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GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

Digital cellular telecommunications system (Phase 2+);
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General description
(GSM 05.01 version 5.4.0)

ETSI

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Foreword

This Global System for Mobile communications Technical Specification (GTS) has been produced by the Special Mobile Group (SMG) of the European Telecommunications Standards Institute (ETSI).

This GTS is an introduction to the 05 series of the digital mobile cellular and personal communication systems operating in the 900 MHz (P-GSM, E-GSM, R-GSM) and 1 800 MHz band (GSM 900 and DCS 1 800).

The contents of this GTS are subject to continuing work within SMG and may change following formal SMG approval. Should SMG modify the contents of this GTS it will then be republished by ETSI with an identifying change of release date and an increase in version number as follows:

Version 5.x.y

where:

- y the third digit is incremented when editorial only changes have been incorporated in the specification;

- x the second digit is incremented for all other types of changes, i.e. technical enhancements, corrections, updates, etc.

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

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1 Scope

This Global System for Mobile communications Technical Specification (GTS) is an introduction to the 05 series of the GSM technical specifications for GSM and DCS 1 800. It is not of a mandatory nature, but consists of a general description of the organization of the physical layer with reference to the technical specifications where each part is specified in detail. It introduces furthermore, the reference configuration that will be used throughout this series of technical specifications.

1.1 Normative references

This GTS 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 GTS 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 350): "Digital cellular telecommunications system (Phase 2+); Abbreviations and acronyms".

[2] GSM 03.03 (ETS 300 927): "Digital cellular telecommunications system (Phase 2+); Numbering, addressing and identification".

[3] GSM 03.20 (ETS 300 929): "Digital cellular telecommunications system (Phase 2+); Security related network functions".

[4] GSM 03.22 (ETS 300 930): "Digital cellular telecommunications system (Phase 2+); Functions related to Mobile Station (MS) in idle mode and group receive mode".

[5] GSM 04.03: "Digital cellular telecommunications system (Phase 2+); Mobile Station - Base Station System (MS - BSS) interface; Channel structures and access capabilities".

[6] GSM 04.08 (ETS 300 940): "Digital cellular telecommunications system (Phase 2+); Mobile radio interface layer 3 specification".

[7] GSM 04.21 (ETS 300 945): "Digital cellular telecommunications system (Phase 2+); Rate adaption on the Mobile Station - Base Station System (MS-BSS) Interface".

[8] GSM 05.02 (ETS 300 908): "Digital cellular telecommunications system (Phase 2+); Multiplexing and multiple access on the radio path".

[9] GSM 05.03 (ETS 300 909): "Digital cellular telecommunications system (Phase 2+); Channel coding".

[10] GSM 05.04 (ETS 300 959): "Digital cellular telecommunications system; Modulation".

[11] GSM 05.05 (ETS 300 910): "Digital cellular telecommunications system (Phase 2+); Radio transmission and reception".

[12] GSM 05.08 (ETS 300 911): "Digital cellular telecommunications system (Phase 2+); Radio subsystem link control".

[13] GSM 05.10 (ETS 300 912): "Digital cellular telecommunications system (Phase 2+); Radio subsystem synchronization".

[14] GSM 03.30 (ETR 364): "Digital cellular telecommunications system; Radio network planning aspects".

1.2 Abbreviations

Abbreviations used in this GTS are listed in GSM 01.04 [1].

2 Set of channels

The radio subsystem provides a certain number of logical channels that can be separated into two categories according to GSM 04.03 [5]:

1) The traffic channels (TCH): they are intended to carry two types of user information streams: encoded speech and data. Two types of traffic channels are defined: Bm or full-rate (TCH/F) and Lm or half-rate (TCH/H) traffic channels. For the purpose of this series of technical specifications, the following traffic channels are distinguished:

   - full rate speech TCH (TCH/FS);
   - half rate speech TCH (TCH/HS);
   - 14,4 kbit/s full rate data TCH (TCH/F14.4)
   - 9,6 kbit/s full rate data TCH (TCH/F9.6);
   - 4,8 kbit/s full rate data TCH (TCH/F4.8);
   - 4,8 kbit/s half rate data TCH (TCH/H4.8);
   - ≤ 2,4 kbit/s full rate data TCH (TCH/F2.4);
   - ≤ 2,4 kbit/s half rate data TCH (TCH/H2.4);
   - cell broadcast channel (CBCH).

   All channels are bi-directional unless otherwise stated. Unidirectional downlink full rate channels, TCH/FD are defined as the downlink part of the corresponding TCH/F. Unidirectional uplink full rate channels are FFS.

   Multislot configurations are defined as multiple (1 up to 8) full rate channels allocated to the same MS. At least one channel shall be bi-directional (TCH/F). The multislot configuration is symmetric if all channels are bi-directional (TCH/F) and asymmetric if at least one channel is unidirectional (TCH/FD).

   High Speed Circuit Switched Data (HSCSD) is an example of multislot configuration, in which all channels shall have the same channel mode.

