TSG-RAN Working Group1 meeting #17
Stockholm, Sweden, November 21 – 24, 2000

TSGR1#17(00)1477

Agenda item:

Source: NTT DoCoMo

Title: Editorial corrections in TS 25.212 and TS 25.222

Document for: Decision

This document includes CRs on both TS 25.212 and TS 25.222 which to correct wording in abbreviations, CRC attachment, 1st interleaving and 2nd interleaving section, and to clarify bits padding and pruning for rectangular matrix of 2nd interleaving. Through these corrections, the CRC attachment operation itself and the channel interleaving algorithm itself are not changed at all. The major corrections, which should be applied for both TS 25.212 and TS 25.222 commonly, are as follows:

Section 3.3 Abbreviations (only for 25.212)

- The abbreviation of CRC was corrected to "Cyclic Redundancy Check" instead "Cyclic Redundancy Code".

Section 4.2.1 CRC attachment (corrected title)

- To align how to entitle with the other sub-sections in the "Transport channel coding/multiplexing" section, i.e. the transmitter side operation basis, the title of this sub-section was changed to "CRC attachment" because the current title "Error detection" basically indicates the operation at the receiver side.

- Exact words of "size of CRC parity" were described to clarify what is signalled from higher layers.

Section 4.2.1.1 CRC Calculation

- L_i, was explained as the number of parity bits.

- Editorial corrections were made for the variable i.e. "D" should be italic letters.

Section 4.2.1.2 Relation between input and output of the CRC attachment block (corrected section number and title)

- The title of this section was corrected to the exact name of the functional block in figure 1 and 2, i.e. "CRC attachment block" instead "Cyclic Redundancy Check".

Section 4.2.5.2 1st interleaver operation

- The description about the number of input bits was corrected.

- The numbering of columns and rows were clarified for the interleaving matrix.

Section 4.2.11 2nd interleaving

- The description about padding bits to be pruned at output of 2nd interleaving, which was missing in the current specification, was added.

- The numbering of columns and rows were clarified for the interleaving matrix.

- The notation of the inter-column permutation pattern P2 was aligned with the preferred mathematical notation shown in TS 25.201 Annex A.

CHANGE REQUEST

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25.212 CR 100r1 Current Version: 3.4.0

GSM (AA.BB) or 3G (AA.BBB) specification number ? *? CR number as allocated by MCC support team*

For submission to: RAN #10	for approval	X	Strategic		*(for SMG use only)*
list expected approval meeting # here ?	For information		non-strategic		

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 [X] UTRAN / Radio [X] Core Network [ ]
(at least one should be marked with an X)

Source:	NTT DoCoMo
Date:	21-Nov.-2000
Subject:	Editorial corrections in TS 25.212
Work item:	

Category: *(only one category shall be marked with an X)*

F	Correction	X
A	Corresponds to a correction in an earlier release	
B	Addition of feature	
C	Functional modification of feature	
D	Editorial modification	

Release:

Phase 2	
Release 96	
Release 97	
Release 98	
Release 99	X
Release 00	

Reason for change:
To correct wording in CRC attachment, 1st interleaving and 2nd interleaving sections.
To clarify bits padding and pruning for rectangular matrix of 2nd interleaving.
To align mathematical notations with preferred notations shown in TS 25.201 Annex A.

Clauses affected: 3.3, 4.2.1, 4.2.1.1, 4.2.1.1.1, 4.2.5.2 and 4.2.11 of TS 25.212

Other specs affected:

Other 3G core specifications		? List of CRs:
Other GSM core specifications		? List of CRs:
MS test specifications		? List of CRs:
BSS test specifications		? List of CRs:
O&M specifications		? List of CRs:

Other comments:

TrCH number: Transport channel number represents a TrCH ID assigned to L1 by L2. Transport channels are multiplexed to the CCTrCH in the ascending order of these IDs.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

$?x?$	round towards ?, i.e. integer such that $x ? ?x? < x+1$
$?x?$	round towards -?, i.e. integer such that $x\text{-}1 < ?x? ? x$
$?x?$	absolute value of x
sgn(x)	signum function, i.e. $\operatorname{sgn}(x) ? \begin{cases} 1; & x ? 0 \\ ?1; & x ? 0 \end{cases}$
N_{first}	The first slot in the *TG*, located in the first compressed radio frame if the TG spans two frames.
N_{last}	The last slot in the *TG*, located in the second compressed radio frame if the TG spans two frames.
N_{tr}	Number of transmitted slots in a radio frame.

Unless otherwise is explicitly stated when the symbol is used, the meaning of the following symbols is:

i	TrCH number
j	TFC number
k	Bit number
l	TF number
m	Transport block number
n_i	Radio frame number of TrCH i.
p	PhCH number
r	Code block number
I	Number of TrCHs in a CCTrCH.
C_i	Number of code blocks in one TTI of TrCH i.
F_i	Number of radio frames in one TTI of TrCH i.
M_i	Number of transport blocks in one TTI of TrCH i.
$N_{data,j}$	Number of data bits that are available for the CCTrCH in a radio frame with TFC j.
$N_{data,j}^{cm}$	Number of data bits that are available for the CCTrCH in a compressed radio frame with TFC j.
P	Number of PhCHs used for one CCTrCH.
PL	Puncturing Limit for the uplink. Signalled from higher layers
RM_i	Rate Matching attribute for TrCH i. Signalled from higher layers.

