss measurements $L_{P\text{-}CCPCH}$ 310 or, dependent upon the path loss correlation metric, using parameter adjustments to α and/or a bandwidth-adjusted filtered signal (L_0) equivalent to a filtered version of the instantaneous path loss measurements $L_{P\text{-}CCPCH}$ 310 (L_0).

For high-speed UE scenarios, the path loss correlation metric 315 is likely to report low path loss correlation. As such, it is envisaged that the $L_{P\text{-}CCPCH}$ direct measurements 310 are not used in the up-link power control equation 325, which also receives the other control inputs 340, as specified in the UTRA standard. This course of action is appropriate since the $L_{P\text{-}CCPCH}$ direct measurements 310 cannot be guaranteed to be applicable to other timeslots in the same radio frame period.

It is within the contemplation of the invention that many techniques could be designed to implement the path loss correlation metric 315 and subsequent adjustment and/or derivation algorithm 320. However, two examples of how the inventive concepts of the present invention could be applied are described below with respect to FIG. 4 and FIG. 6.

Referring now to FIG. 4, a block schematic diagram 209 of a preferred open-loop power control scheme, on which the arrangement of FIG. 3 is based, is illustrated.

As indicated earlier, instantaneous path loss measurements $L_{P\text{-}CCPCH}$ 310 are performed for each received frame. Notably, the results of these measurements are used to perform a path loss correlation metric by inputting them to a differentiator function 415, followed by a thresholder 420 and frequency counter 430. It is envisaged that the differentiator function 415 may be considered essentially as a high-pass filter. Alternatively, for example, the differentiator function 415 may perform a bi-linear transform of a standard difference equation, as known in the art.

In the differentiator function 415, each consecutive $L_{P\text{-}CCPCH}$ 310 measurement (in dB) is compared to the same measurement for the previous frame, and a difference value (Y) produced:

$$Y = \text{abs}\ (x_{(n)} - x_{(n-1)}) \qquad [2]$$

The sign of the difference is discarded by taking the absolute (abs) value, and the value is checked in the thresholder 420 to see whether it is above or below a threshold value TdB 425 that is held as a constant in a memory element of the UE 112. This comparison is then input to a counter 430, to determine an α-based switch control signal 460. The α-based switch control signal 460 ensures that the switch 410 selects the most appropriate measurement to use in the power control equation 325.

If, for example, the counter determines that more than P% of these differences provided by the differentiator function 415 are observed to be smaller than TdB 425, say over a time period T_{span}, it can be assumed that there is good path loss correlation over time. Hence, the unfiltered path loss values ($L_{P-CCPCH}$) 455 (direct instantaneous path loss measurements) are selected for the UL open-loop calculations in response to the α-based switch control signal 460 (where α='1').

Conversely, if less than P% of these differences provided by the differentiator function 415 are observed to be smaller than TdB 425, it can be assumed that there is poor path loss correlation per time period. In such a case, the filtered $L_{P-CCPCH}$ value (L_0) 450, output from the LPF 335, is selected for the UL open-loop calculations in response to the α-based switch control signal 460 (where α='0').

Hence, the power control processing function 209 of the preferred embodiment of the present invention involves setting the α value between a logical '1' and a logical '0' dependent upon the frame-to-frame path loss correlation seen in the radio channel.

It is envisaged that suitable values for the above parameters could be, for example, respectively:

T_{span}: of the order of 1 or 2 seconds;

TdB 425: of the order of 2 or 3dB; and

P%: of the order of 70%-80%.

Hence, a weighting of α is given to $L_{P-CCPCH}$, and a weighting of $(1-\alpha)$ is given to L_0. So if $\alpha=0$, we end up using only filtered path loss L_0. If $\alpha=1$, we end up using only instantaneous $L_{P-CCPCH}$ measurements. The switch in FIG. 4 therefore denotes this hard-switching between the two path loss measurements (filtered and unfiltered).

Hence, in the context of this embodiment, the path loss correlation metric determines whether an adapted L_0 or the direct $L_{P-CCPCH}$ measurements are used in the UL power control equation 325. Again, it is envisaged that for high-speed scenarios, the L_0 measurements are used in the up-link power control equation 325. Other control inputs such as SIR_{Target} 446, a constant value 444 and I_{BTS} 442 are used, as specified in the UTRA standard. An adjustment algorithm, designed to maximise the benefit of such a scheme, is again used in conjunction with the output 350 of the up-link power control equation 325.

It is within the contemplation of the invention that other inputs may also be used in the final PC equation, together with the path loss correlation indication described herein.

Referring now to FIG. 5, an alternative manner of illustrating the power control processing function 209 of the embodiment of FIG. 4, is shown. Again, instantaneous path loss measurements $L_{P\text{-}CCPCH}$ 310 are performed for each received frame. The results of these measurements are used to derive a path loss correlation metric by inputting them to a differentiator function 415, as in FIG. 4.

The output of the differentiator function is then input to an α decision logic function 510 that includes a thresholder 420 followed by a frequency counter 430. The operation is the same as that for FIG. 4, albeit in this arrangement, all three inputs (α, $L_{P\text{-}CCPCH}$ 310 and L_0 320) are input directly to the power control equation 325. Hence, no switch or switch control signal, per se, is used to prevent a measurement from being used by the power control equation 325. Clearly, similar parameters to those described with reference to FIG. 4 would also be applicable in FIG. 5.

Referring now to FIG. 6, a block schematic diagram 209 of an alternative embodiment for implementing the open-loop power control scheme of FIG. 3, is illustrated.

Again, instantaneous path loss measurements $L_{P\text{-}CCPCH}$ 310 are performed for each received frame. Notably, the results of these measurements are used to perform a path loss correlation metric by inputting them to a differentiator function followed by variance estimator 605.

Again, as in the example of FIG. 4, each consecutive $L_{P\text{-}CCPCH}$ 310 measurement from the PCCPCH RSCP signal (in dBm) is compared to the same measurement for the previous frame and a difference value produced $(x_n - x_{n-1})$. In contrast to the embodiment of FIG. 4, the difference value is then squared to produce a variance estimation Δ_n, where:

$$\Delta_n = (x_n - x_{n-1})^2 \qquad [3]$$

The variance estimation Δ_n is then filtered using, for example, a simple IIR filter 610 to produce the function:

$$F_n = A.F_{n-1} + B.\Delta_n \qquad [4]$$

where: A and B are filter coefficients, and
'A+B' = '1'

It is noteworthy that if n=0, i.e. it is the first iteration, the IIR filter 610 is initialised with:

$$F_0 = \Delta_n \qquad [5]$$

The α decision logic 615 then derives α_n from F_n via a lookup table 620. A typical example is shown below in Table 1.

Table 1:

α_n	F_n
0	<3
0.1	<3.5
0.2	<4
0.3	<4.3
0.4	<4.6
0.5	<4.9
0.6	<5.2
0.7	<5.5
0.8	<5.8
0.9	<6.1
1.0	<6.4

In operation, the lowest value of α_n satisfying the right hand column is selected. The values in the right hand column are preferably programmable and may be used to optimise performance the performance of the power control scheme. The values in the right hand column of the table effectively control the variation of α in response to the variance estimate of the differentiated path loss. They may be optimised either via computer simulation of loop performance, or via appropriate in-field or laboratory testing.

The various components within the UE 112 are realised in this embodiment in integrated component form. Of course, in other embodiments, they may be realized in discrete form, or a mixture of integrated components and discrete components, or indeed any other suitable form.

Furthermore, in this embodiment the power control processor function is implemented preferably in a digital signal processor. However, it is within the contemplation of the invention that the power control processor function 209 described in the above embodiments can be embodied in any suitable form of software, firmware or hardware. The power control processor function 209 may be controlled by processor-implementable instructions and/or data, for carrying out the methods and processes described, which are stored in a storage medium or memory, for example the memory element 216. The processor-implementable instructions and/or data may include any of the following:

(i) The algorithm for deriving the α and/or L_0 parameters,

(ii) A new or adapted lookup table,

(iii) A new or adapted path loss correlation metric algorithm for use in function 315,

(iv) A new threshold value 425,

(v) A new frequency counter value (P), or

(vi) A new time period T_{span}, used to generate the path loss correlation metric.

The memory can be a circuit component or module, e.g. a RAM or PROM, or a removable storage medium such as a disk, or other suitable medium.

It will be understood that the method and arrangement for open-loop power control described above provides at least the following advantages:

(i) Improved power control performance for slow moving mobiles without compromising performance at high speed.

(ii) Implementation of the path loss correlation metric improves the UE power control performance whilst remaining standard compliant with the UTRA-TDD PC operation.

(iii) Although the use of a path loss correlation metric finds particular benefits in an up-link open-loop scenario, similar measurements can be used by the Node B or BTS to improve the accuracy in closed loop power control techniques. Hence, the technique is also beneficial in a down-link context.

(iv) The equipment designer has a choice on how best to implement the inventive concepts, using either an α adjustment or adjustment of the LPF characteristics.

Hence, the aforementioned method and arrangement for providing power control substantially negates at least the problems associated with the update rate limitations of the PC scheme in an UTRA-TDD CDMA wireless communication system. Furthermore, improved power control at lower speeds is achieved when there is a good correlation of path loss across a radio frame period, by using the instantaneous measurement of RSCP for use in the UL open-loop PC calculations. Conversely, when there is little or no correlation of path loss across the radio frame at high speeds, the filtered (mean) RSCP measurement is used for UL open-loop PC.

Thus, a configuration and method for effecting power control in a wireless communication system has been described wherein the aforementioned disadvantages associated with prior art arrangements has been substantially alleviated.

Whilst specific, and preferred, implementations of the present invention are described above, it is clear that one skilled in the art could readily apply variations and modifications of such inventive concepts.

Claims

1. A method for performing power control in a wireless communication unit operating in a wireless communication system, the method comprising the steps of:

determining a path loss correlation metric to derive one or more parameters pertaining to a wireless transmission; and

adjusting an output power level of said wireless communication unit in response to said one or more parameters.

2. The method for performing power control in a wireless communication unit according to Claim 1, wherein said step of adjusting an output power level of said wireless communication unit is performed in an open-loop power control manner for an up-link transmission by a wireless subscriber communication unit.

3. The method for performing power control in a wireless communication unit according to any preceding Claim, wherein the step of adjusting an output power level of said wireless communication unit is performed in one or more of the following steps based on said path loss correlation metric:

adjusting a weighting parameter;

adjusting one or more filter parameters that adjust a frequency response of a filter.

4. The method for performing power control in a wireless communication unit according to any preceding Claim, the method further comprising the step of:

making a number of instantaneous path loss measurements (LP-CCPCH) over a number of frames received by said wireless communication unit;

wherein said step of determining said path loss correlation metric is based on said number of instantaneous path loss measurements.

5. The method for performing power control in a wireless communication unit according to Claim 4, wherein said step of determining said path loss correlation metric includes the step of:

comparing a first instantaneous path loss measurement to one or more previous instantaneous path loss measurements.

6. The method for performing power control in a wireless communication unit according to Claim 5, the method further comprising the steps of:

producing a difference value from said comparison step; and

discarding a sign of said difference value to obtain an absolute difference value to provide a path loss correlation indication.

7. The method for performing power control in a wireless communication unit according to Claim 6, the method further comprising the step of:

comparing said absolute difference value with a threshold to provide a path loss correlation metric.

8. The method for performing power control in a wireless communication unit according to Claim 6 or Claim 7, the method further comprising the step of:

selecting said number of instantaneous path loss measurements in calculating an adjustment of output power level if said absolute difference value is determined to be above or below a threshold for more than a specified percentage of a period of time; or

selecting a filter adjusted input of said number of instantaneous path loss measurements in calculating an adjustment of output power level if said absolute difference value is determined to be above or below a threshold for more than a specified percentage of a period of time.

9. The method for performing power control in a wireless communication unit according to Claim 6, the method further comprising the step of:

performing a variance estimation of said difference value to provide a path loss correlation metric.

10. The method for performing power control in a wireless communication unit according to Claim 9, the method further comprising the step of:

performing an averaging function, for example using an IIR filter, to provide a time-averaged path loss correlation metric.

11. The method for performing power control in a wireless communication unit according to Claim 10, when dependent upon Claim 4, the method further comprising the step of:

comparing said time-averaged path loss correlation metric to values held in a lookup table, for example a lookup table indexed as a function of the path loss correlation metric, in order to calculate a weighting parameter based on a path loss correlation metric.

12. The method for performing power control in a wireless communication unit according to Claim 11, the method further comprising the step of:

selecting said instantaneous path loss measurements or a filtered number of instantaneous path loss measurements in calculating an adjustment of output power level based on said weighting parameter (α).

13. The method for performing power control in a wireless communication unit according to Claim 8 or Claim 12, the method further comprising the step of:

selecting said number of filtered instantaneous path loss measurements for calculating an output power level of said wireless communication unit when said wireless communication unit is travelling at a relatively high speed; or

selecting said instantaneous path loss measurements for calculating an output power level of said wireless communication unit when said wireless communication unit is travelling at a relatively low speed.

14. The method for performing power control in a wireless communication unit according to any preceding Claim, the method further comprising the step of:

performing spectral analysis on said correlation of instantaneous path loss measurements to derive said weighting parameter or said one or more filter parameters.

15. The method for performing power control in a wireless communication unit according to any preceding Claim, wherein said power control is performed by a wireless subscriber unit for use in an open-loop up-link power control mode of operation.

16. A wireless communication unit adapted to incorporate the method steps of any of preceding Claims 1 to 15.

17. The wireless communication unit according to Claim 16, wherein said communication unit is a user equipment for use in an open loop power control arrangement.

18. The wireless communication unit according to Claim 16, wherein said communication unit is a base transceiver station or Node B for use in a closed loop power control arrangement.

19. A wireless communication system adapted to incorporate the method steps of any of preceding Claims 1 to 15.

20. The wireless communication system according to Claim 19, wherein said communication system is an UTRA-TDD CDMA wireless communication system.

21. A wireless communication unit capable of performing power control when operating in a wireless communication system, the wireless communication unit comprising:

a power control processing function that includes:

a path loss correlation metric determination function to derive one or more parameters pertaining to a wireless transmission; and

adjustment means operably coupled to said path loss correlation metric determination function to adjust an output power level of said wireless communication unit in response to said one or more parameters.

