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Radio subsystem synchronization
(3GPP TS 45.010 version 13.2.0 Release 13)

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650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

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

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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1 Scope

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

1.1 References

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

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- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
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[1] 3GPP TR 21.905: 'Vocabulary for 3GPP Specifications'.

[2] 3GPP TS 25.123: 'Requirements for support of radio resource management (TDD)'.

[3] 3GPP TS 25.133: 'Requirements for support of radio resource management (FDD)'.

[4] 3GPP TR 43.030: 'Radio network planning aspects'.

[5] 3GPP TS 43.052: 'Lower layers of the Cordless Telephony System (CTS) Radio Interface; Stage 2'.

[6] 3GPP TS 43.059: 'Functional stage 2 description of Location Services (LCS) in GERAN'.

[7] 3GPP TS 43.064: 'Overall description of the GPRS radio interface; Stage 2'.

[8] 3GPP TS 44.018: 'Mobile radio interface layer 3 specification, Radio Resource Control Protocol'.

[9] 3GPP TS 44.060: 'General Packet Radio Service (GPRS); Mobile Station (MS) - Base Station System (BSS) interface; Radio Link Control/ Medium Access Control (RLC/MAC) protocol'.

[10] 3GPP TS 45.002: 'Multiplexing and multiple access on the radio path'.

[11] 3GPP TS 45.005: 'Radio transmission and reception'.

[12] 3GPP TS 45.008: 'Radio subsystem link control'.

[13] 3GPP TS 45.050: 'Background for RF Requirements'.

[14] 3GPP TS 45.056: 'CTS-FP Radio Sub-system'.

[15] 3GPP TS 45.004: 'Modulation'.

[16] 3GPP TS 36.133: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management'.

[17] 3GPP TS 36.211: 'Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation'.

1.2 Definitions and abbreviations

In addition to those below, abbreviations used in the present document are listed in 3GPP TR 21.905.

BTS: Base Transceiver Station.

BTTI: Basic TTI.

Coverage Class: see definition in 3GPP TS 43.064.

CTS-FP: CTS Fixed Part.

CTS-MS: MS operating in CTS mode.

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

Current Serving CTS-FP: CTS-FP on one of whose channels (TCH or CTS control channels) the CTS-MS is currently operating.

EC: See definition in 3GPP TS 43.064.

EC-GSM-IoT: See definition in 3GPP TS 43.064.

FANR (Fast Ack/Nack Reporting): Fast Ack/Nack Reporting enables the use of a PAN field within an RLC/MAC block for EGPRS data transfer or for EGPRS2 data transfer. FANR enables the mobile station to transmit in the uplink direction a PAN field corresponding to a downlink TBF. Similarly FANR enables the network to transmit in the downlink direction a PAN field corresponding to an uplink TBF.

MS timing offset: 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 symbol, 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 symbols, but with a timing advance of T symbols, the reported timing offset will be P-T quantized to the nearest symbol. For GPRS the MS timing offset is not reported.

Normal Symbol Period: duration of a symbol for bursts using a modulating symbol rate of 1625/6 ksymb/s (see 3GPP TS 45.004); it is equal to 48/13 µs. This symbol duration is used for transmission of GMSK, 8PSK, 16QAM and 32QAM modulated bursts on downlink and GMSK, 8PSK and 16QAM modulated bursts on uplink (see 3GPP TS 45.004).

Observed Frequency Offset (OFO): difference of frequency of signals received by a CTS-MS from a CTS-FP and a BTS. The Observed Frequency Offset is measured and reported by the CTS-MS on CTS-FP requirement. The Observed Frequency Offset is expressed in ppm with an accuracy of 1/64 ppm (i.e. about 0,016 ppm).

PAN: Piggy-backed Ack/Nack.

Quarter symbol number: timing of quarter symbol periods (12/13 µs or 10/13 µs depending on the actual symbol period used) within a timeslot. A symbol can represent 1 to 5 bits depending upon modulation.

Reduced Latency: refers to the use of FANR either in BTTI configuration or in RTTI configuration for EGPRS and EGPRS2.

Reduced Symbol Period: duration of a symbol for bursts using a modulating symbol rate of 325 ksymb/s (see 3GPP TS 45.004); it is equal to 40/13 µs. This symbol duration is used for transmission of QPSK, 16QAM and 32QAM modulated bursts on uplink and downlink (see 3GPP TS 45.004).

RTTI: Reduced TTI.

Symbol Period: symbol period is the duration of a symbol and shall refer to normal symbol period unless explicitly clarified to be the reduced symbol period.

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

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

Time group (TG): used for compact**,** time groups shall be numbered from 0 to 3 and a particular time group shall be referred to by its time group number (TG) (see 3GPP TS 45.002).

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Timeslot number: timing of timeslots within a TDMA frame.

Timing Advance: 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.

Timing Advance Index: Timing Advance Index TAI used for GPRS, which determines the position of the subchannel on PTCCH (see 3GPP TS 45.002) used by the MS to send an access burst, from which the network can derive the timing advance.

TTI: Transmission Time Interval.

2 General description of synchronization system

This clause gives a general description of the synchronization system. Detailed requirements are given in clauses 3 to 7.

The BTS sends signals on the BCCH carrier or, for COMPACT on the CPBCCH carrier, 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, control channel frames, and (for COMPACT) the rotation of time groups 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 for circuit-switched handovers. 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 for circuit-switched handovers are included in annex A.

