**Agenda item:**

| | |
|---|---|
| **Source:** | Nokia |
| **Title:** | Clarifying text proposal for TFCI repetition encoding |
| **Document for:** | Approval |

**Summary:**

In downlink channels whose spreading factor is less than 128 the TFCI bits are repetition encoded. In order to remove any possible ambiquity how it is done a text proposal is made to TS 25.212 v2.0.1.

**----------Start 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 0. Correspondingly, if the TFCI word is extended to 7-10 bits the channel encoding is done as explained in the section 0. For improved TFCI detection reliability, in downlink, repetition is used by increasing the number of TFCI bits within a slot.

#### *4.3.1.1 Coding of default TFCI word*

If the number of TFCI bits is up to 6, the TFCI bits are encoded using punctured biorthogonal (30, 6) block code. The coding procedure is as shown in Figure 1~~Figure 1~~~~Figure 1~~.

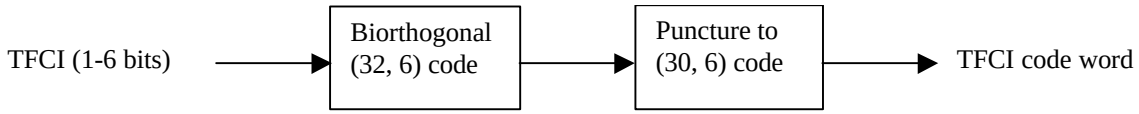


**Figure 1: Channel coding of TFCI bits**

If the TFCI consist of less than 6 bits, it is padded with zeros to 6 bits, by setting the most significant bits to zero. The receiver can use the information that not all 6 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,…,32, form an orthogonal set, $S_{C_{32}} = \{C_{32,1}, C_{32,2}, ..., C_{32,32}\}$, of 32 code words of length 32 bits. By taking the binary complements of the code words of $S_{C_{32}}$ , another set, $\overline{S}_{C_{32}} = \{\overline{C}_{32,1}, \overline{C}_{32,2}, ..., \overline{C}_{32,32}\}$ 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 Figure 2~~Figure 3~~~~Figure 2~~.

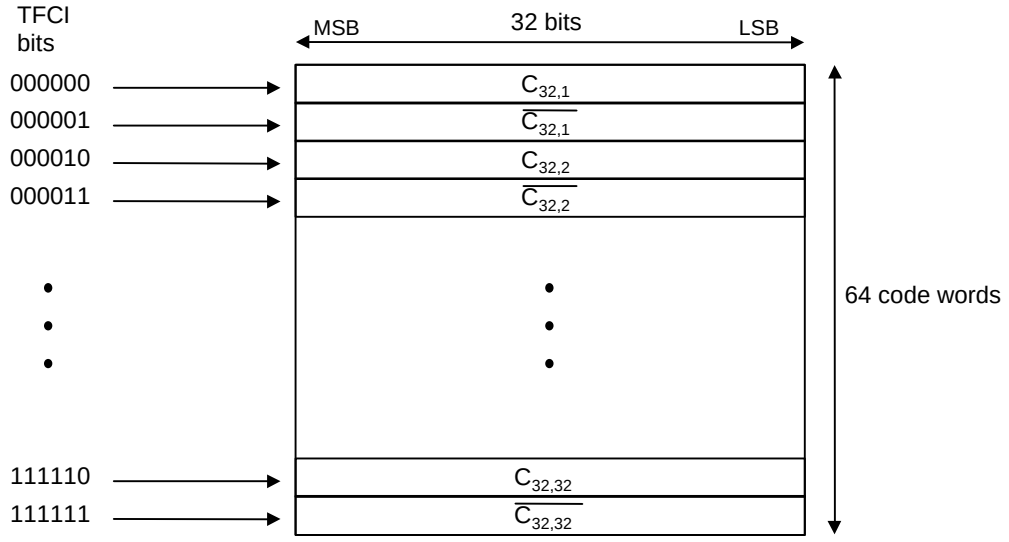


**Figure ~~2~~3~~2~~: Mapping of TFCI bits to biorthogonal code words**

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 Figure 2~~Figure 3~~~~Figure 2~~).