22. The wireless communication unit according to Claim 21, the wireless communication unit further comprising:

a receiver operably coupled to said power control processing function for receiving a transmission from a transmitting wireless communication unit and providing a signal for analysis; and

calculation means operably coupled to said receiver path loss correlation metric determination function for receiving said signal and determining a number of instantaneous path loss values to be forwarded to said path loss correlation metric determination function.

23. The wireless communication unit according to Claim 21 or Claim 22, wherein said adjustment means adjusts an output power level of said wireless communication unit in

an open-loop power control manner for an up-link transmission by a wireless subscriber communication unit.

24. The wireless communication unit according to any of preceding Claims 21 to 23, wherein said adjustment means includes a weighting parameter input and/or a filter input and said adjustment means adjusts an output power level of said wireless communication unit in one or more of the following ways:

adjusts a weighting parameter based on a path loss correlation metric;

adjusts one or more filter parameters that adjust a frequency response of a filter in response to said path loss correlation metric.

25. The wireless communication unit according to any of preceding Claims 21 to 24, wherein said power control processing function performs a number of instantaneous path loss measurements (LP-CCPCH) over a number of frames received by said wireless communication unit and said path loss correlation metric is based on said number of instantaneous path loss measurements.

26. The wireless communication unit according to Claim 25, wherein said path loss correlation metric determination function comprises a differentiator function utilising one or more instantaneous path loss measurements to obtain a path loss correlation indication.

27. The wireless communication unit according to Claim 26, wherein said differentiator function produces a difference value and discards a sign of said difference value to obtain an absolute difference value to provide a path loss correlation indication.

28. The wireless communication unit according to Claim 27, the power control processing function further comprising decision logic operably coupled to said differentiator function to compare said absolute difference value with a threshold to provide a path loss correlation metric.

29. The wireless communication unit according to Claim 28, wherein said path loss correlation metric determination is based on a number of parameter values, wherein said parameter values include one or more of the following:

a period of time, for example of the order of one or two seconds,

said threshold value for a difference between said path loss correlation metrics,

a number of samples where said threshold value is exceeded over said period of time.

30. The wireless communication unit according to Claim 29, wherein said one or more parameter values are substantially of the order of the following:

period of time is between a half and three seconds;

threshold value is between one and five dB;

number of samples is between 70% to 80%.

31. The wireless communication unit according to any of preceding Claims 28 to 30, the power control processing function further comprising a switch and switch control, operably coupled to said decision logic, said switch and switch control configured to:

select said number of instantaneous path loss measurements in calculating an adjustment of output power level if said absolute difference value is determined to be above or below a threshold over a period of time; or

select a filter-adjusted input of said number of instantaneous path loss measurements in calculating an adjustment of output power level if said absolute difference value is determined to be above or below a threshold over a period of time.

32. The wireless communication unit according to Claim 27, the path loss correlation metric determination function comprising a variance estimator function to determine a variance of said difference value(s) to provide a path loss correlation metric.

33. The wireless communication unit according to Claim 32, the path loss correlation metric determination function further comprising:

a decision logic function that includes an averaging function, for example an infinite impulse response filter, operably coupled to said variance estimator function, to provide a time-averaged path loss correlation metric.

34. The wireless communication unit according to Claim 33, when dependent upon Claim 24, wherein said decision logic function is operably coupled to a lookup table and compares said time-averaged path loss correlation metric to values held in a lookup table, for example a lookup table indexed as a function of the path loss correlation metric, in order to calculate a weighting parameter based on a path loss correlation metric.

35. The wireless communication unit according to Claim 34, the power control processing function further comprising calculation means for calculating an output transmit power level for said wireless communication unit, said calculation means selecting said number of instantaneous path loss measurements or a filter-adjusted value of said number of instantaneous path loss measurements in calculating an adjustment of output power level based on said weighting parameter.

36. The wireless communication unit according to any of preceding Claims 21 to 35, wherein said power control is performed by a wireless subscriber communication unit for use in an open-loop up-link power control mode of operation.

37. The wireless communication unit according to Claim 36 when dependent upon Claim 31 or Claim 35, wherein said power control processing function selects said filtered path loss measurements for calculating an output power level of said wireless communication unit when said wireless communication unit is travelling at a relatively

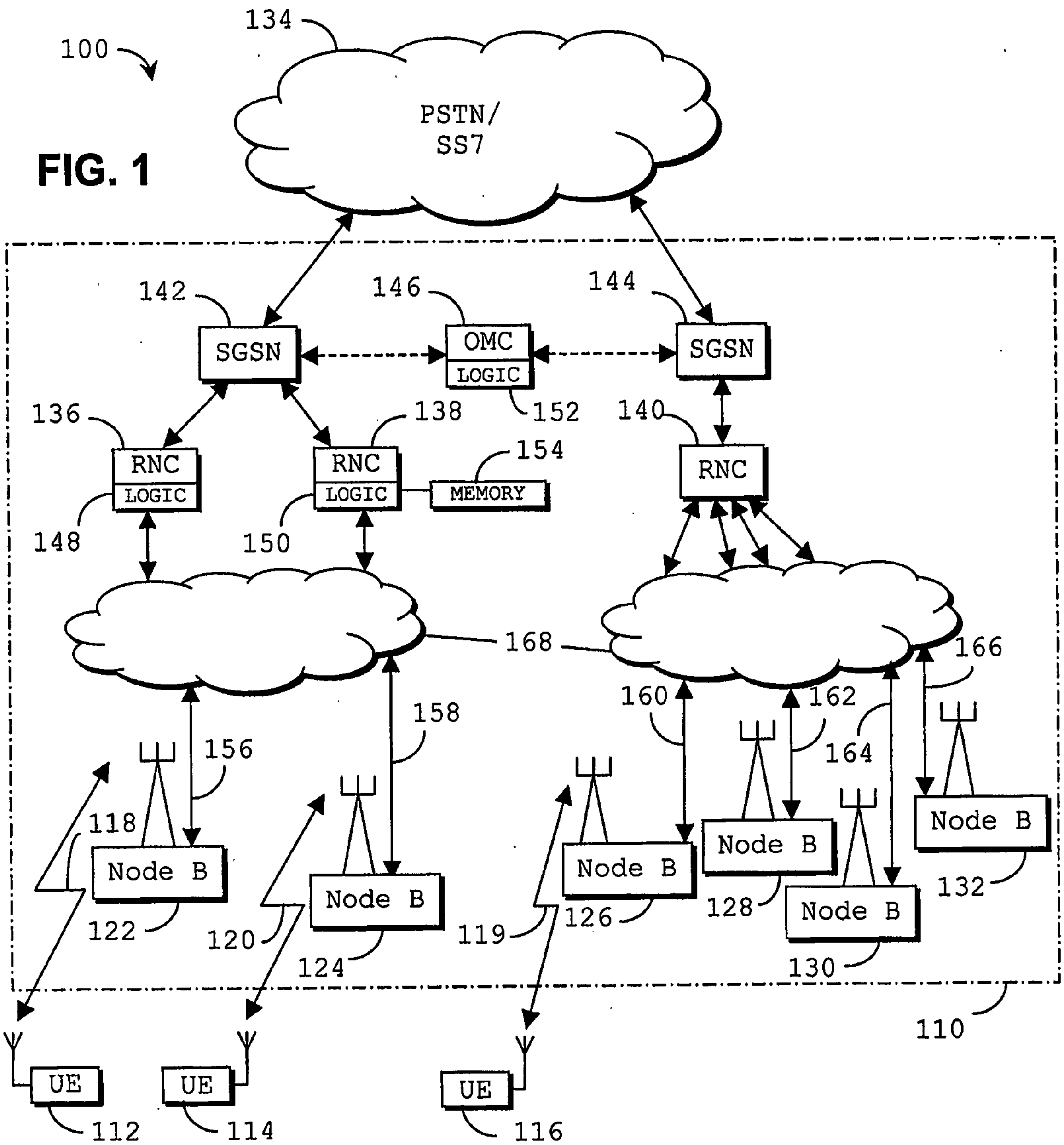
high speed; and/or selects said instantaneous path loss measurements for calculating an output power level of said wireless communication unit when said wireless communication unit is travelling at a relatively low speed.

38. The wireless communication unit according to any of preceding Claims 21 to 35, wherein said wireless communication unit is a base transceiver station or Node B for use in an closed loop power control arrangement.

39. A storage medium storing processor-implementable instructions for controlling a processor to carry out the method of any of Claims 1 to 15.

40. A differentiator adapted to utilise one or more instantaneous path loss measurements to obtain a path loss correlation indication in accordance with any of Claims 26 to 28.

FIG. 1


100
134
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SS7
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146
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LOGIC
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164
166
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Node B
122
120
Node B
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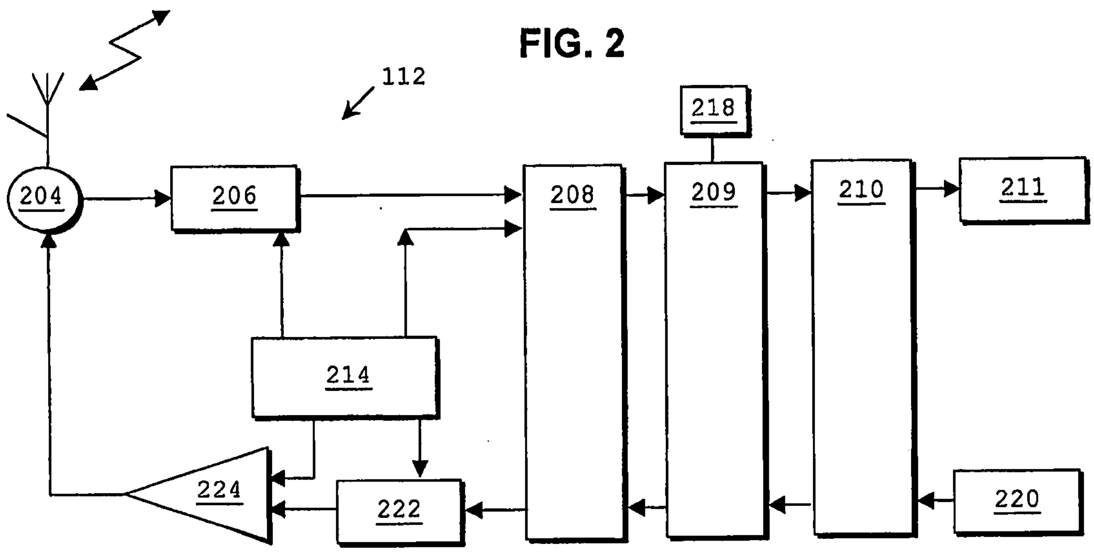
132
110
UE
112
UE
114
UE
116