Temporary variables, i.e. variables used in several (sub)clauses with different meaning.

x, X
y, Y
z, Z

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ARQ	Automatic Repeat Request
BCH	Broadcast Channel
BER	Bit Error Rate
BLER	Block Error Rate
BS	Base Station
CCPCH	Common Control Physical Channel
CCTrCH	Coded Composite Transport Channel
CFN	Connection Frame Number
CRC	Cyclic Redundancy Check~~Code~~
DCH	Dedicated Channel
DL	Downlink (Forward link)
DPCCH	Dedicated Physical Control Channel
DPCH	Dedicated Physical Channel

DPDCH	Dedicated Physical Data Channel
DS-CDMA	Direct-Sequence Code Division Multiple Access
DSCH	Downlink Shared Channel
DTX	Discontinuous Transmission
FACH	Forward Access Channel
FDD	Frequency Division Duplex
FER	Frame Error Rate
GF	Galois Field
MAC	Medium Access Control
Mcps	Mega Chip Per Second
MS	Mobile Station
OVSF	Orthogonal Variable Spreading Factor (codes)
PCCC	Parallel Concatenated Convolutional Code
PCH	Paging Channel
PhCH	Physical Channel
PRACH	Physical RandomAccess Channel
RACH	Random Access Channel
RSC	Recursive Systematic Convolutional Coder
RX	Receive
SCH	Synchronisation Channel
SF	Spreading Factor
SFN	System Frame Number
SIR	Signal-to-Interference Ratio
SNR	Signal to Noise Ratio
TF	Transport Format
TFC	Transport Format Combination
TFCI	Transport Format Combination Indicator
TPC	Transmit Power Control
TrCH	Transport Channel
TTI	Transmission Time Interval
TX	Transmit
UL	Uplink (Reverse link)

4.2.1 CRC attachment~~Error detection~~

Error detection is provided on transport blocks through a Cyclic Redundancy Check (CRC). The size of the CRC is 24, 16, 12, 8 or 0 bits and it is signalled from higher layers what CRC ~~length~~size that should be used for each TrCH.

4.2.1.1 CRC Calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

- $g_{CRC24}(\cancel{D}D) = \cancel{D}D^{24} + \cancel{D}D^{23} + \cancel{D}D^{6} + \cancel{D}D^{5} + \cancel{D}D + 1$;
- $g_{CRC16}(\cancel{D}D) = \cancel{D}D^{16} + \cancel{D}D^{12} + \cancel{D}D^{5} + 1$;
- $g_{CRC12}(\cancel{D}D) = \cancel{D}D^{12} + \cancel{D}D^{11} + \cancel{D}D^{3} + \cancel{D}D^{2} + \cancel{D}D + 1$;
- $g_{CRC8}(\cancel{D}D) = \cancel{D}D^{\cancel{8}8} + \cancel{D}D^{7} + \cancel{D}D^{4} + \cancel{D}D^{3} + \cancel{D}D + 1$.

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \Box, a_{imA_i}$, and the parity bits by $p_{im1}, p_{im2}, p_{im3}, \Box, p_{imL_i}$. A_i is the ~~length~~size of a transport block of TrCH i, m is the transport block number, and $\cancel{L_i}L_i$ is the number of parity bits. L_i can take the values 24, 16, 12, 8, or 0 depending on what is signalled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_{im1}D^{A_i ? 23} ? a_{im2}D^{A_i ? 22} ? \Box ? a_{imA_i}D^{24} ? p_{im1}D^{23} ? p_{im2}D^{22} ? \Box ? p_{im23}D^{1} ? p_{im24}$$

yields a remainder equal to 0 when divided by $g_{CRC24}(\cancel{D}D)$, polynomial:

$$a_{im1}D^{A_i ? 15} ? a_{im2}D^{A_i ? 14} ? \Box ? a_{imA_i}D^{16} ? p_{im1}D^{15} ? p_{im2}D^{14} ? \Box ? p_{im15}D^{1} ? p_{im16}$$

yields a remainder equal to 0 when divided by $g_{CRC16}(\cancel{D}D)$, polynomial:

$$a_{im1}D^{A_i ? 11} ? a_{im2}D^{A_i ? 10} ? \Box ? a_{imA_i}D^{12} ? p_{im1}D^{11} ? p_{im2}D^{10} ? \Box ? p_{im11}D^{1} ? p_{im12}$$

yields a remainder equal to 0 when divided by $g_{CRC12}(\cancel{D}D)$ and polynomial:

$$a_{im1}D^{A_i ? 7} ? a_{im2}D^{A_i ? 6} ? \Box ? a_{imA_i}D^{8} ? p_{im1}D^{7} ? p_{im2}D^{6} ? \Box ? p_{im7}D^{1} ? p_{im8}$$

yields a remainder equal to 0 when divided by $g_{CRC8}(\cancel{D}D)$.

If no transport blocks are input to the CRC calculation ($M_i = 0$), no CRC attachment shall be done. If transport blocks are input to the CRC calculation (M_i ? 0) and the size of a transport block is zero ($A_i = 0$), CRC shall be attached, i.e. all parity bits equal to zero.

4.2.1.2~~4.2.1.1.1~~ Relation between input and output of the CRC attachment block~~Cyclic Redundancy Check~~

The bits after CRC attachment are denoted by $b_{im1}, b_{im2}, b_{im3}, \Box, b_{imB_i}$, where $B_i = A_i + L_i$. The relation between a_{imk} and b_{imk} is:

$$b_{imk} ? a_{imk} \qquad k = 1, 2, 3, \ldots, A_i$$

$$b_{imk} ? p_{im(L_i ? 1 ? (k ? A_i))} \qquad k = A_i + 1, A_i + 2, A_i + 3, \ldots, A_i + L_i$$

$Np_{i,\max}^{TTI,m}$ is defined in the Rate Matching subclause 4.2.7.

$P1_{F_i}$ (x) defines the inter column permutation function for a TTI of length F_i ? 10ms, as defined in Table 3 in section 4.2.5.2. $P1_{F_i}$ (x) is the Bit Reversal function of x on $\log_2(F_i)$ bits.

NOTE 1: C[x], x= 0 to F_i– 1, the number of bits p which have to be inserted in each of the F_i segments of the TTI, where x is the column number before permutation, i.e. in each column of the first interleaver. C[$P1_{F_i}$(x)] is equal to $Np_{i,\max}^{m?F_i?x}$ for x equal 0 to F_i–1 for fixed positions. It is noted $Np_i^{m?F_i?x}$ in the following initialisation step.

