TSG RAN WG1 Meeting #20 ***TSGR1#20(01)0530***
Busan, Korea, 21st – 25th May 2001

Agenda Item: 8.3 - Gated DPCCH Transmission

Source: Philips

Title: Mapping of TFCI words in Basic Gating Periods

Document for: Discussion

Introduction

During DPCCH Basic Gating Periods, the number of transmitted slots in each radio frame is reduced to 3 or 5 depending on the gating rate. This means that in the UL, and in the DL for SF≥128, only 10 TFCI bits are transmitted per radio frame when the gating rate is 1/3, and only 6 TFCI bits when the gating rate is 1/5.

It is necessary to consider what should be transmitted in those TFCI bits which are available during basic gating periods.

The transport formats which may occur during basic gating periods are:

- no transport blocks at all;
- zero-length transport blocks on one or more of the transport channels.

The simplest case would be that the Transport Format Combination Set in gated mode only contained two TFCs for the basic gating periods – one TFC with no transport blocks and one TFC with some zero-length transport blocks to which CRCs would be attached .

In any case, the number of different TFCs in the basic gating period would be very much smaller than in normal mode.

The small number of transmitted TFCI bits which are available in basic gating periods can usefully carry information about this small number of possible TFCs, thus supporting the use of CRCs for maintaining outer loop power control during gating.

The mapping to the transmitted TFCI bits can be achieved by heavily puncturing the usual 32-bit coded TFCI word.

A useful way of determining which bits to puncture is to maximise the distance between transmitted codewords for small numbers of TFCs. For example, if only two TFCs are possible during basic gating periods, the distance between the transmitted codewords for TFC#0 and TFC#1 should be equal to the number of transmitted TFCI bits in the radio frame. As the phase can be obtained from the pilot bits, maximising the distance between transmitted TFCI codewords will give more reliable decoding performance for the small number of transmitted TFCI bits than if the transmitted codewords for the first two TFCs were orthogonal. In any case, only two orthogonal codewords exist when the number of transmitted bits is 6 or 10.

The maximum possible distances between transmitted codewords can be achieved by many different puncturing patterns. From an implementation point of view, it is also desirable to ensure that the puncturing pattern for 6 transmitted bits (gating rate 1/5) is the same as the puncturing pattern for the first 6 of 10 transmitted bits (gating rate 1/3).

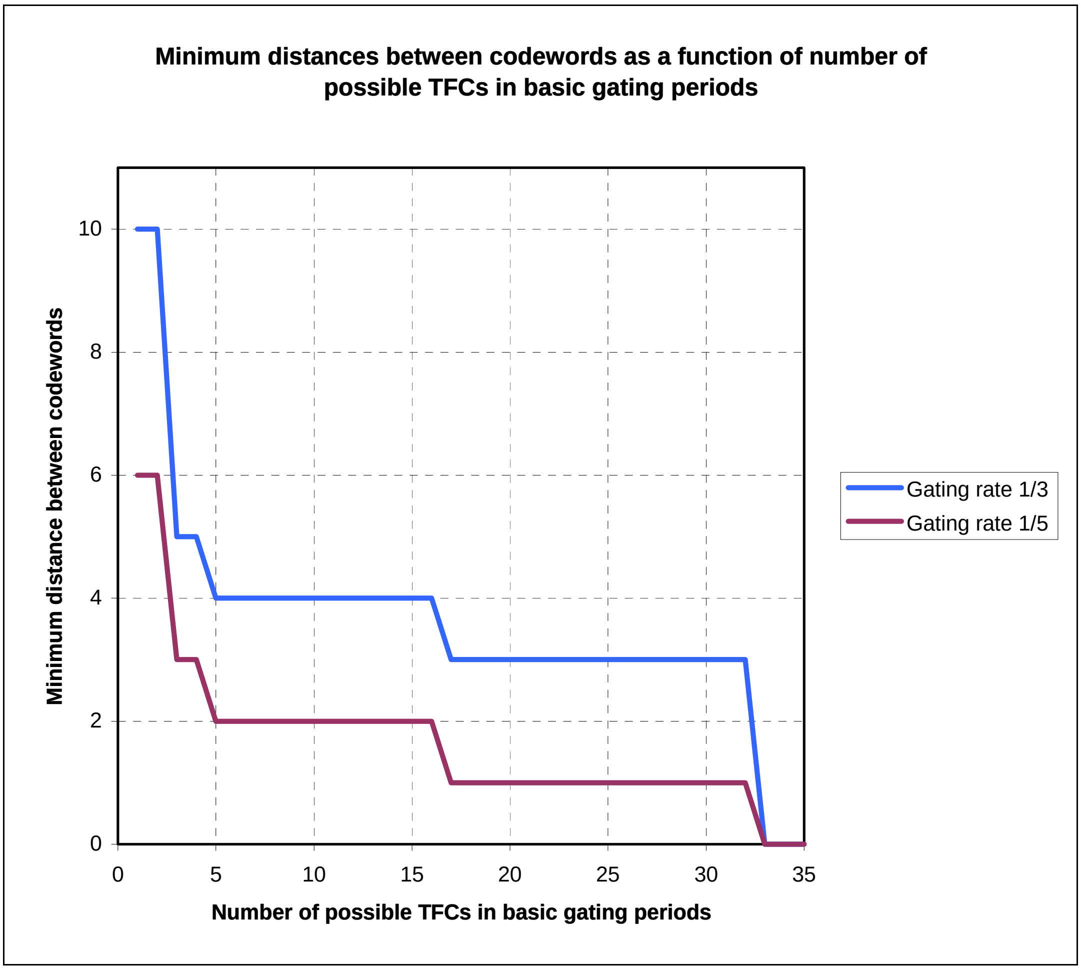
There are still many puncturing patterns which meet this criterion in addition to maximising the distances between transmitted codewords for both gating rate 1/5 and gating rate 1/3.