   NOTE: For the maximum number of timeslots to be used for a HSCSD configuration, see GSM 03.34.

2) The signalling channels: these can be sub-divided into BCCH (broadcast control channel), CCCH (common control channel), SDCCH (stand-alone dedicated control channel) and ACCH (associated control channel). An associated control channel is always allocated in conjunction with, either a TCH, or a SDCCH. Two types of ACCH are defined: continuous stream (slow ACCH) and burst stealing mode (fast ACCH). For the purpose of this series of technical specifications, the following signalling channels are distinguished:

   - stand-alone dedicated control channel, four of them mapped on the same basic physical channel as the CCCH (SDCCH/4);

   - stand-alone dedicated control channel, eight of them mapped on a separate basic physical channel (SDCCH/8);

   - full rate fast associated control channel (FACCH/F);

   - half rate fast associated control channel (FACCH/H);

   - slow, TCH/F associated, control channel (SACCH/TF);

   - slow, TCH/H associated, control channel (SACCH/TH);

   - slow, TCH/F associated, control channel for multislot configurations (SACCH/M);

   - slow, SDCCH/4 associated, control channel (SACCH/C4);

- slow, SDCCH/8 associated, control channel (SACCH/C8);
- broadcast control channel (BCCH);
- random access channel (i.e. uplink CCCH) (RACH);
- paging channel (part of downlink CCCH) (PCH);
- access grant channel (part of downlink CCCH) (AGCH);
- notification channel (part of downlink CCCH) (NCH).

All associated control channels have the same direction (bi-directional or unidirectional) as the channels they are associated to. The unidirectional SACCH/MD is defined as the downlink part of SACCH/M.

When there is no need to distinguish between different sub-categories of the same logical channel, only the generic name will be used, meaning also all the sub-categories (SACCH will mean all categories of SACCHs, SACCH/T will mean both the slow, TCH associated, control channels, etc.).

The logical channels mentioned above are mapped on physical channels that are described in this set of technical specifications. The different physical channels provide for the transmission of information pertaining to higher layers according to a block structure.

3 Reference configuration

For the purpose of elaborating the physical layer specification, a reference configuration of the transmission chain is used as shown in annex A. This reference configuration also indicates which parts are dealt with in details in which technical specification. It shall be noted that only the transmission part is specified, the receiver being specified only via the overall performance requirements. With reference to this configuration, the technical specifications in the 05 series address the following functional units:

- GSM 05.02: burst building, and burst multiplexing;
- GSM 05.03: coding, reordering and partitioning, and interleaving;
- GSM 05.04: differential encoding, and modulation;
- GSM 05.05: transmitter, antenna, and receiver (overall performance).

This reference configuration defines also a number of points of vocabulary in relation to the name of bits at different levels in the configuration. It must be outlined, in the case of the encrypted bits, that they are named only with respect to their position after the encryption unit, and not to the fact that they pertain to a flow of information that is actually encrypted.

4 The block structures

The different block structures are described in more detail in GSM 05.03 (Channel coding). A summarized description appears in table 1, in terms of net bit rate, length and recurrence of blocks.

Table 1: Channel block structures

Type of channel	net bit rate (kbit/s)	block length (bits)	block recurrence (ms)
full rate speech TCH[1]	13,0	182 + 78	20
half rate speech TCH[2]	5,6	95 + 17	20
data TCH (14,4 kbit/s) [3]	14,5	290	20
data TCH (9,6 kbit/s)[3]	12,0	60	5
data TCH (4,8 kbit/s)[3]	6,0	60	10
data TCH (≤ 2,4 kbit/s)[3]	3,6	36	10
full rate FACCH (FACCH/F)	9,2	184	20
half rate FACCH (FACCH/H)	4,6	184	40
SDCCH	598/765 (≈ 0,782)	184	3 060/13 (235)
SACCH (with TCH)[4]	115/300 (≈ 0,383)	168 + 16	480
SACCH (with SDCCH)[4]	299/765 (≈ 0,391)	168 + 16	6 120/13 (≈ 471)
BCCH	598/765 (≈ 0,782)	184	3 060/13 (≈ 235)
AGCH[5]	n*598/765 (≈ 0,782)	184	3 060/13 (≈ 235)
NCH[5]	m*598/765 (≈ 0,782)	184	3 060/13 (≈ 235)
PCH[5]	p*598/765 (≈ 0,782)	184	3 060/13 (≈ 235)
RACH[5]	r*26/765 (≈ 0,034)	8	3 060/13 (≈ 235)
CBCH	598/765 (≈ 0,782)	184	3 060/13 (≈ 235)

NOTE 1: For full rate speech, the block is divided into two classes according to the importance of the bits (182 bits for class I and 78 bits for class II).

NOTE 2: For half rate speech, the block is divided into two classes according to the importance of the bits (95 bits for class I and 17 bits for class II).

NOTE 3: For data services, the net bit rate is the adaptation rate as defined in GSM 04.21.

NOTE 4: On SACCH, 16 bits are reserved for control information on layer 1, and 168 bits are used for higher layers.

