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Technical Specification

GEO-Mobile Radio Interface Specifications;
Part 5: Radio interface physical layer specifications;
Sub-part 7: Radio Subsystem Synchronization;
GMR-2 05.010

Reference

DTS/SES-002-05010

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ETSI

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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IPRs:

Project	Company	Title	Country of Origin	Patent n°	Countries Applicable
TS 101 377 V1.1.1	Digital Voice Systems Inc		US	US 5,715,365	US
TS 101 377 V1.1.1	Digital Voice Systems Inc		US	US 5,754,974	US
TS 101 377 V1.1.1	Digital Voice Systems Inc		US	US 5,226,084	US
TS 101 377 V1.1.1	Digital Voice Systems Inc		US	US 5,701,390	US
TS 101 377 V1.1.1	Digital Voice Systems Inc		US	US 5,826,222	US

IPR Owner: Digital Voice Systems Inc
One Van de Graaff Drive Burlington,
MA 01803
USA

Contact: John C. Hardwick
Tel.: +1 781 270 1030
Fax: +1 781 270 0166

Project	Company	Title	Country of Origin	Patent n°	Countries Applicable
TS 101 377 V1.1.1	Ericsson Mobile Communication	Improvements in, or in relation to, equalisers	GB	GB 2 215 567	GB
TS 101 377 V1.1.1	Ericsson Mobile Communication	Power Booster	GB	GB 2 251 768	GB
TS 101 377 V1.1.1	Ericsson Mobile Communication	Receiver Gain	GB	GB 2 233 846	GB
TS 101 377 V1.1.1	Ericsson Mobile Communication	Transmitter Power Control for Radio Telephone System	GB	GB 2 233 517	GB

IPR Owner: Ericsson Mobile Communications (UK) Limited
The Keytech Centre, Ashwood Way
Basingstoke
Hampshire RG23 8BG
United Kingdom

Contact: John Watson
Tel.: +44 1256 864 821

Project	Company	Title	Country of Origin	Patent n°	Countries Applicable
TS 101 377 V1.1.1	Hughes Network Systems		US	Pending	US

IPR Owner: Hughes Network Systems
11717 Exploration Lane
Germantown, Maryland 20876
USA

Contact: John T. Whelan
Tel: +1 301 428 7172
Fax: +1 301 428 2802

Project	Company	Title	Country of Origin	Patent n°	Countries Applicable
TS 101 377 V1.1.1	Lockheed Martin Global Telecommunic. Inc	2.4-to-3 KBPS Rate Adaptation Apparatus for Use in Narrowband Data and Facsimile Communication Systems	US	US 6,108,348	US
TS 101 377 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Cellular Spacecraft TDMA Communications System with Call Interrupt Coding System for Maximizing Traffic ThroughputCellular Spacecraft TDMA Communications System with Call Interrupt Coding System for Maximizing Traffic Throughput	US	US 5,717,686	US
TS 101 377 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Enhanced Access Burst for Random Access Channels in TDMA Mobile Satellite System	US	US 5,875,182	
TS 101 377 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Spacecraft Cellular Communication System	US	US 5,974,314	US
TS 101 377 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Spacecraft Cellular Communication System	US	US 5,974,315	US
TS 101 377 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Spacecraft Cellular Communication System with Mutual Offset High-argin Forward Control Signals	US	US 6,072,985	US
TS 101 377 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Spacecraft Cellular Communication System with Spot Beam Pairing for Reduced Updates	US	US 6,118,998	US

IPR Owner: Lockheed Martin Global Telecommunications, Inc.
900 Forge Road
Norristown, PA. 19403
USA

Contact: R.F. Franciose
Tel.: +1 610 354 2535
Fax: +1 610 354 7244

Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The contents of the present document are subject to continuing work within TC-SES and may change following formal TC-SES approval. Should TC-SES 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 1.m.n

where:

- the third digit (n) is incremented when editorial only changes have been incorporated in the specification;
- the second digit (m) is incremented for all other types of changes, i.e. technical enhancements, corrections, updates, etc.

The present document is part 5, sub-part 7 of a multi-part deliverable covering the GEO-Mobile Radio Interface Specifications, 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; GMR-2 05.001";

Sub-part 2: "Multiplexing and Multiple Access on the Radio Path; GMR-2 05.002";

Sub-part 3: "Channel Coding; GMR-2 05.003";

Sub-part 4: "Modulation; GMR-2 05.004";

Sub-part 5: "Radio Transmission and Reception; GMR-2 05.005";

Sub-part 6: "Radio Subsystem Link Control; GMR-2 05.008";

Sub-part 7: "Radio Subsystem Synchronization; GMR-2 05.010";

Part 6: "Speech coding specifications".

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.

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

Since GMR is derived from GSM, the organization of the GMR specifications closely follows that of GSM. The GMR numbers have been designed to correspond to the GSM numbering system. All GMR specifications are allocated a unique GMR number as follows:

GMR-n xx.zyy

where:

- xx.0yy (z = 0) is used for GMR specifications that have a corresponding GSM specification. In this case, the numbers xx and yy correspond to the GSM numbering scheme.
- xx.2yy (z = 2) is used for GMR specifications that do not correspond to a GSM specification. In this case, only the number xx corresponds to the GSM 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 specifications as follows:

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

NOTE: Any references to GSM 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 specification.

- If a GMR specification does not exist, the corresponding GSM specification may or may not apply. The applicability of the GSM specifications is defined in GMR-n 01.201.