NOTE 2: cbi[x], x=0 to F_i – 1, the counter of the number of bits p inserted in each of the F_i segments of the TTI, i.e. in each column of the first interleaver x is the column number before permutation.

col = 0

while col < F_i **do** -- here col is the column number after column permutation

C[$P1_{F_i}$ (col)] = $Np_i^{m?F_i?col}$ -- initialisation of number of bits p to be inserted in each of the F_i segments of the TTI number *m*

cbi[$P1_{F_i}$ (col)] = 0 -- initialisation of counter of number of bits p inserted in each of the F_i segments of the TTI

col = col +1

end do

n = 0, m = 0

while n < X_i **do** -- from here col is the column number before column permutation

col = *n* mod F_i

if cbi[col] < C[col] **do**

$x_{i,n}$ = p -- insert one p bit

cbi[col] = cbi[col]+1 -- update counter of number of bits p inserted

else -- no more p bit to insert in this segment

$x_{i,n} = z_{i,,m}$

m = m+1

endif

n = n +1

end do

4.2.5.2 1st interleaver operation

The 1st interleaving is a block interleaver with inter-column permutations. The input bit sequence to the ~~1st~~ block interleaver is denoted by $x_{i,1}, x_{i,2}, x_{i,3}, \ldots, x_{i,X_i}$, where *i* is TrCH number and X_i the number of bits. ~~(at this stage~~ Here X_i is ~~assumed and~~ guaranteed to be an integer multiple of the number of radio frames in the TTI~~)~~. The output bit sequence from the block interleaver is derived as follows:

(1) Select the number of columns C1 from table 4 depending on the TTI. The columns are numbered 0, 1, …, C1 - 1 from left to right.

(2) Determine the number of rows of the matrix, R1 defined as~~:~~

R1 = X_i / C1.

The rows of the matrix are numbered 0, 1, …, R1 - 1 from top to bottom.

(3) Write the input bit sequence into the R1 $\times$ C1 ~~rectangular~~ matrix row by row starting with bit $x_{i,1}$ in ~~the first~~ column 0 of ~~the first~~ row 0 and ending with bit $x_{i,(R1\times C1)}$ in column C1 - 1 of row R1 - 1:

$$\begin{bmatrix} x_{i,1} & x_{i,2} & x_{i,3} & \ldots & x_{i,C1} \\ x_{i,(C1+1)} & x_{i,(C1+2)} & x_{i,(C1+3)} & \ldots & x_{i,(2\times C1)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ x_{i,((R1-1)\times C1+1)} & x_{i,((R1-1)\times C1+2)} & x_{i,((R1-1)\times C1+3)} & \ldots & x_{i,(R1\times C1)} \end{bmatrix}$$

(4) Perform the inter-column permutation for the matrix based on the pattern $\left\langle P1_{C1}(j)\right\rangle_{j\in\{0,1,\ldots,C1-1\}}$ shown in table 4, ~~-~~where $P1_{C1}(j)$ is the original column position of the *j*-th permuted column. After permutation of the columns, the bits are denoted by y_{ik}:

$$\begin{bmatrix} y_{i,1} & y_{i,(R1+1)} & y_{i,(2\times R1+1)} & \ldots & y_{i,((C1-1)\times R1+1)} \\ y_{i,2} & y_{i,(R1+2)} & y_{i,(2\times R1+2)} & \ldots & y_{i,((C1-1)\times R1+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{i,R1} & y_{i,(2\times R1)} & y_{i,(3\times R1)} & \ldots & y_{i,(C1\times R1)} \end{bmatrix}$$

(5) Read the output bit sequence ~~$y_{i1}, y_{i2}, y_{i3}, \ldots, y_{i,(C1\times R1)}$~~ $y_{i,1}, y_{i,2}, y_{i,3}, \ldots, y_{i,(C1\times R1)}$ of the ~~1st~~ block interleav~~ing~~ering column by column from the inter-column permuted R1 $\times$ C1 matrix. Bit $y_{i,1}$ corresponds to ~~the first~~ row 0 of ~~the first~~ column 0 and bit $y_{i,(R1\times C1)}$ corresponds to row R1 - 1 of column C1 - 1.

Table 4 Inter-column permutation patterns for 1st interleaving

TTI	Number of columns C1	Inter-column permutation patterns <$P1_{C1}(0)$, $P1_{C1}(1)$, …, $P1_{C1}(C1-1)$>
10 ms	1	<0>
20 ms	2	<0,1>
40 ms	4	<0,2,1,3>
80 ms	8	<0,4,2,6,1,5,3,7>

Bits on second PhCH after physical channel segmentation:

$u_{2,k} = x_{f(k+U)}$ $k = 1, 2, \ldots, U$

…

Bits on the P^{th} PhCH after physical channel segmentation:

$u_{P,k} = x_{f(k+(P-1)?U)}$ $k = 1, 2, \ldots, U$

where f is such that :

- for modes other than compressed mode by puncturing, $x_{f(k)} = x_k$, i.e. $f(k) = k$, for all k.
- for compressed mode by puncturing, bit $u_{1,1}$ corresponds to the bit x_k with smallest index k when the bits p are not counted, bit $u_{1,2}$ corresponds to the bit x_k with second smallest index k when the bits p are not counted, and so on for bits $u_{1,3}, \ldots u_{1,U}, u_{2,1}, u_{2,2}, \ldots u_{2,U}, \ldots u_{P,1}, u_{P,2}, \ldots u_{P,U}$.

4.2.10.1 Relation between input and output of the physical segmentation block in uplink

The bits input to the physical segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$. Hence, $x_k = s_k$ and $Y = S$.

4.2.10.2 Relation between input and output of the physical segmentation block in downlink

The bits input to the physical segmentation are denoted by $w_1, w_2, w_3, \ldots, w_{(PU)}$. Hence, $x_k = w_k$ and $Y = PU$.

