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Channel Coding
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1. Reason for changes

Modification to table 3.

GSM Recommendation: 05.03

Title: CHANNEL CODING

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Number of pages: 22

Note: (tba) indicates a section to be added later.

Recommendation 05.03
CHANNEL CODING

1. SCOPE:

A reference configuration of the transmission chain is shown in Rec.05.01. According to this reference configuration, this recommendation specifies the data blocks given to the encryption unit.
It includes the specification of encoding, reordering, interleaving and the stealing flag. It does not specify the channel decoding method.

The definition is given for each kind of logical channel, starting from the data provided to the channel encoder by the speech coder, the data terminal equipment, or the controler of the MS or BS. The definitions of the logical channel types used in this recommendation are given in Rec.05.02, a summary is in annex 1.

2. GENERAL

2.1 GENERAL ORGANISATION:

Each channel has its own coding and interleaving scheme. However, the channel coding and interleaving is organised in order to have as much as possible a unified decoder structure.

Each channel uses, in this order, the following sequence of operations:

- The information bits are coded with a systematic block code, building words of information + parity bits.

- These information + parity bits are encoded with a convolutional code, building the coded bits.

- Reordering and interleaving the coded bits, and adding a stealing flag, gives the interleaved bits.

All those operations are made block by block, the size of which depends on the channel. However, most of the channels use at one point a common structure which is a block of 456 coded bits, interleaved and mapped onto bursts in a very similar way for all of them. Figure 1 gives a diagram showing the general structure of the channel coding.

This block of 456 coded bits is the basic structure of the channel coding scheme. In the case of speech TCH, this block carries the information of one speech frame. In case of control channels, it carries one message.

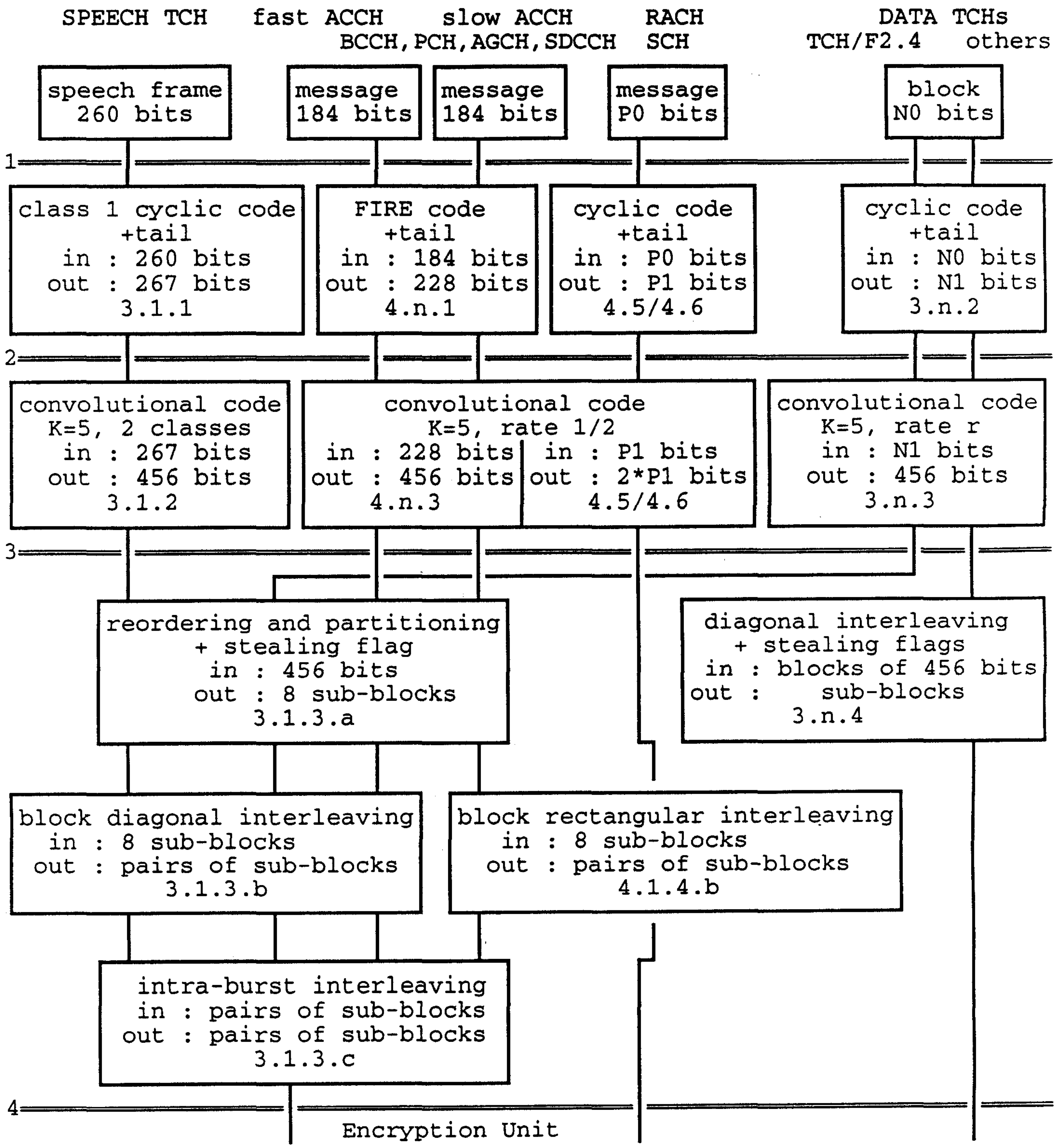

Figure 1: CHANNEL CODING AND INTERLEAVING ORGANIZATION
In the case of DATA TCHs. N0, N1. n depends on the type of data TCH.
In each box, the last line indicates the chapter defining the function.