1 Scope

The present document defines the requirements for synchronization on the GMR-2 radio subsystem. However, it does not define the synchronization algorithms to be used in the MES and Gateway.

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 and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

[1] GMR-2 01.004 (ETSI TS 101 377-1-1): "GEO-Mobile Radio Interface Specifications; Part 1: General specifications; Sub-part 1: Abbreviations and Acronyms; GMR-2 01.004".

[2] GMR-2 04.004 (ETSI TS 101 377-4-3): "GEO-Mobile Radio Interface Specifications; Part 4: Radio interface protocol specifications; Sub-part 3: Layer 1 General requirements; GMR 2 04.004".

[3] GMR-2 04.008 (ETSI TS 101 377-4-7): "GEO-Mobile Radio Interface Specifications; Part 4: Radio interface protocol specifications; Sub-part 7: Mobile radio interface Layer 3 Specifications; GMR-2 04.008".

[4] GMR-2 05.001 (ETSI TS 101 377-5-1): "GEO-Mobile Radio Interface Specifications; Part 5: Radio interface physical layer specifications; Sub-part 1: Physical Layer on the Radio Path; GMR-2 05.001".

[5] GMR-2 05.002 (ETSI TS 101 377-5-2): "GEO-Mobile Radio Interface Specifications; Part 5: Radio interface physical layer specifications; Sub-part 2: Multiplexing and Multiple Access on the Radio Path; GMR-2 05.002".

[6] GMR-2 05.005 (ETSI TS 101 377-5-5): "GEO-Mobile Radio Interface Specifications; Part 5: Radio interface physical layer specifications; Sub-part 5: Radio Transmission and Reception; GMR-2 05.005".

[7] GMR-2 05.008 (ETSI TS 101 377-5-6): "GEO-Mobile Radio Interface Specifications; Part 5: Radio interface physical layer specifications; Sub-part 6: Radio Subsystem Link Control; GMR-2 05.008".

3 Definitions and Abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Coarse Timing Advance (CTA): is defined for each spotbeam. It is the least round-trip propagation time experienced anywhere in the spotbeam at any time of day, adjusted downward to the nearest integer number of Forward Bit Periods (FBP). CTA is expressed in units of Forward Bit Periods.

Fine Timing Advance (FTA): is defined to be the difference in round trip propagation delay between the satellite and a MES located at the CTA location in a spotbeam and the satellite and a MES located anywhere in a spotbeam. The MES will use the CTA when transmitting a random access and will receive the FTA in the assignment message which follows a random access. FTA is represented as an integer number of quarter return bit periods. Note that a forward bit period is the same as a quarter return bit period.

True Timing Advance (TTA): is calculated by each MES and is equal to the sum of the CTA and FTA. TTA is equal to the round trip propagation delay between the satellite and a MES located anywhere in a spotbeam (assuming numerical resolution and round-off errors neglected).

Delta Timing Advance (DTA): is a parameter calculated by the Gateway which instructs the MES to advance or retard its transmissions to the Gateway. DTA is used to correct MES timing offsets caused by MES and satellite movement after a link has been established with a gateway. DTA is represented in units of quarter return bit periods (1 forward bit period) and can range from +12 (advance by 12 quarter return bit periods) to -12 (retard by 12 quarter return bit periods).

MES Timing Offset: difference between the delay of the received signal relative to the expected signal from a MES if there were no change in the path length between the MES and gateway since the last Delta Timing Advance was implemented. MES timing offset is determined by the gateway. For example, for a MES with a round trip propagation delay of P bits, but with a True Timing Advance (CTA + FTA) of T bits, the reported timing offset will be P-T quantized to the nearest quarter-return bit. This is determined by the gateway and adjustments are sent on the forward S-SACCH for that MES in the form of a Delta Timing Advance.

Quarter Bit Number: timing of quarter bit periods (forward 12/13 µs; return 48/13 µs)

Current Spotbeam: satellite spotbeam on which the MES is currently camping, i.e., the spotbeam in which the MES is registered (advantaged environment) or will register when possible (disadvantaged environment).

Timebase Counters: set of counters which determine the timing state of signals transmitted by the NCC, gateway or MES

Forward Epoch Delay (FED): total delay associated with a given forward carrier described as follows:

$$\text{Forward Epoch Delay} = CO \times FSP + FSG \times SD$$

Where:

CO = Channel Offset

FSP = Forward Slot Period

FSG = Forward Stagger Group

SD = Stagger Delay

Return Epoch Delay (RED): total delay associated with a given return carrier described as follows:

$$\text{Return Epoch Delay} = CO \times FSP$$

Where:

CO and FSP are as defined for FED above.

Forward Slot Period (FSP): duration of one time slot in TDMA frame in a forward carrier

FSP = Forward Slot Period = 15/26 ms

Channel Offset (CO): number representing the integer number of Forward Slot Periods included in the Forward Epoch Delay for a given carrier:

CO = Channel Offset = Integer number $0 < CO < (51 \times 8 - 1)$

Forward Stagger Group (FSG): number representing the integer number of Stagger Delay increments included of the Forward Epoch Delay:

FSG = Forward Stagger Group = Integer number $0 < FSG < 3$

Stagger Delay (SD): incremental element of the fractional portion of the Forward Epoch Delay. The Stagger Delay is set to 39 Forward Bit Periods (approximately FSP/4).