In downlink, when the SF is lower then 128 the encoded and punctured TFCI code words are repeated four times yielding 8 encoded TFCI bits per slot. Mapping of repeated bits to slots is explained in section 4.3.3.1.

### *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, $S_{C_{16}} = \{C_{16,1}, C_{16,2}, ..., C_{16,16}\}$ and its binary complement, $\overline{S}_{C_{16}} = \{\overline{C}_{16,1}, \overline{C}_{16,2}, ..., \overline{C}_{16,16}\}$. 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 Table 1~~Table 1~~~~Table 1~~.

**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).

In downlink, when the SF is lower then 128 the encoded and punctured extended TFCI code words are repeated four times yielding 8 encoded TFCI bits per slot. Mapping of repeated bits to slots is explained in section 4.3.3.2.

## 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.

4.3.3.Interleaving of TFCI words

### *4.3.3.1 Interleaving of default TFCI word*

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~~Figure 5~~Figure 3. Within a slot the more significant bit is transmitted before the less significant bit.

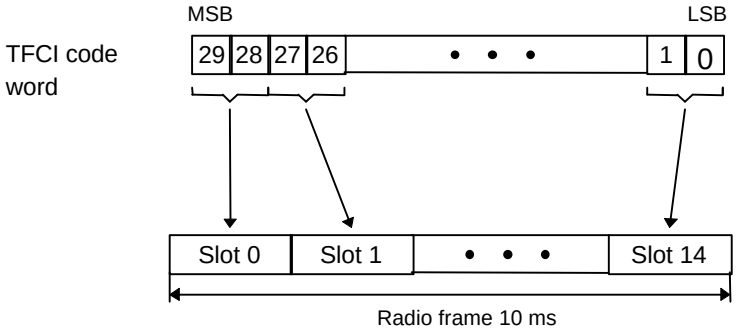


**Figure 3~~5~~3: Time multiplexing of code words of (30, 6) code to the slots of the radio frame**

For downlink physical channels whose SF is lower than 128, bits of the TFCI code words are repeated and mapped to slots as shown in the Table x. Code word bits are denoted as $b_{i,j}$, where subscript i, indicates bit position in the code word (i=29 is the MSB bit) and subscript j indicates bit repetition. In each slot transmission order of the bits is from left to right in the Table x.