Interface 1 : Information bits (d) 2 : Information + parity bits (u)
3 : coded bits (c) 4 : interleaved bits (e)

In the case of fast ACCH, such a block is stolen from the TCH, used for an ACCH message, and is inserted in the TCH interleaving stucture. Each block of 456 coded bits has in addition a stealing flag (8 bits), indicating if the block belongs to the TCH or to the fast ACCH. In case of slow ACCH, BCCH or CCCH, this stealing flag is dummy.

Some cases do not fit in the general organisation, and do not use the block of 456 coded bits. They are the random access messages of the RACH on uplink and the synchronisation information broadcast on the SCH.

2.2 Naming Convention

For ease of understanding a naming convention for bits is given for use throughout the recommendation :

- General naming
  "k" and "j" for numbering of bits in data blocks and bursts.

  "K_x" gives the amount of bits in one block, where "x" refers to the data type

  "n" is used for numbering of delivered data blocks where

  "N" marks a certain data block

  "B" is used for numbering of bursts or blocks where

  "B_0" marks the first burst or block carrying bits from the data block with n = 0 (first data block in the transmission)

- Data delivered to the encoding unit (interface 1 in fig. 1) :

  d (n, k) or d (k) for $k = 0,1,\ldots\ldots,K_d-1$
  $n = 0,1,\ldots\ldots,N,N+1,\ldots\ldots$

- Data after the first encoding step (block code, cyclic code ; interface 2 in fig. 1) :

  u(n,k) or u (k) for $k = 0,1,\ldots,K_u-1$
  $n = 0,1,\ldots,N,N+1,\ldots$

- Data after the second encoding step (convolutional code ; interface 3 in fig. 1) :

  c(n,k) or c(k) for $k = 0,1,\ldots\ldots,K_c-1$
  $n = 0,1,\ldots\ldots,N,N+1,\ldots$

- Interleaved data :

  i(B,k) for $k = 0,1,....,K_i-1$
  $B = B_0, B_0+1,....$

- Bits in one burst (interface 4 in fig. 1) :
  e(B,k) for $k = 0,1,......,114,115$
  $B = B_0, B_0 + 1,....$

3 TRAFFIC CHANNELS (TCH):

Two kinds of traffic channels are considered: speech and data. Both of them use the same general structure (see fig.1), and in both cases, a piece of information can be stolen by the fast ACCH.

3.1 Speech channel at full rate (TCH/FS):

The speech coder delivers to the channel encoder a sequence of blocks of data. In case of a full rate speech TCH, one block of data corresponds to one speech frame. Each block contains 260 information bits,including 182 bits of class 1 (protected bits), and 78 bits of class 2 (no protection), (see Tables 2 and 3)

The bits delivered by the speech codec are labeled {d(0), d(1),..., d(259)}, defined in the order of decreasing importance, as specified in 06.10.

3.1.1 Parity and tailing for a speech frame:

a) Parity bits:

The 50 first bits of class 1 are protected by three parity bits used for error detection. These parity bits are added to the 50 bits, according to a degenerate (shortened) cyclic code (53,50,2), using the generator polynomial:

$$g(D) = D^3 + D + 1$$

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

$$d(0)D^{52} + d(1)D^{51} + ... + d(49)D^3 + p(0)D^2 + p(1)D + p(2)$$

where p(0), p(1), p(2) are the parity bits, when divided by g(D), yields a remainder equal to $1 + D + D^2$

b) Tailing bits and reordering:

The information and parity bits of class 1 are reordered, defining 189 information + parity + tail bits of class 1, {u(0), u(1),..., u(188)} defined by:

$u(k) = d(2k)$ and $u(184-k) = d(2k+1)$ for $k=0,1,...,90$
$u(91+k) = p(k)$ for $k=0,1,2$
$u(k) = 0$ (tail bits) for $k=185, 186, 187, 188$

3.1.2 Convolutional encoder:

The class 1 bits are encoded with the 1/2 rate convolutional code defined by the polynomials:

$$G0 = 1 + D^3 + D^4$$
$$G1 = 1 + D + D^3 + D^4$$

The coded bits {c(0), c(1),..., c(455)} are then defined by:

- class 1 : $c(2k) = u(k) + u(k-3) + u(k-4)$
  $c(2k+1) = u(k) + u(k-1) + u(k-3) + u(k-4)$

  for $k=0,1,.....,188$ and $u(k)=0$ if $k<0$

- class 2 : $c(378+k) = d(182+k)$ for $k=0,1,....,77$

3.1.3 Interleaving

The coded bits are reordered and interleaved according to the following rule :

$i(B,j) = c(n,k)$

for $k = 0,1,....,455$

$n = 0,1,....,N,N+1,....$

$B = B_0 + 4. n + k \bmod (8)$

$j = 2[(49k) \bmod 57] + [(k \bmod 8) \text{ div } 4]$

The result of the interleaving is a distribution of the reordered 456 bits of a given data block, n=N, over 8 blocks using the even numbered bits of the first 4 blocks ($B = B_0 + 4N + 0,1,2,3$) and odd numbered bits of the last 4 blocks ($B = B_0 + 4 N + 4,5,6,7$). The reordered bits of the following data block, n = N+1, use the even numbered bits of the blocks $B = B_0 + 4 N + 4,5,6,7$ and the odd numbered bits of the blocks $B= B_0 + 4 (N+2) + 0,1,2,3$. Continuing with the next data blocks shows that one block always carries 57 bit of data from one data blocks (n =N) and 57 bit of data from the next block (n = N+1), where the bits from the data block with the higher number always are the even numbered data bits, else the odd numbered.

The block of coded data is interleaved "block diagonal", where a new data block starts every 4th block and is distributed over 8 blocks.

3.1.4 Mapping on a Burst

The mapping is given by the rule :

e(B,j) = i(B,j) and e(B, 59+j) = i(B,57 + j)
for j = 0,... 56

and

e(B,57) = hl(B) and e(B,58) = hu(B)

The two bits, labeled hl(B) and hu(B) on burst number B are flags used for indication of control channel signalling.

- hl(B) = 0 and hu(B) = 0 indicates, that all bits in burst B belong to a traffic channel frame.
- hu(B) = 1 indicates that all even numbered bits are used for signalling purposes.
- hl(B) = 1 indicates that all odd numbered bits are used for signalling purposes.

In a traffic channel these flags indicate stolen bits for signalling purposes (see section 4.2.5).

3.2 Speech channel at half rate (TCH/HS):

To be defined for a future evolution of the system.

3.3 Data channel at full rate, 9.6 kbit/s services:

The definition of a 12.0 kbit/s data flow for data services is given in Recommendation 04.21.

3.3.1 Interface with user unit:

The user unit delivers to the encoder a bit stream organised in blocks of 60 information bits (data frames) every 5 ms. Four such blocks are dealt with together in the coding process {d(0),...,d(239)}. For non-transparent services those four blocks will align with one 240-bit RLP frame.

3.3.2 Block code:

The block of 4 * 60 information bits is not encoded, but only increased with 4 tail bits equal to 0 at the end of the block.

u(k)=d(k) k=0,...,239
u(k)=0 k=240,...,243

3.3.3 Convolutional encoder:

This block of 244 bits {u(0),...,u(243)} is encoded with the punctured convolutional code of rate 1/2 defined by the following polynomials:

$G0 = 1 + D^3 + D^4$
$G1 = 1 + D + D^3 + D^4$

resulting in 488 coded bits {C(0), C(1),..., C(487)} with

$$C(2k) = u(k) + u(k-3) + u(k-4)$$
$$C(2k+1) = u(k) + u(k-1) + u(k-3) + u(k-4)$$
$$\text{for } k = 0,\ldots 243 \quad ; u(k)=0, K<0$$

The code is punctured in such a way that the following 32 coded bits:

{C(11 + 15j); j = 0,..,31} are not transmitted.

The result is a block of 456 coded bits, {c(0),..., c(455)}

3.3.4 Interleaving:

The coded bits are reordered and interleaved according to the following rule :

$$i(B,j) = c(n,k)$$

for $k = 0,\ldots.,455$

$n = 0,1,\ldots,N,N+1,\ldots.$

$B = Bo + 4n + k \bmod (19) + k \operatorname{div} 114$

$j = k \bmod (19) + 19 \ [k \bmod (6)]$

The result of the interleaving is a distribution of the reordered 114 bit of a given data block, n = N, over 19 blocks, 6 bits equally distributed in each block, in a diagonal way over consecutive blocks.

The block of coded data is interleaved "diagonal", where a new block of coded data starts with every block and is distributed over 19 blocks.

3.3.5 Mapping on a Burst

The mapping is done as specified for TCH/FS in section 3.1.4 On bitstealing by a FACCH, see section 4.2.5.

3.4 Data channel at full rate, 4.8 kbit/s services (TCH/F4.8):

The definition of a 6.0 kbit/s data flow for data services is given in Recommendation 04.21.

3.4.1 Interface with user unit:

The user unit delivers to the encoder a bit stream organised in blocks of 60 information bits (data frames) every 10 ms, {d(0),..., d(59)}.