4.2.11 2nd interleaving

The 2nd interleaving is a block interleaver and consists of bits input to a matrix with padding, ~~with~~the inter-column permutations~~s~~ for the matrix and bits output from the matrix with pruning. The bits input to the ~~2nd~~ block interleaver are denoted by $u_{p,1}, u_{p,2}, u_{p,3}, \ldots, u_{p,U}$, where p is PhCH number and U is the number of bits in one radio frame for one PhCH. The output bit sequence from the block interleaver is derived as follows:

(1) ~~Set the number of columns~~Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

(2) Determine the number of rows of the matrix, R2, by finding minimum integer R2 such that:

$U ? \mathrm{R2} ? \mathrm{C2}$.

The rows of rectangular matrix are numbered 0, 1, 2, …, R2 - 1 from top to bottom.

(3) Write ~~T~~the ~~bits~~ input bit sequence $u_{p,1}, u_{p,2}, u_{p,3}, \ldots, u_{p,U}$ ~~to the 2nd interleaving are written~~ into the R2 ? C2 ~~rectangular~~ matrix row by row~~.~~ starting with bit $y_{p,1}$ in column 0 of row 0:

$$\begin{bmatrix} u_{p,1} & u_{p,2} & u_{p,3} & \ldots & u_{p,30} \\ u_{p,31} & u_{p,32} & u_{p,33} & \ldots & u_{p,60} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ u_{p,((R2-1)?30+1)} & u_{p,((R2-1)?30+2)} & u_{p,((R2-1)?30+3)} & \ldots & u_{p,(R2?30)} \end{bmatrix}$$

$$\begin{bmatrix} y_{p,1} & y_{p,2} & y_{p,3} & \ldots & y_{p,C2} \\ y_{p,(C2+1)} & y_{p,(C2+2)} & y_{p,(C2+3)} & \ldots & y_{p,(2?C2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{p,((R2-1)?C2+1)} & y_{p,((R2-1)?C2+2)} & y_{p,((R2-1)?C2+3)} & \ldots & y_{p,(R2?C2)} \end{bmatrix}$$

where $y_{p,k} = u_{p,k}$ for k = 1, 2, …, U and if R2 × C2 > U, the dummy bits are padded such that $y_{p,k}$ = 0 or 1 for k = U + 1, U + 2, …, R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern ~~P2(*j*) (*j* = 0, 1, ..., C2-1)~~ $\langle P2(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, where P2(*j*) is the original column position of the *j*-th permuted column. After permutation of the columns, the bits are denoted by ~~y_{pk}~~ $y'_{p,k}$.

$$\begin{bmatrix} y_{p,1} & y_{p,(R2+1)} & y_{p,(2R2+1)} & \cdots & y_{p,(29R2+1)} \\ y_{p,2} & y_{p,(R2+2)} & y_{p,(2R2+2)} & \cdots & y_{p,(29R2+2)} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ y_{p,R2} & y_{p,(2R2)} & y_{p,(3R2)} & \cdots & y_{p,(30R2)} \end{bmatrix} \quad \begin{bmatrix} y'_{p,1} & y'_{p,(R2+1)} & y'_{p,(2R2+1)} & \cdots & y'_{p,((C2-1)R2+1)} \\ y'_{p,2} & y'_{p,(R2+2)} & y'_{p,(2R2+2)} & \cdots & y'_{p,((C2-1)R2+2)} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ y'_{p,R2} & y'_{p,(2R2)} & y'_{p,(3R2)} & \cdots & y'_{p,(C2R2)} \end{bmatrix}$$

(5) The output of the ~~2nd~~ block interleav~~ing~~er is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were ~~not present~~padded ~~in~~to the input ~~bit sequence~~of the matrix before the inter-column permutation, i.e. bits ~~y_{pk}~~ $y'_{p,k}$ that corresponds to bits ~~u_{pk}~~ $y_{p,k}$ with $k > U$ are removed from the output. The bits after 2nd interleaving are denoted by $v_{p,1}, v_{p,2}, \ldots, v_{p,U}$, where $v_{p,1}$ corresponds to the bit ~~$y_{p,k}$~~ $y'_{p,k}$ with smallest index k after pruning, $v_{p,2}$ to the bit ~~$y_{p,k}$~~ $y'_{p,k}$ with second smallest index k after pruning, and so on.

Table 7 Inter-column permutation pattern for 2nd interleaving

Number of columns C2	Inter-column permutation pattern < P2(0), P2(1), …, P2(~~29~~C2-1) >
30	<0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17>

Document R1-00-1477
*e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx*

CHANGE REQUEST

Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly.

25.222	**CR**	**053r1**	Current Version: 3.4.0

GSM (AA.BB) or 3G (AA.BBB) specification number ? *? CR number as allocated by MCC support team*

For submission to:	RAN #10	for approval	X	Strategic	(for SMG use only)
list expected approval meeting # here ?		For information		non-strategic	

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

Source:	NTT DoCoMo	**Date:**	21-Nov.-2000
Subject:	Editorial corrections in TS 25.222		
Work item:			

Category:	F	Correction	X	**Release:**	Phase 2	
	A	Corresponds to a correction in an earlier release			Release 96	
(only one category	B	Addition of feature			Release 97	
shall be marked	C	Functional modification of feature			Release 98	
with an X)	D	Editorial modification			Release 99	X
					Release 00	

Reason for change: To correct wording in CRC attachment, 1st interleaving and 2nd interleaving sections.
To clarify bits padding and pruning for rectangular matrix of 2nd interleaving.
To align mathematical notations with preferred notations shown in TS 25.201 Annex A.

Clauses affected: 4.2.1, 4.2.1.1, 4.2.1.2, 4.2.5 and 4.2.10 of TS 25.222

Other specs affected:	Other 3G core specifications		?	List of CRs:
	Other GSM core specifications		?	List of CRs:
	MS test specifications		?	List of CRs:
	BSS test specifications		?	List of CRs:
	O&M specifications		?	List of CRs:

Other comments:

Primarily, transport channels are multiplexed as described above, i.e. into one data stream mapped on one or several physical channels. However, an alternative way of multiplexing services is to use multiple CCTrCHs (Coded Composite Transport Channels), which corresponds to having several parallel multiplexing chains as in figure 1, resulting in several data streams, each mapped to one or several physical channels.