*Table x. Mapping order of repetition encoded TFCI code word bits into slots.*

| Slot | TFCI code word bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | $b_{29,1}$ | $b_{29,2}$ | $b_{29,3}$ | $b_{29,4}$ | $b_{28,1}$ | $b_{28,2}$ | $b_{28,3}$ | $b_{28,4}$ |
| 1 | $b_{27,1}$ | $b_{27,2}$ | $b_{27,3}$ | $b_{27,4}$ | $b_{26,1}$ | $b_{26,2}$ | $b_{26,3}$ | $b_{26,4}$ |
| 2 | $b_{25,1}$ | $b_{25,2}$ | $b_{25,3}$ | $b_{25,4}$ | $b_{24,1}$ | $b_{24,2}$ | $b_{24,3}$ | $b_{24,4}$ |
| 3 | $b_{23,1}$ | $b_{23,2}$ | $b_{23,3}$ | $b_{23,4}$ | $b_{22,1}$ | $b_{22,2}$ | $b_{22,3}$ | $b_{22,4}$ |
| 4 | $b_{21,1}$ | $b_{21,2}$ | $b_{21,3}$ | $b_{21,4}$ | $b_{20,1}$ | $b_{20,2}$ | $b_{20,3}$ | $b_{20,4}$ |
| 5 | $b_{19,1}$ | $b_{19,2}$ | $b_{19,3}$ | $b_{19,4}$ | $b_{18,1}$ | $b_{18,2}$ | $b_{18,3}$ | $b_{18,4}$ |
| 6 | $b_{17,1}$ | $b_{17,2}$ | $b_{17,3}$ | $b_{17,4}$ | $b_{16,1}$ | $b_{16,2}$ | $b_{16,3}$ | $b_{16,4}$ |
| 7 | $b_{15,1}$ | $b_{15,2}$ | $b_{15,3}$ | $b_{15,4}$ | $b_{14,1}$ | $b_{14,2}$ | $b_{14,3}$ | $b_{14,4}$ |
| 8 | $b_{13,1}$ | $b_{13,2}$ | $b_{13,3}$ | $b_{13,4}$ | $b_{12,1}$ | $b_{12,2}$ | $b_{12,3}$ | $b_{12,4}$ |
| 9 | $b_{11,1}$ | $b_{11,2}$ | $b_{11,3}$ | $b_{11,4}$ | $b_{10,1}$ | $b_{10,2}$ | $b_{10,3}$ | $b_{10,4}$ |
| 10 | $b_{9,1}$ | $b_{9,2}$ | $b_{9,3}$ | $b_{9,4}$ | $b_{8,1}$ | $b_{8,2}$ | $b_{8,3}$ | $b_{8,4}$ |
| 11 | $b_{7,1}$ | $b_{7,2}$ | $b_{7,3}$ | $b_{7,4}$ | $b_{6,1}$ | $b_{6,2}$ | $b_{6,3}$ | $b_{6,4}$ |
| 12 | $b_{5,1}$ | $b_{5,2}$ | $b_{5,3}$ | $b_{5,4}$ | $b_{4,1}$ | $b_{4,2}$ | $b_{4,3}$ | $b_{4,4}$ |
| 13 | $b_{3,1}$ | $b_{3,2}$ | $b_{3,3}$ | $b_{3,4}$ | $b_{2,1}$ | $b_{2,2}$ | $b_{2,3}$ | $b_{2,4}$ |
| 14 | $b_{1,1}$ | $b_{1,2}$ | $b_{1,3}$ | $b_{1,4}$ | $b_{0,1}$ | $b_{0,2}$ | $b_{0,3}$ | $b_{0,4}$ |

### *4.3.3.2 Interleaving of extended TFCI word*

After 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~~Figure 7~~Figure 4. Note that $b_{1,i}$ and $b_{2,i}$ denote the bit *i* of code word 1 and code word 2, respectively.

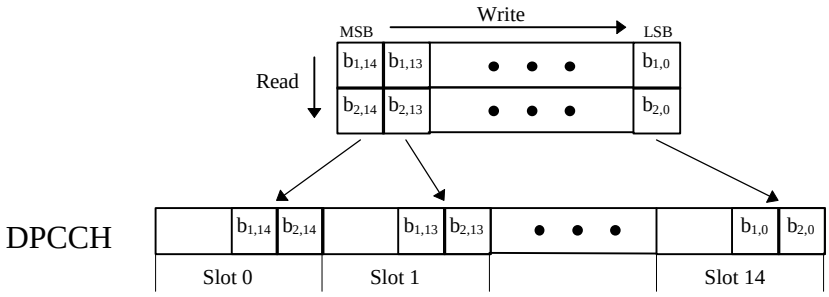


**Figure ~~4~~7~~4~~: Interleaving of extended TFCI code words**

For downlink physical channels whose SF is lower than 128, bits of the extended TFCI code words are repeated and mapped to slots as shown in the Table y. Code word bits are denoted as $b_{i,j}^{k}$, where subscript k indicates the code word, subscript i indicates bit position in the code word (i=14 is the MSB bit) and subscript j indicates bit repetition. In each slot transmission order of the bits is from left to right in the Table y.

*Table y. Mapping order of repetition encoded extended TFCI code word bits to slots.*

