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GEO-Mobile Radio Interface Specifications (Release 3);
Third Generation Satellite Packet Radio Service;
Part 5: Radio interface physical layer specifications;
Sub-part 7: Radio Subsystem Synchronization;
GMR-1 3G 45.010

Reference

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Foreword

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The present document is part 5, sub-part 7 of a multi-part deliverable covering the GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service, as identified below:

Part 1: "General specifications";

Part 2: "Service specifications";

Part 3: "Network specifications";

Part 4: "Radio interface protocol specifications";

Part 5: "Radio interface physical layer specifications":

Sub-part 1: "Physical Layer on the Radio Path: General Description; GMR-1 3G 45.001";

Sub-part 2: "Multiplexing and Multiple Access; Stage 2 Service Description; GMR-1 3G 45.002";

Sub-part 3: "Channel Coding; GMR-1 3G 45.003";

Sub-part 4: "Modulation; GMR-1 3G 45.004";

Sub-part 5: "Radio Transmission and Reception; GMR-1 3G 45.005";

Sub-part 6: "Radio Subsystem Link Control; GMR-1 3G 45.008";

Sub-part 7: "Radio Subsystem Synchronization; GMR-1 3G 45.010";

Part 6: "Speech coding specifications";

Part 7: "Terminal adaptor specifications".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

GMR stands for GEO (Geostationary Earth Orbit) Mobile Radio interface, which is used for Mobile Satellite Services (MSS) utilizing geostationary satellite(s). GMR is derived from the terrestrial digital cellular standard GSM and supports access to GSM core networks.

The present document is part of the GMR Release 3 specifications. Release 3 specifications are identified in the title and can also be identified by the version number:

- Release 1 specifications have a GMR 1 prefix in the title and a version number starting with "1" (V1.x.x).
- Release 2 specifications have a GMPRS 1 prefix in the title and a version number starting with "2" (V2.x.x).
- Release 3 specifications have a GMR-1 3G prefix in the title and a version number starting with "3" (V3.x.x).

The GMR release 1 specifications introduce the GEO-Mobile Radio interface specifications for circuit mode Mobile Satellite Services (MSS) utilizing geostationary satellite(s). GMR release 1 is derived from the terrestrial digital cellular standard GSM (phase 2) and it supports access to GSM core networks.

The GMR release 2 specifications add packet mode services to GMR release 1. The GMR release 2 specifications introduce the GEO-Mobile Packet Radio Service (GMPRS). GMPRS is derived from the terrestrial digital cellular standard GPRS (included in GSM Phase 2+) and it supports access to GSM/GPRS core networks.

The GMR release 3 specifications evolve packet mode services of GMR release 2 to 3rd generation UMTS compatible services. The GMR release 3 specifications introduce the GEO-Mobile Radio Third Generation (GMR-1 3G) service. Where applicable, GMR-1 3G is derived from the terrestrial digital cellular standard 3GPP and it supports access to 3GPP core networks.

Due to the differences between terrestrial and satellite channels, some modifications to the GSM or 3GPP standard are necessary. Some GSM and 3GPP specifications are directly applicable, whereas others are applicable with modifications. Similarly, some GSM and 3GPP specifications do not apply, while some GMR specifications have no corresponding GSM or 3GPP specification.

Since GMR is derived from GSM and 3GPP, the organization of the GMR specifications closely follows that of GSM or 3GPP as appropriate. The GMR numbers have been designed to correspond to the GSM and 3GPP numbering system. All GMR specifications are allocated a unique GMR number. This GMR number has a different prefix for Release 2 and Release 3 specifications as follows:

- Release 1: GMR n xx.zyy.
- Release 2: GMPRS n xx.zyy.
- Release 3: GMR-1 3G xx.zyy.

where:

- xx.0yy (z = 0) is used for GMR specifications that have a corresponding GSM or 3GPP specification. In this case, the numbers xx and yy correspond to the GSM or 3GPP numbering scheme.
- xx.2yy (z = 2) is used for GMR specifications that do not correspond to a GSM or 3GPP specification. In this case, only the number xx corresponds to the GSM or 3GPP numbering scheme and the number yy is allocated by GMR.
- n denotes the first (n = 1) or second (n = 2) family of GMR specifications.

