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Technical Specification

GEO-Mobile Radio Interface Specifications;
Part 5: Radio interface physical layer specifications;
Sub-part 5: Radio Transmission and Reception;
GMR-1 05.005

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RTS/SES-001-05005R1

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Contents

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IPRs:

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TS 101 376 V1.1.1	Digital Voice Systems Inc		US	US 5,226,084	US
TS 101 376 V1.1.1	Digital Voice Systems Inc		US	US 5,715,365	US
TS 101 376 V1.1.1	Digital Voice Systems Inc		US	US 5,826,222	US
TS 101 376 V1.1.1	Digital Voice Systems Inc		US	US 5,754,974	US
TS 101 376 V1.1.1	Digital Voice Systems Inc		US	US 5,701,390	US

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Project	Company	Title	Country of Origin	Patent n°	Countries Applicable
TS 101 376 V1.1.1	Ericsson Mobile Communication	Improvements in, or in relation to, equalizers	GB	GB 2 215 567	GB
TS 101 376 V1.1.1	Ericsson Mobile Communication	Power Booster	GB	GB 2 251 768	GB
TS 101 376 V1.1.1	Ericsson Mobile Communication	Receiver Gain	GB	GB 2 233 846	GB
TS 101 376 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
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Project	Company	Title	Country of Origin	Patent n°	Countries Applicable
TS 101 376 V1.1.1	Hughes Network Systems		US	Pending	US

IPR Owner: Hughes Network Systems
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Project	Company	Title	Country of Origin	Patent n°	Countries Applicable
TS 101 376 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 101 376 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 101 376 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 101 376 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Spacecraft Cellular Communication System	US	US 5,974,314	US
TS 101 376 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Spacecraft Cellular Communication System	US	US 5,974,315	US
TS 101 376 V1.1.1	Lockheed Martin Global Telecommunic. Inc	Spacecraft Cellular Communication System with Mutual Offset High-Margin Forward Control Signals	US	US 6,072,985	US
TS 101 376 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

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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 shall 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 5 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: General Description; GMR-1 05.001";

Sub-part 2: "Multiplexing and Multiple Access; Stage 2 Service Description; GMR-1 05.002";

Sub-part 3: "Channel Coding; GMR-1 05.003";

Sub-part 4: "Modulation; GMR-1 05.004";

Sub-part 5: "Radio Transmission and Reception; GMR-1 05.005";

Sub-part 6: "Radio Subsystem Link Control; GMR-1 05.008";

Sub-part 7: "Radio Subsystem Synchronization; GMR-1 05.010";

Part 6: "Speech coding specifications";

Part 7: "Terminal adaptor 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-1 01.201 [7].

1 Scope

The present document defines the performance requirements for the Mobile Earth Station (MES) radio transceiver for the GMR-1 Mobile Satellite System.

Requirements are defined for two categories of parameters:

- those that are required to provide compatibility among the radio channels, connected either to separate or common antennas, which are used in the system. This category also includes parameters providing compatibility with existing systems in the same or adjacent frequency bands;
- those that define the transmission quality of the system.

The normal environmental conditions are defined in annex B. If a parameter is specified without any reference to specific temperature conditions, then its requirement shall be met only over the normal temperature conditions.

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-1 01.004 (ETSI TS 101 376-1-1): "GEO-Mobile Radio Interface Specifications; Part 1: General specifications; Sub-part 1: Abbreviations and acronyms; GMR-1 01.004".

[2] GMR-1 03.022 (ETSI TS 101 376-3-10): "GEO-Mobile Radio Interface Specifications; Part 3: Network specifications; Sub-part 10: Functions related to Mobile Earth station (MES) in idle mode; GMR-1 03.022".

[3] GMR-1 05.004 (ETSI TS 101 376-5-4): "GEO-Mobile Radio Interface Specifications; Part 5: Radio interface physical layer specifications; Sub-part 4: Modulation; GMR-1 05.004".

[4] GMR-1 05.008 (ETSI TS 101 376-5-6): "GEO-Mobile Radio Interface Specifications; Part 5: Radio interface physical layer specifications; Sub-part 6: Radio Subsystem Link Control; GMR-1 05.008".

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

[6] "Microwave Mobile Communications", William C. Jakes, IEEE Press, 1994.