One such puncturing pattern is as follows:

From the coded bits b_i where i = 0, 1, 2, …31, transmit only the following bits:

Gating rate 1/3	0	4	6	8	10	17	19	21	27	29
Gating rate 1/5	0	4	6	8	10	17				

The minimum distances between codewords for these patterns are shown below as a function of the number of TFCs which are possible during basic gating periods.



It can be seen that the minimum distances are especially optimised for the small numbers of TFCs which are likely to occur during basic gating periods, although there is also considerable flexibility for the support of larger numbers of TFCs if desired in the future.

In the DL for SF<128, 24 transmitted TFCI bits are available for gating rate 1/5, and 40 for gating rate 1/3. For gating rate 1/5, there is no need to do any special puncturing, but the coded TFCI word can simply be truncated to 24 bits. This maintains a minimum distance of 10 between the code words for up to 16 TFCs, which is the same as the minimum distance over the whole 1024-word code-space when 30 bits are transmitted. For gating rate 1/3, options include repeating 8 of the coded TFCI bits, or using DTX for 8 bits. For consistency with the compressed mode TFCI mapping, we suggest using DTX.

Conclusions

It is possible to make the small number of transmitted TFCI bits in basic gating periods useful by suitable puncturing of the normal coded TFCI words. This provides support for the use of CRCs on zero-length transport blocks for maintaining outer loop power control during gating.

A draft CR is attached, suggesting how a brief description of the method for mapping coded TFCI bits to the available transmitted bits could be included in a future version of TS25.212.

3GPP TSG-RAN WG1 Meeting #20
Busan, Korea, 21st – 25th May 2001

Tdoc R1-01-0530

CR-Form-v4

CHANGE REQUEST

⌘	**25.212**	**CR**	**???**	⌘ ev	**-**	⌘ Current version:	**3.5.0** ⌘

For ***HELP*** *on using this form, see bottom of this page or look at the pop-up text over the ⌘ symbols.*

Proposed change affects: ⌘ (U)SIM [ ] ME/UE [X] Radio Access Network [X] Core Network [ ]

Title:	⌘	Mapping of TFCI words in Basic Gating Periods		
Source:	⌘	Philips		
Work item code:	⌘	1507	***Date:*** ⌘	2001-05-15
Category:	⌘	**C**	***Release:*** ⌘	REL-5
		Use one of the following categories: ***F*** *(correction)* ***A*** *(corresponds to a correction in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)* Detailed explanations of the above categories can be found in 3GPP TR 21.900.		*Use one of the following releases:* *2 (GSM Phase 2)* *R96 (Release 1996)* *R97 (Release 1997)* *R98 (Release 1998)* *R99 (Release 1999)* *REL-4 (Release 4)* *REL-5 (Release 5)*

Reason for change:	⌘	A description is needed for how to map the TFCI bits to the transmitted slots during basic gating periods.
Summary of change:	⌘	A new sub-clause 4.3.5.3 is added to explain how the bits should be mapped.
Consequences if not approved:	⌘	

Clauses affected:	⌘	4.3.5		
Other specs affected:	⌘	[ ] Other core specifications [ ] Test specifications [ ] O&M Specifications	⌘	
Other comments:	⌘			

How to create CRs using this form:

Comprehensive information and tips about how to create CRs can be found at: http://www.3gpp.org/3G_Specs/CRs.htm. Below is a brief summary:

1) Fill out the above form. The symbols above marked ⌘ contain pop-up help information about the field that they are closest to.

