SLOVENSKI STANDARD
SIST EN 300 912 V6.5.1:2003

01-december-2003

Digitalni celiļ ni telekomunikacijski sistem (faza 2+) ï Sinhronizacija radijskega podsistema (GSM 05.10, razliļ ica 6.5.1, izdaja 1997)

Digital cellular telecommunications system (Phase 2+) (GSM); Radio subsystem synchronization (GSM 05.10 version 6.5.1 Release 1997)

Ta slovenski standard je istoveten z: EN 300 912 Version 6.5.1

ICS:

33.070.50	Globalni sistem za mobilno telekomunikacijo (GSM)	Global System for Mobile Communication (GSM)

SIST EN 300 912 V6.5.1:2003 **en**

ETSI EN 300 912 V6.5.1 (1999-12)

European Standard (Telecommunications series)

Digital cellular telecommunications system (Phase 2+); Radio subsystem synchronization (GSM 05.10 version 6.5.1 Release 1997)

GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS

Reference
REN/SMG-020510Q6R3

Keywords
Digital cellular telecommunications system,
Global System for Mobile communications (GSM)

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Foreword

This European Standard (Telecommunications series) has been produced by the Special Mobile Group (SMG).

The present document defines the requirements for synchronization on the GSM radio sub-system of the digital mobile cellular and personal communication systems operating in the 900 MHz and 1 800 MHz band (GSM 900 and DCS 1 800).

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

Version 6.x.y

where:

6 indicates release 1997 of GSM Phase 2+.

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

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

National transposition dates	
Date of adoption of this EN:	3 December 1999
Date of latest announcement of this EN (doa):	31 March 2000
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 September 2000
Date of withdrawal of any conflicting National Standard (dow):	30 September 2000

1 Scope

The present document defines the requirements for synchronization on the GSM radio sub-system. (However, it does not define the synchronization algorithms to be used in the Base Transceiver Station (BTS) and Mobile Station (MS). These are up to the manufacturer to specify.)

1.2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.
- For this Release 1997 document, references to GSM documents are for Release 1997 versions (version 6.x.y).

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

[2] GSM 03.60: "Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Service Description Stage 2".

[3] GSM 03.64: "Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); GPRS Radio Interface Stage 2".

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

[5] GSM 04.60: "Digital cellular telecommunications system (Phase 2+); General Packet Radio Service (GPRS); Mobile Station (MS) - Base Station System (BSS interface; Radio Link Control (RLC) and Medium Access Control (MAC) Layer Specification".

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

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

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

[9] GSM 03.30: "Digital cellular telecommunications system (Phase 2+); Radio network planning aspects".

1.3 Definitions and abbreviations

In addition to those below, abbreviations used in the present document are listed in GSM 01.04.

BTS: Base Transceiver Station

Timing Advance: A signal sent by the BTS to the MS which the MS uses to advance its timings of transmissions to the BTS so as to compensate for propagation delay

Quarter bit number: The timing of quarter bit periods (12/13 µs) within a timeslot

Timeslot number: The timing of timeslots within a TDMA frame

TDMA frame number: The count of TDMA frames relative to an arbitrary start point

Current Serving BTS: The BTS on one of whose channels (TCH, DCCH, CCCH or PDCH) the MS is currently operating

Timebase counters: A set of counters which determine the timing state of signals transmitted by a BTS or MS

MS timing offset: The delay of the received signal relative to the expected signal from an MS at zero distance under static channel conditions with zero timing advance. This is accurate to ± 1 bit, and reported once per SACCH or after a RACH as. required (i.e. at the same rate as timing advance). For example, for an MS with a round trip propagation delay of P bits, but with a timing advance of T bits, the reported timing offset will be P-T quantized to the nearest bit. For GPRS the MS timing offset is not reported.

Timing Advance Index: The Timing Advance Index TAI used for GPRS, which determines the position of the subchannel on PTCCH (see GSM 05.02) used by the MS to send an access burst, from which the network can derive the timing advance.

2 General description of synchronization system

This clause gives a general description of the synchronization system. Detailed requirements are given in clauses 3 to 6.

The BTS sends signals on the BCCH to enable the MS to synchronize itself to the BTS and if necessary correct its frequency standard to be in line with that of the BTS. The signals sent by the BTS for these purposes are:

a) Frequency correction bursts;

b) Synchronization bursts.

The timings of timeslots, TDMA frames, TCH frames and control channel frames are all related to a common set of counters which run continuously whether the MS and BTS are transmitting or not. Thus, once the MS has determined the correct setting of these counters, all its processes are synchronized to the current serving BTS.

The MS times its transmissions to the BTS in line with those received from the BTS. The BTS sends to each MS a "timing advance" parameter (TA) according to the perceived round trip propagation delay BTS-MS-BTS. The MS advances its timing by this amount, with the result that signals from different MS's arriving at the BTS and compensated for propagation delay. This process is called "adaptive frame alignment".

Additionally, synchronization functions may be implemented in both the MS and the BTS to support the so-called pseudo synchronization scheme. The support of this scheme is optional except that MS shall measure and report the Observed Timing Difference (OTD), which is a mandatory requirement. The detailed specifications of the pseudo-synchronization scheme are included in annex A.