[7] GMR-1 01.201 (ETSI TS 101 376-1-2): "GEO-Mobile Radio Interface Specifications; Part 1: General specifications; Sub-part 2: Introduction to the GMR-1 Family; GMR-1 01.201".

[8] GMR-1 05.002 (ETSI TS 101 376-5-2): "GEO-Mobile Radio Interface Specifications; Part 5: Radio interface physical layer specifications; Sub-part 2: Multiplexing and Multiple Access; Stage 2 Service Description; GMR-1 05.002".

[9] ICD-GPS-200C-IRN-1-2-3 (GPS Interface Control Document): "NAVSTAR GPS Space Segment/Navigation User Interfaces (Public Release Version. February 1995)".

[10] ETSI EN 301 681 (V1.2.1): "Satellite Earth Stations and Systems (SES); Harmonized EN for Mobile Earth Stations (MESs) of Geostationary mobile satellite systems, including handheld earth stations, for Satellite Personal Communications Networks (S-PCN) in the 1,5/1,6 GHz bands under the Mobile Satellite Service (MSS) covering essential requirements under Article 3.2 of the R&TTE Directive".

[11] ITU-R Recommendation M.1480: "Essential Technical Requirements of Mobile Earth Stations of Geostationary Mobile Satellite Systems that are implementing the Global Mobile Personal Communications by Satellite (GMPCS) - Memorandum of Understanding arrangements in parts of the frequency band 1-3 GHz".

3 Definitions and abbreviations

3.1 Definitions

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

burst EIRP: average of the instantaneous EIRP over 90 % of the active portion of a burst

average EIRP: burst EIRP averaging over at least 200 bursts

carrier-on state: An MES is in this state when it is permitted to transmit (i.e. when it is authorized by the Network Control Facility (NCF) to transmit) and when it transmits a signal.

carrier-off state: An MES is in this state when either it is permitted to transmit (i.e. when it is authorized by the Network Control Facility (NCF) to transmit) but when it does not transmit any signal; or when it is not permitted to transmit (i.e. when it is not authorized by the NCF to transmit).

3.2 Abbreviations

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

4 Frequency bands and channel arrangement

4.1 Frequency bands and duplex method

MESs operate in frequency division multiplexing (FDM) mode at L-band in two paired 34 MHz frequency bands, which are allocated world-wide for land mobile satellite service (LMSS). The frequency bands are:

- MES receives: 1 525,0 MHz to 1 559,0 MHz;
- MES transmits: 1 626,5 MHz to 1 660,5 MHz.

In the FDM scheme, L-band downlink (forward) radio frequency (RF) carriers in the satellite-to-MES direction are paired with L-band uplink (return) RF carriers in the MES-to-satellite direction at a frequency offset of 101,5 MHz.

4.2 RF carrier spacing and designation

The 34 MHz operating band is divided into 1 087 paired carriers, with carrier spacing of 31,250 kHz.

Carrier pairs, N, are numbered from 1 through 1 087 ($1 \leq N \leq 1\,087$).

The centre frequency of the carriers in kHz corresponding to a carrier number is given by the expressions in table 4.1.

Table 4.1: Carrier numbers

	Carrier centre frequencies (kHz)	Carrier number
Mobile earth station receive	1 525 000,00 + 31,25 x N	$1 \leq N \leq 1\,087$
Mobile earth station transmit	1 626 500,00 + 31,25 x N	$1 \leq N \leq 1\,087$

The carrier number and centre frequency of the carriers are given in table 4.2. The RF channels are spaced at 31,25 kHz intervals, which provides 32 carriers per MHz.