2) Obtain the latest version for the release of the specification to which the change is proposed. Use the MS Word "revision marks" feature (also known as "track changes") when making the changes. All 3GPP specifications can be downloaded from the 3GPP server under ftp://ftp.3gpp.org/specs/ For the latest version, look for the directory name with the latest date e.g. 2001-03 contains the specifications resulting from the March 2001 TSG meetings.

3) With "track changes" disabled, paste the entire CR form (use CTRL-A to select it) into the specification just in front of the clause containing the first piece of changed text. Delete those parts of the specification which are not relevant to the change request.

4.3.3 Coding of Transport-Format-Combination Indicator (TFCI)

The TFCI is encoded using a (32, 10) sub-code of the second order Reed-Muller code. The coding procedure is as shown in figure 9.

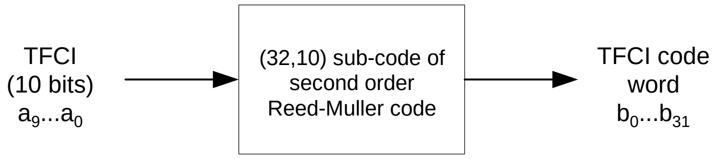


Figure 9: Channel coding of TFCI information bits

If the TFCI consist of less than 10 bits, it is padded with zeros to 10 bits, by setting the most significant bits to zero. The length of the TFCI code word is 32 bits.

The code words of the (32,10) sub-code of second order Reed-Muller code are linear combination of 10 basis sequences. The basis sequences are as in the following table 8.

Table 8: Basis sequences for (32,10) TFCI code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$	$M_{i,5}$	$M_{i,6}$	$M_{i,7}$	$M_{i,8}$	$M_{i,9}$
0	1	0	0	0	0	1	0	0	0	0
1	0	1	0	0	0	1	1	0	0	0
2	1	1	0	0	0	1	0	0	0	1
3	0	0	1	0	0	1	1	0	1	1
4	1	0	1	0	0	1	0	0	0	1
5	0	1	1	0	0	1	0	0	1	0
6	1	1	1	0	0	1	0	1	0	0
7	0	0	0	1	0	1	0	1	1	0
8	1	0	0	1	0	1	1	1	1	0
9	0	1	0	1	0	1	1	0	1	1
10	1	1	0	1	0	1	0	0	1	1
11	0	0	1	1	0	1	0	1	1	0
12	1	0	1	1	0	1	0	1	0	1
13	0	1	1	1	0	1	1	0	0	1
14	1	1	1	1	0	1	1	1	1	1
15	1	0	0	0	1	1	1	1	0	0
16	0	1	0	0	1	1	1	1	0	1
17	1	1	0	0	1	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1	1
19	1	0	1	0	1	1	0	1	0	1
20	0	1	1	0	1	1	0	0	1	1
21	1	1	1	0	1	1	0	1	1	1
22	0	0	0	1	1	1	0	1	0	0
23	1	0	0	1	1	1	1	1	0	1
24	0	1	0	1	1	1	1	0	1	0
25	1	1	0	1	1	1	1	0	0	1
26	0	0	1	1	1	1	0	0	1	0
27	1	0	1	1	1	1	1	1	0	0
28	0	1	1	1	1	1	1	1	1	0
29	1	1	1	1	1	1	1	1	1	1
30	0	0	0	0	0	1	0	0	0	0
31	0	0	0	0	1	1	1	0	0	0

The TFCI information bits a_0 , a_1 , a_2 , a_3 , a_4 , a_5 , a_6 , a_7 , a_8 , a_9 (where a_0 is LSB and a_9 is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the CCTrCH in the associated DPCH radio frame.

The output code word bits b_i are given by:

$$b_i = \sum_{n=0}^{9} (a_n \times M_{i,n}) \bmod 2$$

where $i = 0, \ldots, 31$.

The output bits are denoted by b_k, $k = 0, 1, 2, \ldots, 31$.