3.4.2 Block code:

Sixten bits equal to 0 are added to the 60 information bits, the result being a block of 76 bits, {u(0),..., u(75)}, with:

u(19k+p) = d(15k+p) for k = 0,...,3 and p = 0,...,14;
u(19k+p) = 0 for k = 0,...,3 and p = 15,...,18.

Two such blocks forming a block of 152 bits {u'(0),...,u'(151)} are dealt with together in the rest of the coding process

u'(k) = u1(k) , k=0,..,75 (u1 = 1:st block)
u'(k+76) = u2(k) , k=0,..,75 (u2 = 2:nd block)

3.4.3 Convolutional encoder:

This block of 152 bits is encoded with the convolutional code of rate 1/3 defined by the following polynomials:

$G1 = 1 + D + D^3 + D^4$
$G2 = 1 + D^2 + D^4$
$G3 = 1 + D + D^2 + D^3 + D^4$

The result is a block of 3 * 152 = 456 coded bits, {c(0),...c(455)},

c(3k) = u'(k)+u'(k-1)+ u'(k-3)+u'(k-4)
c(3k+1) = u'(k)+ u'(k-2)+ u'(k-4)
c(3k+2) = u'(k)+u'(k-1)+u'(k-2)+u'(k-3)+u'(k-4)
for k = 0,...,151 ; u'(k)=0, k<0

3.4.4 Interleaving:

The interleaving is done as specified for the TCH/F.9.6 in section 3.3.4

3.4.5 Mapping on a Burst

The mapping is done as specified for the TCH/FS in section 3.1.4. On bitstealing for signalling purposes by a FACCH, see section 4.2.5.

3.5 Data channel at half rate, 4.8 kbit/s services (TCH/H4.8):

The definition of a 6.0 kbit/s data flow for data services is given in Recommendation 04.21.

3.5.1 Interface with user unit:

The user unit delivers to the encoder a bit stream organised in blocks of 60 information bits (data frames) every 10 ms. Four such blocks are dealt with together in the coding process {d(0),...,d(239)}.

For non transparent services those four blocks shall align with one complete 240-bit RLP frame.

3.5.2 Block code:

The block encoding is done as specified for the TCH/F9.6 in section 3.3.2.

3.5.3 Convolutional encoder:

The convolutional encoding is done as specified for the TCH/F9.6 in section 3.3.3.

3.5.4 Interleaving:

The interleaving is done as specified for the TCH/F9.6 in section 3.3.4.

3.5.5 Mapping on a Burst

The mapping is done as specified for the TCH/FS in section 3.1.4. On bitstealing for signalling purposes by a FACCH, see section 4.2.5.

3.6 Data channel at full rate, 2.4 kbit/s and less services (TCH/F2.4):

The definition of a 3.6 kbit/s data flow for data services is given in Recommendation 04.21.

3.6.1 Interface with user unit:

The user unit delivers to the encoder a bit stream organised in blocks of 36 information bits (data frames) every 10 ms. Two such blocks are dealt with together in the coding process{d(0),...,d(71)}.

3.6.2 Block code:

This block of 72 information bits is not encoded, but only increased with four tail bits equal to 0 at the end of the block.

$$u(k) = d(k) \quad , k= 0,\ldots,71$$
$$u(k) = 0 \quad , k=72,\ldots,75$$

3.6.3 Convolutional encoder:

This block of 76 bits {u(0),...u(75)} is encoded with the convolutional code of rate 1/6 defined by the following polynomials:

$$G1 = 1 + D + D^3 + D^4$$
$$G2 = 1 + D^2 + D^4$$
$$G3 = 1 + D + D^2 + D^3 + D^4$$
$$G1 = 1 + D + D^3 + D^4$$
$$G2 = 1 + D^2 + D^4$$
$$G3 = 1 + D + D^2 + D^3 + D^4$$

The result is a block of 456 coded bits : {c(0), c(1),...,c(455)}, defined by

$$c(6k) = c(6k+3) = u(k)+u(k-1)+u(k-3)+u(k-4)$$
$$c(6k+1) = c(6k+4) = u(k)+u(k-2)+u(k-4)$$
$$c(6k+2) = c(6k+5) = u(k)+u(k-1)+u(k-2)+u(k-3)+u(k-4)$$
$$\text{for} \quad k = 0,\ldots,75 \quad ; \quad u(k) = 0,\ k<0$$

3.6.4 Interleaving:

The interleaving is done as specified for the TCH/FS in section 3.1.3

3.6.5 Mapping on a Burst

The mapping is done as specified for the TCH/FS in section 3.1.4.

3.7 Data channel at half rate, ≤2.4 kbit/s services (TCH/H2.4):

The definition of a 3.6 kbit/s data flow for data services is given in Recommendation 04.21

3.7.1 Interface with user unit:

The user unit delivers to the encoder a bit stream organised in blocks of 36 information bits (data frames) every 10 ms. Two such blocks are dealt with together in the coding process, {d(0),...,d(71)}.

3.7.2 Block code:

The block of 72 information bits is not encoded, but only increased with 4 tail bits equal to 0, at the end of the block.