4.2.1 CRC attachment~~Error detection~~

Error detection is provided on transport blocks through a Cyclic Redundancy Check (CRC). The size of the CRC is 24, 16, 12, 8 or 0 bits and it is signalled from higher layers what CRC ~~length~~size that should be used for each TrCH.

4.2.1.1 CRC Calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

- $g_{CRC24}(\cancel{D}D) = \cancel{D}D^{24} + \cancel{D}D^{23} + \cancel{D}D^{6} + \cancel{D}D^{5} + \cancel{D}D + 1;$
- $g_{CRC16}(\cancel{D}D) = \cancel{D}D^{16} + \cancel{D}D^{12} + \cancel{D}D^{5} + 1;$
- $g_{CRC12}(\cancel{D}D) = \cancel{D}D^{12} + \cancel{D}D^{11} + \cancel{D}D^{3} + \cancel{D}D^{2} + \cancel{D}D + 1;$
- $g_{CRC8}(\cancel{D}D) = \cancel{D}D^{\cancel{8}8} + \cancel{D}D^{7} + \cancel{D}D^{4} + \cancel{D}D^{3} + \cancel{D}D + 1.$

Denote the bits in a transport block delivered to layer 1 by $a_{im1}, a_{im2}, a_{im3}, \square\ , a_{imA_i}$, and the parity bits by $p_{im1}, p_{im2}, p_{im3}, \square\ , p_{imL_i}$. A_i is the ~~length~~size of a transport block of TrCH i, m is the transport block number, and ~~L_i~~L_i is the number of parity bits. L_i can take the values 24, 16, 12, 8, or 0 depending on what is signalled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_{im1}D^{A_i ? 23} ? a_{im2}D^{A_i ? 22} ? \square\ ? a_{imA_i}D^{24} ? p_{im1}D^{23} ? p_{im2}D^{22} ? \square\ ? p_{im23}D^{1} ? p_{im24}$$

yields a remainder equal to 0 when divided by $g_{CRC24}(\cancel{D}D)$, polynomial:

$$a_{im1}D^{A_i ? 15} ? a_{im2}D^{A_i ? 14} ? \square\ ? a_{imA_i}D^{16} ? p_{im1}D^{15} ? p_{im2}D^{14} ? \square\ ? p_{im15}D^{1} ? p_{im16}$$

yields a remainder equal to 0 when divided by $g_{CRC16}(\cancel{D}D)$, polynomial:

$$a_{im1}D^{A_i ? 11} ? a_{im2}D^{A_i ? 10} ? \square\ ? a_{imA_i}D^{12} ? p_{im1}D^{11} ? p_{im2}D^{10} ? \square\ ? p_{im11}D^{1} ? p_{im12}$$

yields a remainder equal to 0 when divided by $g_{CRC12}(\cancel{D}D)$ and polynomial:

$$a_{im1}D^{A_i ? 7} ? a_{im2}D^{A_i ? 6} ? \square\ ? a_{imA_i}D^{8} ? p_{im1}D^{7} ? p_{im2}D^{6} ? \square\ ? p_{im7}D^{1} ? p_{im8}$$

yields a remainder equal to 0 when divided by $g_{CRC8}(\cancel{D}D)$.

If no transport blocks are input to the CRC calculation ($M_i = 0$), no CRC attachment shall be done. If transport blocks are input to the CRC calculation (M_i ? 0) and the size of a transport block is zero ($A_i = 0$), CRC shall be attached, i.e. all parity bits equal to zero.

4.2.1.2 Relation between input and output of the CRC attachment block~~Cyclic Redundancy Check~~

The bits after CRC attachment are denoted by $b_{im1}, b_{im2}, b_{im3}, \square\ , b_{imB_i}$, where $B_i = A_i + L_i$. The relation between a_{imk} and b_{imk} is:

$$b_{imk} ? a_{imk} \qquad k = 1, 2, 3, \ldots, A_i$$

$$b_{imk} \; ? \; p_{im(L_i \, ? \, 1 \, ? \, (k \, ? \, A_i))} \quad k = A_i + 1, A_i + 2, A_i + 3, \ldots, A_i + L_i$$

4.2.3.3 Concatenation of encoded blocks

After the channel coding for each code block, if C_i is greater than 1, the encoded blocks are serially concatenated so that the block with lowest index *r* is output first from the channel coding block, otherwise the encoded block is output from channel coding block as it is. The bits output are denoted by $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where *i* is the TrCH number and $E_i = C_iY_i$. The output bits are defined by the following relations:

$$c_{ik} = y_{i1k} \quad k = 1, 2, \ldots, Y_i$$

$$c_{ik} = y_{i,2,(k-Y_i)} \quad k = Y_i + 1, Y_i + 2, \ldots, 2Y_i$$

$$c_{ik} = y_{i,3,(k-2Y_i)} \quad k = 2Y_i + 1, 2Y_i + 2, \ldots, 3Y_i$$

$$\vdots$$

$$c_{ik} = y_{i,C_i,(k-(C_i-1)Y_i)} \quad k = (C_i - 1)Y_i + 1, (C_i - 1)Y_i + 2, \ldots, C_iY_i$$

If no code blocks are input to the channel coding ($C_i = 0$), no bits shall be output from the channel coding, i.e. $E_i = 0$.

4.2.4 Radio frame size equalisation

Radio frame size equalisation is padding the input bit sequence in order to ensure that the output can be segmented in F_i data segments of same size as described in the subclause 4.2.6.

The input bit sequence to the radio frame size equalisation is denoted by $c_{i1}, c_{i2}, c_{i3}, \ldots, c_{iE_i}$, where *i* is TrCH number and E_i the number of bits. The output bit sequence is denoted by $t_{i1}, t_{i2}, t_{i3}, \ldots, t_{iT_i}$, where T_i is the number of bits. The output bit sequence is derived as follows:

$t_{ik} = c_{ik}$, for k = 1… E_i and

$t_{ik} = \{0, 1\}$ for k= E_i +1… T_i, if $E_i < T_i$

where

$T_i = F_i * N_i$ and

$N_i = \lceil E_i / F_i \rceil$ is the number of bits per segment after size equalisation.