A GMR system is defined by the combination of a family of GMR specifications and GSM and 3GPP specifications as follows:

- If a GMR specification exists it takes precedence over the corresponding GSM or 3GPP specification (if any). This precedence rule applies to any references in the corresponding GSM or 3GPP specifications.

NOTE: Any references to GSM or 3GPP specifications within the GMR specifications are not subject to this precedence rule. For example, a GMR specification may contain specific references to the corresponding GSM or 3GPP specification.

- If a GMR specification does not exist, the corresponding GSM or 3GPP specification may or may not apply. The applicability of the GSM and 3GPP specifications is defined in ETSI TS 101 376-1-2 [8].

1 Scope

The present document presents the requirements for synchronizing timing and frequency between the MES and the Gateway Station (GS) in the GMR-1 3G Mobile Satellite System for circuit switch and packet switch modes of operation.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document in Release 7 or to the latest version of that document in the latest release less than 7.

In the case of a reference to a GMR-1 3G document, a non-specific reference implicitly refers to the latest version of that document in the same Release as the present document.

[1] ETSI TS 101 376-1-1: "GEO-Mobile Radio Interface Specifications (Release 2) General Packet Radio Service; Part 1: General specifications; Sub-part 1: Abbreviations and acronyms; GMPRS-1 01.004".

NOTE: This is a reference to a GMR-1 Release 2 specification. See the introduction for more details.

[2] ETSI TS 101 376-4-8: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 8: Mobile Radio Interface Layer 3 Specifications; GMR-1 3G 44.008".

[3] ETSI TS 101 376-5-2: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 2: Multiplexing and Multiple Access; Stage 2 Service Description; GMR-1 3G 45.002".

[4] ETSI TS 101 376-5-5: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 5: Radio Transmission and Reception; GMR-1 3G 45.005".

[5] ETSI TS 101 376-5-6: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 6: Radio Subsystem Link Control; GMR-1 3G 45.008".

[6] ETSI TS 101 376-5-7 (V1.3.1): "GEO-Mobile Radio Interface Specifications (Release 1); Part 5: Radio interface physical layer specifications; Sub-part 7: Radio Subsystem Synchronization; GMR-1 05.010".

NOTE: This is a reference to a GMR-1 Release 1 specification. See the introduction for more details.

[7] ETSI TS 101 376-4-12: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 12: Mobile Earth Station (MES) - Base Station System (BSS) interface; Radio Link Control/Medium Access Control (RLC/MAC) protocol; GMR-1 3G 44.060".

[8] ETSI TS 101 376-1-2: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 1: General specifications; Sub-part 2: Introduction to the GMR-1 family; GMR-1 3G 41.201".

[9] ETSI TS 101 376-4-13: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 4: Radio interface protocol specifications; Sub-part 13: Radio Resource Control (RRC) protocol; Iu Mode; GMR-1 3G 44.118".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

Not applicable.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in GMR-1 3G 41.201 [8] and the following apply:

Frequency Correction (FC): in-call frequency correction sent over FACCH channel

frequency offset: frequency correction sent over AGCH channel

guard time violation: message to indicate the violation of Rx/Tx burst guard time

MAC_FORWARD_TS_OFFSET: offset in number of timeslots of MAC-slot 0 or D-MAC-slot 0 relative to the start of the downlink frame

MAC_RETURN_TS_OFFSET: offset in number of timeslots of MAC-slot 0 or D-MAC-slot 0 relative to the start of the uplink frame

Precorrection Indication (PI): timing delay pre-compensated by the MES in the RACH transmission

RACH_TS_OFFSET: RACH window offset relative to the start of BCCH window within the same frame, measured in number of timeslots

RACH_SYMBOL_OFFSET: RACH timing offset in symbols

NOTE: The offset between RACH window and the start of the reference frame seen from the MES. Measured in number of symbols.