Two such blocks forming a block of 152 bits {u(0),...,u(151)} are dealt with together in the rest of the coding process.

u(k) = d1(k) , k=0,...,75 (d1 = 1:st information block)
u(k+76) = d2(k) , k=0,...,75 (d2 = 2:nd information block)
u(k) = 0 , k=72,...,75,148,...,151

3.7.3 Convolutional encoder:

The convolutional encoding is done as specified for the TCH/F4.8 in section 3.4.3.

3.7.4 Interleaving:

The interleaving is done as specified for the TCH/F4.8 in section 3.4.4.

3.7.5 Mapping on a Burst

The mapping is done as specified for the TCH/FS in section 3.1.4. On bit stealing for signalling purposes by a FACCH, see section 4.2.5.

4. CONTROL CHANNELS :

4.1 Slow associated control channel (SACCH):

4.1.1 Block constitution:

The message delivered to the encoder has a fixed size of 184 information bits {d(0),...,d(183)}. It is delivered on a burst mode.

4.1.2 Block code:

The block of 184 information bits is encoded, using a shortened binary cyclic code (FIRE code), with the following generator polynomial :

$$g(D) = (D^{23} + 1).(D^{17} + D^{3} + 1)$$

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

$$u(0).D^{223} + u(1).D^{222} + ... + u(222).D + u(223)$$

where {u(0), u(1),..., u(183)} are the information bits (u(k)=d(k), k=0,...,183) and {u(184), u(185),..., u(223)} are the parity bits (u(k+184)=p(k), k=0,...,39), when divided by g(D) yields a remainder equal to $1 + D + D^2 + \ldots + D^{39}$.

The result is a block of 224 bits, completed by 4 tail bits equal to 0 at the end of the block : {u(0), u(1),...,u(223)}, with u(224) to u(227) equal to 0.

4.1.3 Convolutional encoder:

This block of 228 bits is encoded with the 1/2 rate convolutional code (identical to the one used for TCH/FS) defined by the polynomials:

$$G0 = 1 + D^3 + D^4$$
$$G1 = 1 + D + D^3 + D^4$$

This results in a block of 456 coded bits : {c(0),...,c(455)} defined by

$$c(2k) = u(k) + u(k-3) + u(k-4)$$
$$c(2k+1) = u(k) + u(k-1) + u(k-3) + u(k-4)$$
$$\text{for } k = 0,\ldots,227 \;;\quad u(k)=0,\ k<0$$

4.1.4 Interleaving:

The coded bits are reordered and interleaved according to the following rule

$$i(B,j) = c(n,k)$$

$$\text{for } k = 0,1\ldots\ldots,455$$

$$n = 0,1\ldots\ldots,N,N+1,\ldots.$$

$$B = B_0 + 4 \cdot n + k \bmod (4)$$

$$j = 2\,[\,(49k) \bmod 57\,] + [\,(k \bmod 8) \operatorname{div} 4\,]$$

The result of the reordering of bits is the same as given for a TCH/FS (section 3.1.3) as can be seen from the evaluation of the bit number-index j, distributing the 456 bits over 4 blocks on even numbered bits and 4 blocks on odd numbered bits. The resulting 4 blocks are built by putting blocks with even numbered bits and blocks with odd numbered bits together into one block.

The block of coded data is interleaved "block rectangular" where a new data block starts every 4th block and is distributed over 4 blocks.

4.1.5 Mapping on a Burst

The mapping is given by the rule

$e(B,j) = i(B,j)$ and $e(B,59+j) = i(B,57+j)$ for $j = 0,...,56$

and

$e(B,57) = hl(B)$ and $e(B,58) = hu(B)$

The two bits labeled hl(B) and hu(B) on burst number B are flags used for indication of control channel signalling. They are set to "1" for a SACCH.

4.2 Fast associated control channel (FACCH):

4.2.1 Block constitution:

The message delivered to the encoder has a fixed size of 184 information bits. It is delivered on a burst mode.

4.2.2 Block code:

The block encoding is done as specified for the SACCH in section 4.1.2.

4.2.3 Convolutional encoder :

The convolutional encoding is done as specified for the SACCH in section 4.1.3.

4.2.4 Interleaving:

The interleaving is done as specified for the TCH/FS in section 3.1.3.

4.2.5 Mapping on a Burst

A FACCH frame of 456 coded bits is mapped on 8 consecutive bursts as specified for the TCH/FS in section 3.1.4. As a FACCH is transmitted on bits which are stolen in a burst from the traffic channel, the even numbered bits in the first 4 bursts and the odd numbered bits of the last 4 bursts are stolen.

To indicate this to the receiving device the flags hl(B) and hu(B) have to be set according to the following rule :

hu(B) = 1 for the first 4 burst
(even numbered bits are stolen)

hl(B) = 1 for the last 4 bursts
(odd numbered bits are stolen)

The consequences of this bitstealing by a FACCH is for a

- speech channel (TCH/FS) and data channel (TCH/F2.4) : One full frame of data is stolen by the FACCH.

