

TSG-RAN Working Group 1 meeting #9

***TSGR1#9(99)j95***

Dresden, Germany

November 30 – December 3, 1999

**Agenda item:**

**Source:** Nokia

**Title:** CR 25.212 – 021: Update for 4.1.3.2.3 of TS25.212-v300

**Document for:** Decision

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The current text of the section 4.1.3.2.3 of TS 25.212 V3.0.0 explains the Turbo Code Internal Interleaver in a bit complicated way. The algorithm to generating indexes for turbo interleaving is proposed to rewrite in a clearer manner. Furthermore, the connection to 4.2.2.2 is shown as well.

<b>CHANGE REQUEST</b>		Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.	
<b>25.212</b>	<b>CR</b>	<b>021rev1</b>	Current Version: <b>3.0.0</b>
GSM (AA.BB) or 3G (AA.BBB) specification number ↑		↑ CR number as allocated by MCC support team	
For submission to: <b>RAN #6</b> list expected approval meeting # here ↑	for approval <input checked="" type="checkbox"/> for information <input type="checkbox"/>	strategic <input type="checkbox"/> non-strategic <input type="checkbox"/>	(for SMG use only)

Form: CR cover sheet, version 2 for 3GPP and SMG      The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

**Proposed change affects:** (U)SIM  ME  UTRAN / Radio  Core Network   
 (at least one should be marked with an X)

**Source:** Nokia **Date:** 29-Nov-1999

**Subject:** Update for 4.1.3.2.3 of 25.212 for clarification

**Work item:**

<b>Category:</b>	F Correction <input type="checkbox"/> A Corresponds to a correction in an earlier release <input type="checkbox"/> B Addition of feature <input type="checkbox"/> C Functional modification of feature <input type="checkbox"/> D Editorial modification <input checked="" type="checkbox"/>		<b>Release:</b>	Phase 2 <input type="checkbox"/> Release 96 <input type="checkbox"/> Release 97 <input type="checkbox"/> Release 98 <input type="checkbox"/> Release 99 <input checked="" type="checkbox"/> Release 00 <input type="checkbox"/>
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(only one category shall be marked with an X)

**Reason for change:** The current text explains the Turbo Code Internal Interleaver in a very complicated way.  
 The connection to 4.2.2.2 is missing, i.e., there is no text to describe how bits from 4.2.2.2 are interleaved in 4.1.3.2.3.

**Clauses affected:** 4.1.3.2.3 of TS25.212

<b>Other specs affected:</b>	Other 3G core specifications <input type="checkbox"/> Other GSM core specifications <input type="checkbox"/> MS test specifications <input type="checkbox"/> BSS test specifications <input type="checkbox"/> O&M specifications <input type="checkbox"/>	→ List of CRs: → List of CRs: → List of CRs: → List of CRs: → List of CRs:	
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**Other comments:**



<----- double-click here for help and instructions on how to create a CR.

#### 4.1.3.2.3.4.2.3.2.3 Turbo code internal interleaver

Figure 54 depicts the overall 8 state PCCC Turbo coding scheme including Turbo code internal interleaver. A length of a turbo code internal interleaver is allowed to take any value from 320 to 5114 inclusive assigned according to the rules described in 4.2.2.2. The length is denoted by  $K=K_i$  for a TrCH  $i$ . Elements of a turbo code internal interleaver are denoted by  $T(k)$ ,  $k = 1, 2, \dots, K$ , and each of them stands for the original position of an  $k$ :th interleaved bit. The range of  $T(k)$  is  $1 \leq T(k) \leq K$ .

The bits input to the turbo code internal interleaver are denoted by  $O_{ir1}, O_{ir2}, O_{ir3}, \dots, O_{irK}$  and the bits after interleaving are denoted by  $x_{ir1}, x_{ir2}, x_{ir3}, \dots, x_{irK}$ , where  $i$  is a TrCH number and  $r$  is a code block number (for details see 4.2.2.2). The relationship between the two is defined by:  $x_{irk} = O_{iT(k)}$  for  $k = 1, 2, \dots, K$ .