Forward Bit Period (FBP): duration of a bit in a forward TDMA burst. Forward Bit Period is equal to 48/13 µs (approx.3,7 µs)

Return Bit Period (RBP): duration of a bit in a return TDMA burst. Return Bit Period is equal to 192/13 µs (approx.14,8 µs)

Frame Period (FP): duration of a TDMA frame, equal to 60/13 ms (approx. 4,6 ms). Frame period is same for forward and return channels. A Forward Frame is comprised of 8 slots whereas a Return Frame is comprised of 2 slots, each 4 times as long as a forward slot.

TDMA Frame Number (FN): count of TDMA frames relative to the carrier hyperframe epoch

Timeslot Number (TN): is an integer in the range of 0 to 7 which identifies a specific burst period in a TDMA frame.

Forward TN Group: Timeslot Number indexing a specific burst period in a forward TDMA Frame. Integer number in range of 0 to 7.

Return TN Group: Timeslot Number indexing a specific burst period in a return TDMA Frame. Integer number in range of 0 to 7.

Bearer Channel Type: defines the Type of Bearer Service which determines the submultiplexing scheme for sharing TN groups between multiple MESs as specified in GMR-2 05.002 [5], clause 9:

Bearer Channel Type	TN Submultiplexing Scheme
FR (Full Rate)	No Submultiplexing
HR (Half Rate)	Tx/Rx every other frame
QR (Quarter Rate)	Tx/Rx every fourth frame
ER (Eighth Rate)	Tx/Rx every eighth frame

Forward Submultiplex Index (FSMI): index for submultiplexing the same TN Group between different MESs using bearer channels less than Full Rate (FR):

N/A for Full Rate Bearer Channels

0 or 1 for Half Rate Bearer Channels

0, 1, 2, or 3 for Quarter Rate Bearer Rate Channels

0, 1, 2, 3, 4, 5, 6, or 7 for Eight Rate Bearer Channels

Return Submultiplex Index (RSMI): index for submultiplexing the same TN Group between different MESs using bearer channels less than Full Rate (FR):

Same range definitions as per Forward Submultiplex Index

Assignment_Delta: integer number used in determining the offsets between assigned forward and return channels TN groups and sub-multiplex indices.

Spotbeam Region: integer number (0 or 1) identifying a MES as being in one of two types of regions within a Large spotbeam (where satellite-to-MES Delay Variation (DV) exceeds a Frame Period (FP)). Spotbeam Region is used to modify the TN and Submultiplex Index assignment equations to avoid transmit/receive overlap in all regions of a large spotbeam.

N: Number of TDMA frames per Hyper Frame Cycle.

$N=2\,048 \times 51 \times 26 = 2\,715\,648$

S-RACH Configuration: defines the size of the S-RACH slot in terms of Frame Periods. S-RACH configuration can have values of 2 through 9

Frame Epoch: beginning of a frame period

T_off: Time offset (in units of frame periods) between transmit and receipt of the same frame number at the MES (frame number within any given hyperframe cycle)

q: difference, in frame number, between the transmit frame number at a given return frame epoch and the frame number of the last received (forward) frame at the MES

r: time difference (in units of frame periods) between last receive frame epoch and the next transmit frame epochs at the MES

Int[x]: for a rational number 'x', Int[x] is defined as the integer portion of x.

e.g.

Int[1,5] = 1,0, Int[1,0] = 1,0, Int[0,0] = 0,0, Int[-1,0] = -1,0, Int[-1,5] = -1,0

Frac[x]: for a rational number 'x', Frac[x] is defined as the fractional portion of 'x'

Frac[1,5] = 0,5, Frac[1,0] = 0,0, Frac[0,0] = 0,0, Frac[-1,0] = 0,0, Frac[-1,5] = -0,5

Ceiling_Function[x]: for a rational number 'x', Ceiling_Function[x] is the functional equivalent of rounding to the nearest integer in the direction of $+\infty$:

Ceiling_Function[x] = Int[x] + 1 when Frac[x] > 0,0

Ceiling_Function[x] = Int[x] when Frac[x] $\Leftrightarrow$ 0,0

e.g.

Ceiling_Function[1,5] = 2,0, Ceiling_Function[1,0] = 1,0, Ceiling_Function[0,0] = 0,0,

Ceiling_Function[-1,0] = -1,0, Ceiling_Function[-1,5] = -1,0

Floor_Function[x]: for a rational number 'x', Floor_Function[x] is the functional equivalent of rounding to the nearest integer in the direction of $-\infty$:

Floor_Function[x] = Int[x] when Frac[x] $\Downarrow$ 0,0

Floor_Function[x] = Int[x] - 1 when Frac[x] < 0,0

e.g.

Floor_Function[1,5] = 1,0, Floor_Function[1,0] = 1,0, Floor_Function [0,0] = 0,0

Floor_Function[-1,0] = -1,0, Floor_Function[-1,5] = -2,0

X Mod n: for integer numbers 'X' and n, X Mod n performs a modulo n function on the number X.

X Mod n = X - (n × Floor_Function[X/n])

e.g.

13 Mod 8 = 5 -13 Mod 8 = 3

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in GMR-2 01.004 [1] apply.

4 General Description of Synchronization System

This clause gives a general description of the synchronization system. Detailed requirements are given in clauses 5 to 8. For a fuller description of the sub-multiplexing functions refer to GMR-2 05.002 [5].