Table 4.2: Carrier numbers and frequencies

MES-RX centre freq. (kHz)	MES-TX centre freq. (kHz)	Carrier numbers (N)
1 525 031,25	1 626 531,25	1
1 525 062,50	1 626 562,50	2
1 529 937,50	1 631 437,50	158
1 529 968,75	1 631 468,75	159
1 530 000,00	1 631 500,00	160
1 530 031,25	1 631 531,25	161
1 532 937,50	1 634 437,50	254
1 532 968,75	1 634 468,75	255
1 533 000,00	1 634 500,00	256
1 543 968,75	1 645 468,75	607
1 544 000,00	1 645 500,00	608
1 544 968,75	1 646 468,75	639
1 545 000,00	1 646 500,00	640
1 554 968,75	1 656 468,75	959
1 555 000,00	1 656 500,00	960
1 558 968,75	1 660 468,75	1 087

4.3 RF carrier used for synchronization and spot beam selection

To minimize the time spent by MESs during spot beam synchronization, identification, and selection, a subset of RF carriers called broadcast control channel (BCCH) carriers is used by the network to broadcast BCCHs. MES synchronization to the BCCH carrier is defined in GMR-1 05.008 [4] and GMR-1 05.010 [5].

4.4 Frequency assignment to spot beams

L-band RF carriers are configured for each spot beam, depending on traffic demand, frequency reuse considerations, and available spectrum as a result of coordination with other systems using the same spectrum. Any RF channel can be used in any spot beam.

5 Stability requirements

5.1 Frequency and symbol timing stability

The stability of the transmitter carrier frequency and symbol timing allows coherent demodulation at the destination receiver, and ensures compatibility with the spacecraft timeslots. Stability is measured under operational conditions encountered in a mobile satellite communications environment. The terminal's receiver tracking dominates in defining its transmit accuracy. These requirements, therefore, implicitly define to the receiver's tracking accuracy requirements.

5.1.1 Definition of operating conditions

Table 5.1 summarizes the attributes of the 3 operational conditions used in the specifications that follow:

- The Steady State condition provides a model of operation with stationary channel conditions.
- The Profile condition provides a model of varying conditions, such as acceleration, that change over time. The parameter Fs defines the rate of change of frequency during ramps (in Hz/s).
- The Outage condition provides a model of conditions when the communication link is temporarily interrupted, while the terminal is accelerating. The parameter Fs, again, defines the rate of change of frequency.

Table 5.1: Definition of operational conditions

Operational condition	Description	Frequency parameters	Timing parameters	Measurement description	Figure reference
Steady State		none	none	Over any 30-s interval	
Profile (Fs)	Frequency and timing profile	Freq. slope (Hz/s) = Fs	Time change consistent with frequency (see note 1)	Anywhere in repeated profile (see note 2)	Figure 5.2
Outage (Fs)	Outage during frequency ramp	Freq. slope (Hz/s) = Fs	Time change consistent with frequency (see note 1)	During first second following signal re-emergence (see note 3)	Figure 5.3

NOTE 1: The delay in timing is consistent with the corresponding frequency profile and a carrier frequency (fc). Delay varies as a function of frequency as follows:

$$\Delta D = \frac{-1}{f_c} \int_0^T f_d(t)dt$$

where:

D is the delay between, for example, the satellite and a terminal (s),

ΔD is the difference in delay since t=0,

f_c is the carrier frequency (Hz), and

f_d is the frequency offset (Doppler) (Hz).

Increases in delay correspond to negative values for the Doppler frequency, as would occur when the satellite and a terminal move apart. Figure 5.1 depicts a profile conforming to the requirements with Fs = 30 Hz, with f_c = 1,5 GHz. The initial delay is arbitrary. Note that the total variation in delay is around 1,25 μs, and the frequency variation is 300 Hz.

NOTE 2: The profile in figure 5.2 is repeated continuously. The measurement shall be made over a period of at least 30 s, beginning at least 10 s after the start of the test.

NOTE 3: The outage shall be 5 s long and shall be induced at least 5 s following the start of the frequency/timing ramp, as shown in figure 5.3.