4.2.5 1st interleaving

The 1[st] interleaving is a block interleaver with inter-column permutations. The input bit sequence to the ~~1[st]~~ block interleaver is denoted by $x_{i,1}, x_{i,2}, x_{i,3}, \ldots, x_{i,X_i}$, where *i* is TrCH number and X_i the number of bits. ~~(at this stage~~ Here X_i is ~~assumed and~~ guaranteed to be an integer multiple of the number of radio frames in the TTI~~)~~. The output bit sequence from the block interleaver is derived as follows:

1) select the number of columns C1 from table 4~~;~~ depending on the TTI. The columns are numbered 0, 1, …, C1 - 1 from left to right.

2) determine the number of rows of the matrix, R1 defined as

~~–~~R1 = ~~X_I~~ X_i / C1.~~;~~

The rows of the matrix are numbered 0, 1, …, R1 - 1 from top to bottom.

3) write the input bit sequence into the R1 × C1 ~~rectangular~~ matrix row by row starting with bit $x_{i,1}$ in ~~the first~~ column 0 of ~~the first~~ row 0 and ending with bit ~~$x_{i,(R1 \times C1)}$~~ $x_{i,(\mathrm{R1} \times \mathrm{C1})}$ in column ~~C1~~ C1 - 1 of row ~~R1;~~ R1 – 1:

$$\begin{bmatrix} x_{i,1} & x_{i,2} & x_{i,3} & \ldots & x_{i,C1} \\ x_{i,(C1+1)} & x_{i,(C1+2)} & x_{i,(C1+3)} & \ldots & x_{i,(2\times C1)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ x_{i,((R1-1)\times C1+1)} & x_{i,((R1-1)\times C1+2)} & x_{i,((R1-1)\times C1+3)} & \ldots & x_{i,(R1\times C1)} \end{bmatrix}$$

4) Perform the inter-column permutation for the matrix based on the pattern $\langle P1_{C1}(j) \rangle_{j \in \{0,1,\ldots,C1-1\}}$ shown in table 4, where $P1_{C1}(j)$ is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by $y_{i,k}$:

$$\begin{bmatrix} y_{i,1} & y_{i,(R1+1)} & y_{i,(2\times R1+1)} & \ldots & y_{i,((C1-1)\times R1+1)} \\ y_{i,2} & y_{i,(R1+2)} & y_{i,(2\times R1+2)} & \ldots & y_{i,((C1-1)\times R1+2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{i,R1} & y_{i,(2\times R1)} & y_{i,(3\times R1)} & \ldots & y_{i,(C1\times R1)} \end{bmatrix}$$

5) Read the output bit sequence ~~$y_{i1}, y_{i2}, y_{i3}, \ldots, y_{i,(C1\times R1)}$~~ $y_{i,1}, y_{i,2}, y_{i,3}, \ldots, y_{i,(C1\times R1)}$ of the ~~1st~~ block interleaver~~ing~~ column by column from the inter-column permuted R1 × C1 matrix. Bit $y_{i,1}$ corresponds to ~~the first~~ row 0 of ~~the first~~ column 0 and bit $y_{i,(R1\times C1)}$ corresponds to row R1 - 1 of column C1 - 1.

~~The bits input to the 1st interleaving are denoted by $t_{i,1}, t_{i,2}, t_{i,3}, \ldots, t_{i,T_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{i,k} = t_{i,k}$ and $X_i = T_i$.~~

~~The bits output from the 1st interleaving are denoted by $d_{i,1}, d_{i,2}, d_{i,3}, \ldots, d_{i,T_i}$, and $d_{i,k} = y_{i,k}$~~

Table 4 Inter-column permutation patterns for 1st interleaving

TTI	Number of columns C1	Inter-column permutation patterns <$P1_{C1}(0)$, $P1_{C1}(1)$, …, $P1_{C1}(C1-1)$>
10 ms	1	<0>
20 ms	2	<0,1>
40 ms	4	<0,2,1,3>
80 ms	8	<0,4,2,6,1,5,3,7>

4.2.5.1 Relation between input and output of 1st interleaving

The bits input to the 1st interleaving are denoted by $t_{i,1}, t_{i,2}, t_{i,3}, \ldots, t_{i,T_i}$, where i is the TrCH number and T_i the number of bits. Hence, $x_{i,k} = t_{i,k}$ and $X_i = T_i$.

The bits output from the 1st interleaving are denoted by $d_{i,1}, d_{i,2}, d_{i,3}, \ldots, d_{i,T_i}$, and $d_{i,k} = y_{i,k}$.

end do

end if

A repeated bit is placed directly after the original one.

4.2.8 TrCH multiplexing

Every 10 ms, one radio frame from each TrCH is delivered to the TrCH multiplexing. These radio frames are serially multiplexed into a coded composite transport channel (CCTrCH).

The bits input to the TrCH multiplexing are denoted by $f_{i,1}, f_{i,2}, f_{i,3}, \ldots, f_{i,V_i}$, where i is the TrCH number and V_i is the number of bits in the radio frame of TrCH i. The number of TrCHs is denoted by I. The bits output from TrCH multiplexing are denoted by $s_1, s_2, s_3, \ldots, s_S$, where S is the number of bits, i.e. $S = \sum_i V_i$. The TrCH multiplexing is defined by the following relations:

$$s_k = f_{1,k} \qquad k = 1, 2, \ldots, V_1$$

$$s_k = f_{2,(k-V_1)} \qquad k = V_1+1, V_1+2, \ldots, V_1+V_2$$

$$s_k = f_{3,(k-(V_1+V_2))} \qquad k = (V_1+V_2)+1, (V_1+V_2)+2, \ldots, (V_1+V_2)+V_3$$

$$\vdots$$

$$s_k = f_{I,(k-(V_1+V_2+\ldots+V_{I-1}))} \qquad k = (V_1+V_2+\ldots+V_{I-1})+1, (V_1+V_2+\ldots+V_{I-1})+2, \ldots, (V_1+V_2+\ldots+V_{I-1})+V_I$$

4.2.9 Physical channel segmentation

When more than one PhCH is used, physical channel segmentation divides the bits among the different PhCHs. The bits input to the physical channel segmentation are denoted by $s_1, s_2, s_3, \ldots, s_S$, where S is the number of bits input to the physical channel segmentation block. The number of PhCHs is denoted by P.