Every interleaving index  $T(k)$  shall satisfy the following stepwise algorithm:

##### 4.2.3.2.3.1 Algorithm for turbo interleaver

The following section specific notation is used for the parameters in the algorithm:

<u><math>K</math></u>	<u>Length of Turbo Code Internal Interleaver for a TrCH</u>
<u><math>A</math></u>	<u>Number of rows of an <math>A</math> times <math>B</math> matrix</u>
<u><math>B</math></u>	<u>Number of columns of an <math>A</math> times <math>B</math> matrix</u>
<u><math>I</math></u>	<u>Prime number</u>
<u><math>m</math></u>	<u>Primitive root for <math>I</math></u>
<u><math>ROP</math></u>	<u>Row order pattern</u>
<u><math>BR</math></u>	<u>Base sequence</u>
<u><math>Q</math></u>	<u>Minimum prime integer sequence</u>
<u><math>MIS</math></u>	<u>Minimum row order index sequence</u>
<u><math>i</math></u>	<u>Index in row dimension</u>
<u><math>j</math></u>	<u>Index in column dimension</u>
<u><math>i_0</math></u>	<u>Index in row dimension</u>
<u><math>z</math></u>	<u>Candidate index for Turbo Code Internal Interleaver</u>

1. Assign values for the number of rows  $A$ , the number of columns  $B$ , the prime number  $I$ , and the primitive root  $m$  depending on  $K$ :

If  $480 < K < 531$  then

$A = 10$ ;

$I = 53$ ;

$B = 53$ ;

$m = 2$ ;

else

$A = 20$ ;

find a least prime  $I$  such that  $K \leq A*(I+1)$ ;

select  $B$  by

$$B = \begin{cases} I-1 & \text{if } K \leq A*(I-1), \\ I & \text{if } A*(I-1) < K \leq A*I, \\ I+1 & \text{if } A*I < K \leq A*(I+1). \end{cases}$$

select  $m$  from Table 2 below on the right side of  $I$ .

endif

2. Select the row order pattern  $ROP$  out of  $Pattern_1$ ,  $Pattern_2$ , and  $Pattern_3$  depending on  $K$ :

<u><math>K</math></u>	<u><math>ROP</math></u>
<u>320 to 480:</u>	<u><math>Pattern_1</math>; (inclusive)</u>
<u>481 to 530:</u>	<u><math>Pattern_3</math>;</u>
<u>531 to 2280:</u>	<u><math>Pattern_1</math>;</u>
<u>2281 to 2480:</u>	<u><math>Pattern_2</math>;</u>
<u>2481 to 3160:</u>	<u><math>Pattern_1</math>;</u>
<u>3161 to 3210:</u>	<u><math>Pattern_2</math>;</u>
<u>3211 to 5114:</u>	<u><math>Pattern_1</math>;</u>

$Pattern_1$ : {19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 10, 8, 13, 17, 3, 1, 16, 6, 15, 11}.

$Pattern_2$ : {19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 16, 13, 17, 15, 3, 1, 6, 11, 8, 10}.

$Pattern_3$ : {9, 8, 7, 6, 5, 4, 3, 2, 1, 0}.

3. Construct the base sequence  $BR(j)$ ,  $j=0,1,2,\dots, I-2$ , by  $BR(0)=1$  and

$$\underline{BR(j) = (m * BR(j-1)) \text{ modulo } I \text{ for } j = 1, 2, \dots, I-2.}$$

4. Select the minimum prime integer sequence  $Q(i)$ ,  $i=0,1,\dots, A-1$ , such that  $Q(0)=1$  and  $\gcd(Q(i), I-1)=1$ ,  $Q(i) > 6$ , and  $Q(i) > Q(i-1)$  for  $i=1,2,\dots, A-1$ . Here  $\gcd(x, y)$  is the greatest common divisor of integers  $x$  and  $y$ .

5. Calculate the minimum row index sequence  $MIS(i)$ ,  $i=0,1,\dots, A-1$ , by

$$\underline{MIS(i) = \begin{cases} ROP(i) * B & \text{if } B = I-1, \\ ROP(i) * B + 1 & \text{if } B = I \text{ or } B = I+1. \end{cases}}$$

6. Elements of  $T(k)$  are same as ones obtained from the steps 6.1-6.4

6.1. Set  $i_0 = 0$  and  $k = 1$ ;

6.1.1 if  $K=A*B$  and  $B=(I+1)$  then  $T(k)=MIS(i_0) + I$ ;  $k = k + 1$ ;  $i_0 = i_0 + 1$ ; endif

6.1.2 for  $i = i_0, i_0 + 1, i_0 + 2, \dots, A-1$  do

6.1.3  $z = MIS(i) + BR(0)$ ;

6.1.4 if  $z \notin K$  then  $T(k) = z$ ;  $k = k + 1$ ; else prune  $z$ ; endif

6.1.5 endfor

6.2. for  $j = 1, 2, \dots, J - 2$  do

6.2.1 for  $i = 0, 1, 2, \dots, A - 1$  do

6.2.2  $z = MIS(i) + BR(j * Q(i))$  modulo  $(I - 1)$ ;

6.2.3 if  $z \notin K$  then  $T(k) = z$ ;  $k = k + 1$ ; else prune  $z$ ; endif

