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Digital cellular telecommunications system (Phase 2) (GSM); Channel coding (GSM 05.03 version 4.5.1)

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Digital cellular telecommunications system (Phase 2); Channel coding (GSM 05.03 version 4.5.1)

ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
X.400: c=fr, a=atlas, p=etsi, s=secretariat - **Internet:** secretariat@etsi.fr

Tel.: +33 4 92 94 42 00 - Fax: +33 4 93 65 47 16

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Foreword

This fourth edition European Telecommunication Standard (ETS) has been produced by the Special Mobile Group (SMG) of the European Telecommunications Standards Institute (ETSI).

This ETS specifies the channel coding of used within the digital cellular telecommunications system (Phase 2).

The specification from which this ETS has been derived was originally based on CEPT documentation, hence the presentation of this ETS may not be entirely in accordance with the ETSI/PNE Rules.

Transposition dates	
Date of adoption of this ETS:	5 December 1997
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1 Scope

A reference configuration of the transmission chain is shown in GSM 05.01. According to this reference configuration, this European Telecommunication Standard (ETS) 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 controller of the MS or BS. The definitions of the logical channel types used in this technical specification are given in GSM 05.02, a summary is in annex 1.

1.2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

[1] GSM 01.04 (ETR 100): "Digital cellular telecommunications system (Phase 2); Abbreviations and acronyms".

[2] GSM 04.08 (ETS 300 557): "Digital cellular telecommunications system (Phase 2); Mobile radio interface layer 3 specification".

[3] GSM 04.21 (ETS 300 562): "Digital cellular telecommunications system (Phase 2); Rate adaption on the Mobile Station - Base Station System (MS - BSS) Interface ".

[4] GSM 05.01 (ETS 300 573): "Digital cellular telecommunications system (Phase 2); Physical layer on the radio path; General description".

[5] GSM 05.02 (ETS 300 574): "Digital cellular telecommunications system (Phase 2); Multiplexing and multiple access on the radio path".

[6] GSM 05.05: (ETS 300 577): "Digital cellular telecommunications system (Phase 2); Radio transmission and reception".

[7] GSM 06.10 (ETS 300 580-2): "Digital cellular telecommunications system (Phase 2); Full rate speech transcoding".

[8] GSM 06.20 (ETS 300 581-2): "Digital cellular telecommunications system; Half rate speech Part 2: Half rate speech transcoding".

[9] GSM 06.60 (prEN 301 245): "Digital cellular telecommunications system (Phase 2); Enhanced Full Rate (EFR) speech transcoding".

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1.3 Definitions and abbreviations

Abbreviations used in this ETS are listed in GSM 01.04.

2 General

2.1 General Organization

Each channel has its own coding and interleaving scheme. However, the channel coding and interleaving is organized in such a way as to allow, as much as possible, a unified decoder structure.

Each channel uses the following sequence and order 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 these operations are made block by block, the size of which depends on the channel. However, most of the channels use a block of 456 coded bits which is 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 full rate speech TCH, this block carries the information of one speech frame. In case of control channels, it carries one message.

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In the case of half rate speech TCH, the information of one speech frame is carried in a block of 228 coded bits.

In the case of the Enhanced full rate speech the information bits coming out of the source codec first go though a preliminary channel coding. Then the channel coding as described above takes place.

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In the case of FACCH, a coded message block of 456 bits is divided into eight sub-blocks. The first four sub-blocks are sent by stealing the even numbered bits of four timeslots in consecutive frames used for the TCH. The other four sub-blocks are sent by stealing the odd numbered bits of the relevant timeslot in four consecutive used frames delayed 2 or 4 frames relative to the first frame. Along with each block of 456 coded bits there is, in addition, a stealing flag (8 bits), indicating whether the block belongs to the TCH or to the FACCH. In the case of SACCH, BCCH or CCCH, this stealing flag is dummy.

Some cases do not fit in the general organization, and use short blocks of coded bits which are sent completely in one timeslot. They are the random access messages of the RACH on uplink and the synchronization information broadcast of the SCH on downlink.