- data channels with 114 coded bits (TCH/F9.6 and TCH/H4.8) :
  The bitstealing by a FACCH disturbs 3 bit belonging to the same data block in each of the 8 disturbed bursts. Thus a maximum of 24 bit of one data block may be disturbed.

  - Data channels with 228 coded bits (TCH/F4.8 and TCH/H2.4) :

    The bitstealing by a FACCH disturbs in the worst case 6 bit belonging to the same data block in each of the 8 disturbed bursts. Thus a maximum of 48 bit belonging to one data block may be disturbed.

4.3 Broadcast, Paging and Access grant channels (BCCH, PCH, AGCH):

The coding scheme used for the broadcast, paging and access grant messages is the same as for the SACCH messages, specified in 4.1.

4.4 Stand-alone dedicated control channel:

The coding scheme used for the dedicated control channel messages is the same as for SACCH messages, specified in 4.1.

4.5 Random access channel (RACH):

The burst carrying the random access uplink message has a different structure. It contains 8 information bits d(0),...,d(7).

Six parity bits p(0) to p(5) are defined in such a way that in GF(2) the binary polynomial $d(0)D^{13} + ... + d(7)D^6 + p(0)D^5 + ... + p(5)$, when divided by $D^6+D^5+D^3+D^2+D+1$ yields a remainder equal to $D^5+D^4+D^3+D^2+D+1$.

The six bits of the BSIC, B(0) to B(5), of the BS to which the Random Access is intended, are added bitwise modulo 2 to the six parity bits. P(0) to P(5). This results in six colour bits, C(0) to C(5) defined as C(k) = b(k) + p(k) (k= 0 to 5) where

b(0) = MSB of PLMN colour code
b(5) = LSB of BS colour code.

This defines {u(0), ..., u(17)} by:

u(k) = d(k) (k = 0 to 7)
u(8+k) = c(k) (k = 0 to 5)
u(14+k) = 0 (k = 0 to 3) (tail bits)

The bits {e(0), .., e(35)} are obtained by the same convolutional code of rate 1/2 as for TCH/FS, defined by the polynomials:

$G0 = 1 + D^3 + D^4$
$G1 = 1 + D + D^3 + D^4$

and with

e(2k) = u(k)+ u(k-3)+u(k-4)
e(2k+1) = u(k)+u(k-1)+u(k-3)+u(k-4)
for k = 0, ...,17 ; u(k)=0, k<0

4.6 Synchronisation channel (SCH):

The burst carrying the synchronisation information on the downlink BCCH has a different structure. It contains 25 information bits {d(0), ..., d(24)}, 10 parity bits {p(0),..., p(9)} and 4 tail bits. The precise ordering of the information bits is given in Rec. 04.08, Section 9.1.28 ("Synchronization channel informaion")

The ten parity bits p(0) to p(9) are defined in such a way that in GF(2) the binary polynomial $d(0)D^{34} +...+ d(24)D^{10} + p(0)D^9 +...+ p(9)$, when divided by $D^{10}+D^8+D^6+D^5+D^4+D^2+1$ yields a remainder equal to $D^9+D^8+D^7+D^6+D^5+D^4+D^3+D^2+D+1$.

Thus the encoded bits {u(0),..., u(38)} are:

u(k) = d(k) (k = 0 to 24)
u(25+k) = p(k) (k = 0 to 9)
u(35+k) = 0 (k = 0 to 3) (tail bits)

The bits {e(0),..., e(77)} are obtained by the same convolutional code of rate 1/2 as for TCH/FS, defined by the polynomials:

$G0 = 1 + D^3 + D^4$
$G1 = 1 + D + D^3 + D^4$
and with
e(2k) = u(k)+ u(k-3)+u(k-4)
e(2k+1) = u(k)+u(k-1)+u(k-3)+u(k-4)
for k = 0,....,77 ; u(k)=0, k<0

4.7 Handover Access Burst
The encoding of this burst is as defined in section 4.5 for the random access channel (RACH). The BSIC used shall be the BSIC of the BS to which the HO is done.