SA_BCCH_STN: BCCH window offset relative to the start of the frame, in number of timeslots

SA_FREQ_OFFSET: twice of the downlink beam centre Doppler due to satellite motion only

SA_SIRFN_DELAY: within each multiframe, the first FCCH channel frame number relative to the start of the multiframe

SB_FRAME_TS_OFFSET: offset between downlink frame N and uplink frame N + 7 at the spot-beam centre, measured in number of timeslots

SB_SYMBOL_OFFSET: additional offset between downlink frame N and uplink frame N + 7 at the spot beam centre, measured in number of symbols

Timing Correction (TC): in-call timing correction sent over FACCH channel

timing offset: timing correction sent over AGCH channel

USF Delay Value: if an MES receives a USF in its receive downlink frame N, it applies the USF (i.e. transmits corresponding to the received USF grant) on the uplink frame numbered (N + USF Delay Value)

NOTE: USF Delay Value is decoded from USF_DELAY and USF_DELAY Adjustment parameters in BCCH System Information, and it can take values of 6, 7, 8, 9 or 10.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in GMPRS-1 01.004 [1] apply.

4 General description of synchronization system

4.0 Overview

The GEO-Mobile Radio 1 (GMR-1) satellite system is a multi-spot beam, multicarrier, synchronous system where the timing and frequency on the satellite serve as the reference to synchronize the TDMA transmissions for the MESs, the network GSs and other network elements.

For A/Gb mode only, the satellite may include a switch designed to provide single-hop, TtT connectivity. Such a TDMA satellite switch permits the selection of connection patterns between any slot in the TDMA frame of a return carrier in one spot beam to any other slot in the TDMA frame of a forward carrier in the same spot beam or any other spot beam.

Synchronization in the GMR-1 system is composed of four major tasks:

- timing synchronization;
- frequency synchronization;
- frame synchronization;
- message synchronization.

A master oscillator onboard the GMR-1 spacecraft is the primary reference for all synchronization processes. The fundamental goal of synchronization is to have gateways and mobile earth stations alike operate such that all bursts arrive at the satellite synchronized in timing and frequency.

The above description applies to S and L band mobile link operations.

4.1 System timing structure

The GMR-1 satellite system is a TDMA system. Timing configuration in the system is composed of hyperframe, superframe, multiframe, frame, timeslot, symbol and bit. A hyperframe is the longest repetition time period and 1/40 symbol duration is the smallest measurable and adjustable unit in the system.

A hyperframe has a duration of 3 h 28 min 53 s 760 ms, it contains 4 896 superframes, 19 584 multiframes or 313 344 TDMA frames. One superframe equals to 2,56 s, including four multiframes or 64 TDMA frames. One multiframe includes 16 TDMA frames and each TDMA frame has 24 timeslots. The TDMA frame duration is 40 ms, one timeslot duration is approximately 1,67 ms. In each timeslot, there are 39 symbols, each symbol corresponds to 2 bits. The complete timeframe structure can be seen from the graph shown in ETSI TS 101 376-5-2 [3].

A superframe always starts from the frame that meets FN mod 64 = 0. Within the superframe, the first frame is also the beginning of the first multiframe with multiframe number 00.

4.2 Timebase counter

The timing state of the signals transmitted by the MES and satellite is defined by the following counters:

- bit counter BN (0 to 77);
- timeslot counter TN (0 to 23);
- TDMA frame counter FN (0 to 313 343).

The relationship between these counters is as follows:

- BN increments every 5 000/234 µs;
- TN increments whenever BN changes from count 77 to 0;
- FN increments whenever TN changes from count 23 to 0.

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

- BN is set by the timing of the FCCH timing acquisition;
- TN is set by the timeslot number that is contained in the information fields of the BCCH burst;
- FN is set by the frame number derived from the information fields of the BCCH bursts.

The frame number field definition is given in ETSI TS 101 376-4-8 [2].

4.3 General requirement

4.3.1 Timing and frequency reference point

The satellite is selected to be the reference point for both timing and frequency. For downlink signals, the reference point is the output of the satellite forward link antenna. For uplink signals, the reference point is the input of the satellite return link antenna.