6.2.4 endfor

6.2.9 endfor

6.3. if  $(I - 1) < B$  then

6.3.1 for  $i = 0, 1, 2, \dots, A - 1$  do

6.3.2  $z = MIS(i)$ ;

6.3.3 if  $z \notin K$  then  $T(k) = z$ ;  $k = k + 1$ ; else prune  $z$ ; endif

6.3.4 endfor

6.3.9 endif

6.4. if  $I < B$  then

6.4.1  $i_0 = 0$ ;

6.4.2 if  $K = A * B$  then  $T(k) = MIS(i_0) + 1$ ;  $k = k + 1$ ;  $i_0 = i_0 + 1$ ; endif

6.4.3 for  $i = i_0, i_0 + 1, i_0 + 2, \dots, A - 1$  do

6.4.4  $z = MIS(i) + I$ ;

6.4.5 if  $z \notin K$  then  $T(k) = z$ ;  $k = k + 1$ ; else prune  $z$ ; endif

6.4.6 endfor

6.4.5 endif

The total number of pruned indexes is  $A * B - K$ .

~~The Turbo code internal interleaver consists of mother interleaver generation and pruning. For arbitrary given block length  $K$ , one mother interleaver is selected from the 134 mother interleavers set. The generation scheme of mother interleaver is described in section 4.1.3.2.3.1. After the mother interleaver generation,  $l$  bits are pruned in order to adjust the mother interleaver to the block length  $K$ . The definition of  $l$  is shown in section 4.1.3.2.3.2.~~

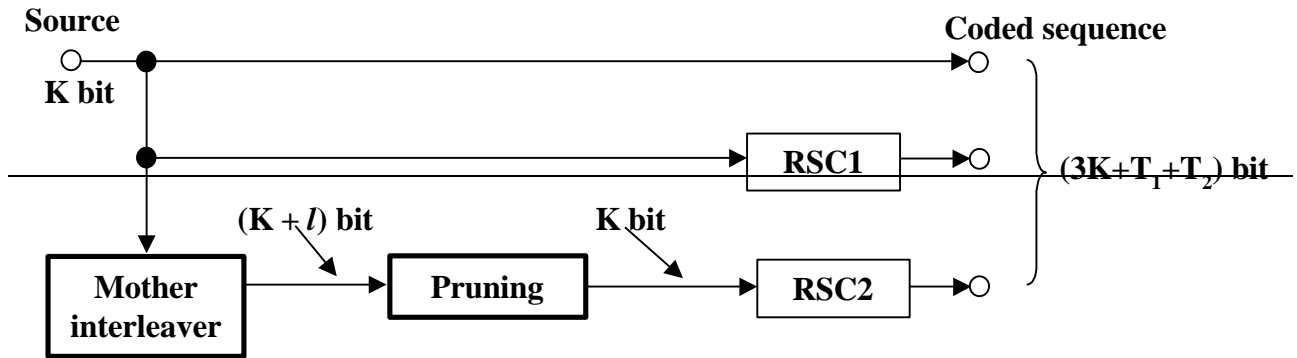


Figure 5: Overall 8 State PCCC Turbo Coding

#### 4.1.3.2.3.1 Mother interleaver generation

The interleaving consists of three stages. In first stage, the input sequence is written into the rectangular matrix row by row. The second stage is intra row permutation. The third stage is inter row permutation. The three stage permutations are described as follows, the input block length is assumed to be  $K$  (320 to 5114 bits).

##### First Stage:

- (1) Determine a row number  $R$  such that

$$R=10 \text{ (} K = 481 \text{ to } 530 \text{ bits; Case-1)}$$

$$R=20 \text{ (} K = \text{any other block length except } 481 \text{ to } 530 \text{ bits; Case-2)}$$

- (2) Determine a column number  $C$  such that

$$\text{Case-1; } C = p = 53$$

Case-2;

- (i) — find minimum prime  $p$  such that,

$$0 \leq (p+1) \cdot K/R,$$

- (ii) — if  $(0 \leq p \cdot K/R)$  then go to (iii),

$$\text{— else } C = p+1.$$

- (iii) — if  $(0 \leq p-1 \cdot K/R)$  then  $C = p-1$ ,

$$\text{— else } C = p.$$

- (3) The input sequence of the interleaver is written into the  $R \times C$  rectangular matrix row by row.

##### Second Stage:

##### A. If $C = p$

- (A-1) Select a primitive root  $g_0$  from table 2.