| Slot | Extended TFCI code word bits | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | $b_{14,1}^{1}$ | $b_{14,2}^{1}$ | $b_{14,3}^{1}$ | $b_{14,4}^{1}$ | $b_{14,1}^{2}$ | $b_{14,2}^{2}$ | $b_{14,3}^{2}$ | $b_{14,4}^{2}$ |
| 1 | $b_{13,1}^{1}$ | $b_{13,2}^{1}$ | $b_{13,3}^{1}$ | $b_{13,4}^{1}$ | $b_{13,1}^{2}$ | $b_{13,2}^{2}$ | $b_{13,3}^{2}$ | $b_{13,4}^{2}$ |
| 2 | $b_{12,1}^{1}$ | $b_{12,2}^{1}$ | $b_{12,3}^{1}$ | $b_{12,4}^{1}$ | $b_{12,1}^{2}$ | $b_{12,2}^{2}$ | $b_{12,3}^{2}$ | $b_{12,4}^{2}$ |
| 3 | $b_{11,1}^{1}$ | $b_{11,2}^{1}$ | $b_{11,3}^{1}$ | $b_{11,4}^{1}$ | $b_{11,1}^{2}$ | $b_{11,2}^{2}$ | $b_{11,3}^{2}$ | $b_{11,4}^{2}$ |
| 4 | $b_{10,1}^{1}$ | $b_{10,2}^{1}$ | $b_{10,3}^{1}$ | $b_{10,4}^{1}$ | $b_{10,1}^{2}$ | $b_{10,2}^{2}$ | $b_{10,3}^{2}$ | $b_{10,4}^{2}$ |
| 5 | $b_{9,1}^{1}$ | $b_{9,2}^{1}$ | $b_{9,3}^{1}$ | $b_{9,4}^{1}$ | $b_{9,1}^{2}$ | $b_{9,2}^{2}$ | $b_{9,3}^{2}$ | $b_{9,4}^{2}$ |
| 6 | $b_{8,1}^{1}$ | $b_{8,2}^{1}$ | $b_{8,3}^{1}$ | $b_{8,4}^{1}$ | $b_{8,1}^{2}$ | $b_{8,2}^{2}$ | $b_{8,3}^{2}$ | $b_{8,4}^{2}$ |
| 7 | $b_{7,1}^{1}$ | $b_{7,2}^{1}$ | $b_{7,3}^{1}$ | $b_{7,4}^{1}$ | $b_{7,1}^{2}$ | $b_{7,2}^{2}$ | $b_{7,3}^{2}$ | $b_{7,4}^{2}$ |
| 8 | $b_{6,1}^{1}$ | $b_{6,2}^{1}$ | $b_{6,3}^{1}$ | $b_{6,4}^{1}$ | $b_{6,1}^{2}$ | $b_{6,2}^{2}$ | $b_{6,3}^{2}$ | $b_{6,4}^{2}$ |
| 9 | $b_{5,1}^{1}$ | $b_{5,2}^{1}$ | $b_{5,3}^{1}$ | $b_{5,4}^{1}$ | $b_{5,1}^{2}$ | $b_{5,2}^{2}$ | $b_{5,3}^{2}$ | $b_{5,4}^{2}$ |
| 10 | $b_{4,1}^{1}$ | $b_{4,2}^{1}$ | $b_{4,3}^{1}$ | $b_{4,4}^{1}$ | $b_{4,1}^{2}$ | $b_{4,2}^{2}$ | $b_{4,3}^{2}$ | $b_{4,4}^{2}$ |
| 11 | $b_{3,1}^{1}$ | $b_{3,2}^{1}$ | $b_{3,3}^{1}$ | $b_{3,4}^{1}$ | $b_{3,1}^{2}$ | $b_{3,2}^{2}$ | $b_{3,3}^{2}$ | $b_{3,4}^{2}$ |
| 12 | $b_{2,1}^{1}$ | $b_{2,2}^{1}$ | $b_{2,3}^{1}$ | $b_{2,4}^{1}$ | $b_{2,1}^{2}$ | $b_{2,2}^{2}$ | $b_{2,3}^{2}$ | $b_{2,4}^{2}$ |
| 13 | $b_{1,1}^{1}$ | $b_{1,2}^{1}$ | $b_{1,3}^{1}$ | $b_{1,4}^{1}$ | $b_{1,1}^{2}$ | $b_{1,2}^{2}$ | $b_{1,3}^{2}$ | $b_{1,4}^{2}$ |
| 14 | $b_{0,1}^{1}$ | $b_{0,2}^{1}$ | $b_{0,3}^{1}$ | $b_{0,4}^{1}$ | $b_{0,1}^{2}$ | $b_{0,2}^{2}$ | $b_{0,3}^{2}$ | $b_{0,4}^{2}$ |

**----------End text proposal----------**