4.1 Overview

System time is referenced to the satellite node in the network. In general, the Mobile Earth Station, NCC, and gateway elements modify their transmissions to align with system time at the satellite node. Several timing biases are intentionally used in the network to modify this general concept. The NCC and gateway transmissions are staggered from the system time reference to achieve more uniform transmitter loading in the ground elements as well as in the satellite. The NCC and the gateways intentionally manipulate the forward and return timeslot relationships as well as the submultiplex index within a the forward and return timeslot group to achieve fine timing advance range with sufficient Mobile Earth Station settling time as well as preclude Mobile Earth Station transmit/receive overlap in spotbeams. Note that the subsequent discussion defines an 8-slot architecture, the tacit assumption is that traffic channels assigned to handheld terminals are Half Rate Traffic Channel (S-TCH/H), since half-rate is the driving case (refer to GMR-2 05.001 [4] for description of channel types and data rates). This equates to a 16-slot separation between signal transmissions.

4.2 System Time Definition

Please refer to table 4.2.1, System Timing Standards and Definitions during the discussion in the subsequent paragraphs.

The longest recurrent time period in system time is called a hyperframe and has a duration of 3h 28min 53s. One hyperframe is subdivided into 2 048 superframes. The superframe is the least common multiple of the two types of multiframes defined below:

a) A 26-frame traffic multiframe (51 per superframe) comprising 26 TDMA frames. This multiframe is used to carry S-TCH and S-SDCCH signals;

b) A 51-frame control multiframe (26 per superframe) comprising 51 TDMA frames. This multiframe is used to carry the control signals, S-HMSCH, S-SCH, S-HBCCH, S-BCCH, and the S-AGCH, S-PCH, S-HPACH and S-RACH.

A TDMA frame is defined to have eight timeslots. The eight timeslots are ordered into eight timeslot number (TN) groups, ranging from 0 to 7. Traffic channels are submultiplexed from one of the eight TN groups using a parameter called submultiplex index (SMI).

Each timeslot consists of 156,25 bits or 625 quarter bits. The return timeslot duration is four times longer than the forward timeslot duration. Four frequencies are used in the return direction to maintain transmission capacity.

A modulo four operation is used to assign return TN groups to the four return carriers while all forward TN groups are assigned to the single forward carrier, thus a trunk in this system is a 200 kHz bandwidth: a single forward carrier, and four associated return sub-carriers.

Table 4.2.1: System Timing Standards and Definitions

System Timing Standards	Time Description			Counter Description		
	Abbreviation	**Duration**		**Abbreviation**	**Number of Increments**	**Range**
Hyperframe	None	51 × 26 × 2 048 × 60/13 ms	3h 28min 53s 760ms	None	1	0 to 0
Superframe	None	51 × 26 × 60/13 ms	6 120 ms	T1	2048	0 to 2 047
Traffic multiframe	None	26 × 60/13 ms	120 ms	None	51	0 to 50
Control Multiframe	None	51 × 60/13 ms	≈235,4 ms	None	26	0 to 25
TDMA frame	FP	60/13 ms	≈4,6 ms	FN	N = 2 715 648 (51 × 26 × 2 048)	0 to N - 1 (0 to 2 715 647)
Forward Timeslot Return Timeslot	FSP RSP	15/26 ms 30/13 ms	≈0,57 ms ≈2,3 ms	TN TN	8 8	0 to 7 0 to 7
Forward bit Return bit	FBP RBP	48/13 µs 192/13 µs	≈3,7 µs ≈14,8 µs	BN BN	156,25 156,25	0 to 155,25 0 to 155,25
Quarter Forward bit Quarter Return bit	QFBP QRBP	12/13 µs 48/13 µs	≈0,9 µs ≈3,7 µs	QN QN	625 625	0 to 624 0 to 624
Control Multiplexing Multiframe	None	102 × 60/13 ms	≈470,8 ms	None	13	0 to 12 [FN mod 2 048]/102
Coarse Timing Advance	None	FBP	Variable	CTA	2^{17}	0 to 2^{17}- 1
Fine Timing Advance	None	QRBP (FBP)	Variable	FTA	2^{16}	0 to 65 535
Delta Timing Advance	None	QRBP (FBP)	Variable	DTA	25	-12 to 12
Channel Offset	None	FSP	≈0,57 ms	CO	408 (51 × 8)	0 to 51 × 8 - 1
Stagger Delay	SD	39 × FBP	≈144,3 µs	NA	NA	NA
Forward Stagger Group	NA	SD	NA	FSG	4	0 to 3
Return Epoch Delay	RED	CO × FSP	Variable	NA	NA	NA
Forward Epoch Delay	FED	CO × FSP + FSG × SD	Variable	NA	NA	NA

Although the basic control multiframe structure uses 26 control multiframes comprising 51 TDMA frames, the multiplexing cycle of the common control signal (CCS) uses 102 TDMA frames. Hence, the actual CCS multiframe starts at even values of the control multiframe counter.

See GMR-2 05.001 [4], clause 7.1 and GMR-2 05.002 [5] for further details on the hyperframe cycle, timing relationships, and multiplexing architecture.

In order to align the Mobile Earth Station transmission to the system time reference at the satellite node, the system design introduced three new timing biases. These biases are applied on a spotbeam basis in the network and are managed by the NCC and gateways.

The Coarse Timing Advance standard accounts for the round trip propagation delay from the satellite to the Mobile Earth Station and from the Mobile Earth Station to the satellite. This parameter is defined as the Mobile Earth Station position that produces the minimum time delay for all orbital positions of the satellite.

The Fine Timing Advance standard accounts for the delay caused by Mobile Earth Station positions in the spotbeam that are not at the position defined by the Coarse Timing Advance standard. Hence it is a two-way delay. The Fine Timing Advance standard is measured from the Mobile Earth Station S-RACH transmissions and is applied to the Mobile Earth Station transmissions prior to establishing a dedicated connection to the gateways.