3 Timebase counters

3.1 Timing state of the signals

The timing state of the signals transmitted by a BTS or MS is defined by the following counters:

- Quarter bit number QN (0 - 624)- Bit number BN (0 - 156);
- Timeslot number TN (0 - 7);
- TDMA frame number FN (0 to (26 x 51 x 2048) - 1 = 2715647).

3.2 Relationship between counters

The relationship between these counters is as follows:

- QN increments every 12/13 µs;
- BN = Integer part of QN/4;
- TN increments whenever QN changes from count 624 to 0;
- FN increments whenever TN changes from count 7 to 0.

4 Timing of transmitted signals

The timing of signals transmitted by the MS and BTS are defined in GSM 05.02.

The MS can use the timing of receipt of the synchronization burst to set up its timebase counters as follows:

QN is set by the timing of the training sequence;

TN = 0 when the synch burst is received;

FN = 51 ((T3-T2) mod (26)) + T3 + 51 x 26 x T1 when the synch burst is received,
(where T3 = (10 x T3') + 1, T1, T2 and T3' being contained in information fields in synchronization burst).

Thereafter, the timebase counters are incremented as in subclause 3.2.

(When adjacent BTS's are being monitored for handover purposes, or for cell reselection purposes in group receive mode, the MS may choose to store the values of QN, TN and FN for all the BTS's whose synchronization bursts have been detected relative to QN, TN and FN for its current serving BTS).

5 BTS Requirements for Synchronization

The conditions under which the requirements of subclauses 5.4 and 5.6 must be met shall be 3 dB below the reference sensitivity level in GSM 05.05 and 3 dB less carrier to interference ratio than the reference interference ratios in GSM 05.05.

5.1 Frequency source

The BTS shall use a single frequency source of absolute accuracy better than 0.05 ppm for both RF frequency generation and clocking the timebase. The same source shall be used for all carriers of the BTS.

5.2 Timebase counters

It is optional whether the timebase counters of different BTS's are synchronized together.

5.3 Internal BTS carrier timing

The channels of different carriers transmitted by a BTS shall be synchronized together, i.e. controlled by the same set of counters. The timing difference between the different carriers shall be less than 1/4 bit periods, measured at the BTS antenna.

5.4 Initial Timing advance estimation

When the BTS detects an access burst transmission on RACH or PRACH, it shall measure the delay of this signal relative to the expected signal from an MS at zero distance under static channel conditions. This delay, called the timing advance, shall be rounded to the nearest bit period and included in a response from the BTS when applicable.

5.5 Maximum timing advance value

The maximum timing advance value shall be 63. If the BTS measures a value larger than this, it shall set the timing advance to 63. (GSM 03.30 defines how the PLMN deals with MS's where the delay exceeds timing advance value 63.)

5.6 Delay tracking

5.6.1 For circuit switched channels

The BTS shall thereafter continuously monitor the delay of the normal bursts sent by from the MS. If the delay changes by more than one bit period, the timing advance shall be advanced or retarded 1 and the new value signalled to the MS.

Restricting the change in timing advance to 1 bit period at a time gives the simplest implementation of the BTS. However the BTS may use a larger change than this but great care must then be used in the BTS design.

5.6.2 For packet switched channels

The BTS shall perform the continuous update timing advance mechanism for all MS working in packet transfer mode for which an PTCCH subchannel is assigned, except for MS class A in dedicated mode. Therefore the BTS shall monitor the delay of the access bursts sent by the MS on PTCCH and respond with timing advance values for all MS performing the procedure on that PDCH. These timing advance values shall be sent via a downlink signalling message on PTCCH.

The BTS shall update the timing advance values in the next downlink signalling message following the access burst.

The BTS may also monitor the delay of the normal bursts and access bursts sent by the MS on PDTCH and PACCH. Whenever an updating of TA is needed, the BTS may send the new TA value in a power control/timing advance message (see GSM 04.60).

For MS class A in dedicated mode the BTS shall follow the procedure described in subclause 5.6.1.

5.6.3 Delay assessment error

For circuit and packed switched channels the delay shall be assessed in such a way that the assessment error (due to noise and interference) is less than 1/2 bit periods for stationary MS. For MS moving at a speed up to 500 km/h the additional error shall be less then 1/4 bit period.

The control loop for the timing advance shall be implemented in such a way that it will cope with MSs moving at a speed up to 500 km/h.

5.7 Timeslot length

Optionally, the BTS may use a timeslot length of 157 bit periods on timeslots with TN = 0 and 4, and 156 bit periods on timeslots with TN = 1, 2, 3, 5, 6, 7, rather than 156,25 bit periods on all timeslots.

5.8 Range of Timing advance

The timing advance shall be in the range 0 to 63. The value 0 corresponds to no timing advance, i.e. the MS transmissions to the BTS are 468,75 bits periods behind (see subclause 6.4). The value 63 corresponds to maximum timing advance, i.e. the MS transmissions are 405,75 bit periods behind.