FIG. 2



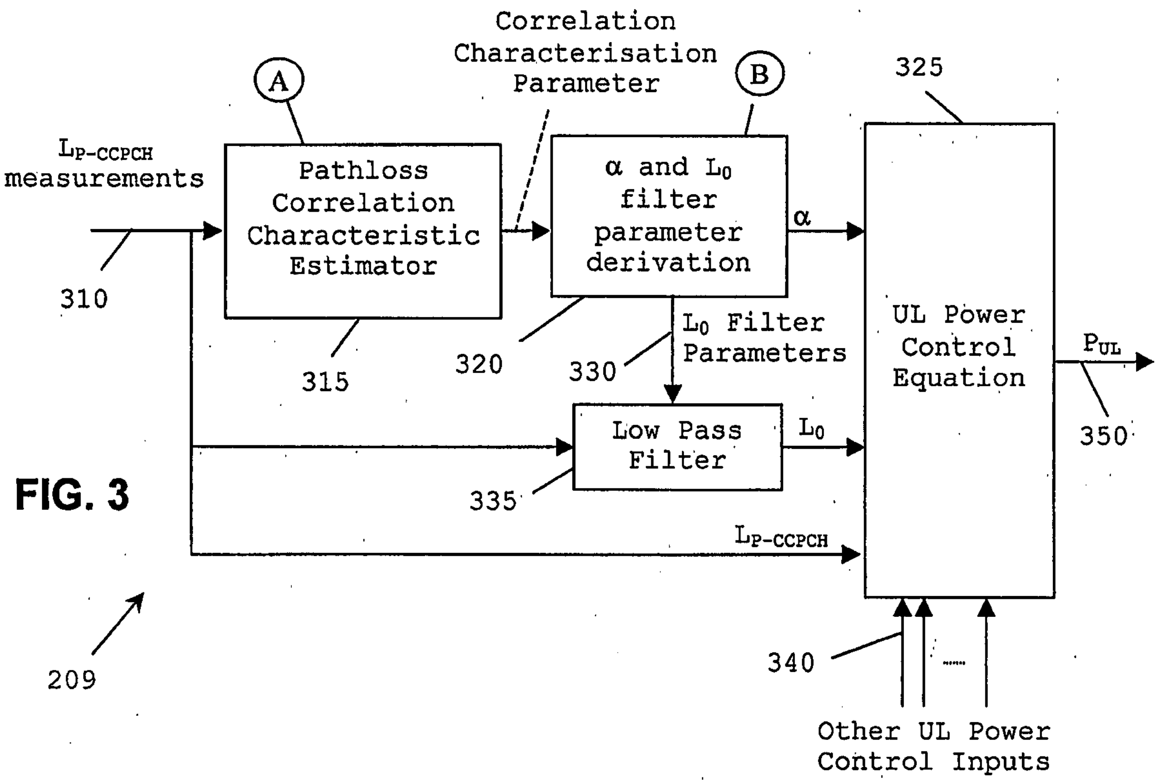
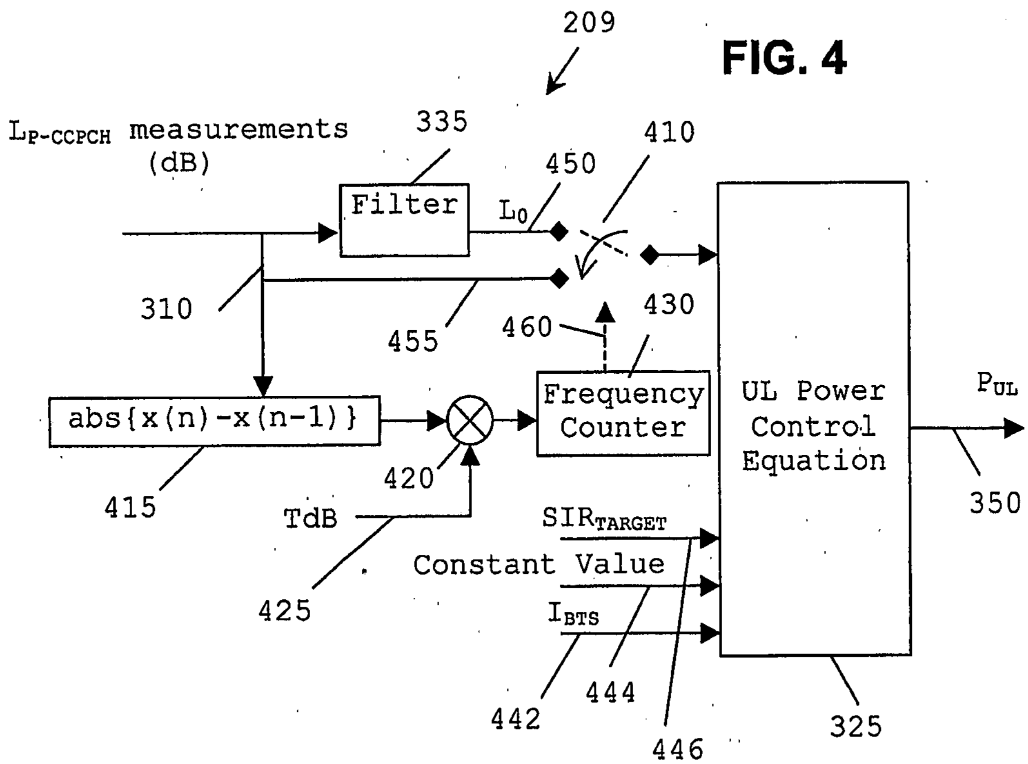
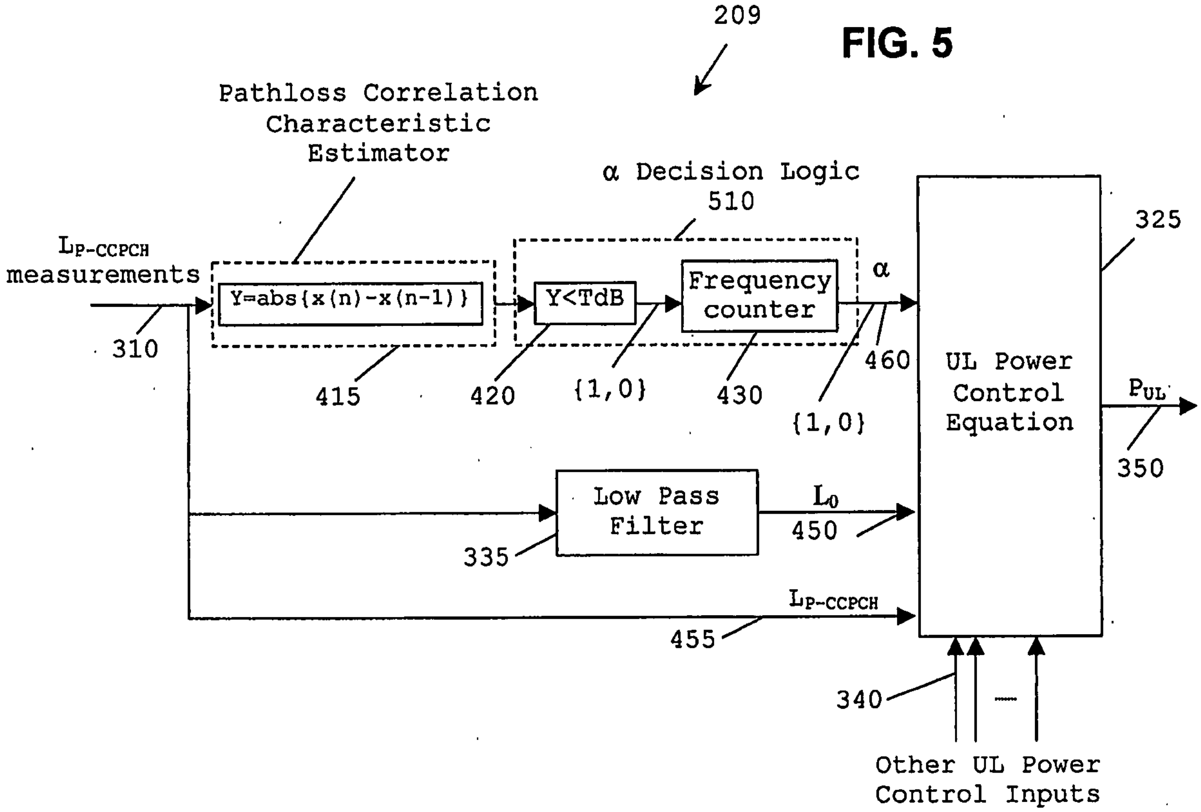

Correlation Characterisation Parameter
A
B
325
$L_{P\text{-}CCPCH}$ measurements
Pathloss Correlation Characteristic Estimator
α and L_0 filter parameter derivation
α
UL Power Control Equation
310
315
320
330
L_0 Filter Parameters
P_{UL}
350
Low Pass Filter
L_0
335
$L_{P\text{-}CCPCH}$
340
Other UL Power Control Inputs

FIG. 3

209

FIG. 4

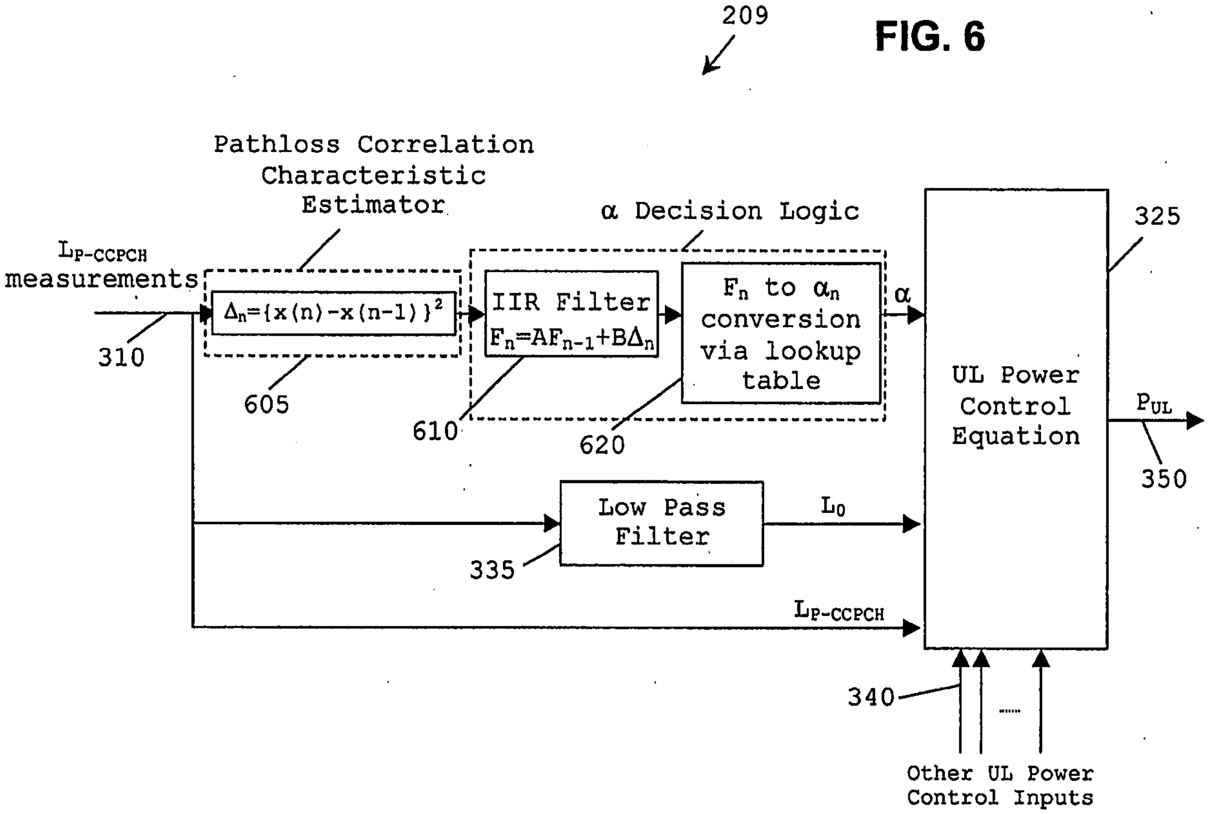

209
L P-CCPCH measurements (dB)
335
Filter
L0
450
410
310
455
460
430
abs{x(n)-x(n-1)}
Frequency Counter
UL Power Control Equation
PUL
415
420
TdB
425
SIRTARGET
Constant Value
IBTS
442
444
446
325
350



209
Pathloss Correlation Characteristic Estimator
α Decision Logic
510
325
Lp-CCPCH measurements
Y=abs(x(n)-x(n-1))
Y<TdB
Frequency counter
α
310
415
420
{1,0}
430
460
{1,0}
UL Power Control Equation
PUL
350
Low Pass Filter
L0
450
335
Lp-CCPCH
455
340
Other UL Power Control Inputs

FIG. 5

FIG. 6


209
Pathloss Correlation Characteristic Estimator
α Decision Logic
$L_{P-CCPCH}$ measurements
$\Delta_n=\{x(n)-x(n-1)\}^2$
IIR Filter
$F_n=AF_{n-1}+B\Delta_n$
F_n to α_n conversion via lookup table
α
UL Power Control Equation
325
P_{UL}
350
310
605
610
620
Low Pass Filter
L_0
335
$L_{P-CCPCH}$
340
Other UL Power Control Inputs

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/04811

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04B7/005

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

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-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 January 2003	21/01/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Lopez Márquez, T

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/04811

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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International Application No
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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/917,968	08/12/2004	Nicholas William Anderson	562492000500

CONFIRMATION NO. 3609

FORMALITIES LETTER

OC000000014095436

25226
MORRISON & FOERSTER LLP
755 PAGE MILL RD
PALO ALTO, CA 94304-1018

Date Mailed: 10/15/2004

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is missing.
  A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$130** for a Large Entity

- **$130** Late oath or declaration Surcharge.

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

12/13/2004 JBALINAN 00000106 031952 10917968

01 FC:1051 130.00 DA

Customer Service Center
Initial Patent Examination Division (703) 308-1202
PART 2 - COPY TO BE RETURNED WITH RESPONSE

MORRISON & FOERSTER LLP
Attorneys at Law
755 Page Mill Road
Palo Alto, California 94304-1018
Telephone: (650) 813-5600
Facsimile: (650) 494-0792

To:

NAME:	FACSIMILE:	TELEPHONE:
Mail Stop Missing Parts **U.S. Patent and Trademark Office**	**703-746-4060**	703-308-1202

FROM: Bryan H. Wyman **DATE:** December 10, 2004

Number of pages with cover page: 11	

Preparer of this slip has confirmed that facsimile number given is correct: 10349/mlp2

CAUTION - CONFIDENTIAL

Comments:

Attorney Docket No.: 562492000500
Group Art Unit: 2681
Examiner: Not Yet Assigned
Application No.: 10/917,968
Filing Date: August 12, 2004
Inventor(s): Nicholas William Anderson
Title: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

Papers enclosed:

1. Transmittal (1 page)
2. Fee Transmittal + duplicate copy for fee processing (2 pages)
3. Power of Attorney (1 page)
4. Notice to File Missing Parts, Part 2 (2 pages)
5. Declaration (2 pages)
6. Statement Under 37 CFR 3.73(b) with copy of Assignment (2 pages)

PA-936366

PTO/SB/21 (09-04)
Approved for use through 07/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas William ANDERSON
Art Unit	2681
Examiner Name	Not Yet Assigned
Attorney Docket Number	562492000500
Total Number of Pages in This Submission	10

ENCLOSURES (*Check all that apply*)

- [x] Fee Transmittal Form + duplicate copy for fee processing (2 pages)
  - [ ] Fee Attached
- [ ] Amendment/Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [x] Reply to Missing Parts/ Incomplete Application
  - [x] Reply to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [x] Power of Attorney, Revocation Change of Correspondence Address (1 page)
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) ______
  - [ ] Landscape Table on CD
- [ ] After Allowance Communication to TC
- [ ] Appeal Communication to Board of Appeals and Interferences
- [ ] Appeal Communication to TC (Appeal Notice, Brief, Reply Brief)
- [ ] Proprietary Information
- [ ] Status Letter
- [x] Other Enclosure(s) (please identify below):

Notice to File Missing Parts, Part 2 (2 pages)
Declaration (2 pages)
Statement Under 37 CFR 3.73(b) with copy of Assignment (2 pages)
Fax Cover Page

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	MORRISON & FOERSTER LLP (Customer No. 25226) Bryan H. Wyman – 48,049		
Signature	[signature]		
Printed name	Bryan H. Wyman		
Date	December 10, 2004	Reg. No.	48,049

I hereby certify that this correspondence is being facsimile transmitted to the Patent and Trademark Office, facsimile no. (703) 746-4060, on the date shown below.

Dated: December 10, 2004 Signature: [signature] (Mae Pattison)

pa-941826

PTO/SB/81 (09-03)
Approved for use through 11/30/2005. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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POWER OF ATTORNEY and CORRESPONDENCE ADDRESS INDICATION FORM

Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas William ANDERSON
Title	POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM
Art Unit	2681
Examiner Name	Not Yet Assigned
Attorney Docket No.	562492000500

I hereby appoint:

[x] Practitioners associated with the Customer Number 25226

OR

[ ] Practitioner(s) named below:

Name	Registration Number	Name	Registration Number

as my/our attorney(s) or agent(s) to prosecute the application identified above, and to transact all business in the United States Patent and Trademark Office connected therewith.

Please recognize or change the correspondence address for the above-identified application to:

[ ] The address associated with the above-mentioned Customer Number.