The Delta Timing Advance standard accounts for Mobile Earth Station and satellite movement once the dedicated link is established with the gateway. The gateway measures the value and signals the Mobile Earth Station to advance or retard its transmission using the forward S-SACCH.

The Channel Offset standard and Forward Stagger Group standard were introduced to reduce the peak-to-average loading on the satellite forward amplifiers due to the CCS carrier and the guard time of each carrier, respectively. See GMR-2 05.002 [5], figure 9.0.4, for the forward/return timing offset convention at the satellite node.

The Channel Offset standard is applied by the NCC on a C-band carrier index spotbeam basis. This means that all carriers in a spotbeam have the same Channel Offset value.(Note that the Equations in clause 6 allow the system to manage the Channel Offset on a carrier Basis).

The Forward Stagger Group standard is applied by the NCC on a carrier basis, hence each carrier has a unique forward stagger group.

Both standards are used to calculate the forward and return epoch delay. The forward epoch delay is the amount of time the forward signal is biased from system time while the return epoch delay is the amount of time a return transmission is advanced so that it arrives at the satellite on time given the corrections for coarse and fine timing are implemented.

4.3 System Channel Assignment

The system design does not use a fixed relationship between the forward and return link TN groups. The channel assignment process for dedicated connections to a gateway selects the forward and return TN group assignment. The assignment process also selects the submultiplex index (SMI) based on the bearer channel type, fine timing advance measurement, forward stagger group, and spotbeam region.

See clause 6 for the details of the assignment process equations and the NCC and gateway requirements.

See GMR-2 05.002 [5], clause 7.5 for further information on TN groups, SMI, and bearer channel type.

To maintain system time at the satellite node, the Mobile Earth Station accounts for the time associated with the forward stagger delay of the Satellite Broadcast Control Channel (S-BCCH) carrier and the Spotbeam Coarse Timing Advance (CTA) for the S-RACH transmissions. Prior to a dedicated link transmission on a new carrier, the Mobile Earth Station accounts for Coarse and Fine Timing Advance, as well as the stagger group associated with the new carrier. See clause 6 for the Mobile Earth Station transmission and frame counter requirements.

4.4 System Operations

The NCC transmits signals through the satellite on the Common Control Signal carrier to enable the MES to synchronize itself to the satellite system and if necessary, correct its frequency standard to be in line with that of the NCC. The logical channels sent by the NCC for these purposes are:

a) S-HMSCH Bursts (Satellite High Margin Synchronization Channel) are used for time synchronization at the quarter bit, bit, slot, and control multiframe level and to obtain frequency correction of the CCS carrier.

b) S-SCH information is used to synchronize the superframe, traffic multiframe, and control multiframe time base counters.

c) S-BCCH/S-HBCCH information is used to obtain the following information elements:

   1) the Coarse Timing Advance for the spotbeam;

   2) the Channel Offset of the signalling carrier;

   3) the Forward Stagger Group of the signalling carrier;

   4) the S-RACH Configuration for the current spotbeam.

The timing of timeslots, TDMA frames, S-TCH frames and control channel frames are all related to a common set of counters which run continuously whether the MES and gateway are transmitting or not. Thus, once the MES has determined the correct setting of these counters, all its processes are synchronized to the current serving spotbeam. See table 4.4.1.

The MES times its transmissions to the satellite in relation to those parameters received via the satellite S-BCCH. The MES uses the CTA parameter as its initial timing advance to transmit a S-RACH to the Satellite. For the initial assignment, the gateway (GSC) sends to each MES a Fine Timing Advance parameter to correct the perceived timing offset. The gateway sends the FTA parameter to correct large errors immediately. The MES transmits using a frame number, FN, advanced relative to the frame number it most recently received, such that the transmitted frame arrives at the satellite at the same time as other frames of the same number from all other users in the spotbeam.

Initially, the gateway sends to the MES the Channel Offset and Forward Stagger Group associated with the channel assignment as well as the full timing advance parameters (to an accuracy of one Forward bit period). See table 4.4.2.

Table 4.4.1: Common Control Channel System Timing Parameters

System Timing Parameter	System Control Basis	Carrier Reference	Logical Channel	Information Transfer Mechanism	Comment	
Quarter Bit Timing	Network	CCS	S-HMSCH	Design	Forward Signal	
Bit Timing	Network	CCS	S-HMSCH	Design	Forward Signal	
Slot Time Start	Network	CCS	S-HMSCH	Design	Forward Signal	
Control Frame Time Start	Network	CCS	S-HMSCH	Design	T3'	
Frequency Correction	Network	CCS	S-HMSCH	Design	Forward Signal	
Superframe Count	Network	CCS	S-SCH	Synchronization Channel Information	T1	
Traffic Multiframe Count	Network	CCS	S-SCH	Synchronization Channel Information	T2	
Control Multiframe Count	Network	CCS	S-SCH	Design	T3'	
Coarse Timing Advance (CTA)	Spotbeam	CCS	S-HBCCH S-BCCH	System Information Type 9	GMR-2 04.008 [3] 11.5.2.45	CCS Configuration Parameters IEI
S-RACH Configuration	Spotbeam	CCS	S-HBCCH S-BCCH	System Information Type 9	GMR-2 04.008 [3] 11.5.2.45	CCS Configuration Parameters IEI
Channel Offset (CO)	Carrier	CCS	S-HBCCH S-BCCH	System Information Type 9	GMR-2 04.008 [3] 11.5.2.46	Forward Epoch Delay IEI
Forward Stagger Group (FSG)	Carrier	CCS	S-HBCCH S-BCCH	System Information Type 9	GMR-2 04.008 [3] 11.5.2.46	Forward Epoch Delay IEI