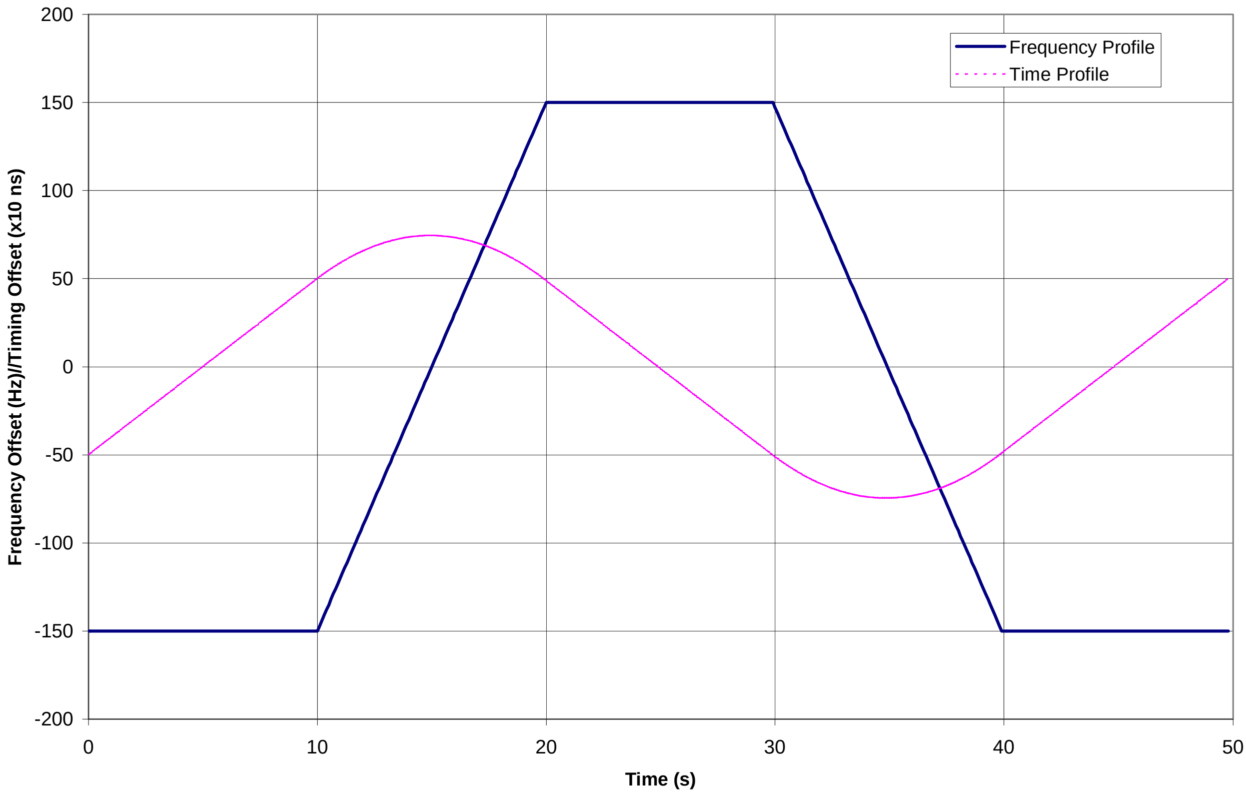


Figure 5.1: Timing variation example profile

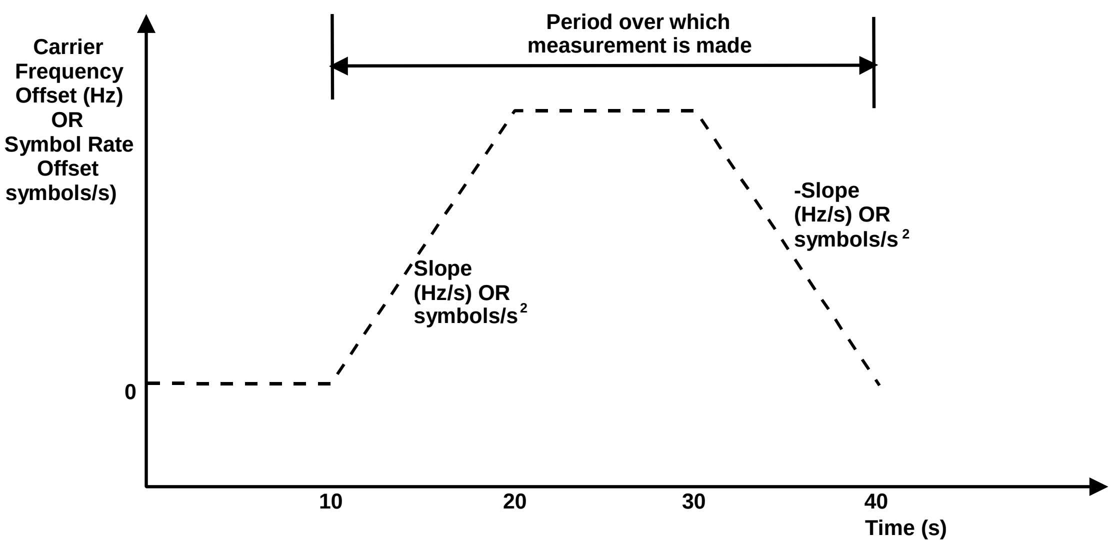


Figure 5.2: Frequency and symbol rate offset profile

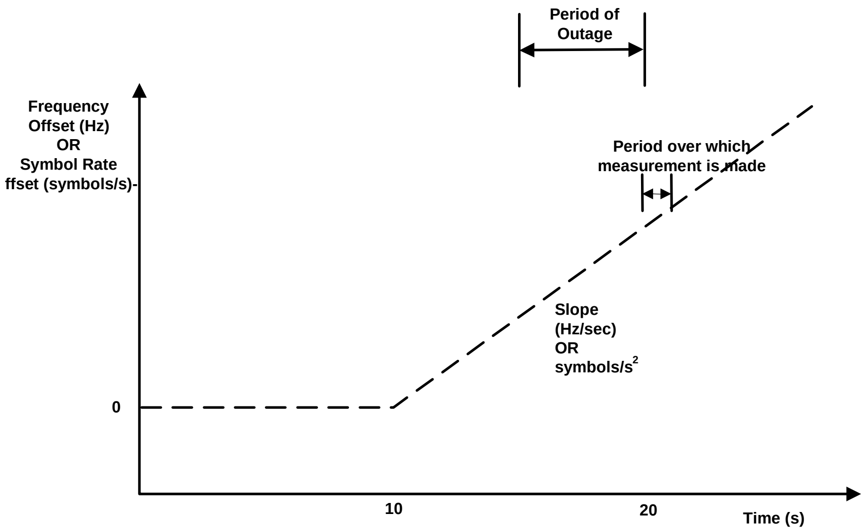


Figure 5.3: Signal outage during a frequency and symbol rate ramp

5.1.2 Frequency and timing stability requirement

In the tests of the requirements of this clause, the MES shall be receiving the logical channel specified in table 5.2, and shall be transmitting any logical channel.

The rms frequency and symbol timing error of the transmitted signal shall not exceed the values given in table 5.2, when the unit is receiving the logical channels given in the table for the operational conditions and E_s/N_0 values are given in the table for each case. The value of E_s/N_0 can be mapped into a power level at the antenna port for each kind of MES, using the equations in annex A.

Table 5.2: Frequency and timing stability requirements

Received logical channel	Operational condition	E_s/N_0 (dB)	RMS Freq. Error (Hz)	RMS timing error (µs)
TCH (see note)	Steady State	5,5	7,0	1,0
DKAB	Steady State	5,5	10,0	2,0
TCH (see note)	Profile (30 Hz)	5,5	10,0	1,0
DKAB	Profile (30 Hz)	5,5	25,0	3,0
TCH (see note)	Outage (15 Hz)	5,5	15,0	3,0
DKAB	Outage (15 Hz)	5,5	25,0	5,0
NOTE: TCH refers to all traffic channels other than DKAB, i.e. TCH-3, TCH-6, TCH-9, FACCH-3, FACCH-6, and FACCH-9.				

5.2 Frequency switching time

MESs shall be capable of switching from any receive frequency to any other receive frequency in less than 1,6 ms and maintain the frequency stability in clause 5.1. MESs shall be capable of switching from any transmit (receive) frequency to any receive (transmit) frequency in less than 2,2 ms and maintain the frequency stability in clause 5.1. During frequency switching, the MES transmit level corresponds to the carrier-off conditions defined in clause 6.4.

These requirements shall be met under the extreme environmental conditions defined in annex B.

5.3 MES time alignment accuracy

The determination of the time offset between receive and transmit bursts at the MES shall be derived from detection of burst synchronization on the forward channels in combination with timing adjustments feedback from the receiver at the other side of the link.

Time offset control messages are broadcast by the network on each spot beam, with the average offset for the particular spot beam. The MESs delay the beginning of their initial transmission with the broadcast value. The accuracy of the correction shall be better than ±1/8 of the transmitted symbol duration.