OR

[ ] The address associated with Customer Number:

OR

[ ] Firm or Individual Name

Address					
City		State		Zip	
Country		Telephone		Fax	

I am the:

[ ] Applicant/Inventor.

[x] Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

SIGNATURE of Applicant or Assignee of Record

Name	Daniel W. Burke, Vice President and General Counsel		
Signature	[signature]		
Date	December 10, 2004	Telephone	(650) 616-4163

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

[x] *Total of 1 forms are submitted.

PATENT
Docket No. 562492000500

DECLARATION FOR UTILITY PATENT APPLICATION

AS A BELOW-NAMED INVENTOR, I HEREBY DECLARE THAT:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM, the specification of which is attached hereto unless the following box is checked:

☒ was filed on August 12, 2004 as United States Application Serial No. 10/917,968.

I HEREBY STATE THAT I HAVE REVIEWED AND UNDERSTAND THE CONTENTS OF THE ABOVE-IDENTIFIED SPECIFICATION, INCLUDING THE CLAIMS, AS AMENDED BY ANY AMENDMENT REFERRED TO ABOVE.

I acknowledge the duty to disclose information which is material to the patentability as defined in 37 C.F.R. § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

Application No.	Country	Date of Filing	Priority Claimed?
			☐Yes ☐No

I hereby claim benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

Application Serial No.	Filing Date

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

Application Serial No.	Filing Date	Status
		☐Patented ☐Pending ☐Abandoned

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

8th Nov 2004
Date

Name: Nicholas William ANDERSON
Residence: Bristol, United Kingdom
Citizenship: United Kingdom
Post Office Address: 72 London Road, Warmley, Bristol, BS30 5JL, United Kingdom

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: Nicholas William ANDERSON

Application No./Patent No.: 10/917,956 Filed/Issue Date: August 12, 2004

Entitled: POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

IPWireless, Inc. (Name of Assignee), a corporation (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. [X] the assignee of the entire right, title, and interest; or

2. [ ] an assignee of less than the entire right, title and interest.
The extent (by percentage) of its ownership interest is ______ %

in the patent application/patent identified above by virtue of either:

A. [x] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy thereof is attached.

OR

B. [ ] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as shown below:

1. From: ____________ To: ____________
The document was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy thereof is attached.

2. From: ____________ To: ____________
The document was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy thereof is attached.

3. From: ____________ To: ____________
The document was recorded in the United States Patent and Trademark Office at Reel ________, Frame ________, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet.

[ ] Copies of assignments or other documents in the chain of title are attached.
[NOTE: A separate copy (*i.e.*, the original assignment document or a true copy of the original document) must be submitted to Assignment Division in accordance with 37 CFR Part 3, if the assignment is to be recorded in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

December 10, 2004	Daniel W. Burke
Date	Typed or printed name
(650) 616-4163	[signature]
Telephone Number	Signature
	Vice President and General Counsel
	Title

pa-930291

Docket No. 662492000600

ASSIGNMENT
SOLE

THIS ASSIGNMENT, by Nicholas William ANDERSON (hereinafter referred to as the assignor), residing at 72 London Road, Warmley, Bristol, BS30 5JL, United Kingdom, witnesseth:

WHEREAS, said assignor has invented certain new and useful improvements in POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM, set forth in an application for Letters Patent of the United States, bearing Serial No. 10/917,968 filed on August 12, 2004; and

WHEREAS, IPWireless Inc., a corporation duly organized under and pursuant to the laws of Delaware and having its principal place of business at 1001 Bayhill Dr., Second Floor, San Bruno, California 94066 (hereinafter referred to as the assignee) is desirous of acquiring the entire right, title and interest in and to said inventions and said application for Letters Patent of the United States, and in and to any Letters Patent or Patents, United States or foreign, to be obtained therefor and thereon:

NOW, THEREFORE, in consideration of One Dollar ($1.00) and other good and sufficient consideration, the receipt of which is hereby acknowledged, said assignor has sold, assigned, transferred and set over, and by these presents does sell, assign, transfer and set over, unto said assignee, its successors, legal representatives and assigns, the entire right, title and interest in and to the above-mentioned inventions, application for Letters Patent, and any and all Letters Patent or Patents in the United States of America and all foreign countries which may be granted therefor and thereon, and in and to any and all divisions, continuations and continuations-in-part of said application, or reissues or extensions of said Letters Patent or Patents, and all rights under the International Convention for the Protection of Industrial Property, the same to be held and enjoyed by said assignee, for its own use and the use of its successors, legal representatives and assigns, to the full end of the term or terms for which Letters Patent or Patents may be granted, as fully and entirely as the same would have been held and enjoyed by the assignor, had this sale and assignment not been made.

AND for the same consideration, said assignor hereby covenants and agrees to and with said assignee its successors, legal representatives and assigns, that, at the time of execution and delivery of these presents, said assignor is the sole and lawful owner of the entire right, title and interest in and to said inventions and the application for Letters Patent above-mentioned, and that the same are unencumbered and that said assignor has good and full right and lawful authority to sell and convey the same in the manner herein set forth.

AND for the same consideration, said assignor hereby covenants and agrees to and with said assignee, its successors, legal representatives and assigns, that said assignor will, whenever counsel of said assignee, or the counsel of its successor, legal representatives and assigns, shall advise that any proceeding in connection with said inventions, or said application for Letters Patent, or any proceeding in connection with Letters Patent for said inventions in any country, including interference proceedings, is lawful and desirable, or that any division, continuation or continuation-in-part of any application for Letters Patent or any reissue or extension of any Letters Patent, to be obtained thereon, is lawful and desirable, sign all papers and documents, take all lawful oaths, and do all acts necessary or required to be done for the procurement, maintenance, enforcement and defense of Letters Patent for said inventions, without charge to said assignee, its successors, legal representatives and assigns, but at the cost and expense of said assignee, its successors, legal representatives and assigns.

AND said assignor hereby requests the Commissioner of Patents to issue said Letters Patent of the United States to said assignee as the assignee of said inventions and the Letters Patent to be issued thereon for the sole use of said assignee, its successors, legal representatives and assigns.

8th Nov 2004 — [signature]

Date — Nicholas William ANDERSON

pa-910541

PTO/SB/17 (12-04)
Approved for use through 07/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Effective on 12/08/2004.
Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).

FEE TRANSMITTAL for FY 2005

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 130.00

Complete if Known	
Application Number	10/917,968
Filing Date	August 12, 2004
First Named Inventor	Nicholas William ANDERSON
Examiner Name	Not Yet Assigned
Art Unit	2681
Attorney Docket No.	562492000500

METHOD OF PAYMENT (check all that apply)

☐ Check ☐ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): ____________

☒ Deposit Account Deposit Account Number: 03-1952 Deposit Account Name: Morrison & Foerster LLP

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☒ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☒ Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17 ☒ Credit any overpayments

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
Application Type	FEE ($)	Small Entity Fee ($)	Fee($)	Small Entity Fee ($)	Fee ($)	Small Entity Fee ($)	Fees Paid ($)
Utility	300	150	500	250	200	100	0.00
Design	200	100	100	50	130	65	0.00
Plant	200	100	300	150	160	80	0.00
Reissue	300	150	500	250	600	300	0.00
Provisional	200	100	0	0	0	0	0.00

2. EXCESS CLAIM FEES

Fee Description	Fee($)	Small Entity Fee ($)
Each claim over 20 or, for Reissues, each claim over 20 and more than in the original patent	50	25
Each independent claim over 3 or, for Reissues, each independent claim more than in the original patent	200	100
Multiple dependent claims	360	180

Total Claims		Extra Claims		Fee ($)		Fee Paid ($)
13	-20	0	x	50.00	=	0.00

HP = highest number of total claims paid for, if greater than 20

Multiple Dependent Claims Fee ($)	Fee Paid ($)
360.00	0.00

Indep. Claims		Extra Claims		Fee ($)		Fee Paid ($)
5	-5	0	x	200.00	=	0.00

HP = highest number of independent claims paid for, if greater than 3

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		Extra Sheets		Number of each additional 50 or fraction thereof		Fee ($)		Fee Paid ($)
	- 100 =		/ 50 =		(round up to a whole number) x		=	0.00

4. OTHER FEE(S)

Non-English Specification, $130 fee (no small entity discount)
Other: Surcharge - for late filing fee or oath or declaration ____________ $130.00

SUBMITTED BY

Signature	[signature]	Registration No. (Attorney/Agent)	48,049	Telephone	(650) 813-5779
Name (Print/Type)	Bryan H. Wyman			Date	December 10, 2004

pa-941835

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/917,968	08/12/2004	Nicholas William Anderson	562492000500

CONFIRMATION NO. 3609

FORMALITIES LETTER

OC000000014095438

25226
MORRISON & FOERSTER LLP
755 PAGE MILL RD
PALO ALTO, CA 94304-1018

Date Mailed: 10/15/2004

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is missing.
  A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$130** for a Large Entity

- **$130** Late oath or declaration Surcharge.

Replies should be mailed to: Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

A copy of this notice MUST be returned with the reply.

Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 3 - OFFICE COPY

PTO/SB/05 (04-04)
Approved for use through 07/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office. U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(ONLY FOR NEW NONPROVISIONAL APPLICATIONS UNDER 37 CFR 1.53(B))

Attorney Docket No.	562492000500
First Inventor	Nicholas William ANDERSON
Title	POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM
Express Mail Label No.	EV 336627356 US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

ADDRESS TO: Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

1. [X] Fee Transmittal Form (e.g., PTO/SB/17) (2 pages)
   (Submit an original and a duplicate for fee processing)
2. [ ] Applicant claims small entity status. See 37 CFR 1.27.
3. [X] Specification [*Total Pages* 27]
   (preferred arrangement set forth below)
   - Descriptive title of the invention
   - Cross Reference to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 4]
5. Oath or Declaration [*Total Sheets*]
   a. [ ] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63(d))
      (for continuation/divisional with Box 18 completed)
      i. [ ] *DELETION OF INVENTOR(S)*
         SIGNED STATEMENT ATTACHED DELETING INVENTOR(S) NAMED IN THE PRIOR APPLICATION, SEE 37 CFR 1.63(D)(2) AND 1.33(B).
6. [X] Application Data Sheet. See 37 CFR 1.76 (2 sheets)
7. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program *(Appendix)*
8. Nucleotide and/or Amino Acid Sequence Submission
   (if applicable, all necessary)
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or ii. [ ] Paper
   c. [ ] Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

9. [ ] Assignment Papers (cover sheet & document(s))
10. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
11. [ ] English Translation Document *(if applicable)*
12. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
13. [ ] Preliminary Amendment
14. [X] Return Receipt Postcard (MPEP 503)
    (Should be specifically itemized)
15. [ ] Certified Copy of Priority Document(s)
    (if foreign priority is claimed)
16. [ ] Nonpublication Request under 35 U.S.C. 122 (b)(2)(B)(i). Applicant must attach form PTO/SB/35 or its equivalent.
17. [ ] Other:

18. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No.: ______

Prior application information: Examiner ______ *Art Unit:* ______

For CONTINUATION OR DIVISIONAL APPS only; The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. CORRESPONDENCE ADDRESS

[X] Customer Number: 25226 *OR* [ ] Correspondence address below

Name					
Address					
City		*State*		*Zip Code*	
Country		*Telephone*		*Fax*	

Name (Print/Type)	Bryan H. Wyman	*Registration No. (Attorney/Agent)*	48,049
Signature	[signature]	*Date*	August 12, 2004

I hereby certify that this correspondence is being deposited with the U.S. Postal Service as Express Mail, Airbill No. EV 336627356 US, in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on the date shown below.

Dated: August 12, 2004 Signature: [signature] (Tia B. Zimmerman)

pa-909812 v1

PTO/SB/17 (10-03)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 942.00

Complete if Known	
Application Number	Not Yet Assigned
Filing Date	Concurrently Herewith
First Named Inventor	Nicholas William Anderson
Examiner Name	Not Yet Assigned
Art Unit	Not Yet Assigned
Attorney Docket No.	562492000500

METHOD OF PAYMENT (*check all that apply*)

☐ Check ☐ Credit Card ☐ Money Order ☐ Other ☐ None

[X] Deposit Account:

Deposit Account Number: 03-1952

Deposit Account Name: Morrison & Foerster LLP

The Director is authorized to: (*check all that apply*)

[X] Charge fee(s) indicated below [X] Credit any overpayments

[X] Charge any additional fee(s) or any underpayment of fee(s)

☐ Charge fee(s) indicated below, **except for the filing fee**

to the above-identified deposit account.

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1001	770	2001	385	Utility filing fee	770.00
1002	340	2002	170	Design filing fee	
1003	530	2003	265	Plant filing fee	
1004	770	2004	385	Reissue filing fee	
1005	160	2005	80	Provisional filing fee	

SUBTOTAL (1) ($) 770.00

2. EXTRA CLAIM FEES FOR UTILITY AND REISSUE

			Extra Claims		Fee from below		Fee Paid
Total Claims	13	-20** =	0	x	18.00	=	0.00
Independent Claims	5	-3** =	2	x	86.00	=	172.00
Multiple Dependent					290.00	=	0.00

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
1202	18	2202	9	Claims in excess of 20
1201	86	2201	43	Independent claims in excess of 3
1203	290	2203	145	Multiple dependent claim, if not paid
1204	86	2204	43	** Reissue independent claims over original patent
1205	18	2205	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 172.00

***or number previously paid, if greater; For Reissues, see above*

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
1051	130	2051	65	Surcharge – late filing fee or oath	
1052	50	2052	25	Surcharge – late provisional filing fee or cover sheet.	
1053	130	1053	130	Non-English specification	
1812	2,520	1812	2,520	For filing a request for *ex parte* reexamination	
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action	
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action	
1251	110	2251	55	Extension for reply within first month	
1252	420	2252	210	Extension for reply within second month	
1253	950	2253	475	Extension for reply within third month	
1254	1,480	2254	740	Extension for reply within fourth month	
1255	2,010	2255	1,005	Extension for reply within fifth month	
1401	330	2401	165	Notice of Appeal	
1402	330	2402	165	Filing a brief in support of an appeal	
1403	290	2403	145	Request for oral hearing	
1451	1,510	1451	1,510	Petition to institute a public use proceeding	
1452	110	2452	55	Petition to revive – unavoidable	
1453	1,330	2453	665	Petition to revive - unintentional	
1501	1,330	2501	665	Utility issue fee (or reissue)	
1502	480	2502	240	Design issue fee	
1503	640	2503	320	Plant issue fee	
1460	130	1460	130	Petitions to the Commissioner	
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)	
1806	180	1806	180	Submission of Information Disclosure Stmt	
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))	
1810	770	2810	385	For each additional invention to be examined (37CFR 1.129(b))	
1801	770	2801	385	Request for Continued Examination (RCE)	
1802	900	1802	900	Request for expedited examination of a design application	

Other fee (specify) ____________________

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0.00

SUBMITTED BY				(Complete (*if applicable*))	
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Signature				*Date*	August 12, 2004

pa-909815 v1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR U.S. LETTERS PATENT

Title:

POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

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56249-20005.00

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POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] This invention relates to power control in a mobile radio system or wireless communication system, and more particularly, to controlling received power levels in a code division multiple access (CDMA) radio system.