Table 4.4.2: SDCCH System Timing Parameters

System Timing Parameter	System Control Basis	Carrier Reference	Logical Channel	Information Transfer Mechanism	Comment	
Channel Offset (CO)	Carrier	SDCCH	S-AGCH	Immediate Assignment	GMR-2 04.008 [3] 11.5.2.46	Forward Epoch Delay IEI
Forward Stagger Group (FSG)	Carrier	SDCCH	S-AGCH	Immediate Assignment	GMR-2 04.008 [3] 11.5.2.46	Forward Epoch Delay IEI
Forward TN Group	Channel	SDCCH	S-AGCH	Immediate Assignment	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Forward SMI/Bearer Type	Channel	SDCCH	S-AGCH	Immediate Assignment	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Return TN Group	Channel	SDCCH	S-AGCH	Immediate Assignment	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Return SMI/Bearer Type	Channel	SDCCH	S-AGCH	Immediate Assignment	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Fine Timing Advance (FTA)	S-RACH measurement	CCS	S-AGCH	Immediate Assignment	GMR-2 04.008 [3] 11.5.2.40	Timing Advance IEI
Delta Timing Advance (DTA)	Channel	TCH	S-SACCH/T	L1 header of Forward S-SACCH	GMR-2 04.004 [2] 8.1	

When assigned a channel, the MES, when acquiring the dedicated channel, must account for the Forward Epoch Delay associated with the carrier on which the channel is transmitted. The Forward Epoch Delay is a function of the Forward Slot Period (FSP) and the Stagger Delay (SD), as well as the Channel Offset (CO) and the Forward Stagger Group (FSG), the latter two being parameters passed to the MES in the assignment message. The Forward Epoch Delay (FED) is equal to:

$$FED = CO \times FSP + FSG \times SD$$

Once the dedicated connection is made to the gateway, the Delta Timing Advance is used to maintain synchronization during normal operations on a traffic channel.

Subsequent channel assignment uses the Channel Offset and Frequency Stagger Group, but not the Fine Timing Advance. See table 4.4.3.

Table 4.4.3: TCH System Timing Parameters

System Timing Parameter	System Control Basis	Carrier Reference	Logical Channel	Information Transfer Mechanism	Comment	
Channel Offset (CO)	Carrier	TCH	S-FACCH	Assignment Command	GMR-2 04.008 [3] 11.5.2.46	Forward Epoch Delay IEI
Forward Stagger Group (FSG)	Carrier	TCH	S-FACCH	Assignment Command	GMR-2 04.008 [3] 11.5.2.46	Forward Epoch Delay IEI
Forward TN Group	Channel	TCH	S-FACCH	Assignment Command	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Forward SMI/Bearer Type	Channel	TCH	S-FACCH	Assignment Command	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Return TN Group	Channel	TCH	S-FACCH	Assignment Command	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Return SMI/Bearer Type	Channel	TCH	S-FACCH	Assignment Command	GMR-2 04.008 [3] 11.5.2.5	Channel Description IEI
Delta Timing Advance (DTA)	Channel	TCH	S-SACCH/T	L1 header of Forward S-SACCH	GMR-2 04.004 [2] 8.1	

5 Timebase Counters

5.1 Timing state

The timing state of the signals transmitted by a NCC, gateway or MES is defined by the following counters:

a) quarter bit number QN (0 - 624);

b) bit number BN (0 - 156);

c) timeslot number TN (0 - 7);

d) TDMA frame number FN (0 to (26 × 51 × 2 048) - 1 = 2 715 647).

5.2 Counter relationship

The relationship between these counters is as follows:

a) QN increments every 12/13 µs on the Forward link and every 48/13 µs on the Return Link;

b) BN = Integer part of QN/4;

c) TN increments whenever QN changes from count 624 to 0;

d) FN increments (mod N) whenever the Forward link TN changes from 7 to 0.

6 Timing of Transmitted Signals

The timing of signals transmitted by the MES and satellite/NCC/gateway are defined in GMR-2 05.002 [5].

The NCC shall broadcast the Channel Offset and Forward Stagger Group, associated with the signalling carrier of a given beam, on the S-BCCH and S-HBCCH.

The NCC shall assign, to each RF channel, an Assignment_Delta (to support derivation of transmit and receive TN and submultiplex assignments) and pass this information to the Gateways.

The NCC shall calculate the following parameter to define the Assignment_Delta:

$$T\_min = (FSG \times SD + CTA \times FBP)$$

The MES synthesizer settling time (SST) shall be less than or equal to 1,5 × FSP so that the NCC shall calculate the Assignment_Delta as follows:

$$\text{Assignment\_Delta} = \left\{ -\left[\mathrm{Int}\left(\frac{T_{\min}}{FSP} - 5{,}5 \right) \right] \right\} \mathrm{mod} 16$$

In order to assign timeslots and submultiplex indices in a manner that precludes overlap of transmit and receive periods for the MES, certain relationships between parameters must be maintained.

First, the gateway shall determine the spotbeam region applicable to the actual location of the MES for which the assignment is to be made:

$$\text{Region} = \left\{ \mathrm{Int}\left[\frac{\frac{FTA \cdot FBP}{FSP} + \mathrm{Frac}\left(\frac{T_{\min}}{FSP} - 5{,}5 \right)}{8} \right] \right\} \mathrm{mod} 2$$

where FTA represents the NCC's measurement of the difference between the receive time of the MES S-RACH and the beginning of the S-RACH slot, quantized to units of forward bit periods.