The transmit to receive timing offset requirements shall be met at the antenna terminal.

The above conditions shall be met in a standard channel (Rician fading, k = 9 dB, 10 Hz Doppler, E_b/N_0 = 5 dB) when the symbol rate of the received signal is fixed, while the carrier frequency of the received signal is varied as follows.

No variation in carrier frequency:

- carrier frequency is initially constant, then varied at +15 Hz/s for 5 s prior to measurement;
- carrier frequency is initially constant, then varied at -15 Hz/s for 5 s prior to measurement.

These requirements shall be met under the extreme environmental conditions defined in annex B.

6 Transmitter characteristics

6.1 Power output characteristics and power class

The carrier is ON during the transmission of bursts; otherwise, the carrier is OFF.

Transmitted power is measured in terms of EIRP (effective isotropic radiated power) averaged on each burst, and EIRP averaged over a set of at least 200 bursts. The former is termed "burst EIRP", and the latter is termed "average EIRP". Burst EIRP is measured by averaging the instantaneous EIRP over 90 % of the active portion of each burst. Average EIRP is measured by averaging the instantaneous EIRP over 90 % of the active portion of the burst and further averaging over at least 200 bursts. EIRP shall be measured in the direction from the MES at which maximum power is transmitted, as observed in the far field. EIRP measurements may be conducted through separate measurements of output power at the antenna terminals and maximum antenna gain. Measurement procedures are beyond the scope of the present document.

The average EIRP of various terminal types shall satisfy the limits in table 6.1 in extreme environmental conditions and shall satisfy the limits in table 6.2 in normal environmental conditions. Normal and extreme environmental conditions are defined in annex B.

Table 6.1: Average EIRP for terminal types - extreme conditions

Power class	Minimum EIRP (dBW), PAS = 0 dB (see note)	Maximum EIRP (dBW), PAS = 0 dB (see note)	Examples
1	4	7	Handheld
2	4	7	Vehicular, no adjustable antenna, no booster
3			Reserved
4	6	11	Vehicular, adjustable antenna, no booster
5			Reserved
6	4	9	Fixed
7			Reserved
Others			Reserved
NOTE: PAS (power attenuation setting) is defined in GMR-1 05.008 [4].			

Table 6.2: Average EIRP for terminal types - normal conditions

Power class	Minimum EIRP (dBW), PAS = 0 dB (see note)	Maximum EIRP (dBW), PAS = 0 dB (see note)	Examples
1	5	7	Handheld
2	5	7	Vehicular, no adjustable antenna, no booster
3			Reserved
4	7	11	Vehicular, adjustable antenna, no booster
5			Reserved
6	5	9	Fixed
7			Reserved
Others			Reserved
NOTE: PAS (power attenuation setting) is defined in GMR-1 05.008 [4].			

In addition, the single burst EIRP shall satisfy the following:

a) the first four bursts of each transmit activity that are not preceded in the past 60 s by a transmit activity of at least four bursts long shall satisfy the limits in table 6.3;

b) each of the remaining bursts shall satisfy the limits in table 6.4.

Requirements in tables 6.3 and 6.4 shall be met under the extreme environmental conditions defined in annex B.

Table 6.3: Single burst EIRP - bursts 1-4

Power Class	EIRP range (dBW), with PAS = 0 dB
1	2 - 8
2	2 - 8
3	
4	4 - 12
5	
6	2 - 10
7	
Others	

Table 6.4: Single burst EIRP - bursts 5 and on

Power Class	EIRP range (dBW), with PAS = 0 dB
1	4 - 7
2	4 - 7
3	
4	6 - 11
5	
6	4 - 9
7	
Others	

These requirements shall be met when the system-level power control (see GMR-1 05.008 [4]) is inactive (e.g. for bursts on a RACCH or SDCCH channel) or when the commanded PAS is equal to 0 dB. When power control is active and PAS is not equal to 0 dB, the unit EIRP shall be solely controlled by the power control loop (see GMR-1 05.008 [4]), and the unit EIRP shall meet the requirements in clause 6.6 of the present document.

