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Title: LCR TDD: Structure and Coding for E-HICH

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1 Introduction

The HARQ acknowledgement indicators are transmitted on a new downlink physical channel termed E-DCH HARQ Acknowledgement Indicator Channel (E-HICH) for 3.84Mcps TDD [1]. For LCR TDD EUL, it is proposed that the downlink physical channel E-HICH is also included for transmitting the HARQ acknowledgement indicators. In this document, structure and coding for E-HICH are discussed and text proposal for TR 25.827[2] is also provided.

2 Structure

Similar to HCR TDD, it is proposed that E-HICH is a SF=16 downlink physical channel and QPSK modulation shall be applied. Multiple users' ACK/NACK indicators are code-division-multiplexed on E-HICH. Different from HCR, it is proposed thatE-HICHs for non-scheduled users carry not only ACK/NACK indicators but also TPC/SS commands. The structures of E-HICH for scheduled users and non-scheduled users are discussed respectively blow.

2.1 Selection of signature sequences

2.1.1 Scheduled users

Each scheduled user's ACK/NACK indicator is spread by a short-term orthogonal code assigned by higher layer.

2.1.2 Non-scheduled users

TPC and SS of scheduled users are transmitted on E-AGCH. Since there are no E-AGCHs for non-scheduled users, it is proposed that E-HICH is used to convey TPC and SS for non-scheduled users. In [3], it is proposed that the 8 spare bits are used to carry TPC and SS. One E-HICH may thus carry at most two non-scheduled users' information. This scheme restricts the number of non-scheduled users carried on one E-HICH. In this section, a new scheme is proposed so that the number of non-scheduled users carried on an E-HICH can be increased.

It is proposed that the 80 signature sequences are divided into 20 groups while each group includes 4 sequences. Every non-scheduled user is assigned one group by higher layer. Among the 4 sequences, one is used to indicate ACK/NACK, and the other three are used to indicate the TPC/SS command. The three sequences and their three reverse sequences are the six possible sequences chosen to indicate the TPC/SS state. The reverse sequence is constructed by reverse every bit of the sequence from 0 to 1 or from 1 to 0. The mapping between the index and the TPC/SS command is shown in table 1. The index is calculated according to the equation: index=2*A+B, (A=0,1,2; B=0,1). A is the relative index of the selected sequence among the three assigned sequences and B equals to 1 when the reverse sequence is chosen, otherwise, B equals to 0. The power of the sequence used for TPC/SS indication can be set differently from the one used to indicate ACK/NACK.

Table 1 Mapping between the index and TPC/SS command

index	TPC command	SS command
0	'DOWN'	'DOWN'
1	'UP'	'DOWN'
2	'DOWN'	'UP'
3	'UP'	'UP'
4	'DOWN'	'Do Nothing'
5	'UP'	'Do Nothing'

2.2 Coding and Multiplexing of acknowledgement indicators on E-HICH

The system may configure several E-HICHs in a cell. Each E-HICH physical channel may carry not only ACK/NACK indicators for scheduled users, but also ACK/NACK indicators, TPC and SS commands for non-scheduled users, with different signature sequences being assigned to scheduled users and/or non-scheduled users. Up to four E-HICHs may be configured for a scheduled transmission. The 2-bit EI on E-AGCH is used to indicate which E-HICH is used by the specific scheduled user while which E-HICH is used by the non-scheduled user is informed by higher layer.

2.2.1 Scheduled user

Channel coding process for E-HICH is proposed below:

- Each ACK/NACK indicator is firstly spread by the corresponding signature sequence to 80 bits.
- Spare bits are appended and the sequence becomes 88-bit long.
- Bit scrambling is applied to each of the 88-bit sequence.
- Each Sequence after bit scrambling is QPSK modulated and amplitude-weighted.
- Multiple acknowledgement indicators are multiplexed. (Multiplexing is transparent when only one ACK/NACK indicator is carried on the E-HICH.)

Physical channel spreading and scrambling operation are then performed in the usual manner.

Figure 1 illustrates the multiplexing of acknowledgement indicators for scheduled users.

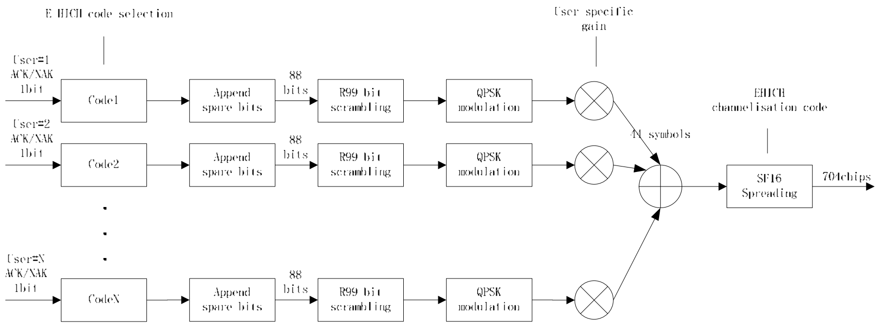

Figure 1 – Multiplexing of acknowledgement indicators for scheduled users

2.2.2 Non-scheduled user

There are two signature sequences on E-HICH for each non-scheduled user.