2. Description of the Prior Art

[0003] Typically, radio signals transmitted with increased power result in fewer errors when received than signals transmitted with decreased power. Unfortunately, signals transmitted with excessive power may interfere with the reception of other signals sharing the radio link. Wireless communication systems employ power control schemes to maintain a target error rate of a signal received on a radio link.

[0004] If a received signal includes a rate of errors far above a target error rate, the received signal may result in an undesirable effect on a delivered service. For example, excessive errors may lead to broken voice during voice calls, low throughput over data links, and glitches in displayed video signals. On the other hand, if the received signal includes a rate of errors well below the target error rate, the mobile radio system is not efficiently using its radio resources. A very low error rate may mean that a signal is transmitted with an excessive level of power and that user could be provided a higher data rate. Alternatively, if the power level of a signal is sufficiently reduced, additional users may be serviced. If data rates are increased, a user may receive a higher level of service. Therefore, if a target error rate for each user is met within a tolerance threshold, a radio resource may be more optimally used.

[0005] A wireless communication system often employ one of either an open loop scheme or a closed loop scheme to control uplink transmit power of a mobile radio. Uplink typically refers to the radio link from a mobile radio to a base station, where as the downlink typically refers to the link from the base station to the mobile radio. A mobile radio is not necessarily mobile and may also be referred to as a mobile, a user, user equipment (UE), a terminal or terminal equipment. A base station may also be referred to as a Node-B.

[0006] The error rate is related to a received signal to noise-plus-interference ratio (SNIR); a higher SNIR generally results in a lower error rate; and conversely, a lower SNIR generally results in a higher error rate. The exact relationship between SNIR and error rate, however, is often a function of several factors including radio channel type and the speed at which a mobile is travelling.

[0007] A target error rate is often reached using a two stage process, which includes an outer loop and an inner loop. A first process may operate as an outer loop and may be tasked to adjust a target received SNIR (SNIR Target). This first process tracks changes in the relationship between SNIR and error rate. The outer loop sets an SNIR Target that is generally used several times by the inner loop. Periodically, the outer loop may adjust or update this SNIR Target used by the inner loop. For example, if an actual error rate exceeds a desired error rate, the outer loop may increase the value of the SNIR Target.

[0008] A second process operates as an inner loop and tries to force the link to exhibit the SNIR Target determined by the outer loop. The inner loop may operate by closed loop or by open loop means.

[0009] In the open loop method of the inner loop process, a UE uses an SNIR Target value that is derived by the network and signalled to the UE. The inner loop running in the UE attempts to maintain the SNIR Target. The UE uses the information signalled to it and monitors the received strength of signals it receives to determine a power level at which it will transmit. Advantageously, this open loop method compensates for fast channel fading by determining the path loss on a per frame bases and by adjusting the transmit power accordingly. Unfortunately, this open loop method is relatively slow at compensating for changes due to interfering signals from other transmitters.

[0010] In the closed loop method of the inner loop process, a closed loop scheme operates to match an SNIR Target. A received SNIR measurement is made by the network on an uplink signal. The SNIR measurement is compared within the network to the SNIR Target value. The inner loop drives the system to match the SNIR Target by issuing transmit power control commands from the network to a UE. The commands instruct the UE to increase or decrease its transmitted power by a predetermined step dB amount. Unfortunately, such closed loop methods demand a very high command update rate to adequately compensate for fast channel fading because of the single-dB-step commands used. At slower update rates, fast channel fading is not tracked adequately since a large number of iterations and long delays are needed to compensate for a change in power that is substantially larger than the dB-step value.

[0011] Both the closed loop scheme and the open loop scheme have their disadvantages. Therefore, an improved method and system are needed that better balances the conflicting goals of reducing errors in a received signal while also reducing interference imposed on signals received at other receivers. An improved method and system are also needed to better reduce the overall residual SNIR fluctuations experienced by each users signal at a receiver.

BRIEF SUMMARY OF THE INVENTION

[0012] Some embodiments provide a method of power control in a radio communications system, the method comprising: determining a path loss of a radio channel between a base station and a remote transceiver; receiving a transmit power control (TPC) command transmitted to the remote transceiver from the base station; and calculating a transmit power level for the remote transceiver based on the path loss and the TPC command.

[0013] Some embodiments provide a method of power control in a radio communications system, the method comprising: receiving a signal at a second transceiver transmitted from a first transceiver; measuring a power level of the received signal; receiving a transmit power control (TPC) command at the second transceiver transmitted from the first transceiver; and calculating a transmit power level for the second transceiver based on the power level of the received signal and the TPC command.

[0014] Some embodiments provide a method of uplink power control in a CDMA radio communications system, the method comprising: receiving an uplink signal; determining an error metric of the uplink signal; updating an SNIR target based on the error metric;measuring a received SNIR of the uplink signal; comparing the measured received SNIR with the SNIR target; assigning a first value to a step indicator if the measured received SNIR is greater than the SNIR target, and assigning a second value to a step indicator if the measured received SNIR is less than the SNIR target; transmitting a transmit power control (TPC) command instructing a transmitter to adjust an uplink transmit power level based on the step indicator; receiving the TPC command including the step indicator; accumulating the step indicator value; broadcasting a downlink signal including an indication of a downlink power level, wherein the signal is transmitted at the downlink power level; measuring the received power of the downlink signal; and setting a transmit power level base on the received power level, the indication of the downlink power level, and the accumulated step indicator value.

[0015] Some embodiments provide a method comprising: measuring a power level of a received signal; receiving a transmit power control (TPC) command; and calculating a transmit power level based on the power level of the received signal and the TPC command.

[0016] Some embodiments provide a radio comprising: a receiver including an output to provide a measured received power level; an accumulator having an input for accepting step increase and decrease instructions and an output providing a sum of past step instructions; a power level setting circuit coupled to the accumulator output and coupled to the receiver output, wherein the power level setting circuit sets a transmit power bases on the accumulator output and the measured received power level; and a transmitter, wherein the transmitter transmits a signal at the set transmit power.

[0017] Other features and aspects of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings which illustrate, by way of example, the features in accordance with embodiments of the invention. The summary is not intended to limit the scope of the invention, which is defined solely by the claims attached hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIGURE 1 shows a block diagram of a wireless communication system.

[0019] FIGURE 2 illustrates a wireless communication system using an open loop scheme.

[0020] FIGURE 3 illustrates a wireless communication system using a closed loop scheme.

[0021] FIGURE 4 illustrates a wireless communication system using elements of both open loop and closed loop schemes, in accordance with the present invention.

[0022] FIGURES 5A, 5B and 5C each illustrate a simulated probability density function of the received SNIR in the network.

DETAILED DESCRIPTION OF THE INVENTION

[0023] In the following description, reference is made to the accompanying drawings which illustrate several embodiments of the present invention. It is understood that other embodiments may be utilized and mechanical, compositional, structural, electrical and operational changes may be made without departing from the spirit and scope of the present disclosure. The following detailed description is not to be taken in a limiting sense, and the scope of the embodiments of the present invention is defined by the claims of the issued patent.

[0024] Some portions of the detailed description which follows are presented in terms of procedures, steps, logic blocks, processing, and other symbolic representations of operations on data bits that can be performed on computer memory. A procedure, computer executed step, logic block, process etc., are here conceived to be a self-consistent sequence of steps or instructions leading to a desired result. The steps are those utilizing physical manipulations of physical quantities. These quantities can take the form of electrical, magnetic, or radio signals capable of being stored, transferred, combined, compared, and otherwise manipulated in a computer system. These signals may be referred to at times as bits, values, elements, symbols, characters, terms, numbers, or the like. Each step may be performed by hardware, software, firmware, or combinations thereof.

[0025] FIGURE 1 shows a block diagram of a wireless communication system. A network 100 may include one or more base station controllers 120, such as a radio network controller (RNC), and one or more base stations 110, such as a Node-B, wherein each Node-B is connected to an RNC. The network 100 communicates with one or more users 140, 150 through a channel 160, also referred to as a radio link, created between a base station and a user.

[0026] Two mechanisms are primarily responsible for changes in the SNIR of a signal travelling through a radio link.

[0027] First, changes in the channel affect the SNIR. The instantaneous path loss between a base station and a user may vary as the user changes position or the user's environment changes. Rapid changes may occur as a result of a transmitted signal combining constructively and destructively as the signal travels along multiple paths from a base station and to the user. Additionally, slower changes may occur due to attenuation of the radio waves with increased distance between the base station and the user. Slower changes may also occur due to signal obstruction by buildings, vehicles and hills.

[0028] Second, signals from other transmitters affect the SNIR. For example, signals intended for other mobile radios or other base stations may increase interference in the radio link and thus reduce a received signal's SNIR.

[0029] In Time Division Duplex (TDD) systems, both uplink and downlink share the same carrier frequency. Due to this reciprocity in the links, path loss measurements made on the downlink by a mobile radio may be used estimate the path loss on the uplink. That is, a measured downlink path loss may be used to estimate the uplink path loss. The estimated uplink path loss will be less reliable with the passing of time but may be adequate within a frame period. Therefore, a mobile radio may determine a transmit power level for an uplink transition that compensates for an estimated uplink path loss, thereby providing a received signal to a base station at an expected input power level.

[0030] Downlink path loss measurements may be facilitated by a beacon channel, which is transmitted from a base station at a reference power level. A mobile radio is informed of the actual transmit power level being used by the base station for the beacon channel. In addition to knowing the actual transmit power level of a beacon channel, the mobile radio may measure a received signal power level. By measuring the received signal power level, the mobile radio can compute a downlink path loss as the difference between the actual transmit power level and the received signal power level. Thus, the mobile radio is able to estimate the uplink path loss in a channel between the base station and the mobile radio and properly set its uplink transmit power level.

[0031] The path loss calculation may be updated as often as a beacon signal is transmitted and received. In a UTRA TDD system in compliance with the third generation partnership project (3GPP) specifications, a beacon signal is transmitted either once or twice every 10 milliseconds (ms). If an uplink transmission follows a beacon transmission within a relatively short period of time, a mobile radio can compensate for the fast fluctuations (fast-fading) in a radio channel. Such is the case for mobiles travelling at slow to moderate speeds if a beacon signal is transmitted either once or twice every 10ms and the uplink transmissions occur in the intervening period.

[0032] Additionally, a radio channel may be adversely affected by changes in interference levels over time. These temporal interference changes may be accommodated by a base station measuring and communicating interference levels seen in each uplink timeslot. In a UTRA TDD system, a table having values of the measured interference for each timeslot may be broadcast to all users via a Broadcast Channel (BCH). The broadcasted information may be updated approximately every 16 frames (160 ms) depending upon the system configuration. In other embodiments, a mobile radio may receive this interference table as a signalled message directed to the individual mobile radio.

[0033] The 3GPP specifications describe two separate schemes for power control of uplink channels: an open loop scheme and a closed loop scheme. For example, in 3GPP 3.84 Megachips per second (Mcps) TDD systems, open loop power control is specified for all uplink channels. In 3GPP 1.28 Mcps TDD systems, open loop power control is specified only for physical random access channels (PRACH). Also defined by 3GPP is an implementation of a closed loop power control scheme. For example, see 3GPP recommendations for UTRA TDD systems operating at 1.28 Mcps for non-PRACH uplink channels.

[0034] In a wireless communication system using an open loop scheme, a network and UE use an outer loop to update and signal to the UE an SNIR Target value, thereby influencing the UE's transmit power. The network updates the SNIR Target value to be signalled based upon an observed error rate on the uplink. Once received, the mobile radio takes into account the signalled SNIR Target value when deriving a transmit power level that it will apply to the next uplink signal transmitted.

[0035] In a 3GPP 3.84 Mcps system incorporating an open loop scheme, a network instructs the UE with an SNIR Target value. The network also signals its beacon transmit power level and may also provide a measure of uplink interference for each timeslot as measured by the network. The UE receives an input signal that is typically a combination of attenuated versions of the network signal, which passed through a radio channel, along with interfering signals from other transmitters. The UE measures the received power level of the attenuated network signal and determines a path loss of the radio channel. The UE also decodes the signalled SNIR Target value from the network signal. The UE computes a transmit power level based on the SNIR Target value, the determined path loss and, if available, the uplink interference measurements.

[0036] FIGURE 2 illustrates a wireless communication system using an open loop scheme. A UE transmits 200 user data at a determined transmit power level. An uplink signal 202, which includes user data 204, propagates through the radio link. The network receives an attenuated version of the transmitted signal. The network measures 207 an uplink interference value and determines 206 an error metric of the uplink signal. The network may use the measured uplink interference value to update 208 an interference measurement table. The interference measurement table may include average measured interference levels for each uplink timeslot.

[0037] The network also uses the error metric to update 210 an SNIR Target value. The network transmits 212 SNIR Target in a signalling message on the downlink 214, which includes the SNIR Target 216. The UE receives and saves 220 the SNIR Target. The network also broadcasts 222 a beacon signal on the downlink 224. The downlink 224 propagates the signal, which includes an indication of the beacon power level 226, over the radio link. The network may also broadcast the interference measurements 228. The UE measures 230 the received power level and saves 232 the interference measurements for later processing.