Next , the gateway must calculate an Assignment_Delta_bis based upon the NCC derived Assignment_Delta and the MES spotbeam Region:

For Region = 0, Assignment_Delta_bis = Assignment_Delta

For Region = 1, Assignment_Delta_bis = (Assignment_Delta + 8)mod 16

Next, a quantity "K" shall be defined whereby:

K = Return_TN_Group + Assignment_Delta_bis

The Gateway shall assign forward and return timeslots with the following relationships:

Forward_TN_Group = (K) mod 8

The Gateway shall assign forward and return submultiplex indices with the following relationships:

FSMI = (RSMI + Int[K/8])mod n

where n is equal to:

a) N/A for FR bearer channels;

b) 2 for HR bearer channels;

c) 4 for QR bearer channels;

d) 8 for ER bearer channels.

The Gateway shall include the following timing related parameters in assignment messages sent to the MES:

a) The Channel Offset (CO) of forward carrier;

b) Forward Stagger Group (FSG);

c) Forward TN group;

d) Return TN group;

e) Forward Submultiplex Index (FSMI);

f) Return Submultiplex Index (RSMI);

g) Bearer Channel Type.

The MES shall use the timing of receipt of the S-SCH burst to set up its Forward Link timebase counters as follows:

a) QN is set by the timing of the training sequence

b) TN is 0 when the S-SCH burst is received

c) FN is $51 \times ((T3 - T2) \bmod (26)) + T3 + 51 \times 26 \times T1$

where:

T3 = 1 when the S-SCH is used or T3 = 0 when the S-HMSCH is used. T1 and T2 are contained in information fields in the S-SCH burst.

Thereafter, the timebase counters are incremented as in clause 5.2.

The MES shall initially set its Return Link Frame counter and timing as follows:

the MES shall calculate the following quantities:

$T\_off = (FSG \times SD + CTA \times FBP)/(FP)$

$q= Ceiling\_Function[T\_off]$

$r = q - T\_off$

Prior to transmission of a Random Access, the MES shall initially set up its return frame clock with return epochs occurring $r \times FP$ after forward epochs and with a difference between forward and return frame counts of q frames.

i.e., the local epoch time of the $(k + q)^{th}$ return frame is given by:

$Rtn\_Epoch((k + q) \bmod N)= Fwd\_Epoch(k) + r \times FP$

where:

N is the Number of frames per Hyperframe Cycle.

The MES shall reset its Forward link Frame Counter following receipt of an assignment message as follows:

$New\_Fwd\_Epoch(k) = Old\_Fwd\_Epoch(k) + (New\_Channel\_Offset - Old\_Channel\_Offset) \times FSP + (New\_Stagger\_Group - Old\_Stagger\_Group)\times SD$

The MES shall reset its Return link Frame Counter and timing as follows:

The MES shall calculate the following quantities:

a) $TTA = (CTA + FTA)$;

b) $T'\_off = (New\_FSG \times SD + TTA \times FBP)/(FP)$;

c) $q' = Ceiling\_Function[T'\_off]$;

d) $r' = q' - T'\_off$.

The MES shall re-set up its return frame clock with return epochs occurring $r' \times FP$ after forward epochs and with a difference between forward and return frame counts of q' frames.

i.e., the local epoch time of the $(k + q')^{th}$ return frame is given by:

$$New\_Rtn\_Epoch((k + q') \bmod N) = New\_Fwd\_Epoch(k) + r' \times FP$$

where:

N is the Number of frames per Hyperframe Cycle.

Thereafter, the MES shall update its fine timing advance (FTA) based upon the Delta Timing Advance parameter signalled to the MES in the Forward Satellite-Slow_Associated_Control_Channel (S-SACCH). The updated FTA is equal to:

$$Updated\_FTA = Current\_FTA + DTA$$

Once the FTA has been updated, the MES must again reset its Return Link Frame Counter and timing, as shown above, in equations a through d, using the updated FTA.

7 NCC/Gateway/Satellite Synchronization

The conditions under which the requirements of clauses 7.4 and 7.6 must be met shall be 3 dB below the reference sensitivity level in GMR-2 05.005 [6] and 3 dB less carrier to interference ratio than the reference interference ratios in GMR-2 05.005 [6].

7.1 Gateway frequency accuracy

The gateway shall use a single frequency source of absolute accuracy better than 1 part in 10^9 for both RF frequency generation and clocking the timebase.

7.2 Gateway synchronization

The gateways shall be mutually synchronized to the NCC system clock standard, and, for all shared TDMA carriers, the timebase counters of the NCC and each gateway shall be synchronized to within +0,5 forward bit periods at the satellite antenna frame of reference.

7.3 Channel Offset, Forward Stagger Group and assignment messages

The Channel Offset and Forward Stagger Group associated with an assigned channel shall be included in assignment messages sent to the MES by the Gateway.

The NCC shall broadcast the Channel Offset and Forward Stagger Group, associated with the signalling carrier of a given beam, on the S-BCCH.

The Channel Offset shall be an integer number in the range of 0 to $(51 \times 8 - 1)$.

The Forward Stagger Group shall be an integer number in the range of 0 to 3.