NOTE 5: CCCH channels are common to all users of a cell; the total number of blocks (m, n, p, r) per recurrence period is adjustable on a cell by cell basis and depends upon the parameters (BS_CC_CHANS, BS_BCCH_SDCCH_COMB, BS_AG_BLKS_RES and NCP) broadcast on the BCCH and specified in GSM 05.02 and GSM 04.08.

5 Multiple access and timeslot structure

The access scheme is Time Division Multiple Access (TDMA) with eight basic physical channels per carrier. The carrier separation is 200 kHz. A physical channel is therefore defined as a sequence of TDMA frames, a time slot number (modulo 8) and a frequency hopping sequence.

The basic radio resource is a time slot lasting ≈ 576,9 µs (15/26 ms) and transmitting information at a modulation rate of ≈ 270.833 kbit/s (1 625/6 kbit/s). This means that the time slot duration, including guard time, is 156,25 bit durations.

We shall describe successively the time frame structures, the time slot structures and the channel organization. The appropriate specifications will be found in GSM 05.02 (multiplexing and multiple access).

5.1 Hyperframes, superframes and multiframes

A diagrammatic representation of all the time frame structures is in figure 1. The longest recurrent time period of the structure is called hyperframe and has a duration of 3 h 28 mn 53 s 760 ms (or 12 533,76 s). The TDMA frames are numbered modulo this hyperframe (TDMA frame number, or FN, from 0 to 2 715 647). This long period is needed to support cryptographic mechanisms defined in GSM 03.20.

One hyperframe is subdivided in 2 048 superframes which have a duration of 6,12 seconds. The superframe is the least common multiple of the time frame structures. The superframe is itself subdivided in multiframes; two types of multiframes exist in the system:

- a 26-frame multiframe (51 per superframe) with a duration of 120 ms, comprising 26 TDMA frames. This multiframe is used to carry TCH (and SACCH/T) and FACCH;

- a 51-frame multiframe (26 per superframe) with a duration of ≈ 235,4 ms (3 060/13 ms), comprising 51 TDMA frames. This multiframe is used to carry BCCH, CCCH (NCH, AGCH, PCH and RACH) and SDCCH (and SACCH/C).

A TDMA frame, comprising eight time slots has a duration of ≈ 4,62 (60/13) ms.

5.2 Time slots and bursts

The time slot is a time interval of ≈ 576,9 µs (15/26 ms), that is 156,25 bit durations, and its physical content is called a burst. Four different types of bursts exist in the system. A diagram of these bursts appears in figure 1.

- normal burst (NB): this burst is used to carry information on traffic and control channels, except for RACH. It contains 116 encrypted bits and includes a guard time of 8,25 bit durations (≈ 30,46 µs);

- frequency correction burst (FB): this burst is used for frequency synchronization of the mobile. It is equivalent to an unmodulated carrier, shifted in frequency, with the same guard time as the normal burst. It is broadcast together with the BCCH. The repetition of FBs is also named frequency correction channel (FCCH);

- synchronization burst (SB): this burst is used for time synchronization of the mobile. It contains a long training sequence and carries the information of the TDMA frame number (FN) and base station identity code (BSIC, see GSM 03.03). It is broadcast together with the frequency correction burst. The repetition of synchronization bursts is also named synchronization channel (SCH);

- access burst (AB): this burst is used for random access and is characterized by a longer guard period (68,25 bit durations or 252 µs) to cater for burst transmission from a mobile which does not know the timing advance at the first access (or after handover).This allows for a distance of 35 km. In exceptional cases of cell radii larger than 35 km, some possible measures are described in GSM 03.30. The access burst is used in the RACH and after handover, as well as on the uplink of a channel used for a voice group call in order to request the use of that uplink.