[0038] With the measured power level and the signalled beacon power level, the UE may determine a path loss. The UE may use the saved received SNIR Target 216, the saved received interference measurements 228 and the computed path loss to set 234 a transmit power level. This transmit power level may be used by transmitter 200 to set the power level of transmitted user data 204 on the uplink 202.

[0039] The 3GPP specifications also define a closed loop scheme. For example, a 3GPP 1.28 Mcps system employs a closed loop scheme using an outer loop and an inner loop. The closed loop TPC scheme is the primary power control mechanism used for all non-PRACH channels in a 1.28 Mcps TDD system. The closed loop TPC scheme is not currently employed for the uplink of 3.84 Mcps TDD systems.

[0040] The outer loop determines an SNIR Target value and the inner loop uses the SNIR Target value. The outer loop includes network components that determine an error metric, such as a bit error rate, a block error rate or a CRC error count, on uplink traffic from UEs. This error metric is used to set and update an SNIR Target value. An inner loop includes network components that use the SNIR Target value computed and set by the outer loop. The network measures a received SNIR value of the uplink signal.

[0041] Next, a comparator determines whether the measured SNIR value is greater than or less than the SNIR Target value. If the measured SNIR value is greater than the SNIR Target value, the network signals a transmit power control (TPC) command on the downlink instructing the UE to reduce its current transmitter power by a step value (e.g., 1 dB). On the other hand, if the measured SNIR value is less than the SNIR Target value, the network signals a TPC command instructing the UE to increase its current transmitter power by the step dB value.

[0042] In a system employing only a closed loop power control scheme, several TPC commands may be necessary to properly bring the UE's transmitted power in line with the SNIR Target value. For example, if a path loss increases from one frame to the next by 15 dB, the system will take 15 TPC commands to compensate for the 15 dB fade. A UE accumulates the increase and decrease TPC commands to determine a proper uplink transmit power level. By increasing and decrease uplink power levels of each UE, a network attempts to control the power level of each UE such that the ratio of the received uplink energy level per transmitted bit to the spectral density of the noise and interference signals is a constant value. This TPC command adjustment process is performed for each UE in a cell. The constant value, however, may be non-uniform among the UEs depending upon the configuration of the system.

[0043] In a closed loop TPC scheme, the inner loop SNIR is maintained via a closed loop method using binary feedback. The feedback indicates either power up or power down. Every time a TPC command is received an integrator in the UE is used within the inner loop to update the UE transmit power by a step amount +/-Δ dB. The TPC commands themselves are derived by the network and are signalled to the UE via a downlink channel. When calculating the proper TPC command to send, the network measures the received SNIR and compares this measured value to an SNIR Target value. If the SNIR is too low, an up command is sent. If the SNIR is too high, a down command is sent. The target SNIR value is updated by the outer loop based upon the observed error performance of the link. In this way, both the inner and outer feedback loops are closed by the TPC signalling.

[0044] FIGURE 3 illustrates a wireless communication system using a closed loop scheme. The closed loop scheme includes an outer loop in which a UE transmits 300 user data over the radio link in an uplink signal 302 that contain the user data 304. The network determines 306 an error metric of the received uplink signal. Using the error metric, the network computes and updates 308 an SNIR Target value.

[0045] The closed loop scheme also includes an inner loop in which the network measures 310 the received SNIR of the uplink signal 302. The network compares 312 the measured SNIR with the SNIR Target determined in the outer loop. The inner loop generates and transmits 314 a TPC command based on the comparison 312. A downlink signal 316 carries the TPC command 318 over the radio link. The UE accumulates 320 the TPC commands and uses the accumulated TPC commands to set 322 a transmit power for future uplink transmissions 300.

[0046] A mobile radio system employing either an open loop scheme or a closed loop scheme has its advantages and disadvantages.

[0047] The open loop scheme advantageously adapts quickly to path loss changes. If the path loss is observed to have worsened, for example by 15 dB in one 10 ms interval, the transmit power may be adjusted accordingly. A further advantage is that the open loop may continue to be partially updated in the absence of user-specific feedback signalling. For example, when a UE does not receive updated SNIR Target values, the outer loop pauses but changes in the path loss may continue to be tracked.

[0048] Disadvantageously, the timeslot interference level update rate in an open loop system is relatively slow. Therefore, a system using an open loop scheme is slower to adapt to interference changes than a system using the closed loop scheme. A further disadvantage of the open loop scheme is that interference is considered to be the same for all UEs in a particular uplink timeslot. That is, each UE assigned to a timeslot uses the same interference measurement signalled by the base station on the BCH. A commonly used interference measurement table makes assumptions about the statistical nature of the interference and does not consider the individual cross-correlation properties of the uplink channelization codes. It is thus left to the outer loop to compensate for these effects, but unfortunately on a slow basis.

[0049] Conversely, the closed loop only scheme is less able to adapt to fast path loss changes because the closed loop can only move by a step Δ dB during each update. Thus, if the path loss has changed between updates by 15 dB and the step Δ dB value is only 1 dB, the closed loop is not able to adjust quickly since it can move only by 1 dB during each cycle. Therefore, for the same update rate (e.g., once per 10 ms), a closed loop TPC scheme is less able to track the fast fading observed in common mobile radio channels. Furthermore, the closed loop may not be updated during a pause in transmission of the TPC commands.

[0050] Advantageously, the closed loop is relatively quick to respond to uplink interference changes since both path loss and interference are accommodated by the same loop. The closed loop scheme using TPC commands has a further advantage in that it allows for per-user interference adaptation, in contrast to the open loop scheme, which broadcasts an average interference table for each timeslot.

[0051] In accordance with the present invention, aspects of both an open loop scheme and a closed loop scheme are strategically combined to form a power control method. Some embodiments of the present invention advantageously combine elements of both open loop and closed loop schemes to control power levels, thereby avoiding one or more of the disadvantages associated with either of the separately used schemes.

[0052] In accordance with some embodiments of the present invention, a UE incorporates the TPC structure of a closed loop scheme and the path loss estimation structure of an open loop scheme. Some embodiments of the present invention allow for both relatively quick adaptation to fast fading and also allow for per-user interference adaptation, and retain the ability to partially update the power control loop even in the temporary absence of TPC commands.

[0053] Some embodiments of the present invention require modifications to one or more elements of a standard mobile radio system. For example, some embodiments require changes to just a UE, while other embodiments require modifications to just the network. Embodiments that modify a UE but not the network allow the UE of the present invention to operate with legacy base stations. Similarly, embodiments that modify the network but not the UE allow the network of the present invention to operate with legacy UEs. Still other embodiments of the present invention require modification to both the network and the UE. Embodiments modifying standard network elements may include changes to just a base station but not a radio network controller (RNC). Other embodiments modify both a base station and an RNC.

[0054] Some embodiments of the present invention, incorporate a loop having three components: an open loop component located in the UE, an SNIR comparison loop located in the network, and an SNIR update component also located in the network.

[0055] First, an open loop component may be located in the UE and driven by measured beacon received power levels and path loss calculations. This loop tries to adapt to all instantaneous path loss changes on a per-beacon transmission basis. The partial power calculated by this loop is a function of the beacon signal transmission power (P_{Tx}) and the beacon received signal code power (RSCP) and is denoted $P_{open}(k)$, where *k* represents the current frame number. P_{Tx} is known to the UE and derived from the base station signalled power level (428, FIGURE 4) and the measured power level for frame *k*, (*RSCP(k)*), may be determined by the UE receiver (432, FIGURE 4). $P_{open}(k)$ may also be a function of a constant value (*C*) to ensure that the transmission arrives at an appropriate power level.

$$P_{open}(k) = P_{Tx} - RSCP(k) + C$$

[0056] Second, an SNIR comparison loop is located in the network, such as in the Node-B. The SNIR comparison loop is driven by received SNIR metrics. A received SNIR is compared to a SNIR Target value, which is set by an outer loop. A comparison result leads to the signalling of a TPC command that is signalled to the UE to change its transmit power. Binary signalling may used, such that the TPC command indicates a change in transmission power by a fixed amount either up or down. Alternately, a multi-level TPC command may be used.

[0057] Third, an outer loop is located in the network, such as in the Node-B or RNC. The outer loop is driven by the data error statistics observed on the uplink transmissions. The outer loop is responsible for setting an SNIR Target level for the SNIR comparison loop.

[0058] An optional auxiliary process in the UE adjusts the transmit power based upon: (a) γ_{SF}, the spreading factor (SF) of the physical channel; and (b) β_{TFC}, the selected transport format (TFC).

[0059] Thus, for the current frame k, the UE may calculate the transmit power $P_{Tx}(k)$ as shown below where K is the initial frame number determined when the power control process begins; TPC_i is -1 for a down TPC command, $+1$ for an up TPC command and 0 if no TPC command is received; and *step* is the magnitude of the amount added to an accumulator upon receipt of each TPC command. The transmit power $P_{Tx}(k)$ may be updated for every frame period. Alternatively, the transmit power $P_{Tx}(k)$ may be updated each time a new TPC command is received. Alternatively, the transmit power $P_{Tx}(k)$ may be updated only when either a TPC command or a new power level is received from the network.

$$P_{Tx}(k) = P_{open}(k) + step \cdot \sum_{i=k-K}^{k} TPC_i + \gamma_{SF} + \beta_{TFC}$$

[0060] An embodiment of a power control scheme, in accordance with the present invention, is shown diagrammatically in FIGURE 4. The γ_{SF} and β_{TFC} adjustment factors are not shown for diagrammatical clarity.

[0061] FIGURE 4 illustrates a wireless communication system using elements of both open loop and closed loop schemes, in accordance with the present invention. A UE transmits 400 user data at a determined transmit power level. An uplink signal 402, which includes the user data 404, propagates through the radio link. The network receives an attenuated version of the transmitted signal.

[0062] The network determines 406 an error metric of the uplink signal 402. Optionally, the network measures an uplink interference level and may update 422 an interference measurement table. Data measured or computed from uplink measurements may be entered into the interference measurement table. The interference measurement table may include average measured interference levels for each uplink timeslot. Within the network the error metric may be used to update 408 an SNIR Target value.

[0063] The network also transmits 424 a beacon signal. The downlink signal 426, which includes an indication of the beacon transmit power level 428, propagates over the radio link. Optionally, the network may broadcast the interference measurements 430. The UE saves 432 the signalled power level, measures the received power level and, if available, saves 434 the interference measurements for later processing.

[0064] As in a closed loop scheme, a UE transmits 400 user data over the radio link in an uplink signal 402 that contain the user data 404. The network determines 406 an error metric of the received uplink signal. Using the error metric, the network computes and updates 408 an SNIR Target value.

[0065] The network also measures 410 the received SNIR of the uplink signal 402. The network compares 412 the measured SNIR with the determined SNIR Target. The network generates and transmits 414 a TPC command based on the comparison 412. A downlink signal 416 carries the TPC command 418 over the radio link. The UE accumulates 420 the TPC commands and uses the accumulated TPC commands in part to set 436 the transmit power level for future uplink transmissions 400.

[0066] As in an open loop scheme, with the measured power level and the signalled beacon power level, the UE may determine a path loss $P_{open}(k)$. The UE may use the saved received interference measurements *I(k)* to adjust the transmission power following a pause in transmission or following a pause in receipt of TPC commands. The UE may use the accumulated TPC commands $\sum_{i=k-K}^{k} TPC_i$ the computed path loss $P_{open}(k)$, adjustment factors γ_{SF} & β_{TFC} and optionally, adjustments based upon *I(k)* to set 436 a transmit power level. This transmit power level $P_{Tx}(k)$ may be used to set the uplink power level of transmitted 400 user data on the uplink 402.

[0067] The downlink signal 426, which contains the power level 428 and may contain the interference measurements 430, is broadcast in a cell. Previous UEs using a closed loop scheme do not use measurements of the downlink received power while monitoring the power level signalling in a beacon broadcast to set the uplink transmission power. Similarly, previous UEs using a closed loop scheme do not compute or do not use computations of the downlink path loss while processing TPC commands. A previous UE simply follows the TPC commands as it is instructed to set its transmit power level. If a network instructs a known UE to increase its transmit power by one step amount, the previous UE shall increase its power level by one step amount.

[0068] In accordance to the present invention, a UE may receive a TPC command instructing it to change its transmit power by one step level in a particular direction, but the UE may actually change its transmit power level by a different amount or in fact an amount in the opposite direction. The UE uses the TPC only as a factor in determining whether to increase transmit power level, decrease transmit power level or leave the transmit power level unchanged.

[0069] For example, assume a UE just transmitted a burst to a Node-B at 20 dBm over a radio link with a path loss of 110 dB. The received power at the Node-B receiver would be –90 dBm, which is the difference between 20 dBm and a loss of 110 dB. Next, assume the Node-B wants to receive an uplink signal from the UE at –89 dBm. The Node-B would signal and the UE would receive a TPC command instructing the UE to increase the uplink transmit power level by 1 dB. Also assume that the path loss improves from the previous frame to this frame by +10 dB (e.g., from 110 dB to 100 dB).

[0070] A previous UE would transmit the next burst at +21 dBm, which is the sum of the previous level (+20 dBm) and the step increase (1 dB). The transmitted +21 dBm signal would probably reach the Node-B at –79 dBm, a signal level that is +10 dB too great because the channel improvement was not taken into account.

[0071] In accordance with the present invention, a UE would account for the new path loss. The previous transmit power level of +20 dBm would be decreased by +10 dB to account for the improved channel path loss of +10 dB. The resulting transmit power level would then be +10 dBm. The UE also accounts for the TPC command by adjusting the transmit power level by the desired step of +1 dB, resulting in a new transmit power level of +11 dBm, which both accounts for the improved channel (+10 dB) and accommodates the Node-B's desire to have a received signal with a step increase (+1 dB). The +11 dBm would reach the Node-B at the desired level of –89 dBm if the channel pathloss estimate was accurate. As shown in this example, the transmit power level dropped 9 dB (from +20 dBm to +11 dBm) even though the Node-B TPC command instructed an increase of 1 dB.