7.4 Delay advance

When a NCC detects a random access transmission from a MES, it shall determine the delay advance of the MES signal relative to a signal timing that would be expected from a MES relative to the coarse timing advance. This delay advance shall be passed by the NCC to the Gateway which is going to anchor the call. The delay shall be assessed in such a way that the assessment error (due to noise and interference as well as all timing uncertainties in the RF/IF and Signalling Equipment paths within the NCC) is less than 1/4 return bit periods for stationary MESs and for MESs moving at speeds up to 100 km/h.

The Gateway shall derive a Fine Timing Advance parameter equivalent to the delay advance quantized to units of Quarter-Return Bit Periods.

7.5 Fine Timing Advance (FTA)

The Fine Timing Advance (FTA) parameter in the initial assignment shall be a 16-bit field representing a number of quarter-return bit periods from 0 to 65 535. The maximum FTA assigned by the network is limited by the maximum S-RACH slot size specified in GMR-2 05.002 [5], table 9.0.5c.

The maximum FTA assignment is determined by:

[Max S-RACH Slot Length (in Frame Periods) - 1] × 1 250

7.6 Delta Timing Advance (DTA) and gateway encoding

The Gateway shall thereafter continuously monitor the delay from the MES Timing offset. If the MES Timing Offset is > 7,0 µs, the Delta Timing Advance shall be advanced or retarded by up to 12 quarter return bits and the value signalled to the MES. The delay shall be assessed in such a way that the assessment error (due to noise and interference) is less than 1/4 return bit periods for stationary MESs and for MESs moving at speeds up to 100 km/h. The control loop for the timing advance shall be implemented in such a way that it will cope with MES's moving at speeds up to 100 km/h.

The gateway shall encode the Delta Timing Advance (DTA) in the Forward S-SACCH Header as follows:

Table 7.6.1: Delta Timing Advance (DTA) encoding in the Forward S-SACCH header

DTA	Change	DTA	Change
14h	-12 (Delay 3 bits)	1h	1 (Advance 1/4 bits)
15h	-11	2h	2 (Advance 1/2 bits)
↓	↓	↓	↓
1Eh	-2	0Bh	11
1Fh	-1 (Delay 1/4 bit)	0Ch	12 (Advance 3 bits)
0		0	

7.7 Timeslot lengths

The NCC and Gateways shall use a forward 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 and 7, rather than 156,25 bit periods on all timeslots which is the duration for all return link timeslots.

8 MES Synchronization

The MES shall only start to transmit to the gateway if the requirements of clauses 8.1 to 8.4 are met.

The conditions under which the requirements of clauses 8.1 to 8.4 must be met shall be 3 dB below the reference sensitivity level in GMR-2 05.005 [6] and 3 dB less carrier to interference ratio than the reference interference ratios in GMR-2 05.005 [6].

8.1 Frequency source and accuracy

The MES carrier frequency shall be accurate to within 0,1 ppm, or accurate to within 0,1 ppm compared to signals received from the gateway. (These signals will have an apparent frequency error due to gateway frequency error and Doppler shift.

NOTE: For single hop mobile-to-mobile calls the only signals received from the Gateway are the S-SACCH bursts.

In the latter case, the signals from the gateway must be averaged over sufficient time that errors due to noise or interference are allowed for within the above 0,1 ppm figure. The MES shall use the same frequency source for both RF frequency generation and clocking the timebase.

8.2 Adjustment of MES timebase

The MES shall keep its internal timebase in line with that of signals received from the gateway.

NOTE: for single hop mobile-to-mobile calls the only signals received from the Gateway are the S-SACCH bursts.

If the MES determines that the timing difference exceeds 1 FBP, it shall adjust its timebase in steps of 1/2 Forward 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 Forward bit periods.

8.3 Timing assessment error

In determining the timing of signals from the gateway, the timings shall be assessed in such a way that the timing assessment error is less than 1 FBP, 99 % confidence, bit periods. The assessment algorithm must be such that the requirements of clause 8.2 can be met.

8.4 MES to Gateway transmission timing

Given that the MES is to transmit in the J^{th} frame (see GMR-2 05.002 [5] for time multiplexing scheme), the MES shall time its transmissions to the gateway according to parameters received from the gateway in the assignment message. After resetting the Rtn_Epoch clock (per clause 4), the MES transmissions to the gateway, measured at the MES antenna, shall be transmitted at the time given by:

$$TTx = New\_Return\_Epoch(J) + Return\_TN\_Group \times FSP$$

The tolerance on these timings shall be ±1/2 return bit period. The MES shall signal the FTA to the gateway in the Return S-SACCH header as specified in clause 8.5.

8.5 MES implementation of new DTA value

When the MES receives a new value of DTA from the gateway on the forward S-SACCH L1 header, it shall implement the new value of DTA in the fourth TDMA frame after the frame containing the last burst of the forward S-SACCH message block.

8.6 FTA values to be used by MES

When the MES accesses a gateway via a random access, the MES shall change the FTA as follows:

The MES shall use a FTA value of 0 for the Random Access burst sent. When a FTA is received from the gateway that FTA shall be used.

8.7 Temporary loss of signal

During a temporary total loss of signal, of up to 64 S-SACCH block periods (refer to GMR-2 05.002 [5]), the MES 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 gateway.

8.8 Intra-beam channel changes

When the MES receives an intra-beam channel change command, it shall be ready to transmit on the new channel within 120 ms of the last timeslot of the message block containing the command. 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 MES is ready to transmit on the new channel shall be less than 20 ms.

8.9 Receipt of a new FTA value

Refer to clause 8.6.

8.10 Ready to transmit

The phrase "ready to transmit within x ms" means that the MES shall transmit no later than the first burst of the first S-TCH or control channel block after the x ms.

History

Document history		
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