The bits after physical channel segmentation are denoted $u_{p,1}, u_{p,2}, u_{p,3}, \ldots, u_{p,U_p}$, where p is PhCH number and U_p is the in general variable number of bits in the respective radio frame for each PhCH. The relation between s_k and $u_{p,k}$ is given below.

Bits on first PhCH after physical channel segmentation:

$$u_{1,k} = s_k \qquad k = 1, 2, \ldots, U_1$$

Bits on second PhCH after physical channel segmentation:

$$u_{2,k} = s_{(k+U_1)} \qquad k = 1, 2, \ldots, U_2$$

…

Bits on the P^{th} PhCH after physical channel segmentation:

$$u_{P,k} = s_{(k+U_1+\ldots+U_{P-1})} \qquad k = 1, 2, \ldots, U_P$$

4.2.10 2nd interleaving

The 2nd interleaving is a block interleaver and consists of bits input to a matrix with padding, the inter-column permutation for the matrix and bits output from the matrix with pruning. The 2nd interleaving can be applied jointly to all data bits transmitted during one frame, or separately within each timeslot, on which the CCTrCH is mapped. The selection of the 2nd interleaving scheme is controlled by higher layer.

4.2.10.1 Frame related 2nd interleaving

In case of frame related 2nd interleaving, the bits input to the ~~2nd~~ block interleaver are denoted by $x_1, x_2, x_3, \ldots, x_U$, where U is the total number of bits after TrCH multiplexing transmitted during the respective radio frame with $S = U = \sum_p U_p$.

The relation between x_k and the bits $u_{p,k}$ in the respective physical channels is given below:

$x_k = u_{1,k}$ $k = 1, 2, \ldots, U_1$

$x_{(k+U_1)} = u_{2,k}$ ~~k~~ $k = 1, 2, \ldots,$ ~~U2~~ U_2

…

$x_{(k+U_1+\ldots+U_{P-1})} = u_{P,k}$ ~~k~~ $k = 1, 2, \ldots,$ ~~UP~~ U_P

The following steps have to be performed once for each CCTrCH:

(1) ~~Set the number of columns~~Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

(2) Determine the number of rows of the matrix, R2, by finding minimum integer R2 such that:

~~U~~ $U \le$ R2 X C2.

The rows of rectangular matrix are numbered 0, 1, 2, …, R2 - 1 from top to bottom.

(3) Write ~~T~~the ~~bits~~ input bit sequence $x_1, x_2, x_3, \ldots, x_U$ ~~to the 2nd interleaving are written~~ into the R2 $\times$ C2 ~~rectangular~~ matrix row by row~~.~~ starting with bit y_1 in column 0 of row 0:

$$\begin{bmatrix} x_1 & x_2 & x_3 & \cdots & x_{30} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{60} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ x_{(R2-1)\times 30+1} & x_{(R2-1)\times 30+2} & x_{(R2-1)\times 30+3} & \cdots & x_{R2\times 30} \end{bmatrix} \begin{bmatrix} y_1 & y_2 & y_3 & \cdots & y_{C2} \\ y_{(C2+1)} & y_{(C2+2)} & y_{(C2+3)} & \cdots & y_{(2\times C2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{((R2-1)\times C2+1)} & y_{((R2-1)\times C2+2)} & y_{((R2-1)\times C2+3)} & \cdots & y_{(R2\times C2)} \end{bmatrix}$$

where $y_k = x_k$ for k = 1, 2, …, U and if R2 $\times$ C2 > U, the dummy bits are padded such that y_k = 0 or 1 for k = U + 1, U + 2, …, R2 $\times$ C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern ~~{P2 (j)} (j = 0, 1, …, C2-1)~~ $\langle P2(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, where P2(~~j~~j) is the original column position of the ~~j~~j-th permuted column. After permutation of the columns, the bits are denoted by ~~yk~~ y'_k.

$$\begin{bmatrix} y_1 & y_{R2+1} & y_{2\times R2+1} & \cdots & y_{29\times R2+1} \\ y_2 & y_{R2+2} & y_{2\times R2+2} & \cdots & y_{29\times R2+2} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{R2} & y_{2\times R2} & y_{3\times R2} & \cdots & y_{30\times R2} \end{bmatrix} \begin{bmatrix} y'_1 & y'_{(R2+1)} & y'_{(2\times R2+1)} & \cdots & y'_{((C2-1)\times R2+1)} \\ y'_2 & y'_{(R2+2)} & y'_{(2\times R2+2)} & \cdots & y'_{((C2-1)\times R2+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_{R2} & y'_{(2\times R2)} & y'_{(3\times R2)} & \cdots & y'_{(C2\times R2)} \end{bmatrix}$$

(5) The output of the ~~2nd~~ block interleav~~ing~~er is the bit sequence read out column by column from the inter-column permuted R2 $\times$ C2 matrix. The output is pruned by deleting dummy bits that were ~~not present~~padded ~~in~~to the

input ~~bit sequence~~of the matrix before the inter-column permutation, i.e. bits ~~y_k~~ y'_k that corresponds to bits ~~x_k~~ y_k with ~~k~~k > ~~U~~U are removed from the output. The bits after frame related 2nd interleaving are denoted by $v_1, v_2, \ldots, v_U$, where ~~v~~v_1 corresponds to the bit ~~y_k~~ y'_k with smallest index ~~k~~k after pruning, ~~v~~v_2 to the bit ~~y_k~~ y'_k with second smallest index ~~k~~k after pruning, and so on.

