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Title	**Uplink CQI channel and ACK channel**
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Re:	This contribution is made for comment #221.
Abstract	Scheme for uplink CQI channel and ACK channel is proposed.
Purpose	Adoption of proposed CQI channel and ACK channel into 802.16-REVd
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Introduction

In the current draft standard IEEE 802.16REVd/D4, there is a coding and modulation scheme of a fast feedback channel using uplink PUSC subchannel. But the same scheme cannot be applied to the optional uplink PUSC subchannel because the performance is not so good due to the less number of tones of optional uplink PUSC subchannel. So efficient coding and modulation scheme should be designed.

In this contribution, the new modulation and coding scheme for fast feedback channel (or CQI(Channel Quality Indicator) channel) using the optional uplink PUSC subchannel is proposed to improve the CQI performance. The subchannel structure for CQI channel is 6 pieces of 3x3 uplink tile. The CQI channel transmission consists of channel encoding over 9-ary alphabet and 9-ary orthogonal modulation for non-coherent reception.

Also, in the current D4 draft, ARQ-ACK message region in D3 draft is missing (actually it is replaced by FAST-FEEDBACK message region), but ARQ-ACK message region should also be supported for optional H-ARQ operation. In this contribution, the ACK channel in the subchannel structure is proposed to facilitate and improve performance of downlink H-ARQ. The subchannel structure for ACK channel is 3 pieces of 3x3 uplink tile. The ACK channel transmission consists of phase rotation and orthogonal modulation for non-coherent reception.

Suggested Change to the Standard

INSERT ‘8.4.10. Uplink Control channels’ next to ‘8.4.9 Channel Coding’.

8.4.10 Uplink control channels

The CQI(Channel Quality Indicator) is periodically reported by the access terminal in the uplink. There are two modes of operation of the CQI channel : Full CQI feedback mode for Diversity user and Differential CQI mode for AMC user. In the Full CQI feedback mode for diversity user, the 5-bit average C/I of Downlink preamble is sent. In the differential C/I feedback mode for AMC user, 5-bit differential C/I feedback for selected bands is sent by access terminal. One CQI channel occupies one subchannel (6 pieces of 3x3 uplink tile).

The uplink ACK (Acknowledgement) provides feedback for Downlink Hybrid ARQ. The access terminal transmits ACK or NAK feedback for Downlink packet data. One ACK channel occupies half subchannel (3 pieces of 3x3 uplink tile).

8.4.10.1 CQI channel encoding

The CQI is represented by 5-bit symbol according to the channel SNR measured in the access terminal. The CQI information is either the full CQI value or the differential CQI value. These 5 bits are encoded into a length 6 codeword over 9-ary alphabet for the error protection as shown in Table 1.

Table 1- CQI Symbol and Codeword Assignments

Channel SNR [dB]	CQI symbol	CQI codeword
-10.0 to -9.0	00000	0 0 0 0 0 0
-9.0 to -8.0	00001	1 1 1 1 1 1

-8.0 to -7.0	00010	2 2 2 2 2 2
-7.0 to -6.0	00011	3 3 3 3 3 3
-6.0 to -5.0	00100	4 4 4 4 4 4
-5.0 to -4.0	00101	5 5 5 5 5 5
-4.0 to -3.0	00110	6 6 6 6 6 6
-3.0 to -2.0	00111	7 7 7 7 7 7
-2.0 to -1.0	01000	8 8 8 8 8 8
-1.0 to 0.0	01001	5 8 6 2 7 4
0.0 to 1.0	01010	3 6 7 0 8 5
1.0 to 2.0	01011	4 7 8 1 6 3
2.0 to 3.0	01100	8 2 0 5 1 7
3.0 to 4.0	01101	6 0 1 3 2 8
4.0 to 5.0	01110	7 1 2 4 0 6
5.0 to 6.0	01111	2 5 3 8 4 1
6.0 to 7.0	10000	0 3 4 6 5 2
7.0 to 8.0	10001	1 4 5 7 3 0
8.0 to 9.0	10010	8 6 2 7 4 3
9.0 to 10.0	10011	6 7 0 8 5 4
10.0 to 11.0	10100	7 8 1 6 3 5
11.0 to 12.0	10101	2 0 5 1 7 6
12.0 to 13.0	10110	0 1 3 2 8 7
13.0 to 14.0	10111	1 2 4 0 6 8
14.0 to 15.0	11000	5 3 8 4 1 0
15.0 to 16.0	11001	3 4 6 5 2 1
16.0 to 17.0	11010	4 5 7 3 0 2
17.0 to 18.0	11011	6 2 7 4 3 1
18.0 to 19.0	11100	7 0 8 5 4 2
19.0 to 20.0	11101	8 1 6 3 5 0
20.0 to 21.0	11110	0 5 1 7 6 4
21.0 to 22.0	11111	1 3 2 8 7 5

8.4.10.2 ACK channel modulation

The ACK channel is orthogonally modulated. The acknowledgement bit B_n^{ACK} of the n-th ACK channel shall be '0' (ACK) if the corresponding downlink packet has been successfully received; otherwise, it shall be a '1' (NAK). The k-th orthogonal modulation symbol of the n-th ACK channel, $M_{n,k}^{ACK}$ (k=0,1,…,8 and n=0,1,…, $N_{ACK}-1$) is made as shown in Table 2.