TABLE 1: REORDERING AND PARTITIONING A CODED BLOCK INTO 8 SUBBLOCKS

j =	0	1	2	3	4	5	6	7
i = 0	k = 0	57	114	171	228	285	342	399
	64	121	178	235	292	349	406	7
	128	185	242	299	356	413	14	71
	192	249	306	363	420	21	78	135
	256	313	370	427	28	85	142	199
5	320	377	434	35	92	149	206	263
	384	441	42	99	156	213	270	327
	448	49	106	163	220	277	334	391
	56	113	170	227	284	341	398	455
	120	177	234	291	348	405	6	63
10	184	241	298	355	412	13	70	127
	248	305	362	419	20	77	134	191
	312	369	426	27	84	141	198	255
	376	433	34	91	148	205	262	319
	440	41	98	155	212	269	326	383
15	48	105	162	219	276	333	390	447
	112	169	226	283	340	397	454	55
	176	233	290	347	404	5	62	119
	240	297	354	411	12	69	126	183
	304	361	418	19	76	133	190	247
20	368	425	26	83	140	197	254	311
	432	33	90	147	204	261	318	375
	40	97	154	211	268	325	382	439
	104	161	218	275	332	389	446	47
	168	225	282	339	396	453	54	111
25	232	289	346	403	4	61	118	175
	296	353	410	11	68	125	182	239
	360	417	18	75	132	189	246	303
	424	25	82	139	196	253	310	367
	32	89	146	203	260	317	374	431
30	96	153	210	267	324	381	438	39
	160	217	274	331	388	445	46	103
	224	281	338	395	452	53	110	167
	288	345	402	3	60	117	174	231
	352	409	10	67	124	181	238	295
35	416	17	74	131	188	245	302	359
	24	81	138	195	252	309	366	423
	88	145	202	259	316	373	430	31
	152	209	266	323	380	437	38	95
	216	273	330	387	444	45	102	159
40	280	337	394	451	52	109	166	223
	344	401	2	59	116	173	230	287
	408	9	66	123	180	237	294	351
	16	73	130	187	244	301	358	415
	80	137	194	251	308	365	422	23
45	144	201	258	315	372	429	30	87
	208	265	322	379	436	37	94	151
	272	329	386	443	44	101	158	215
	336	393	450	51	108	165	222	279
	400	1	58	115	172	229	286	343
50	8	65	122	179	236	293	350	407
	72	129	186	243	300	357	414	15
	136	193	250	307	364	421	22	79
	200	257	314	371	428	29	86	143
	264	321	378	435	36	93	150	207
55	328	385	442	43	100	157	214	271
56	392	449	50	107	164	221	278	335

TABLE 2: ENCODER OUTPUT PARAMETERS IN ORDER OF OCCURANCE AND BIT ALLOCATION WITHIN THE SPEECH FRAME OF 260 BITS/20 ms

	Parameter number	Parameter name	Var. name	Number of bits	Bit number LSB-MSB
Filter Parameters	1	Log. area ratios 1 - 8	LAR 1	6	1 - 6
	2		LAR 2	6	7 - 12
	3		LAR 3	5	13 - 17
	4		LAR 4	5	18 - 22
	5		LAR 5	4	23 - 26
	6		LAR 6	4	27 - 30
	7		LAR 7	3	31 - 33
	8		LAR 8	3	34 - 36
Sub-frame no 1.					LSB-MSB
LTP Parameters	9	LTP lag	N_1	7	37 - 43
	10	LTP gain	b_1	2	44 - 45
RPE Parameters	11	RPE grid position	M_1	2	46 - 47
	12	Block amplitude	x_{max1}	6	48 - 53
	13	RPE-pulse no. 1	$x_1(0)$	3	54 - 56
	14	RPE-pulse no. 2	$x_1(1)$	3	57 - 59
	..	..			....
	25	RPE-pulse no. 13	$x_1(12)$	3	90 - 92
Sub-frame no 2.					LSB-MSB
LTP Parameters	26	LTP lag	N_2	7	93 - 99
	27	LTP gain	b_2	2	100 - 101
RPE Parameters	28	RPE grid position	M_2	2	102 - 103
	29	Block amplitude	x_{max2}	6	104 - 109
	30	RPE-pulse no. 1	$x_2(0)$	3	110 - 112
	31	RPE-pulse no. 2	$x_2(1)$	3	113 - 115
	..	..			....
	42	RPE-pulse no. 13	$x_2(12)$	3	146 - 148
Sub-frame no 3.					LSB-MSB
LTP Parameters	43	LTP lag	N_3	7	149 - 155
	44	LTP gain	b_3	2	156 - 157
RPE Parameters	45	RPE grid position	M_3	2	158 - 159
	46	Block amplitude	x_{max3}	6	160 - 165
	47	RPE-pulse no. 1	$x_3(0)$	3	166 - 168
	48	RPE-pulse no. 2	$x_3(1)$	3	169 - 171
	..	..			....
	59	RPE-pulse no. 13	$x_3(12)$	3	202 - 204
Sub-frame no 4.					LSB-MSB
LTP Parameters	60	LTP lag	N_4	7	205 - 211
	61	LTP gain	b_4	2	212 - 213
RPE Parameters	62	RPE grid position	M_4	2	214 - 215
	63	Block amplitude	x_{max4}	6	216 - 221
	64	RPE-pulse no. 1	$x_4(0)$	3	222 - 224
	65	RPE-pulse no. 2	$x_4(1)$	3	225 - 227
	..	..			....
	76	RPE-pulse no. 13	$x_4(12)$	3	258 - 260

TABLE 3
SUBJECTIVE IMPORTANCE OF ENCODED BITS
(Parameter names and bit indices refer to table 2)