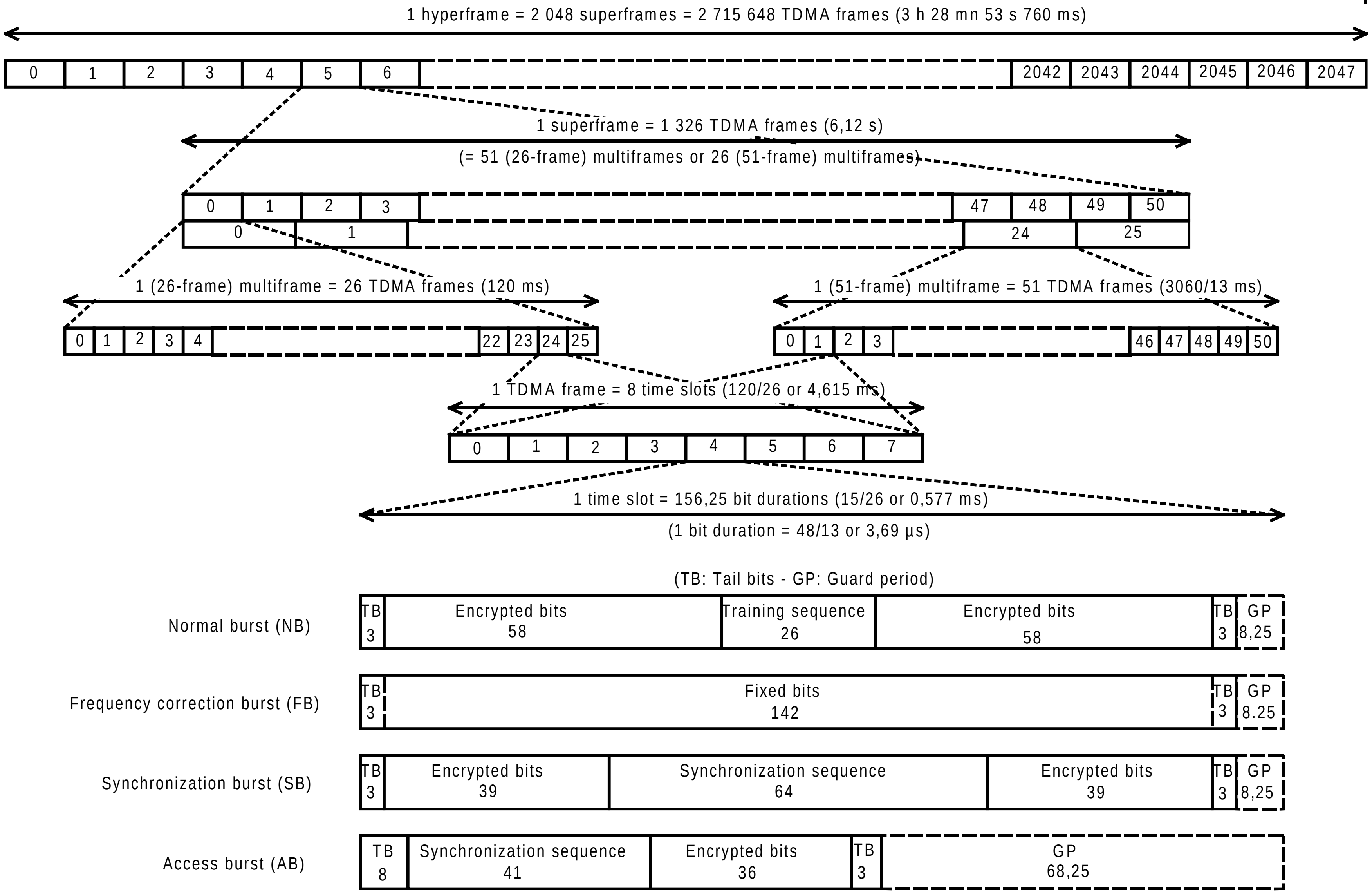


Figure 1: Time frames time slots and bursts

5.3 Channel organization

The channel organization for the traffic channels (TCH), FACCHs and SACCH/T uses the 26-frame multiframe. It is organized as described in figure 2, where only one time slot per TDMA frame is considered.

(a)	T	T	T	T	T	T	T	T	T	T	T	T	A	T	T	T	T	T	T	T	T	T	T	T	T	-

← 26 frames = 120 ms →

(b)	T	t	T	t	T	t	T	t	T	t	T	t	A	T	t	T	t	T	t	T	t	T	t	T	t	a

(a) case of one full rate TCH (b) case of two half rate TCHs

T, t: TDMA frame for TCH -: idle TDMA frame A, a: TDMA frame for SACCH/T

Figure 2: Traffic channel organization

The FACCH is transmitted by pre-empting half or all of the information bits of the bursts of the TCH to which it is associated (see GSM 05.03).

The channel organization for the control channels (except FACCHs and SACCH/T) uses the 51-frame multiframe. It is organized in the downlink and uplink as described in figure 3.

