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UPDATE NOTE

Recommendation GSM 05.10

Radio Sub-system Synchronization

- previous released version	: 3.5.0 (Release 92, phase 1)
- new updated version October 1992	: 3.5.1

1. Reason for changes

Change agreed at SMG plenary no 4, Madrid, SPAIN is included.

2. Details of changes

CR	Title	Sections modified	Ref GSM Doc
CR 13 r1	Clarification of "ready to transmit"	6.	546/92r1

GSM Recommendation 05.10

Title : RADIO SUB-SYSTEM SYNCHRONIZATION

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Contents

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Note { } give explanatory comments to assist the reader

1. Scope

This recommendation defines the requirements for synchronization on the GSM radio sub-system. (However, it does not define the synchronization algorithms to be used in the BS and MS. These are up to the manufacturer to specify.)

2. General Description of Synchronization System

This section gives a general description of the synchronization system. Detailed requirements are given in Sections 3 to 6 below.

The BS sends signals on the BCCH to enable the MS to synchronize itself to the BS and if necessary correct its frequency standard to be in line with that of the BS. The signals sent by the BS 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 BS 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 BS.

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

3. Timebase Counters

3.1 The timing state of the signals transmitted by a BS 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 (26x51x2048)-1 = 2715647)

3.2 The relationship between these counters is as follows:

* QN increments every 12/13 ms
* 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 BS are defined in Recommendation 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 Section 3.2

(When adjacent BS's are being monitored for handover purposes, the MS may choose to store the values of QN, TN and FN for all the BS's whose synchronization bursts have been detected relative to QN, TN and FN for its current serving BS)

5. BS Requirements for Synchronization

The conditions under which the requirements of sections 5.4 and 5.6 must be met shall be 3 dB below the reference sensitivity level in recommendation GSM 05.05 (pr I-ETS 300.033) and 3 dB less carrier to interference ratio than the reference interference ratios in recommendation GSM 05.05 (pr I-ETS 300.033)

5.1 The BS 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 BS.

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

5.3 The channels of different carriers transmitted by a BS shall be synchronized together, ie 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 BS antenna

5.4 When the BS detects a random access CCCH transmission or a message with a long guard time (eg handover acknowledgement) on a TCH, 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 BS when applicable

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

5.6 The BS shall thereafter continuously monitor the delay 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. 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.

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

5.7 Optionally, the BS 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 The timing advance shall be in the range 0 to 63. The value 0 corresponds to no timing advance, ie. the MS transmissions to the BS are 468.75 bits periods behind (see section 6.4). the value 63 corresponds to maximum timing advance, ie. the MS transmissions are 405.75 bit periods behind.

6. MS Requirements for Synchronization

The MS shall only transmit to the BS if the requirements of sections 6.1 to 6.4 are met.

The conditions under which the requirements of sections 6.1 to 6.4 must be met shall be 3 dB below the reference sensitivity level in recommendation GSM 05.05 (pr I-ETS 300.033) and 3 dB less carrier to interference ratio than the reference interference ratios in recommendation GSM 05.05 (pr I-ETS 300.033)

6.1 The MS carrier frequency shall be accurate to within 0.1 ppm, or accurate to within 0.1 ppm compared to signals received from the BS (these signals will have an apparent frequency error due to BS frequency error and Doppler shift). In the latter case the signals from the BS must be averaged over sufficient time that errors due to noise or interference are allowed for within the above 0.1 ppm figure. The MS shall use the same frequency source for both RF frequency generation and clocking the timebase.

6.2 The MS shall keep its internal timebase in line with that of signals received from the BS. If the MS determines that the timing difference exceeds 2ms, it shall adjust its timebase in steps of 1/4 bit period . This adjustment shall be performed at intervals of not less than 1 second and not greater than 2 seconds until the timing difference is less than 1/2 bit periods.

6.3 In determining the timing of signals from the BS, the timings shall be assessed in such a way that the timing assessment error is less than 1/2 bit periods. The assessment algorithm must be such that the requirements of 6.2 can be met.

(In discontinuous reception (DRX), the MS should meet the requirements of sections 6.1 to 6.3 during the times when the receiver is required to be active. This is to enable the requirements of Rec 05.05 to be met)

6.4 The MS shall time its transmissions to the BS according to signals received from the BS. The MS transmissions to the BS, measured at the MS antenna, shall be 468.75-TA bit periods (i.e. 3 timeslots-TA) behind the transmissions received from the BS, where TA is the last timing advance received from the current serving BS. The tolerance on these timings shall be +/- 1 bit period. The MS shall signal the used TA to the BS.

6.5 When the MS receives a new value of TA from the BS on the SACCH, it shall implement the new value of TA at the first TDMA frame belonging to the next reporting period (as defined in 05.08, section 8.4), after the SACCH frame containing the new TA value.

6.6 When the MS accesses a new BS, random access, or the serving BS is changed, handover, the MS shall change the TA as follows:

Random access:
The MS shall use a TA value of 0 for the Random Access burst sent. When a TA is received from the BS that TA shall be used.

Synchronized handover:
After the Handover Access bursts which shall be sent with a TA value of 0 the MS shall use a TA derived from knowledge of the relative timing of the old and the new BS and the value of the TA for the old BS. When a TA is received from the new BS that TA shall be used.

Non-synchronized handover:
The MS shall use a TA value of 0 for the Handover Access bursts sent. When a TA is received in a physical information message that TA shall be used. Before a TA is received from the new BS no valid "used TA" shall be signalled to the new BS.

6.7 During a temporary total loss of signal, of up to 64 SACCH block periods, the MS shall update its timebase with a clock which is accurate to within 0.2 ppm, or to within 0.2 ppm of the signals previously received from the BS.

6.8 When the MS receives an intracell channel change command or a handover command (see rec. 04.08), it shall be ready to transmit on the new channel within 120ms of the last timeslot of the message block containing the command, unless a "starting time" value is given, in which case it shall be ready to transmit on the new channel at the designated starting time, or within 120ms, whichever is the later. The time between the end of the last complete speech or data frame or message block sent on the old channel and the time the MS is ready to transmit on the new channel shall be less than 20ms.

6.9 When the MS receives a new TA value in response to a handover access burst, the MS shall be ready to transmit using the new TA value within 40ms of the end of the last timeslot of the message block containing the new TA value.

Note: The MS shall keep the timings of the neighbour BS's that it is monitoring (according to Rec 05.08) to an accuracy of +/- 1 bit periods.

Note: The phrase "ready to transmit within x ms" means that the MS shall transmit no later than
- the first burst of the first TCH or control channel block that occurs after the x ms, in case of an intracell channel change.
- the first burst of the TCH or control channel that occurs after the x ms, in case of a handover.

It would be acceptable, but not preferred, that the MS, in the handover case, transmits at the first burst of the first TCH or control channel block that occurs after the x ms

7. Vocabulary

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

Quarter bit number : The timing of quarter bit periods (12/13 ms) 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 BS : The BS on one of whose channels (TCH, DCCH or CCCH) the MS is currently operating

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