[0072] Therefore, even though a UE receives a network TPC command instructing it to step up or down its uplink transmit power by 1 dB, the UE may actually change the transmit power level by a different amount. In fact, the UE transmit power level may change in a direction opposite of the TPC command as exemplified above.

[0073] During a period of inactivity on the uplink 402, TPC commands 418 may not have been received by the UE. The UE transmit power level for a subsequent initial transmission 400 may be determined using current updates of the open loop component. That is, the initial transmit power level may be determined based on the beacon power level 428, the measured 432 received power level, and optionally the interference measurements 430. The open loop component does not require feedback, thus may continue to be updated every beacon transmission even during the uplink transmission pause.

[0074] The history stored in the TPC accumulator may be stale. In some circumstances the history may be considered useful and is not reset. Alternatively, the accumulated TPC history could be used to set the uplink transmit power level but with some excess power margin added to ensure a clean start to the loop. Alternatively, the UE may decide to discard the accumulated TPC history and to reset it to a default or initial value. The default or initial value may optionally be based upon a received interference measurement table 430.

[0075] The ability of the open loop component to compensate for fast fading is a function of the channel speed and the delay between the beacon timeslot and the uplink timeslots. Open loop control is often effective at pedestrian speeds as well as at higher speeds if the uplink slots are placed close in time to the beacon. At high mobile speeds, it is likely that power control performance will be improved if beacon RSCP filtering is enabled at the UE. The UE is responsible for detecting whether or not filtering should be applied to the open loop component. Automatic detection of the channel speed may be performed by the UE in order to control the enabling of RSCP filtering. In some embodiments of the present invention, a UE disables a combined open loop/closed loop scheme operating in accordance with the present invention when a UE passes a threshold value indicative of mobile speed.

[0076] Simulations have been performed to illustrate the performance advantages of some embodiments of the present invention. The radio channel simulated here represents an ITU indoor to outdoor and pedestrian model B channel as described in ITU-R M.1225 Guidelines for Evaluation of Radio Transmission Technologies for IMT-2000. The outer loop SNIR target was based upon a 1% error rate. A residual SNIR error term observed at the base station was monitored.

[0077] FIGURES 5A, 5B and 5C each illustrate a simulated probability density function of the received SNIR in the network. In each of the simulations, approximately 10,000 received SNIR values are sampled. Simulation results for each scenario are grouped and collected into bins. The vertical axis shows a number of occurrences for a particular range (bin) of received SNIR values. A sampled received SNIR value that fall within a range defined by a bin is counted as an occurrence for that bin.

[0078] FIGURE 5A shows simulation results for a system using only an open loop scheme. In this plot, the bin width is approximately 0.42 dB. The simulation results show a system good at tracking fast fading in the channel, but not as able to track the interference variations included in the simulation. These values are only updated at the UE via signalling every 160 ms. As such, the error term shows considerable variance at the receiver.

[0079] FIGURE 5B shows simulation results for a system using only a closed loop scheme. In this plot, the bin width is approximately 0.48 dB. The simulation results show a system better able to track the interference changes, but not as able to track the path loss due to being limited in response to the TPC command +/– 1 dB step size.

[0080] FIGURE 5C shows simulation results for a system combining aspects of both open and closed loop schemes (as shown in FIGURE 4). In this plot, the bin width is approximately 0.24 dB. The simulation results show a system able to respond to both path loss and interference changes. Additionally, the residual SNIR error term shows less variance. The plot shows that the variance of this distribution is considerably reduced for the combined power control scheme.

[0081] For the above simulations (using the same fading and interference profiles for each loop method), the following mean transmit powers were obtained:

Power Control Method	**Mean Transmit Power for 1% BLER**
Open Loop: (FIGURE 2)	5.76 dB
Closed Loop: (FIGURE 3)	5.48 dB
Combined Loops: (FIGURE 4)	3.59 dB

Table 1 – Performance of Power Control Schemes

[0082] For the simulated channel and interference scenario, the combined scheme is able to maintain a 1% block error rate (BLER) using 2.17 dB less power than the open loop scheme and 1.89 dB less power than the closed loop scheme. In a real system, this power saving may equate to greater cell coverage, higher uplink capacity and throughput, and increased battery life. The magnitude of the gains may change with different channel speeds, types and interference profiles but the performance of the combined should be better than both the open loop and closed loop schemes when used individually.

[0083] In terms of signalling overhead, the combined scheme helps to avoid a need to signal SNIR Target and interference levels on downlink channels, and has a similar signalling efficiency as the closed loop scheme. In some embodiments, the signalling efficiency is 1 bit per update.

[0084] In a system using the combined power control scheme, a new physical channel on the downlink may be used to carry fast allocation and scheduling information to a user, thereby informing the UE of the uplink resources that it may use. This new physical channel could also be used as the feedback channel for the combined power control scheme. For example, an allocation/scheduling channel could carry TPC commands. Alternatively, the combined scheme may be applied to existing channel types (dedicated or shared uplink physical channels) for UTRA TDD as well as to other TDD systems.

[0085] Some embodiments of the present invention control uplink power levels and may be incorporated into a UE with supporting features incorporated into a base station. For example, a Node-B or RNC may be implemented with a new parameter, either included in a signalling command or a broadcast message, where the new parameter instructs a UE to enable or disable the setting of uplink transmit power level based on both the path loss estimation and the TPC commands. A parameter may indicate whether a UE is to use open loop power control, closed loop power control or a combined scheme.

[0086] Some embodiments of the present invention operate with a downlink signal including both a TPC command and an indication of the downlink transmit power level. In these embodiments, the downlink signal provides both downlinks 416 and 430 (FIGURE 4) in one signal. A UE may receive one physical channel that it decodes for TPC commands, decodes for downlink power level indications, and measures for received power levels. In these embodiments, the UE measures a power level of a received signal, receives a TPC command, and calculates a transmit power level based on the power level of the received signal and the TPC command.

[0087] While the invention has been described in terms of particular embodiments and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to the embodiments or figures described. For example, the combined uplink power control scheme described above may be implemented a mirror image for controlling downlink power. In this case, functions performed by the UE for a combined uplink scheme may be performed by the network. Similarly, functions performed by the network for the combined uplink scheme may be performed by the UE.

[0088] The figures provided are merely representational and may not be drawn to scale. Certain proportions thereof may be exaggerated, while others may be minimized. The figures are intended to illustrate various implementations of the invention that can be understood and appropriately carried out by those of ordinary skill in the art.

[0089] Therefore, it should be understood that the invention can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is not intended to be exhaustive or to limit the invention to the precise form disclosed. It should be understood that the invention can be practiced with modification and alteration and that the invention be limited only by the claims and the equivalents thereof.

CLAIMS

What is claimed is:

1. A method of power control in a radio communications system, the method comprising:

determining a path loss of a radio channel between a base station and a remote transceiver;

receiving a transmit power control (TPC) command transmitted to the remote transceiver from the base station; and

calculating a transmit power level for the remote transceiver based on the path loss and the TPC command.

2. The method of power control of claim 1, the method further comprising transmitting an uplink signal from the remote transceiver at the calculated transmit power level.

3. The method of power control of claim 1, wherein determining the path loss includes:

receiving a downlink signal transmitted from the base station, wherein the downlink signal signals a transmitted power level of the downlink signal; and

measuring a received power level of the downlink signal.

4. The method of power control of claim 3, wherein determining the path loss further includes computing a difference between the signalled transmit power level and the measured received power level.

5. The method of power control of claim 1, the method further comprising:

generating the TPC command; and

transmitting the TPC command from the base station.

6. The method of power control of claim 1, wherein the calculating the transmit power level is additionally based on an adjustment factor.

7. The method of power control of claim 6, wherein the adjustment factor incorporates a spreading factor parameter.

8. The method of power control of claim 6, wherein the adjustment factor incorporates a selected transport format parameter.

9. A method of power control in a radio communications system, the method comprising:

receiving a signal at a second transceiver transmitted from a first transceiver;

measuring a power level of the received signal;

receiving a transmit power control (TPC) command at the second transceiver transmitted from the first transceiver; and

calculating a transmit power level for the second transceiver based on the power level of the received signal and the TPC command.

10. A method of uplink power control in a CDMA radio communications system, the method comprising:

receiving an uplink signal;

measuring a received SNIR of the uplink signal;

comparing the measured received SNIR with an SNIR target;

assigning a first value to a step indicator if the measured received SNIR is greater than the SNIR target, and assigning a second value to a step indicator if the measured received SNIR is less than the SNIR target;

transmitting a transmit power control (TPC) command instructing a transmitter to adjust an uplink transmit power level based on the step indicator;

receiving the TPC command including the step indicator;

accumulating the step indicator value;

broadcasting a downlink signal including an indication of a downlink power level, wherein the signal is transmitted at the downlink power level;

measuring the received power of the downlink signal; and

setting a transmit power level based on the received power level, the indication of the downlink power level, and the accumulated step indicator value.

11. The method of power control of claim 10, further comprising:

determining an error metric of the uplink signal;

updating the SNIR target based on the error metric;

measuring an interference value in the received uplink signal; and

updating an interference measurement table with the interference value;

wherein broadcasting the downlink signal further includes the interference measurement table; and

wherein setting the transmit power level is further based on a value in the interference measurement table.

12. A method comprising:

measuring a power level of a received signal;

receiving a transmit power control (TPC) command; and calculating a transmit power level based on the power level of the received signal and the TPC command.

13. A radio comprising:

a receiver including an output to provide a measured received power level;

an accumulator having an input for accepting step increase and decrease instructions and an output providing a sum of past step instructions;

a power level setting circuit coupled to the accumulator output and coupled to the receiver output, wherein the power level setting circuit sets a transmit power bases on the accumulator output and the measured received power level; and

a transmitter, wherein the transmitter transmits a signal at the set transmit power.

ABSTRACT

A method, system and apparatus for setting a transmit power control level in a wireless communication system. Aspects of both open loop and closed loop transmit power control schemes are used to determine a transmit power level. A method includes measuring a power level of a received signal, receiving a transmit power control (TPC) command, and calculating a transmit power level based on the power level of the received signal and the TPC command.