6 Frequency hopping capability

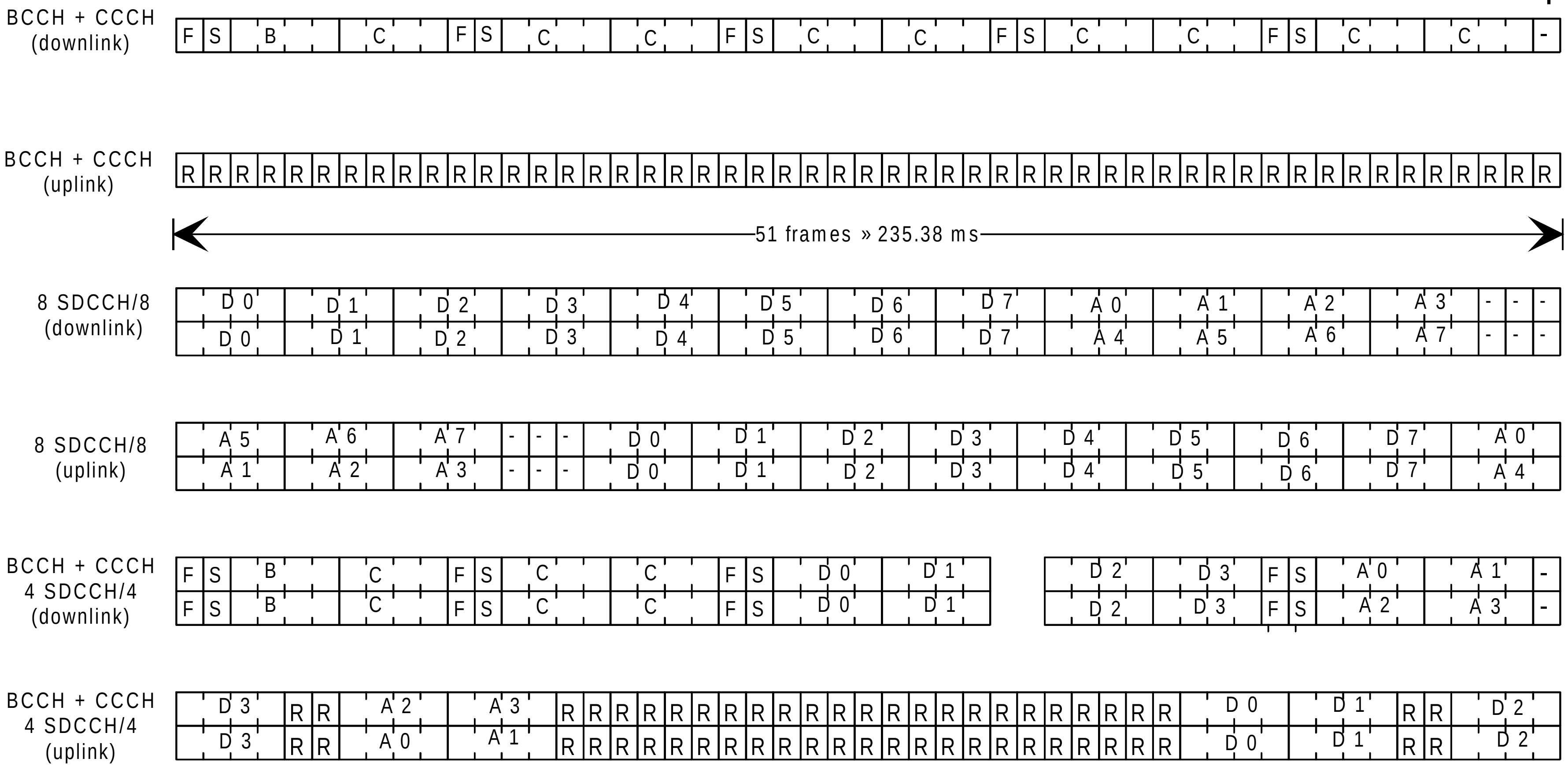
The frequency hopping capability is optionally used by the network operator on all or part of its network. The main advantage of this feature is to provide diversity on one transmission link (especially to increase the efficiency of coding and interleaving for slowly moving mobile stations) and also to average the quality on all the communications through interferers diversity. It is implemented on all mobile stations.

The principle of slow frequency hopping is that every mobile transmits its time slots according to a sequence of frequencies that it derives from an algorithm. The frequency hopping occurs between time slots and, therefore, a mobile station transmits (or receives) on a fixed frequency during one time slot ($\approx$ 577 µs) and then must hop before the time slot on the next TDMA frame. Due to the time needed for monitoring other base stations the time allowed for hopping is approximately 1 ms, according to the receiver implementation. The receive and transmit frequencies are always duplex frequencies.

The frequency hopping sequences are orthogonal inside one cell (i.e. no collisions occur between communications of the same cell), and independent from one cell to an homologue cell (i.e. using the same set of RF channels, or cell allocation). The hopping sequence is derived by the mobile from parameters broadcast at the channel assignment, namely, the mobile allocation (set of frequencies on which to hop), the hopping sequence number of the cell (which allows different sequences on homologue cells) and the index offset (to distinguish the different mobiles of the cell using the same mobile allocation). The non-hopping case is included in the algorithm as a special case. The different parameters needed and the algorithm are specified in GSM 05.02.

In case of multi band operation frequency hopping channels in different bands of operation, e.g. between channels in GSM and DCS, is not supported. Frequency hopping within each of the bands supported shall be implemented in the mobile station.

It must be noted that the basic physical channel supporting the BCCH does not hop.



F: TDMA frame for frequency correction burst
B: TDMA frame for BCCH
D: TDMA frame for SDCCH
R: TDMA frame for RACH

S: TDMA frame for synchronization burst
C: TDMA frame for CCCH
A: TDMA frame for SACCH/C

Figure 3: Channel organization in the 51-frame multiframe

7 Coding and interleaving

A brief description of the coding schemes that are used for the logical channels mentioned in clause 2, plus the synchronization channel (SCH, see subclause 5.2), is made in the following table. For all the types of channels the following operations are made in this order:

- external coding (block coding);
- internal coding (convolutional coding);
- interleaving.