In downlink, when the SF < 128 the encoded TFCI code words are repeated yielding 8 encoded TFCI bits per slot in normal mode and 16 encoded TFCI bits per slot in compressed mode. Mapping of repeated bits to slots is explained in subclause 4.3.5.

4.3.4 Operation of Transport-Format-Combination Indicator (TFCI) in Split Mode

If one of the DCH 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 cell. The use of such a functionality shall be indicated by higher layer signalling.

The TFCI is encoded using a (16, 5) bi-orthogonal (or first order Reed-Muller) code. The coding procedure is as shown in figure 10.

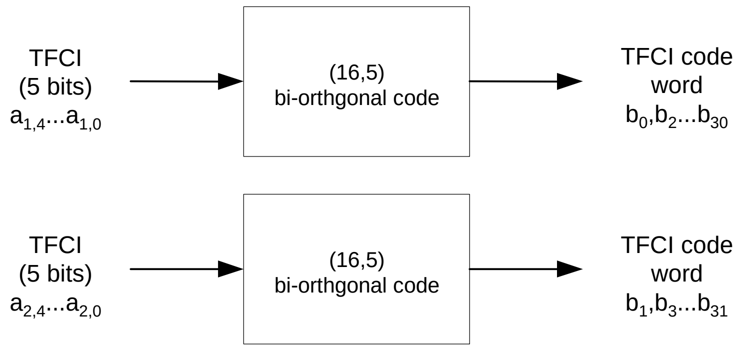


Figure 10: Channel coding of split mode TFCI information bits

The code words of the (16,5) bi-orthogonal code are linear combinations of 5 basis sequences as defined in table 9.

Table 9: Basis sequences for (16,5) TFCI code

i	$M_{i,0}$	$M_{i,1}$	$M_{i,2}$	$M_{i,3}$	$M_{i,4}$
0	1	0	0	0	1
1	0	1	0	0	1
2	1	1	0	0	1
3	0	0	1	0	1
4	1	0	1	0	1
5	0	1	1	0	1
6	1	1	1	0	1
7	0	0	0	1	1
8	1	0	0	1	1
9	0	1	0	1	1
10	1	1	0	1	1
11	0	0	1	1	1
12	1	0	1	1	1
13	0	1	1	1	1
14	1	1	1	1	1
15	0	0	0	0	1

The first set of TFCI information bits ($a_{1,0}$, $a_{1,1}$, $a_{1,2}$, $a_{1,3}$, $a_{1,4}$ where $a_{1,0}$ is LSB and $a_{1,4}$ is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the DCH CCTrCH in the associated DPCH radio frame.

The second set of TFCI information bits ($a_{2,0}$, $a_{2,1}$, $a_{2,2}$, $a_{2,3}$, $a_{2,4}$ where $a_{2,0}$ is LSB and $a_{2,4}$ is MSB) shall correspond to the TFC index (expressed in unsigned binary form) defined by the RRC layer to reference the TFC of the associated DSCH CCTrCH in the corresponding PDSCH radio frame.

The output code word bits b_k are given by:

$$b_{2i} = \sum_{n=0}^{4} (a_{1,n} \times M_{i,n}) \bmod 2 ; \qquad b_{2i+1} = \sum_{n=0}^{4} (a_{2,n} \times M_{i,n}) \bmod 2$$

where i = 0, …, 15.

The output bits are denoted by b_k, k = 0, 1, 2, …, 31.

4.3.5 Mapping of TFCI words

4.3.5.1 Mapping of TFCI word in normal mode

The bits of the code word are directly mapped to the slots of the radio frame. Within a slot the bit with lower index is transmitted before the bit with higher index. The coded bits b_k, are mapped to the transmitted TFCI bits d_k, according to the following formula:

$d_k = b_{k \bmod 32}$

For uplink physical channels regardless of the SF and downlink physical channels, if SF≥128, k = 0, 1, 2, …, 29. Note that this means that bits b_{30} and b_{31} are not transmitted.

For downlink physical channels whose SF < 128, k = 0, 1, 2, …, 119. Note that this means that bits b_0 to b_{23} are transmitted four times and bits b_{24} to b_{31} are transmitted three times.

4.3.5.2 Mapping of TFCI word in compressed mode

The mapping of the TFCI bits in compressed mode is different for uplink, downlink with SF ≥ 128 and downlink with SF < 128.

