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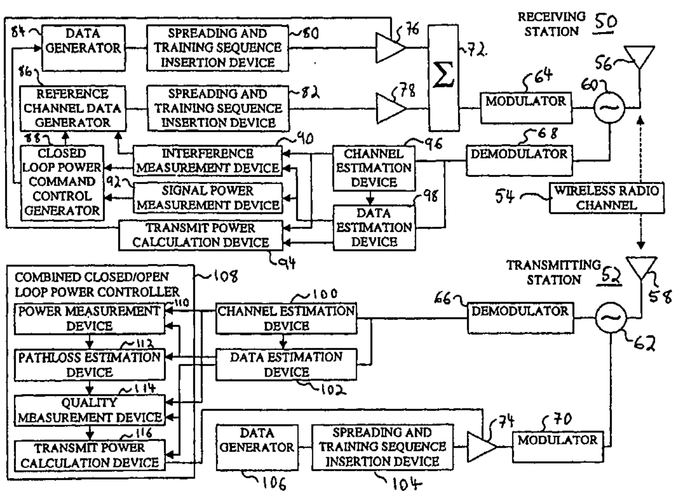
(54) Title: COMBINED CLOSED LOOP/OPEN LOOP POWER CONTROL IN A TIME DIVISION DUPLEX COMMUNICATION SYSTEM



(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.

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 $\mathbf{30_1}$ determines the signal to interference ratio (SIR) of a communication received from the UE $\mathbf{32_1}$. The determined SIR is compared to a target SIR (SIR_{TARGET}). Based on the comparison, the base station $\mathbf{30_1}$ transmits a power command, b_{TPC}. After receiving the power command, the UE $\mathbf{32_1}$ 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**.

$$T_{UE} = P_{BS}(n) + L \qquad \textbf{Equation 1}$$

$$P_{BS}(n) = P_{BS}(n-1) + b_{TPC}\,\Delta_{TPC} \qquad \textbf{Equation 2}$$

$$b_{TPC} = \begin{cases} 1: \text{if } SIR_{BS} < SIR_{TARGET} \\ -1: \text{if } SIR_{BS} > SIR_{TARGET} \end{cases} \qquad \textbf{Equation 3}$$

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