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Hanover, Germany,
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Source: Samsung

Title: **Text proposal regarding TFCI coding for FDD**

Document for: Approval

Proposed Text

In [1], Samsung proposed the new Extended TFCI coding scheme having an optimal minimum distance and almost no complexity increase. This text proposal describes the text changes related to TFCI coding for FDD mode according to the contribution.

---------- Start of Text Proposal ----------

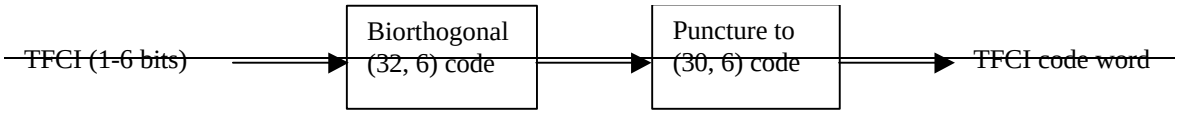
4.3 Coding for layer 1 control

4.3.1 Coding of Transport-format-combination indicator (TFCI)

The number of TFCI bits is variable and is set at the beginning of the call via higher layer signalling. ~~Encoding of the TFCI bits depends on the number of them. If there are at most 6 bits of TFCI, the channel encoding is done as described in section **Error! Reference source not found.**. Correspondingly, if the TFCI word is extended to 7-10 bits the channel encoding is done as explained in the section **Error! Reference source not found.**.~~ For improved TFCI detection reliability, in downlink, repetition is used by increasing the number of TFCI bits within a slot when SF is less than 128.

~~4.3.1.1 Coding of default TFCI word~~

~~If the number of TFCI bits is up to 6, the~~ The TFCI bits are encoded using (30, 10) punctured ~~biorthogonal (30, 6) block code~~ sub-code of the second order Reed-Muller code. The coding procedure is as shown in **Error! Reference source not found.**.



~~Figure 1: Channel coding of TFCI bits~~

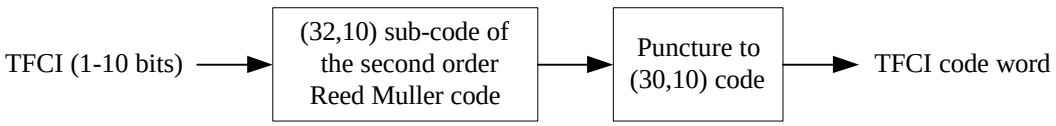


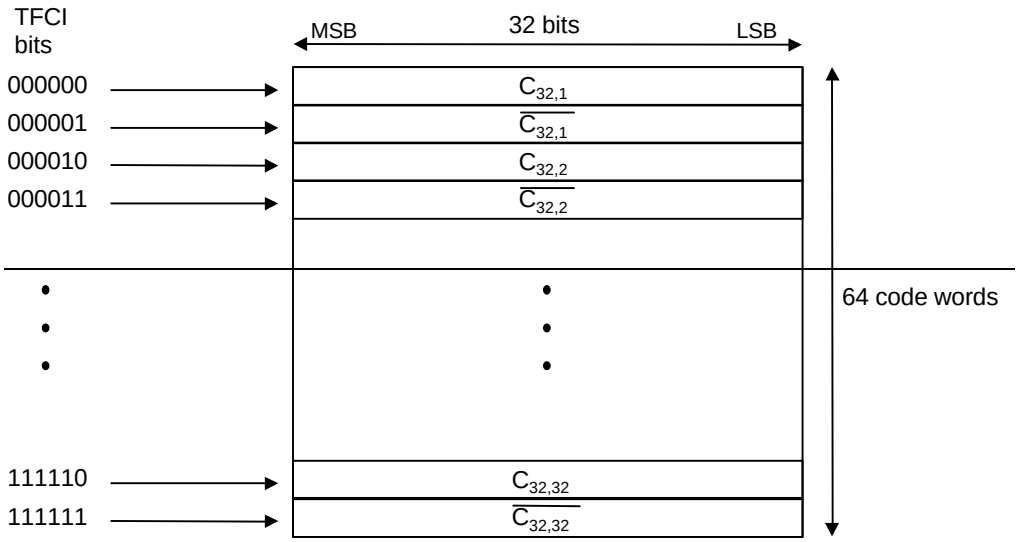
Figure 1: Channel coding of TFCI bits

If the TFCI consist of less than ~~6~~10 bits, it is padded with zeros to ~~6~~10 bits, by setting the most significant