4.3.2 MES requirement

The following requirements shall apply to the MES side:

- Both transmitter and receiver timing shall be derived from the same timebase.
- Both transmitter and receiver frequency shall be derived from the same frequency source.
- The MES shall use the same source for both RF frequency generation and clicking the timebase.
- All return link signals (control channel and traffic channel) transmitted from the MESs shall achieve frame/timeslot alignment on the satellite timing reference point, i.e. input of satellite antenna.
- In various operation modes, synchronization shall be maintained under the worst case timing and frequency drift rate due to MES-satellite relative motion and MES master oscillator stability. The MES oscillator long term stability shall be better than 5 ppm. The MES oscillator short-term stability shall maintain all timing offset, frequency offset and symbol rate requirement specified in ETSI TS 101 376-5-5 [4] in the absence of received signal up to 5 s. The maximum timing drift rate due to MES-satellite relative motion is 0,32 µs/s. The maximum frequency drift rate due to MES acceleration is 24,6 Hz/s.
- MES receiver's time and frequency search ranges (apertures) shall be large enough to accommodate the variations (specified in clause 4.3.3) in the network transmit time and frequency in addition to the satellite-MES relative motion induced time and frequency shifts (see annex A for an informative description), MES oscillator drifts, etc. The MES receiver, operating with such values of time and frequency apertures, shall achieve the performance requirements (i.e. BER, FER, time and frequency estimation accuracies, etc.) specified in ETSI TS 101 376-5-5 [4].

4.3.3 Network requirement

The following requirements shall apply to the network side:

- All forward link signals (control channel and traffic channel) transmitted from the network shall achieve frame/timeslot alignment on the satellite timing reference point, i.e. output of satellite antenna.
- Both forward and return link signals shall be adjusted by the network to maintain a fixed frame and slot relative timing on the satellite timing reference point. This adjustment shall be capable of handling the worst case timing and frequency drift caused by satellite motion and user motion.
- Forward and return link timeslots shall be assigned by the network to meet the follows: A 1,0 ms guard time shall be left for the MES to switch between transmit and receive frequencies. A 1,0 ms guard time shall be left for the MES to switch between two different receive frequencies.
- At the initial call setup, the network shall be able to estimate the RACH signal arrival to the accuracy better than 12,6 Hz 1-sigma in frequency, 3,6 µs 1-sigma in timing, under the condition of AWGN channel.
- The network shall ensure that the maximum variation between the transmit time of a CCCH burst and the transmit time of a PDCH burst does not exceed 1,1 µs. Similarly, the maximum burst-to-burst variation in the PDCH transmit time shall not exceed 1,1 µs. Burst-to-burst variations in the network transmit frequency shall not exceed 10 Hz.

4.3.4 Measurement conditions

- In the following, all timing and frequency related parameters are defined under the condition of AWGN channel, with $E_b / N_0 = -0,5\ dB$.
- In the following, unless specifically specified, all timing and frequency related parameters are defined as 1-sigma value.

5 Timing synchronization, TtG/GtT Session

5.0 Overview

The general requirement for MES timing synchronization is that the MES shall transmit signals that are time aligned and frame number aligned with the system timing on the satellite reference point.

The MES timing alignment is achieved by correcting transmission timing with factors provided by a Gateway Station (GS). RACH timing is setup by factors provided over the BCCH. The GS transmits a frame number on the BCCH which is received and used by the MES to establish its local frame numbering process.

For the case in which the MES operates in A/Gb dedicated mode, TCH or SDCCH timing is corrected with corrective factors given over the AGCH. During a call, timing correction is provided by FACCH (TCH3) or SACCH (TCH6/TCH9).

For the case in which the MES operates in the packet mode, shared or dedicated, receive timing shall be corrected by monitoring BCCH, PCH, PDCH, or DCH and transmission timing shall be corrected with factors provided by the GS. The GS provides correction factors via AGCH, PACCH, or DACCH based on the MES mode and situation, which is explained here.

5.1 General description

The whole system is synchronized on the satellite. The network adjusts FCCH/FCCH3 and BCCH transmission so that each of these channels leaves from the satellite antenna at the predefined system timing. An MES derives its local timing reference from the signals received from the satellite. By listening to the FCCH/FCCH3, both timing and frequency synchronization can be achieved for CCCH channels.

From a cold start, MESs initially search for and acquire the FCCH/FCCH3 sent in each spot beam. The MES's frame timing is then synchronized to system timing.