Importance class	Parameter name	Parameter number	Bit	Label	Class
1	Log area ratio 1	1	5	d0	
	block amplitude	12, 29, 46, 63	5	d1, d2, d3, d4	
2	Log area ratio 1	1	4		
	Log area ratio 2	2	5		
	Log area ratio 3	3	4		
3	Log area ratio 1	1	3		
	Log area ratio 2	2	4		
	Log area ratio 3	3	3		1
	Log area ratio 4	4	4		
	LTP lag	9, 26, 43,60	6		
	Block amplitude	12, 29, 46, 63	4		
	Log area ratio 2,5,6	2, 5, 6	3		
	LTP lag	9, 26, 43, 60	5		
	LTP lag	9, 26, 43, 60	4		
	LTP lag	9, 26, 43, 60	3		
	LTP lag	9, 26, 43, 60	2		
4	Block amplitude	12, 29, 46, 63	3		
	Log area ratio 1	1	2		
	Log area ratio 4	4	3		
	Log area ratio 7	7	2		
	LTP lag	9, 26, 43, 60	1	...d48, d49	
	Log area ratio 5,6	5, 6	2	d50...	
	LTP gain	10, 27, 44, 61	1		
	LTP lag	9, 26, 43, 60	0		
	Grid position	11, 28, 45, 62	1		
5	Log area ratio 1	1	1		
	Log area ratio 2, 3, 8, 4	2, 3, 8, 4	2		
	Log area ratio 5, 7	5, 7	1		
	LTP gain	10, 27, 44, 61	0		
	Block amplitude	12, 29, 46, 63	2		1
	RPE pulses	13..25	2		
	RPE pulses	30..42	2		
	RPE pulses	47..59	2		
	RPE pulses	64..76	2		
	Grid position	11, 28, 45, 62	0		
	Block amplitude	12, 29, 46, 63	1		
	RPE pulses	13..25	1		
	RPE pulses	30..42	1		
	RPE pulses	47..59	1		
	RPE pulses	64..67	1	...d181	
	RPE pulses	68..76	1	d182	
6	Log area ratio 1	1	0		
	Log area ratio 2, 3, 6	2, 3, 6	1		
	Log area ratio 7	7	0		
	Log area ratio 8	8	1		
	Log area ratio 8, 3	8, 3	0		2
	Log area ratio 4	4	1		
	Log area ratio 4, 5	4, 5	0		
	Block amplitude	12, 29, 46, 63	0		
	RPE pulses	13..25	0		
	RPE pulses	30..42	0		
	RPE pulses	47..59	0		
	RPE pulses	64..76	0		
	Log area ratio 2, 6	2,6	0		

ANNEX 1
SUMMARY OF CHANNEL TYPES

TCH/FS : full rate speech trafic channel
TCH/F9.6: 9.6 kbit/s full rate data traffic channel
TCH/F4.8: 4.8 kbit/s full rate data traffic channel
TCH/H4.8: 4.8 kbit/s half rate data traffic channel
TCH/F2.4: ≤ 2.4 kbit/s full rate data traffic channel
TCH/H2.4: ≤ 2.4 kbit/s half rate data traffic channel

SACCH : slow associated control channel
FACCH : fast associated control channel
SDCCH : stand-alone dedicated control channel
BCCH : broadcast control channel
PCH : paging channel
AGCH : access grant channel
RACH : random access channel
SCH : synchronisation channel

NOTE :

With respect to Recs 05.01 and 05.02 the subcategories of channels(eg. FACCH/F, FACCH/H,...) are not distinguished since they use the same coding scheme as the main channel type.

ANNEX 2
SUMMARY OF POLYNOMIALS USED FOR CONVOLUTIONAL CODES

$G0 = 1 + D^3 + D^4$	TCH/FS, TCH/F9.6, TCH/H4.8, SDCCH, BCCH, PCH, SACCH, FACCH, AGCH, RACH, SCH
$G1 = 1 + D + D^3 + D^4$	TCH/FS, TCH/F9.6, TCH/H4.8, SACCH, FACCH, SDCCH, BCCH, PCH, AGCH, RACH, SCH, TCH/F4.8, TCH/F2.4, TCH/H2.4
$G2 = 1 + D^2 + D^4$	TCH/F4.8, TCH/F2.4, TCH/H2.4
$G3 = 1 + D + D^2 + D^3 + D^4$	TCH/F4.8, TCH/F2.4, TCH/H2.4

ANNEX 3
EXAMPLES

Several examples are given for different channels. In each case, the blocks of information bits are chosen as follows :

{u(0),u(1),........} is defined by :

$u(k)=1$ for $k \in [0,8]$
$u(k)= u(k-5) + u(k-9)$ for $k \in [9,\infty]$

1. Speech TCH:

An example is given on the following page for a speech TCH, with x_1=182 bits in class 1 and x_2=78 bits in class 2.

The content of two consecutive speech frames A and B, chosen at random as explained above, is processed as explained in 3.1, and the four bursts which are in common with those two speech frames are presented :

```
            | B0 B1 B2 B3 B4 B5 B6 B7 |   speech frame B

| A0 A1 A2 A3 A4 A5 A6 A7 |               speech frame A
              ^  ^  ^  ^
```

4 bursts common to frame A and B

In the burst description, the label PR represents the 26 bits of preamble. The stealing flags of both frames are set to 0(=00000000).

The tail bits (two 0 at each end of a burst) are represented.