bits to zero. The receiver can use the information that not all ~~6~~10 bits are used for the TFCI, thereby reducing the error rate in the TFCI decoder. The length of the TFCI code word is 30 bits. Thus there are 2 bits of (encoded) TFCI in every slot of the radio frame.

~~The TFCI bits are first encoded using biorthogonal (32, 6) code. The code words of the biorthogonal block code are from the level 32 of the code three of OVSF codes defined in document TS 25.213. The code words, $C_{32,I}$, $I = 1,\ldots,32$, form an orthogonal set, $S_{C_{32}} = \{C_{32,1}, C_{32,2},\ldots, C_{32,32}\}$, of 32 code words of length 32 bits. By taking the binary complements of the code words of $S_{C_{32}}$, another set, $\overline{S}_{C_{32}} = \{\overline{C}_{32,1}, \overline{C}_{32,2},\ldots, \overline{C}_{32,32}\}$ is formed. These two sets are mutually biorthogonal yielding total of 64 different code words.~~

~~Mapping of the TFCI bits to the biorthogonal code words is done as shown in the **Error! Reference source not found.**.~~



~~Figure 2: Mapping of TFCI bits to biorthogonal code words~~

~~Biorthogonal code words, $C_{32,i}$ and $\overline{C}_{32,i}$, are encoded into TFCI code words of length 30 bits by puncturing the two least significant bits (i.e. the two last bits on right in the **Error! Reference source not found.**).~~

~~4.3.1.2 Coding of extended TFCI word~~

~~If the number of TFCI bits is 7-10 the TFCI information field is split into two words of length 5 bits as shown in the following formula: .~~

~~$n := \lfloor \sqrt{TFCI} \rfloor$; n is the largest integer being smaller than or equal to the square root of the transmitted TFCI value.~~

~~if $TFCI < n^2 + n$~~

~~then $Word1 := n$; $Word2 := TFCI - n^2$~~

~~else $Word2 := n$; $Word1 := n^2 + 2n - TFCI$~~

~~Both of the words are first encoded using biorthogonal (16, 5) block code. The code words of the biorthogonal (16, 5) code are from two mutually biorthogonal sets, $S_{C16} = \{C_{16,1}, C_{16,2}, ..., C_{16,16}\}$ and its binary complement, $\overline{S}_{C16} = \{\overline{C}_{16,1}, \overline{C}_{16,2}, ..., \overline{C}_{16,16}\}$. Words of set S_{C16} are from the level 16 of the code three of OVSF codes defined in document TS 25.213. The mapping of information bits to code words is shown in the **Error! Reference source not found.**.~~

~~Table 1: Mapping of information bits to code words for biorthogonal (16, 5) code~~

~~Information bits~~	~~Code word~~
~~00000~~	~~$C_{16,1}$~~
~~00001~~	~~$\overline{C}_{16,1}$~~
~~00010~~	~~$C_{16,2}$~~
~~...~~	~~...~~
~~11101~~	~~$\overline{C}_{16,15}$~~
~~11110~~	~~$C_{16,16}$~~
~~11111~~	~~$\overline{C}_{16,16}$~~

~~Biorthogonal code words, $C_{16,i}$ and $\overline{C}_{16,i}$, are then encoded into TFCI code words of length 15 bits by puncturing the least significant bit (i.e. the rightmost bit).~~

Firstly, TFCI is encoded by the (32,10) sub-code of second order Reed-Muller code. The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of 10 basis sequences: all 1's, 5 OVSF codes ($C_{32,2}$, $C_{32,3}$, $C_{32,5}$, $C_{32,9}$, $C_{32,17}$), and 4 masks (Mask1, Mask2, Mask3, Mask4). The 4 mask sequences are as following Table 1.