4.3.5.2.1 Uplink compressed mode

For uplink compressed mode, the slot format is changed so that no TFCI coded bits are lost. The different slot formats in compressed mode do not match the exact number of TFCI coded bits for all possible TGLs. Repetition of the TFCI bits is therefore used.

Denote the number of bits available in the TFCI fields of one compressed radio frame by D and the number of bits in the TFCI field in a slot by N_{TFCI}. The parameter E is used to determine the number of the first TFCI bit to be repeated.

E= N_{first} N_{TFCI}, if the start of the transmission gap is allocated to the current frame.
$E = 0$, if the start of the transmission gap is allocated to the previous frame and the end of the transmission gap is allocated to the current frame.

The TFCI coded bits b_k are mapped to the bits in the TFCI fields d_k. The following relations define the mapping for each compressed frame.

$d_k = b_k$

where k = 0, 1, 2, …, min (31, D-1).

If D > 32, the remaining positions are filled by repetition (in reversed order):

$d_{D-k-1} = b_{(E+k) \bmod 32}$

where k = 0, …, D-33.

4.3.5.2.2 Downlink compressed mode

For downlink compressed mode, the slot format is changed so that no TFCI coded bits are lost. The different slot formats in compressed mode do not match the exact number of TFCI bits for all possible TGLs. DTX is therefore used if the number of bits available in the TFCI fields in one compressed frame exceeds the number of TFCI bits given from the slot format. The block of bits in the TFCI fields where DTX is used starts on the first TFCI field after the transmission gap. If there are more bits available in the TFCI fields before the transmission gap than TFCI bits, DTX is also used on the bits in the last TFCI fields before the transmission gap.

Denote the number of bits available in the TFCI fields of one compressed radio frame by D and the number of bits in the TFCI field in a slot by N_{TFCI}. The parameter E is used to determine the position of the first bit in the TFCI field on which DTX is used.

$E = N_{first} N_{TFCI}$, if the start of the transmission gap is allocated to the current frame.
$E = 0$, if the start of the transmission gap is allocated to the previous frame and the end of the transmission gap is allocated to the current frame.

Denote the total number of TFCI bits to be transmitted by F. $F = 32$ for slot formats nA or nB, where $n = 0, 1, \ldots, 11$ (see table 11 in [2]). Otherwise, $F = 128$. The TFCI coded bits b_k are mapped to the bits in the TFCI fields d_k. The following relations define the mapping for each compressed frame.

If $E > 0$,

$$d_k = b_{k \bmod 32}$$

where $k = 0, 1, 2, \ldots, \min(E, F)-1$.

If $E < F$,

$$d_{k+D-F} = b_{k \bmod 32}$$

where $k = E, \ldots, F-1$.

DTX is used on d_k where $k = \min(E, F), \ldots, \min(E, F) + D - F - 1$.

4.3.5.3 Mapping of TFCI word in Basic Gating Periods

During Basic Gating Periods, the number of coded TFCI bits transmitted per radio frame is reduced in proportion to the gating rate. The coded TFCI word shall be punctured to map it to the transmitted TFCI bits in each radio frame as described in sub-clauses 4.3.5.3.1 and 4.3.5.3.2.

4.3.5.3.1 Gating rate 1/3

For uplink physical channels regardless of the SF and downlink physical channels with SF≥128, the coded bits b_k shall be mapped to the transmitted TFCI bits d_j in the radio frame according to the following relation:

$$d_j = b_k$$

where j and k are related as follows:

j	0	1	2	3	4	5	6	7	8	9
k	0	4	6	8	10	17	19	21	27	29

For downlink physical channels with SF<128, the coded bits b_k shall be mapped to the transmitted TFCI bits d_k in the radio frame according to the following relation:

$$d_k = b_k$$

where $k = 0, 1, 2, \ldots, 31$. DTX shall be used in the TFCI bits d_k where $k = 32, 33, 34, \ldots, 39$.

4.3.5.3.2 Gating rate 1/5

For uplink physical channels regardless of the SF and downlink physical channels with SF≥128, the coded bits b_k shall be mapped to the transmitted TFCI bits d_j in the radio frame according to the following relation:

$d_j = b_k$

where *j* and *k* are related as follows:

j	0	1	2	3	4	5
k	0	4	6	8	10	17

For downlink physical channels with SF<128, the coded bits b_k shall be mapped to the transmitted TFCI bits d_k in the radio frame according to the following relation:

$d_k = b_k$

where k = 0, 1, 2, …, 23.