After coding the different channels (except RACH and SCH) are constituted by blocks of coded information bits plus coded header (the purpose of the header is to distinguish between TCH and FACCH blocks). These blocks are interleaved over a number of bursts. The block size and interleaving depth are channel dependent. All these operations are specified in GSM 05.03.

Type of channel	bits/block data+parity+tail1	convolutional code rate	coded bits per block	interleaving depth
TCH/FS			456	8
class I[2]	182 + 3 + 4	1/2	378	
class II	78 + 0 + 0	-	78	
TCH/HS			228	4
class I[3]	95+3+6	104/211	211	
class II	17+0+0		17	
TCH/F14.4	290 + 0 + 4	294/456	456	19
TCH/F9.6	4*60 + 0 + 4	244/456	456	19
TCH/F4.8	60 + 0 + 16	1/3	228	19
TCH/H4.8	4*60 + 0 + 4	244/456	456	19
TCH/F2.4	72 + 0 + 4	1/6	456	8
TCH/H2.4	72 + 0 + 4	1/3	228	19
FACCH/F	184 + 40 + 4	1/2	456	8
FACCH/H	184 + 40 + 4	1/2	456	6
SDCCHs SACCHs BCCH NCH AGCH PCH				
CBCH	184 + 40 + 4	1/2	456	4
RACH	8 + 6 + 4	1/2	36	1
SCH	25 + 10 + 4	1/2	78	1

NOTE 1: The tail bits mentioned here are the tail bits of the convolutional code.

NOTE 2: The 3 parity bits for TCH/FS detect an error on 50 bits of class I.

NOTE 3: The 3 parity bits for TCH/HS detect an error on 22 bits of class I.

8 Modulation

The modulation scheme is gaussian MSK (GMSK) with BT = 0,3. As already mentioned the modulation rate is 1 625/6 kbit/s (≈ 270,83 kbit/s). This scheme is specified in detail in GSM 05.04 (Modulation and demodulation).

9 Transmission and reception

The modulated stream is then transmitted on a radio frequency carrier. The frequency bands and channel arrangement are the following.

i) Standard or primary GSM 900 Band, P-GSM;
For Standard GSM 900 Band, the system is required to operate in the following frequency band:
890 - 915 MHz: mobile transmit, base receive
935 - 960 MHz: base transmit, mobile receive

ii) Extended GSM 900 Band, E-GSM (includes Standard GSM 900 band);
For Extended GSM 900 Band, the system is required to operate in the following frequency band:
880 - 915 MHz: mobile transmit, base receive
925 - 960 MHz: base transmit, mobile receive

iii) Railways GSM 900 Band, R-GSM (includes Standard and Extended GSM 900 Band);

For Railways GSM 900 Band, the system is required to operate in the following frequency band:

876 - 915 MHz: mobile transmit, base receive
921 - 960 MHz: base transmit, mobile receive

iv) DCS 1 800 Band;
For DCS 1 800, the system is required to operate in the following frequency band:
1 710 - 1 785 MHz: mobile transmit, base receive
1 805 - 1 880 MHz: base transmit, mobile receive

NOTE 1: The term GSM 900 is used for any GSM system which operates in any 900 MHz band.

NOTE 2: The BTS may cover the complete band, or the BTS capabilities may be restricted to a subset only, depending on the operator needs.

Operators may implement networks on a combination of the frequency bands above to support multi band mobile stations which are defined in GSM 02.06.

The RF channel spacing is 200 kHz, allowing for 194 (GSM 900) and 374 (DCS 1 800) radio frequency channels, thus leaving a guard band of 200 kHz at each end of the subbands.

The specific RF channels, together with the requirements on the transmitter and the receiver will be found in GSM 05.05 (Transmission and reception).

In order to allow for low power consumption for different categories of mobiles (e.g. vehicle mounted, hand-held, ..), different power classes have been defined. For GSM 900 there are four power classes with the maximum power class having 8 W peak output power (ca 1 W mean output power) and the minimum having 0,8 W peak output power. For DCS 1 800 there are three power classes of 4 W peak output power, 1 W peak output power (ca 0,125 W mean) and 0,25 W peak output power.

Multi band mobile stations may have any combinations of the allowed power classes for each of the bands supported.

The power classes are specified in GSM 05.05.

The requirements on the overall transmission quality together with the measurement conditions are also in GSM 05.05.

10 Other layer 1 functions

The transmission involves other functions. These functions may necessitate the handling of specific protocols between BS and MS. Relevant topics for these cases are:

1) The power control mechanisms which adjust the output level of the mobile station (and optionally of the base station) in order to ensure that the required quality is achieved with the less possible radiated power. Power levels with 2 dB steps have been defined for that purpose. This is described in GSM 05.08 (radio subsystem link control) and GSM 05.05.

2) The synchronization of the receiver with regard to frequency and time (time acquisition and time frame alignment). The synchronization problems are described in GSM 05.10 (synchronization aspects).