- (A-2) Construct the base sequence  $c(i)$  for intra row permutation as:

$$c(i) = [g_0 \times c(i-1)] \bmod p, \quad i = 1, 2, \dots, (p-2), \quad c(0) = 1.$$

- (A-3) Select the minimum prime integer set  $\{q_j\}$  ( $j=1, 2, \dots, R-1$ ) such that

$$\text{g.c.d}\{q_j, p-1\} = 1$$

$$q_j \geq 6$$

$$q_j \gg q_{(j+1)}$$

where g.c.d. is greatest common divider. And  $q_0 = 1$ .

(A 4) The set  $\{q_j\}$  is permuted to make a new set  $\{p_j\}$  such that

$$p_{P(j)} = q_j, j = 0, 1, \dots, R-1,$$

where  $P(j)$  is the inter-row permutation pattern defined in the third stage.

(A 5) Perform the  $j$  th ( $j = 0, 1, 2, \dots, R-1$ ) intra row permutation as:

$$c_j(i) = c([i \times p_j] \bmod (p-1)), \quad i = 0, 1, 2, \dots, (p-2), \text{ and } c_j(p-1) = 0,$$

where  $c_j(i)$  is the input bit position of  $i$  th output after the permutation of  $j$  th row.

#### B. If $C = p+1$

(B 1) Same as case A 1.

(B 2) Same as case A 2.

(B 3) Same as case A 3.

(B 4) Same as case A 4.

(B 5) Perform the  $j$  th ( $j = 0, 1, 2, \dots, R-1$ ) intra row permutation as:

$$c_j(i) = c([i \times p_j] \bmod (p-1)), \quad i = 0, 1, 2, \dots, (p-2), \quad c_j(p-1) = 0, \text{ and } c_j(p) = p,$$

(B 6) If  $(K = C \times R)$  then exchange  $c_{R-1}(p)$  with  $c_{R-1}(0)$ .

where  $c_j(i)$  is the input bit position of  $i$  th output after the permutation of  $j$  th row.

#### C. If $C = p-1$

(C 1) Same as case A 1.

(C 2) Same as case A 2.

(C 3) Same as case A 3.

(C 4) Same as case A 4.

(C 5) Perform the  $j$  th ( $j = 0, 1, 2, \dots, R-1$ ) intra row permutation as:

$$c_j(i) = c([i \times p_j] \bmod (p-1)) - 1, \quad i = 0, 1, 2, \dots, (p-2),$$

where  $c_j(i)$  is the input bit position of  $i$  th output after the permutation of  $j$  th row.

#### Third Stage:

(1) Perform the inter-row permutation based on the following  $P(j)$  ( $j=0, 1, \dots, R-1$ ) patterns, where  $P(j)$  is the original row position of the  $j$  th permuted row.

$$P_A: \{19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 10, 8, 13, 17, 3, 1, 16, 6, 15, 11\} \text{ for } R=20$$

$$P_B: \{19, 9, 14, 4, 0, 2, 5, 7, 12, 18, 16, 13, 17, 15, 3, 1, 6, 11, 8, 10\} \text{ for } R=20$$

$$P_C: \{9, 8, 7, 6, 5, 4, 3, 2, 1, 0\} \text{ for } R=10$$

The usage of these patterns is as follows:

$$\text{Block length } K: P(j)$$

320 to 480 bit:  $P_A$

481 to 530 bit:  $P_C$

531 to 2280 bit:  $P_A$

2281 to 2480 bit:  $P_B$

2481 to 3160 bit:  $P_A$

3161 to 3210 bit:  $P_B$

3211 to 5114 bit:  $P_A$

(2) The output of the mother interleaver is the sequence read out column by column from the permuted  $R \times C$  matrix.

**Table 2: Table of prime  $p_\lambda$  and associated primitive root  $\mu$**

$p_\lambda$	$\mu_{g_0}$	$P_\lambda$	$\mu_{g_0}$	$p_\lambda$	$\mu_{g_0}$	$P_\lambda$	$\mu_{g_0}$	$p_\lambda$	$\mu_{g_0}$
17	3	59	2	103	5	157	5	211	2
19	2	61	2	107	2	163	2	223	3
23	5	67	2	109	6	167	5	227	2
29	2	71	7	113	3	173	2	229	6
31	3	73	5	127	3	179	2	233	3
37	2	79	3	131	2	181	2	239	7
41	6	83	2	137	3	191	19	241	7
43	3	89	3	139	2	193	5	251	6
47	5	97	5	149	2	197	2	257	3
53	2	101	2	151	6	199	3		

**4.1.3.2.3.2 Definition of number of pruning bits**

The output of the mother interleaver is pruned by deleting the  $l$  bits in order to adjust the mother interleaver to the block length  $K$ , where the deleted bits are non-existent bits in the input sequence. The pruning bits number  $l$  is defined as:

$$l = R \times C - K,$$

where  $R$  is the row number and  $C$  is the column number defined in section 4.1.3.2.3.1.