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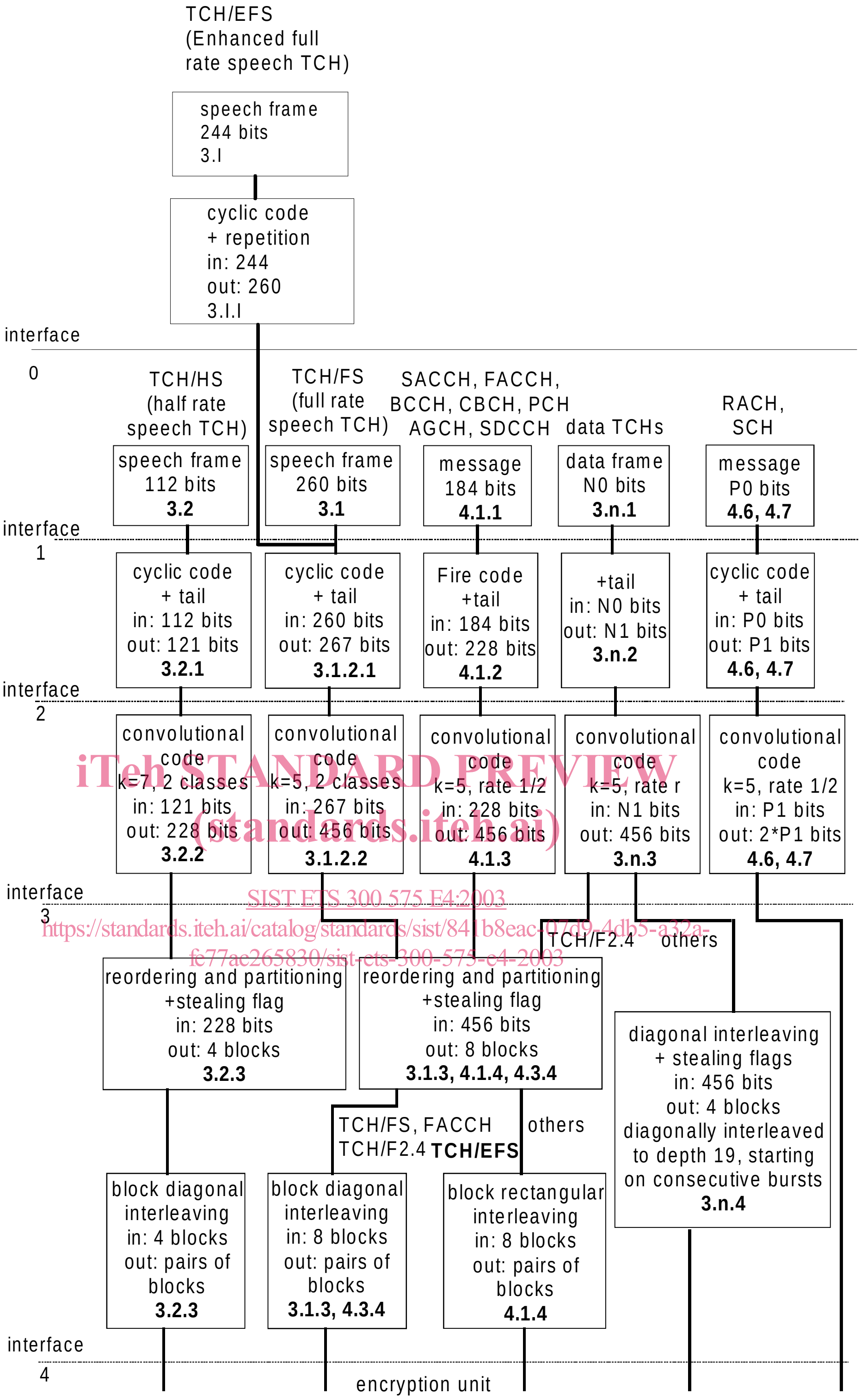

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Figure 1: Channel Coding and Interleaving Organization

In each box, the last line indicates the chapter defining the function. In the case of RACH, P0=8 and P1=18; in the case of SCH, P0=25 and P1=39. In the case of data TCHs, N0, N1 and n depend on the type of data TCH.