3) The hand-over and quality monitoring which are necessary to allow a mobile to continue a call during a change of physical channel. This can occur either because of degradation of the quality of the current serving channel, or because of the availability of another channel which can allow communication at a lower Tx power level, or to prevent a MS from grossly exceeding the planned cell boundaries. In the case of duplex point-to-point connections, the choice of the new channel is done by the network (base station control and MSC) based on measurements (on its own and on adjacent base stations) that are sent on a continuous basis by the mobile station via the SACCHs. The requirements are specified in GSM 05.08 (radio subsystem link control).

4) The measurements and sub-procedures used in the first selection or reselection of a base station by a mobile are specified in GSM 05.08 (radio subsystem link control). (The overall selection and reselection procedures, together with the idle mode activities of a mobile are defined in GSM 03.22 (functions related to MS in idle mode).)

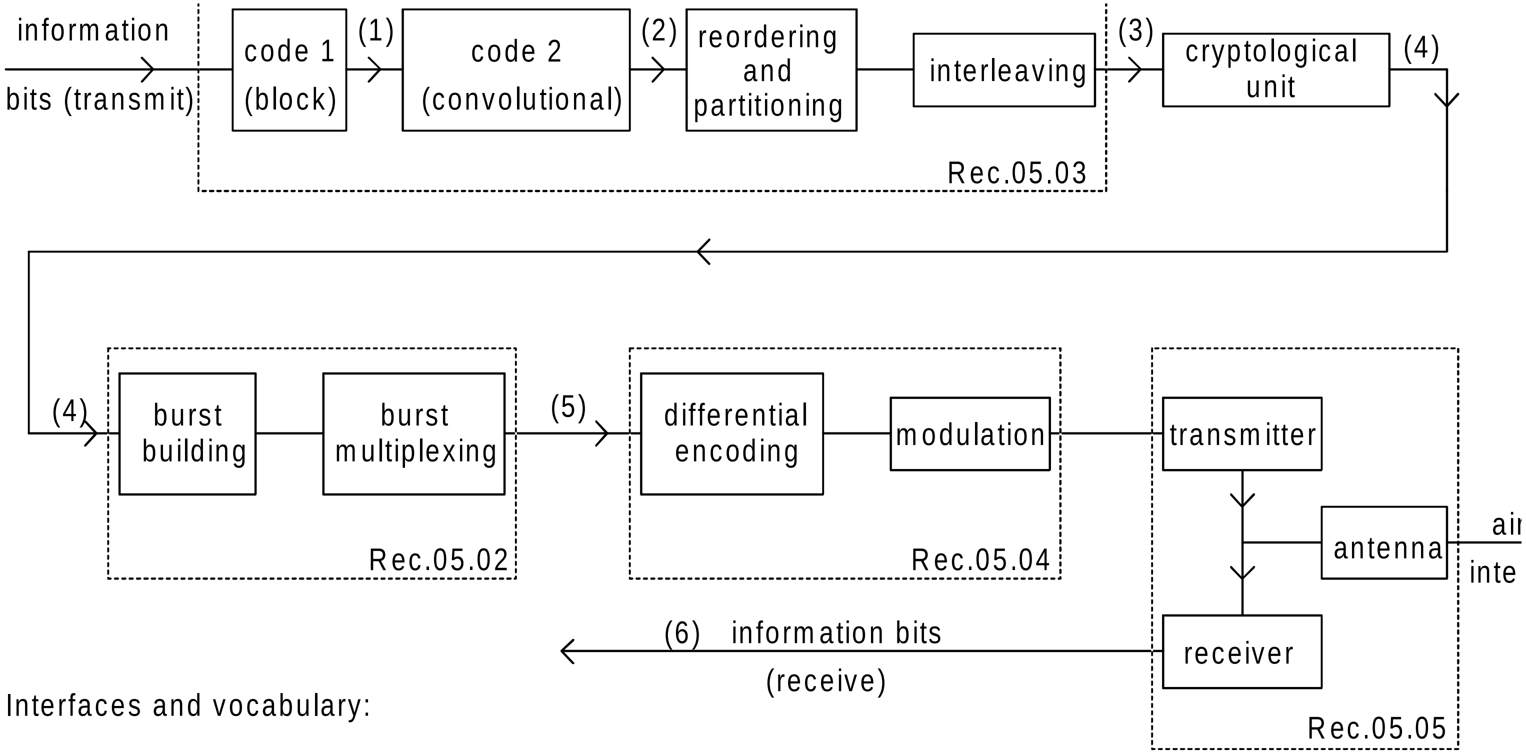
5) The measurements and sub-procedures used by an MS in selecting a base station for reception of a voice group or a voice broadcast call are specified in GSM 05.08 (radio subsystem link control). The overall voice group and voice broadcast cell change procedures, being similar to the reselection procedures related to the idle mode activities of an MS, are defined in GSM 03.22 (functions related to MS in idle mode).

11 Performance

Under typical urban fading conditions (i.e. multipath delays no greater than 5 μs), the quality threshold for full-rate speech is reached at a C/I value of approximately 9 dB. The maximum sensitivity is approximately -104 dBm for base stations and GSM mobiles and -102 dBm and -100 dBm for GSM 900 small MSs (see GSM 05.05) and DCS 1 800 hand-helds, respectively.