Table 2- Orthogonal Modulation for ACK channel

B_n^{ACK}	$M_{n,k}^{ACK}$
0	1 1 1 1 1 1 1 1 1
1	$1 \ \exp\left(j\frac{2\pi}{3}\right) \ \exp\left(j\frac{4\pi}{3}\right) \ \exp\left(j\frac{2\pi}{3}\right) \ \exp\left(j\frac{4\pi}{3}\right)$ $1 \ \exp\left(j\frac{4\pi}{3}\right) \ 1 \ \exp\left(j\frac{2\pi}{3}\right)$

Then the modulated symbols are mapped to the subcarriers allocated to the *n*-th ACK channel, as follows.

$$c_{n,k}^{ACK} = \begin{cases} M_{n,k}^{ACK} & if\ k = 0,1,\text{L}\ ,8 \\ \exp\left(j\frac{2\pi}{3}\right) M_{n,k-9}^{ACK} & if\ k = 9,10,\text{L}\ ,17 \\ \exp\left(j\frac{4\pi}{3}\right) M_{n,k-18}^{ACK} & if\ k = 18,19,\text{L}\ ,26 \end{cases}$$

where

$c_{n,k}^{ACK}$ = mapping symbol of the k-th ACK subcarrier in the n-th ACK channel

$M_{n,k}^{ACK}$ = modulation symbol index of the k-th modulation symbol made from the n-th ACK bit as shown in Table 2

n = ACK channel index from the set $[0 \sim N_{ACK} - 1]$

k = ACK subcarrier index of an ACK channel from the set [0 ~ 26]

8.4.10.3 CQI channel modulation

The CQI channel is orthogonally modulated. After CQI encoding, the CQI codeword symbols are entered to the orthogonal modulator. Each code symbol of the CQI codeword makes one orthogonal modulation pattern. The modulation pattern of the n-th CQI channel, comprised of 9 symbols $M_{n,9k}^{CQI}$, $M_{n,9k+1}^{CQI}$, … , $M_{n,9k+8}^{CQI}$, is made from the k-th code symbols of the n-th CQI channel codeword $C_{n,k}^{CQI}$ as shown in Table 3.

Table 3- Orthogonal Modulation for CQI channel

CQI codeword, $C_{n,k}^{CQI}$	$M_{n,9k}^{CQI}$, $M_{n,9k+1}^{CQI}$, … , $M_{n,9k+8}^{CQI}$
0	1 1 1 1 1

	1 1 1 1
1	$1\ \exp\left(j\frac{2\pi}{9}\right)\ \exp\left(j\frac{4\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{8\pi}{9}\right)\ \exp\left(j\frac{10\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{14\pi}{9}\right)\ \exp\left(j\frac{16\pi}{9}\right)$
2	$1\ \exp\left(j\frac{4\pi}{9}\right)\ \exp\left(j\frac{8\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{16\pi}{9}\right)\ \exp\left(j\frac{2\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{10\pi}{9}\right)\ \exp\left(j\frac{14\pi}{9}\right)$
3	$1\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ 1\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ 1\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)$
4	$1\ \exp\left(j\frac{8\pi}{9}\right)\ \exp\left(j\frac{16\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{14\pi}{9}\right)\ \exp\left(j\frac{4\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{2\pi}{9}\right)\ \exp\left(j\frac{10\pi}{9}\right)$
5	$1\ \exp\left(j\frac{10\pi}{9}\right)\ \exp\left(j\frac{2\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{4\pi}{9}\right)\ \exp\left(j\frac{14\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{16\pi}{9}\right)\ \exp\left(j\frac{8\pi}{9}\right)$
6	$1\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ 1\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ 1\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)$
7	$1\ \exp\left(j\frac{14\pi}{9}\right)\ \exp\left(j\frac{10\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{2\pi}{9}\right)\ \exp\left(j\frac{16\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{8\pi}{9}\right)\ \exp\left(j\frac{4\pi}{9}\right)$
8	$1\ \exp\left(j\frac{16\pi}{9}\right)\ \exp\left(j\frac{14\pi}{9}\right)\ \exp\left(j\frac{12\pi}{9}\right)\ \exp\left(j\frac{10\pi}{9}\right)\ \exp\left(j\frac{8\pi}{9}\right)\ \exp\left(j\frac{6\pi}{9}\right)\ \exp\left(j\frac{4\pi}{9}\right)\ \exp\left(j\frac{2\pi}{9}\right)$

Orthogonal modulation and subcarrier mapping is done as follows.

$$c_{n,k}^{CQI} = M_{n,k}^{CQI} \qquad if\ k = 0,1,\mathsf{L}\ ,53$$

where

$c_{n,k}^{CQI}$ = mapping symbol of the k-th CQI subcarrier in the n-th CQI channel

$M_{n,k}^{CQI}$ = modulation symbol index of the k-th modulation symbol made from the n-th CQI bit as shown in Table 3

n = CQI channel index from the set $[0 \sim N_{CQI} - 1]$

k = CQI subcarrier index of an CQI channel from the set [0 ~ 53]