Mask 1	00101000011000111111000001110111
Mask 2	00000001110011010110110111000111
Mask 3	00001010111110010001101100101011
Mask 4	00011100001101110010111101010001

Table 1. Mask sequences

For information bits a_0, a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9(a_0 is MSB and a_9 is LSB), the encoder structure is as following Figure 2.

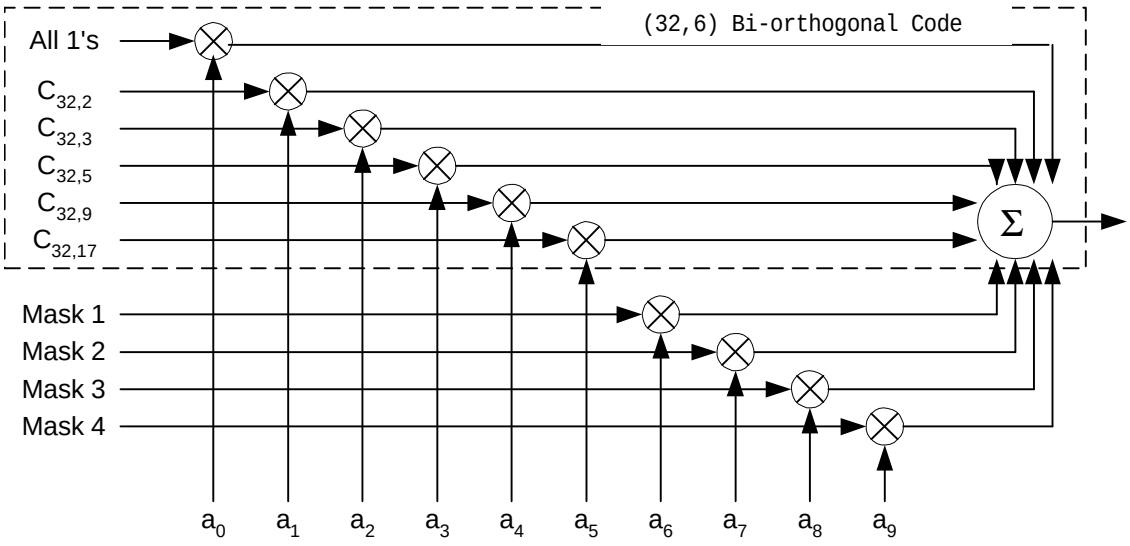


Figure 2. Encoder structure for (32,10) sub-code of second order Reed-Muller code

Then, the code words of the (32,10) sub-code of second order Reed-Muller code are punctured into length 30 by puncturing 1-st and 17-th bits.

4.3.2 Operation of Transport-format-combination indicator (TFCI) in soft handover

In the case of DCH in soft handover situation, ~~each Node B shall transmit the identical (30,6) code word for the UE.~~

~~In the case of extended TFCI coding,~~ the Node B shall operate with one of the following modes:

- Both words are identical from all links
- If one of the links is associated with a DSCH, the TFCI code word may be split in such a way that the code word relevant for TFCI activity indication is not transmitted from every Node B. The use of such a functionality shall be indicated by higher layer signalling. (Split Mode)

4.3.2.1 Coding of TFCI word in soft handover (Split Mode)

In Split Mode, TFCI information is encoded by biorthogonal (16, 5) block code. The code words of the biorthogonal (16, 5) code are from two mutually biorthogonal sets, $S_{C_{16}} = \{C_{16,1}, C_{16,2}, ..., C_{16,16}\}$ and its binary complement, $\overline{S}_{C_{16}} = \{\overline{C}_{16,1}, \overline{C}_{16,2}, ..., \overline{C}_{16,16}\}$. Code words of set $S_{C_{16}}$ are from the level 16 of the code three of OVSF codes defined in document TS 25.213. The mapping of information bits to code words is shown in the **Error! Reference source not found.**2.