- ACK/NACK is spread by the signature sequence assigned by higher layer to 80 bits. Another sequence is chosen according to TPC/SS command.
- Spare bits are appended to both of the two sequences and they both become 88-bit long.
- Bit scrambling is applied to each of the 88-bit sequence.
- Each Sequence after bit scrambling is QPSK modulated.
- The sequence used to indicate TPC/SS is multiplied by a factor set by Node-B. Two sequences belonging to one non-scheduled user are added.
- The amplitudes of different users are adjusted and then multiplexed together.

Physical channel spreading and scrambling operation are then performed in the usual manner.

Figure 2 illustrates the multiplexing of acknowledgement indicators for non-scheduled users.

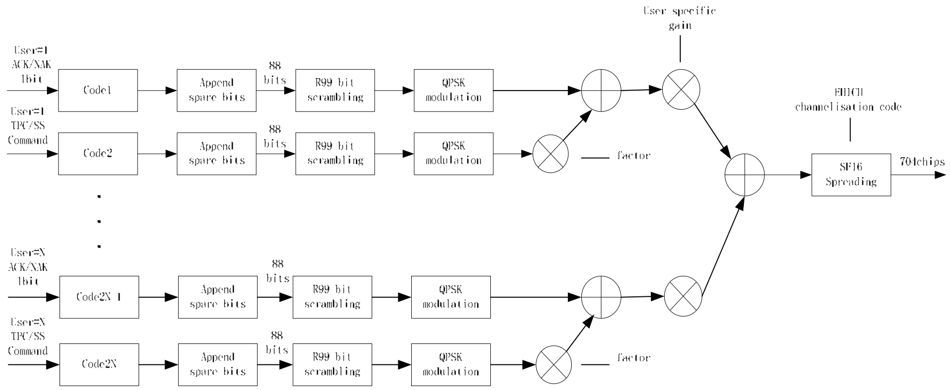

Figure 2 – Multiplexing of acknowledgement indicators for non-scheduled users

3 Signature Sequences

It is proposed to have a common signature sequence of length 80 irrespective of scheduled users or non-schedule users. The sequences are the rows of an orthogonal matrix of order 80 which is Kronecker tensor product of one Hadamard matrix of order 20 and another Hadamard matrix of order 4. Two Hadamard matrices used to construct the orthogonal matrix of order 80 are listed in Table 2 and Table 3 below.

Table 2 – Hadamard matrix of order 4

m	0	1	2	3
$C_{4,0,m}$	1	1	1	1
$C_{4,1,m}$	1	0	1	0
$C_{4,2,m}$	1	1	0	0
$C_{4,3,m}$	0	1	1	0

Table 3 – Hadamard matrix of order 20

k	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
$C_{20,0,k}$	1	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	0	1	1	0
$C_{20,1,k}$	0	1	0	0	0	0	1	0	0	0	1	1	1	0	0	0	1	0	1	1
$C_{20,2,k}$	0	0	1	0	0	0	0	1	0	0	0	1	1	1	0	1	0	1	0	1
$C_{20,3,k}$	0	0	0	1	0	0	0	0	1	0	0	0	1	1	1	1	1	0	1	0

$C_{20,4,k}$	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	0	1	1	0	1
$C_{20,5,k}$	0	1	1	1	1	1	0	0	0	0	0	1	0	0	1	1	1	0	0	1
$C_{20,6,k}$	1	0	1	1	1	0	1	0	0	0	1	0	1	0	0	1	1	1	0	0
$C_{20,7,k}$	1	1	0	1	1	0	0	1	0	0	0	1	0	1	0	0	1	1	1	0
$C_{20,8,k}$	1	1	1	0	1	0	0	0	1	0	0	0	1	0	1	0	0	1	1	1
$C_{20,9,k}$	1	1	1	1	0	0	0	0	0	1	1	0	0	1	0	1	0	0	1	1
$C_{20,10,k}$	0	0	1	1	0	1	0	1	1	0	1	0	0	0	0	0	1	1	1	1
$C_{20,11,k}$	0	0	0	1	1	0	1	0	1	1	0	1	0	0	0	1	0	1	1	1
$C_{20,12,k}$	1	0	0	0	1	1	0	1	0	1	0	0	1	0	0	1	1	0	1	1
$C_{20,13,k}$	1	1	0	0	0	1	1	0	1	0	0	0	0	1	0	1	1	1	0	1
$C_{20,14,k}$	0	1	1	0	0	0	1	1	0	1	0	0	0	0	1	1	1	1	1	0
$C_{20,15,k}$	0	1	0	0	1	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0
$C_{20,16,k}$	1	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
$C_{20,17,k}$	0	1	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0
$C_{20,18,k}$	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0
$C_{20,19,k}$	1	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1

Let C_4 denote the 4x4 Hadamard matrix and C_{20} denote the 20x20 Hadamard matrix. The 80x80 Hadamard matrix C_{80} is the Kronecker tensor product of C_{20} and C_4.

$$C_{80} = C_{20} \otimes C_4$$

Note: Kronecker product is not commutative, i.e. $A \otimes B \neq B \otimes A$.

The Kronecker tensor product of two matrices ($A \otimes B$) maps two arbitrarily dimensioned matrices into a larger matrix. Given the nxm matrix A and the pxq matrix B,

$$A = \begin{pmatrix} a_{11} & \cdots & a_{1m} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nm} \end{pmatrix}_{n\times m}, \quad B = \begin{pmatrix} b_{11} & \cdots & b_{1q} \\ \vdots & \ddots & \vdots \\ b_{p1} & \cdots & b_{pq} \end{pmatrix}_{p\times q}$$

their Kronecker tensor product $A \otimes B$ is the (np)x(mq) matrix

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