While in dual transfer mode an MS performs all the tasks of dedicated mode. In addition, upper layers can require the release of all the packet resources, which triggers the transition to dedicated mode, or the release of the RR resources, which triggers the transition either to idle mode and packet idle mode or, depending upon network and MS capabilities, to packet transfer mode.
When handed over to a new cell, the MS leaves the dual transfer mode, enters the dedicated mode where it switches to the new cell, may read the system information messages sent on the SACCH and may then enter dual transfer mode in the new cell (see 3GPP TS 44.060).

In CTS, the CTS-FP sends signals on the CTSBCH to enable the MS to synchronize itself to the CTS-FP and if necessary correct its frequency standard to be in line with that of the CTS-FP.

The signals sent by the CTS-FP for these purposes are:

a) Frequency correction bursts;

b) Synchronization bursts.

The timings of timeslots, TDMA frames, CTSBCH, CTSARCH, CTSAGCH and CTSPCH frames are all related to a first common set of counters which run continuously whether the CTS-MS and CTS-FP are transmitting or not. Thus, once the CTS-MS has determined the correct setting of these first counters, the CTS-MS is able to attach to the current serving CTS-FP. In addition, during CTS-MS attachment, the CTS-FP sends to the CTS-MS the remaining counters for SACCH and TCH frames. Then, all processes of the CTS-MS are synchronized to the current serving CTS-FP.

The CTS-MS times its transmissions to the CTS-FP in line with those received from the CTS-FP. The timing advance parameter is set to zero for CTS.

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Additionally, the CTS-FP may be assisted by a CTS-MS to adjust its frequency source. When required by the CTS-FP, the CTS-MS estimates if possible and reports the Observed Frequency Offset of the CTS-FP with a specified BTS. The CTS-FP may then adjust its frequency source according to this value.

3 Timebase counters

3.1 Timing state of the signals

The timing state of the signals transmitted by a BTS (for normal symbol period), a MS (for normal symbol period), a CTS-FP, or an Compact BTS and MS is defined by the following counters:

- Quarter symbol number QN (0 - 624)
- Symbol number BN (0 - 156);
- Timeslot number TN (0 - 7);
- TDMA frame number FN (0 to (26 x 51 x 2048) - 1 = 2715647); or
- for a non attached CTS-MS, TDMA frame number modulo 52 T4 (0 - 51); or
- for Compact, TDMA frame number FN (0 to (52 x 51 x 1024) -1 = 2715647).

In CTS, the CTS-MS shall manage different sets of counters for CTS operation and GSM operation.

Alternatively, in case of transmission using reduced symbol period, for a BTS or an MS the following counters have the following ranges:

- Quarter symbol number QN (0-749)
- Symbol number BN (0-187)

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3.2 Relationship between counters

The relationship between these counters is as follows:

- QN increments every 12/13 µs for normal symbol period and every 10/13µs for Reduced Symbol Period;
- BN = Integer part of QN/4;
- TN increments whenever QN changes from count 624 to 0 for normal symbol periodand whenever QN changes from count 749 to 0 for reduced symbol period;
- FN increments whenever TN changes from count 7 to 0; or
- for a CTS-MS, T4 increments whenever TN changes from count 7 to 0.

4 Timing of transmitted signals

The timing of signals transmitted by the MS, BTS and CTS-FP are defined in 3GPP TS 45.002.

i) 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).

ii) For Compact, 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;

FN = (R1 x 51 + R2) x 52 + 51 when the synch burst is received (where R1 and R2 are contained in information fields in synchronization burst);

TN is determined from TG as described in 3GPP TS 45.002, where TG is contained in information fields in synchronization burst.

iii) For CTS, the timebase counters are set as follows:

QN is set by the timing of the training sequence;

TN is set according to the CTSBCH-SB position (see Annex C);

T4 = 51 when the CTSBCH-SB is received (prior to attachment);

FN = (51 ((T3-T2) mod (26)) + T3 + 51 x 26 x T1) mod (2715648) when the CTS-MS receives the last CTSAGCH burst of the non-hopping access procedure, where T2 = T4 mod (26), and T1 and T3 being contained in this CTS immediate assignment message.

iv) For EC-GSM-IoT, the MS may use the timing of receipt of the synchronization burst on EC-SCH to set up its timebase counters as follows:

QN is set by the timing of the training sequence;

TN = 1 when the synch burst is received

FN = RFN_{QH} + 51 x 26 x 512 x QUARTER_HYPERFRAME_INDICATOR

where,

RFN_{QH} = FN within a quarter hyperframe = (51 x 52 x T1') + (4 x 51 x T2' + 51 x T2") + T3" when the synch burst is received

T1', T2' is contained from information fields in the synchronization burst, and,

T2" is signalled through the cyclic shift pattern used on the EC-SCH, see 3GPP TS 45.003.

T3 is determined e.g. by the device through the identification of the mapping of the FCCH, or EC-SCH, onto the specific TDMA frames within the 51-multiframe

QUARTER_HYPERFRAME_INDICATOR is obtained in the immediate assignment, see 3GPP TS 44.018.

NOTE: Depending on the coverage condition, the MS may optionally use the timing of receipt of the synchronization burst (SCH) to set up its timebase counters as described in i).

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).

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5 BTS Requirements for Synchronization

5.0 General

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 or input level for reference performance, whichever applicable, in 3GPP TS 45.005 and 3 dB less carrier to interference ratio than the reference interference ratios in 3GPP TS 45.005.