Interfaces:

1) information bits (d);
2) information + parity + tail bits (u);
3) coded bits (c);
4) interleaved bits (e).

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2.2 Naming Convention

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

- 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 preliminary channel encoding unit (for EFR only):

  s(k) for k = 1..., K_s

- Data delivered by the preliminary channel encoding unit (for EFR only) before bits rearrangement

  w(k) for k = 1..., K_w

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

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  d(k) for k = 0,1,...,K_d - 1

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

  u(k) for k = 0,1,...,K_u - 1

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

  c(n,k) or c(k) for k = 0,1,...,K_c - 1
  n = 0,1,...,N,N + 1,...

- 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 figure 1):

  e(B,k) for k = 0,1,...,114,115
  B = B_0, B_0 + 1,....

3 Traffic Channels (TCH)

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

3.1 Speech channel at full rate (TCH/FS and TCH/EFS)

The speech coder (whether Full rate or Enhanced full rate) delivers to the channel encoder a sequence of blocks of data. In case of a full rate and enhanced full rate speech TCH, one block of data corresponds to one speech frame.

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For the full rate coder each block contains 260 information bits, including 182 bits of class 1 (protected bits), and 78 bits of class 2 (no protection), (see table 2).

The bits delivered by the speech coder are received in the order indicated in GSM 06.10 and have to be rearranged according to table 2 before channel coding as defined in subclauses 3.1.1 to 3.1.4. The rearranged bits are labelled {d(0),d(1),...,d(259)}, defined in the order of decreasing importance.

For the EFR coder each block contains 244 information bits. The block of 244 information bits, labelled s(1).., s(244), passes through a preliminary stage, applied only to EFR (see figure 1) which produces 260 bits corresponding to the 244 input bits and 16 redundancy bits. Those 16 redundancy bits correspond to 8 CRC bits and 8 repetition bits, as described in subclause 3.1.1. The 260 bits, labelled w(1)..w(260), have to be rearranged according to table 7 before they are delivered to the channel encoding unit which is identical to that of the TCH/FS. The 260 bits block includes 182 bits of class 1(protected bits) and 78 bits of class 2 (no protection). The class 1 bits are further divided into the class 1a and class 1b, class 1a bits being protected by a cyclic code and the convolutional code whereas the class 1b are protected by the convolutional code only.

3.1.1 Preliminary channel coding for EFR only

3.1.1.1 CRC calculation

An 8-bit CRC is used for error-detection. These 8 parity bits (bits w253-w260) are generated by the cyclic generator polynomial: $g(D) = D^8 + D^4 + D^3 + D^2 + 1$ from the 65 most important bits (50 bits of class 1a and 15 bits of class 1b). These 65 bits *(b(1)-b(65))* are taken from the table 5 in the following order (read row by row, left to right):

s39	s40	s41	s42	s43	s44	s48	s87	s45	s2
s3	s8	s10	s18	s19	s24	s46	s47	s142	s143
s144	s145	s146	s147	s92	s93	s195	s196	s98	s137
s148	s94	s197	s149	s150	s95	s198	s4	s5	s11
s12	s16	s9	s6	s7	s13	s17	s20	s96	s199
s1	s14	s15	s21	s25	s26	s28	s151	s201	s190
s240	s88	s138	s191	s241					

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

$$b(1)D^{72} + b(2)D^{71} + ... + b(65)D^{8} + p(1)D^{7} + p(2)D^{6} + ... + p(7)D^{1} + p(8)$$

p(1) - p(8): the parity bits (w253-w260)

b(1) - b(65) = the data bits from the table above

when divided by *g(D),* yields a remainder equal to 0.

3.1.1.2 Repetition bits

The repeated bits are s70, s120, s173 and s223. They correspond to one of the bits in each of the PULSE_5, the most significant one not protected by the channel coding stage.

3.1.1.3 Correspondence between input and output of preliminary channel coding

The preliminary coded bits w(k) for k = 1 to 260 are hence defined by:

w(k) = s(k) for k = 1 to 71
w(k) = s(k-2) for k = 74 to 123
w(k) = s(k-4) for k = 126 to 178
w(k) = s(k-6) for k = 181 to s230
w(k) = s(k-8) for k = 233 to s252