Multi band MSs shall meet the requirements on each band of operation respectively.

Annex A (informative): Reference configuration



Interfaces and vocabulary:

(1) info + parity bits

(2) coded bits

(3) interleaved bits

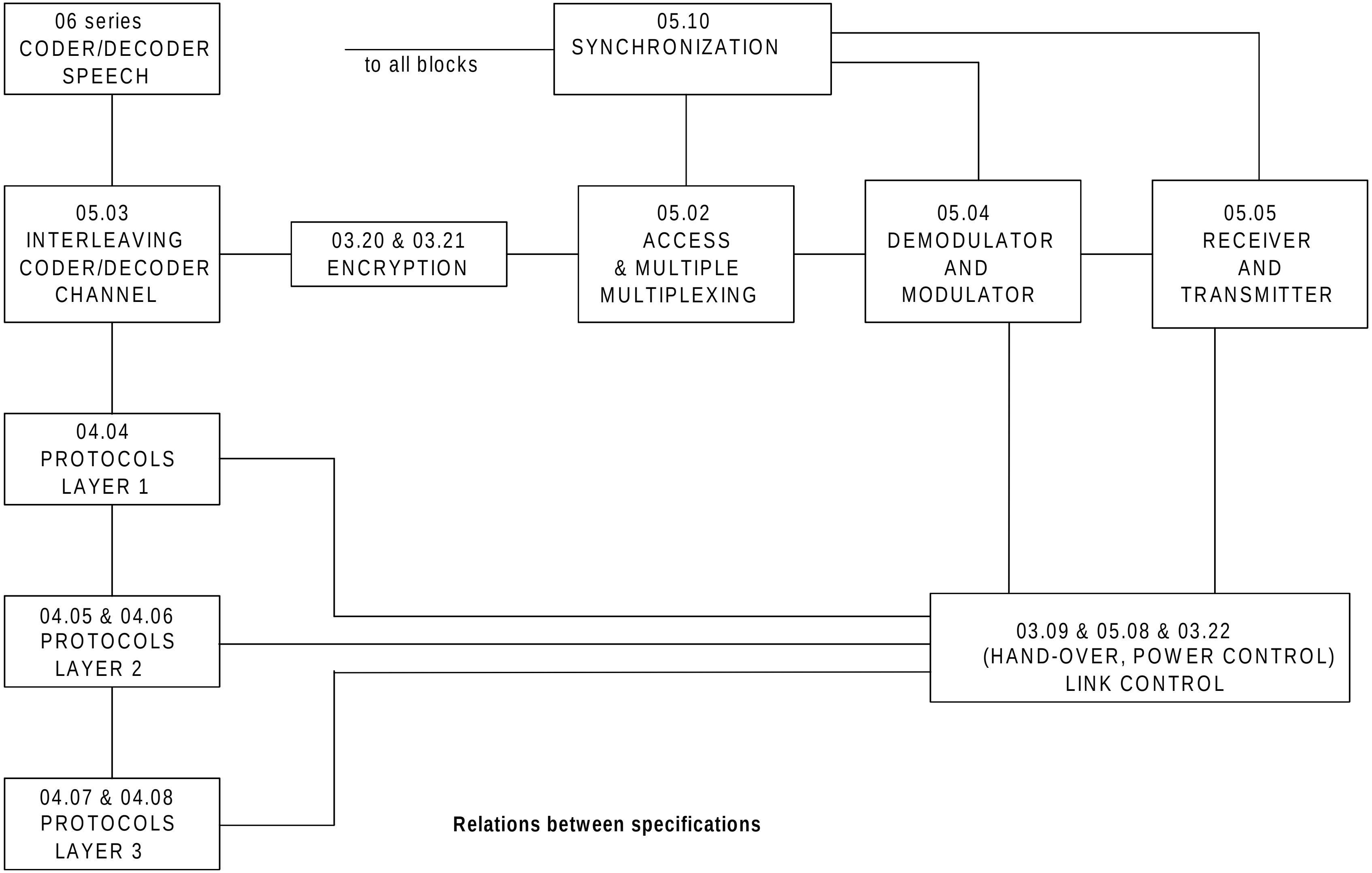
(4) encrypted bits

(5) modulating bits

(6) information bits (receive)

REFERENCE CONFIGURATION

Annex B (informative): Relations between specification



Relations between specifications

Annex C (informative): Change control history

SPEC	SMG	CR	PHA	VERS	NEW_VE	SUBJECT
05.01	S18	A005	2+	4.6.0	5.0.0	Addition of ASCI features
05.01	S20	A006	2+	5.0.0	5.1.0	Introduction of high speed circuit switched data
05.01	s21	A007	2+	5.1.0	5.2.0	Introduction of R-GSM band
05.01	s22	A009	2+	5.2.0	5.3.0	Clarification of the frequency definition text in section
05.01	s25	A011	R96	5.3.0	5.4.0	14.4kbps Data Service

History

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