Table 2: Mapping of information bits to code words for biorthogonal (16, 5) code

Information bits	**Code word**
00000	$C_{16,1}$
00001	$\overline{C}_{16,1}$
00010	$C_{16,2}$
...	...
11101	$\overline{C}_{16,15}$
11110	$C_{16,16}$
11111	$\overline{C}_{16,16}$

Biorthogonal code words, $C_{16,i}$ and $\overline{C}_{16,i}$, are then punctured into length 15 by puncturing 1-st bit.

4.3.3 Interleaving of TFCI words

4.3.3.1 Interleaving of ~~default~~ TFCI word in Normal Mode

As only one code word for TFCI ~~of maximum length of 6 bits~~ is needed no channel interleaving for the encoded bits are done. Instead, the bits of the code word are directly mapped to the slots of the radio frame as depicted in the Figure 3. Within a slot the more significant bit is transmitted before the less significant bit.

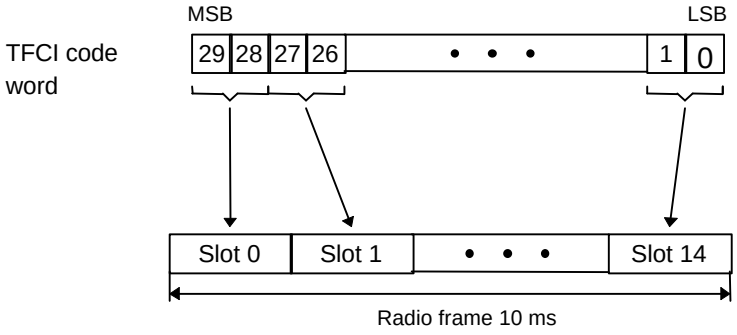


Figure 3: Time multiplexing of code words of (30, 6) code to the slots of the radio frame

4.3.3.2 Interleaving of ~~extended~~ TFCI word in Split Mode

During soft handover in Split Mode, a~~A~~fter channel encoding of the two 5 bit TFCI words there are two code words of length 15 bits. They are interleaved and mapped to DPCCH as shown in the Figure 4. Note that $b_{1,i}$ and $b_{2,i}$ denote the bit *i* of code word 1 and code word 2, respectively.

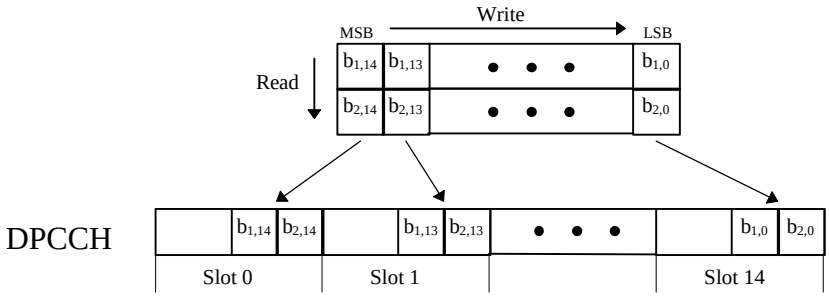


Figure 4: Interleaving of ~~extended~~ TFCI code words in Split Mode

References

[1] 3GPP TSGR1#6 (99)xxx, 'Harmonization impact on TFCI and New Optimal Coding for extended TFCI with almost no Complexity increase(Rev2)', Source: Samsung

[2] 3GPP TSGR1#7 (99)a86, 'TS 25.212 V2.0.1 (1999-08) Multiplexing and channel coding (FDD)'