4.2.10.2 Timeslot related 2nd interleaving

In case of timeslot related 2nd interleaving, the bits input to the ~~2nd~~ block interleaver are denoted by $x_{t,1}, x_{t,2}, x_{t,3}, \ldots, x_{t,U_t}$, where t refers to a certain timeslot, and U_t is the number of bits transmitted in this timeslot during the respective radio frame.

In each timeslot t the relation between $x_{t,k}$ and $u_{t,p,k}$ is given below with ~~P_t~~P_t refering to the number of physical channels within the respective timeslot:

$$x_{t,k} = u_{t,1,k} \quad k = 1, 2, \ldots, U_{t1}$$

$$x_{t,(k+U_{t1})} = u_{t,2,k} \quad k = 1, 2, \ldots, U_{t2}$$

…

$$x_{t,(k+U_{t1}+\ldots+U_{t(P_t-1)})} = u_{t,P_t,k} \quad k = 1, 2, \ldots, U_{tP_t}$$

The following steps have to be performed for each timeslot t, on which the respective CCTrCH is mapped:

(1) ~~Set the number of columns~~Assign C2 = 30 to be the number of columns of the matrix. The columns of the matrix are numbered 0, 1, 2, …, C2 - 1 from left to right.

(2) Determine the number of rows of the matrix, R2, by finding minimum integer R2 such that:

~~U_t~~U_t ≤ R2 × C2.

The rows of rectangular matrix are numbered 0, 1, 2, …, R2 - 1 from top to bottom.

(3) Writhe ~~T~~the ~~bits~~ input bit sequence $x_{t,1}, x_{t,2}, x_{t,3}, \ldots, x_{t,U_t}$ ~~to the 2nd interleaving are written~~ into the R2 × C2 ~~rectangular~~ matrix row by row~~.~~ starting with bit $y_{t,1}$ in column 0 of row 0:

$$\begin{bmatrix} x_{t,1} & x_{t,2} & x_{t,3} & \ldots & x_{t,30} \\ x_{t,31} & x_{t,32} & x_{t,33} & \ldots & x_{t,60} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ x_{t,((R2-1)\times30+1)} & x_{t,((R2-1)\times30+2)} & x_{t,((R2-1)\times30+3)} & \ldots & x_{t,(R2\times30)} \end{bmatrix}$$

$$\begin{bmatrix} y_{t,1} & y_{t,2} & y_{t,3} & \ldots & y_{t,C2} \\ y_{t,(C2+1)} & y_{t,(C2+2)} & y_{t,(C2+3)} & \ldots & y_{t,(2\times C2)} \\ \vdots & \vdots & \vdots & \ldots & \vdots \\ y_{t,((R2-1)\times C2+1)} & y_{t,((R2-1)\times C2+2)} & y_{t,((R2-1)\times C2+3)} & \ldots & y_{t,(R2\times C2)} \end{bmatrix}$$

where $y_{t,k} = x_{t,k}$ for k = 1, 2, …, U_t and if R2 × C2 > U_t, the dummy bits are padded such that $y_{t,k}$ = 0 or 1 for $k = U_t + 1, U_t + 2$, …, R2 × C2. These dummy bits are pruned away from the output of the matrix after the inter-column permutation.

(4) Perform the inter-column permutation for the matrix based on the pattern ~~P2(j) (j = 0, 1, …, C2-1)~~ $\langle P2(j) \rangle_{j \in \{0,1,\ldots,C2-1\}}$ that is shown in table 7, where P2(~~j~~j) is the original column position of the j-th permuted column. After permutation of the columns, the bits are denoted by ~~$y_{t,k}$~~ $y'_{t,k}$.

$$\begin{bmatrix} y_{t,1} & y_{t,(R2+1)} & y_{t,(2R2+1)} & \cdots & y_{t,(29R2+1)} \\ y_{t,2} & y_{t,(R2+2)} & y_{t,(2R2+2)} & \cdots & y_{t,(29R2+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y_{t,R2} & y_{t,(2R2)} & y_{t,(3R2)} & \cdots & y_{t,(30R2)} \end{bmatrix} \begin{bmatrix} y'_{t,1} & y'_{t,(R2+1)} & y'_{t,(2R2+1)} & \cdots & y'_{t,((C2-1)R2+1)} \\ y'_{t,2} & y'_{t,(R2+2)} & y'_{t,(2R2+2)} & \cdots & y'_{t,((C2-1)R2+2)} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ y'_{t,R2} & y'_{t,(2R2)} & y'_{t,(3R2)} & \cdots & y'_{t,(C2R2)} \end{bmatrix}$$

(5) The output of the ~~2nd~~ block interleav~~ing~~er is the bit sequence read out column by column from the inter-column permuted R2 × C2 matrix. The output is pruned by deleting dummy bits that were ~~not present~~padded ~~in~~to the input ~~bit sequence~~of the matrix before the inter-column permutation, i.e. bits ~~$y_{t,k}$~~ $y'_{t,k}$ that corresponds to bits ~~$x_{t,k}$~~ $y_{t,k}$ with $k > U_t$ are removed from the output. The bits after time slot 2nd interleaving are denoted by $v_{t,1}, v_{t,2}, \ldots, v_{t,U_t}$, where $v_{t,1}$ corresponds to the bit ~~$y_{t,k}$~~ $y'_{t,k}$ with smallest index k after pruning, $v_{t,2}$ to the bit ~~$y_{t,k}$~~ $y'_{t,k}$ with second smallest index k after pruning, and so on.

Table 7 Inter-column permutation pattern for 2nd interleaving

Number of Columns ~~number~~ C2	Inter-column permutation pattern < P2(0), P2(1), …, P2(~~29~~C2-1) >
30	<0, 20, 10, 5, 15, 25, 3, 13, 23, 8, 18, 28, 1, 11, 21, 6, 16, 26, 4, 14, 24, 19, 9, 29, 12, 2, 7, 22, 27, 17>