pa-910795

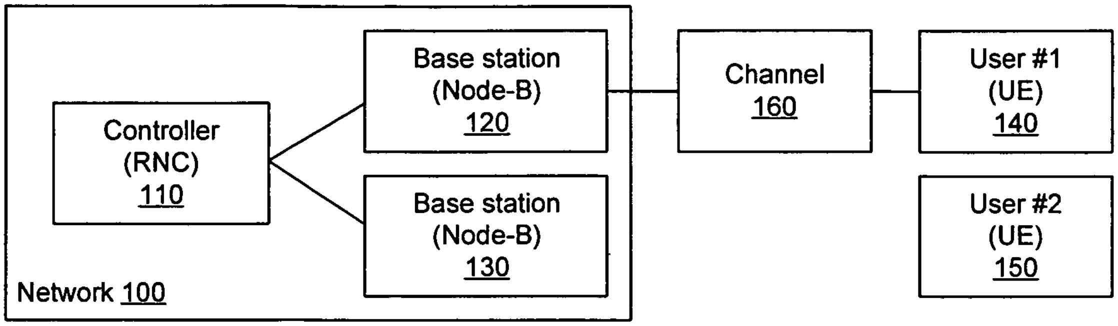


FIGURE 1

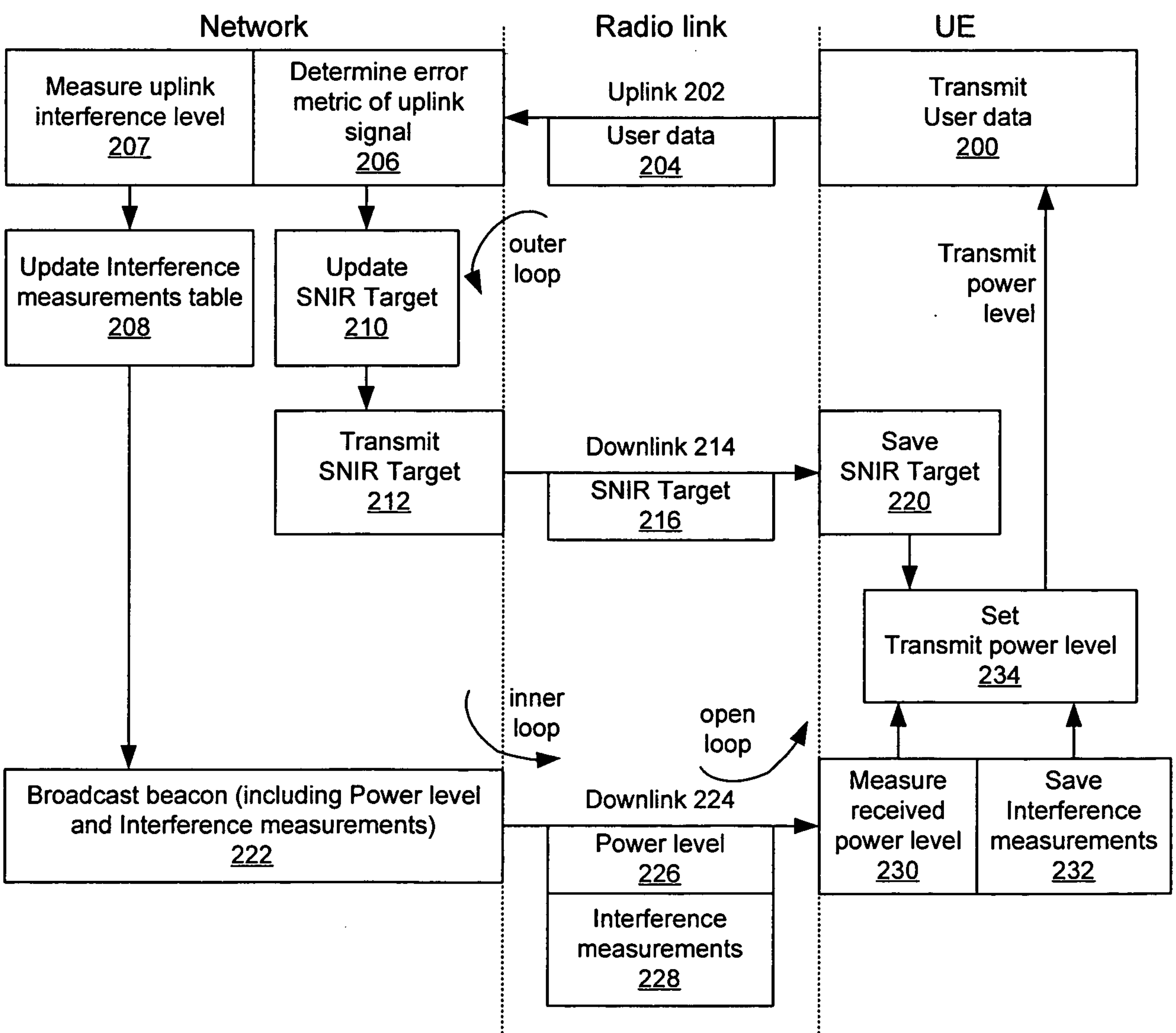


FIGURE 2

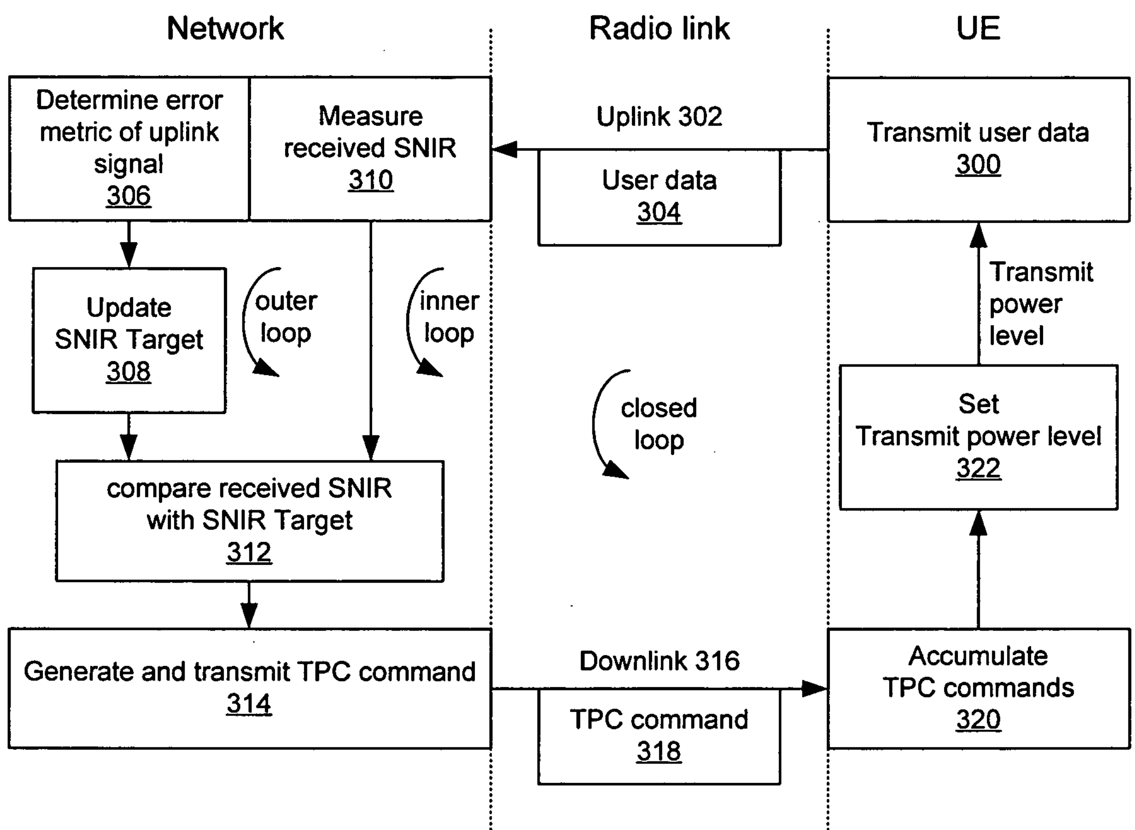

Network
Radio link
UE
Determine error metric of uplink signal 306
Measure received SNIR 310
Uplink 302
User data 304
Transmit user data 300
Update SNIR Target 308
outer loop
inner loop
Transmit power level
closed loop
Set Transmit power level 322
compare received SNIR with SNIR Target 312
Generate and transmit TPC command 314
Downlink 316
TPC command 318
Accumulate TPC commands 320

FIGURE 3

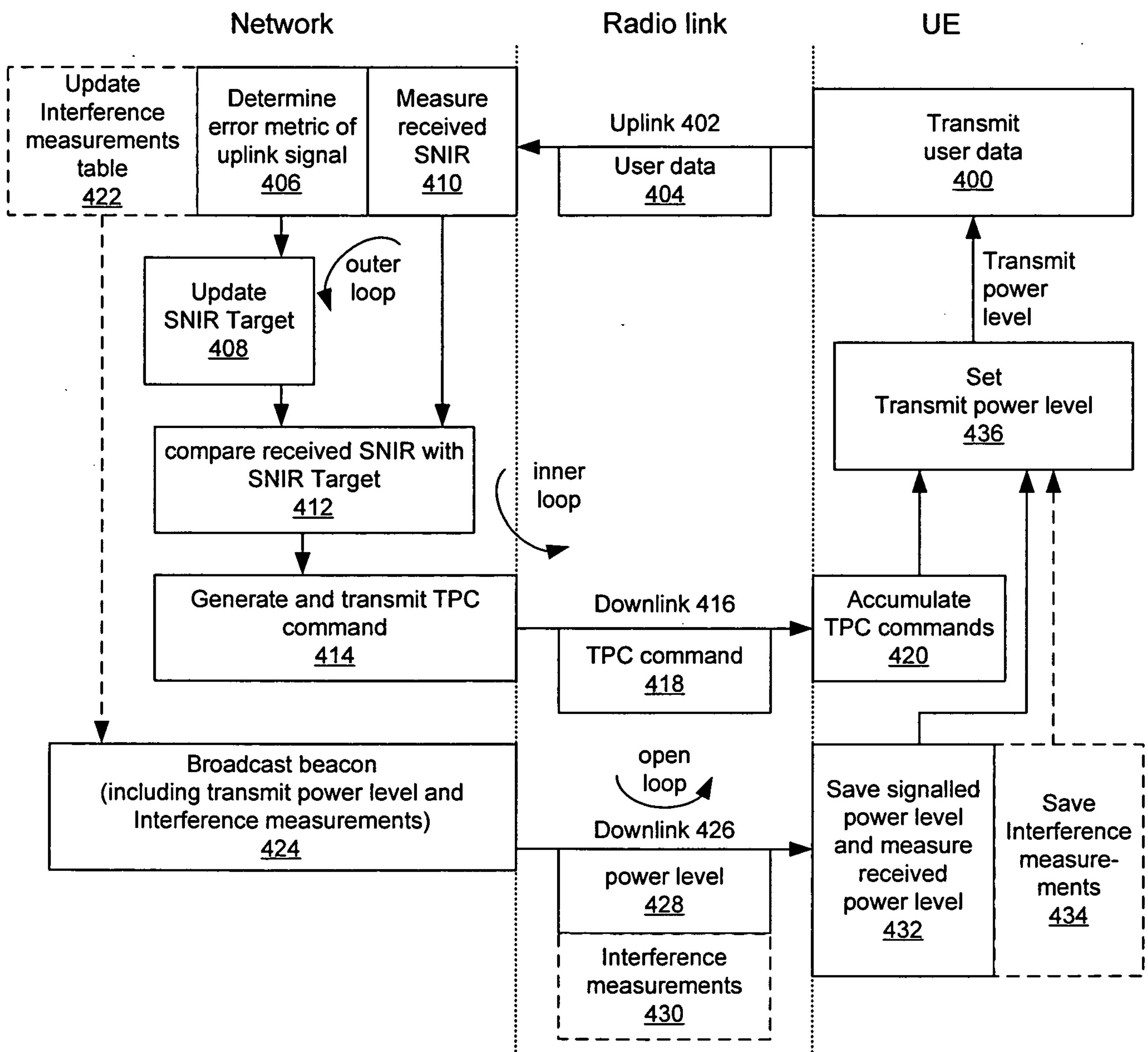

Network
Radio link
UE
Update Interference measurements table 422
Determine error metric of uplink signal 406
Measure received SNIR 410
Uplink 402
User data 404
Transmit user data 400
Update SNIR Target 408
outer loop
Transmit power level
Set Transmit power level 436
compare received SNIR with SNIR Target 412
inner loop
Generate and transmit TPC command 414
Downlink 416
TPC command 418
Accumulate TPC commands 420
Broadcast beacon (including transmit power level and Interference measurements) 424
open loop
Downlink 426
power level 428
Interference measurements 430
Save signalled power level and measure received power level 432
Save Interference measure-ments 434

FIGURE 4

App. No.: Not Yet Assigned
Inventor: Nicholas William ANDERSON
Docket No.: 562492000500
Title: "POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM"

FIGURE 5A

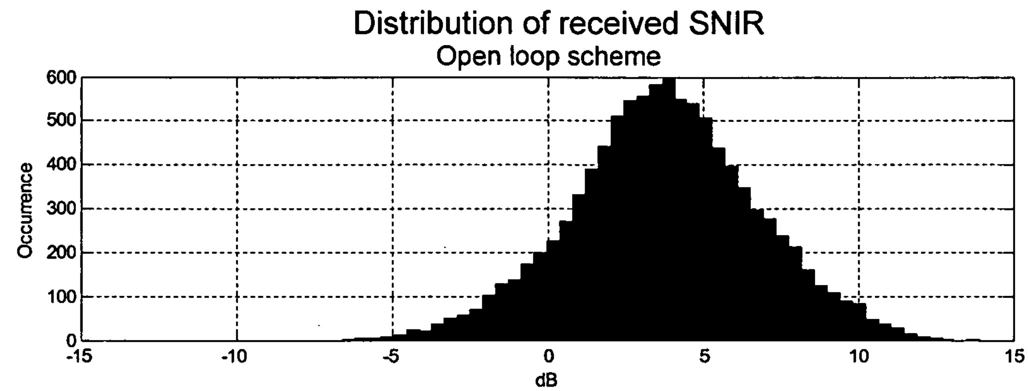


FIGURE 5B

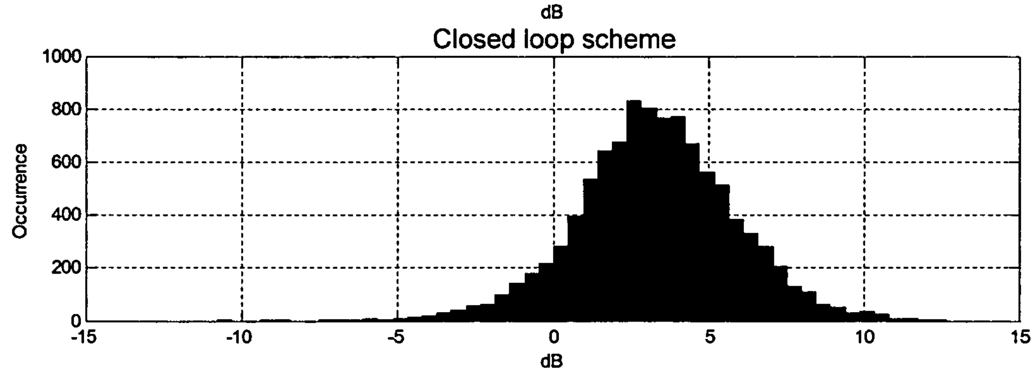
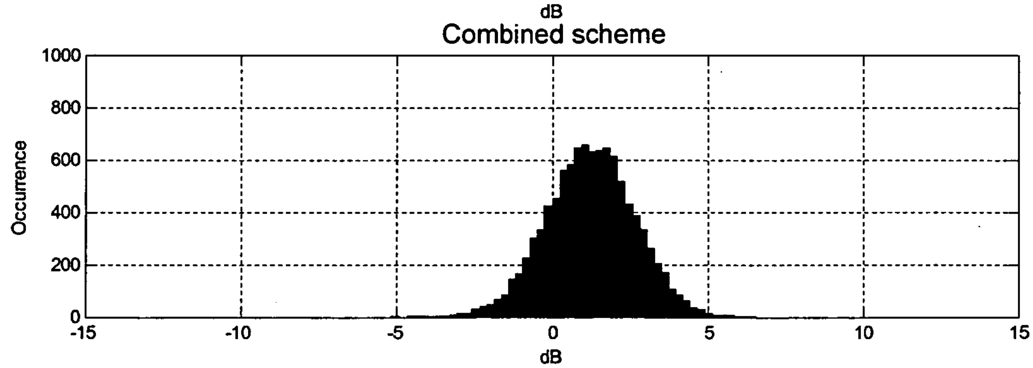


FIGURE 5C



PATENT APPLICATION SERIAL NO. ____________________

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

08/17/2004 AOSMAN1 00000003 031952 10917968

01 FC:1001 770.00 DA
02 FC:1201 172.00 DA

PTO-1556
(5/87)

*U.S. Government Printing Office: 2002 — 489-267/69033

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2003

Application or Docket Number: 10917968

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	13	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	13 minus 20=	* 0
INDEPENDENT CLAIMS	5 minus 3 =	* 2
MULTIPLE DEPENDENT CLAIM PRESENT		☐

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐ RATE	FEE	OR	OTHER THAN SMALL ENTITY RATE	FEE
BASIC FEE	385.00	OR	BASIC FEE	770.00
XS 9=		OR	XS18=	
X43=		OR	X86=	172
+145=		OR	+290=	
TOTAL		OR	TOTAL	942

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Application Data Sheet

Application Information

Application Type::	Regular
Subject Matter::	Utility
Suggested Group Art Unit::	Not Yet Assigned
CD-ROM or CD-R?::	None
Sequence submission?::	None
Computer Readable Form (CRF)?::	No
Title::	POWER CONTROL IN A WIRELESS COMMUNICATION SYSTEM
Attorney Docket Number::	562492000500
Request for Early Publication?::	No
Request for Non-Publication?::	No
Small Entity?::	No
Petition included?::	No
Secrecy Order in Parent Appl.?::	No

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Correspondence Information

Correspondence Customer Number:: 25226

Representative Information

Representative Customer Number:: 25226