6.2 Antenna radiation pattern

The antenna radiation pattern for the handheld MES, with the antenna fully deployed and with no conducting objects in the vicinity of the unit, has a 2 dB beamwidth of at least 90°. The axial ratio of the radiated wave shall be less than 5 dB over the frequency range at a 20° elevation and less than 2 dB over the frequency range at zenith.

6.3 Transmit polarization

Radiation is left-hand circularly polarized.

6.4 Carrier-off conditions

When the MES transmitter is OFF or outside the time window defined by the ramp-up, nominal burst, and ramp-down intervals, the maximum EIRP from an MES shall be -30 dBm or less.

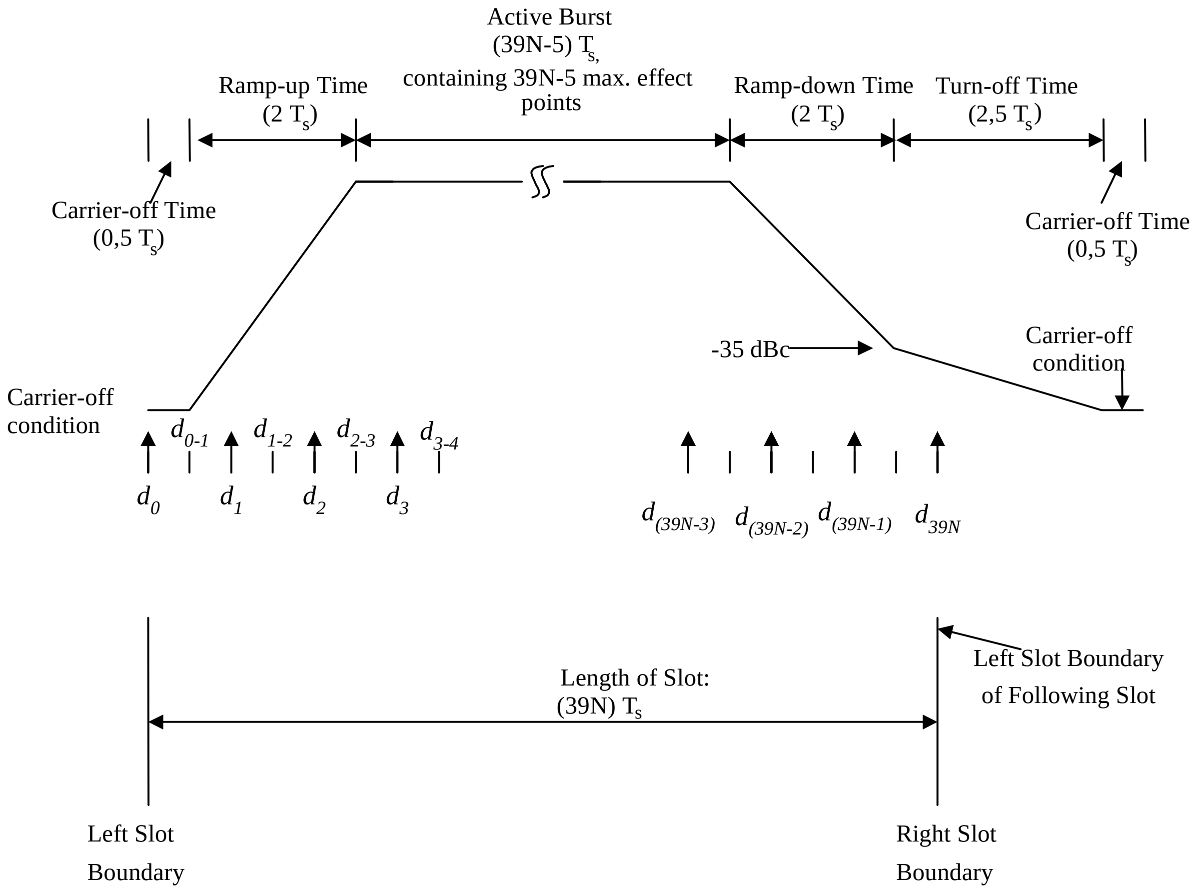
These requirements shall be met under the extreme environmental conditions defined in annex B.

6.5 Ramp-up and ramp-down

The transition from the carrier-off state to the active transmit state is the burst ramp-up, and the corresponding transition at the end of the burst is the burst ramp-down. The precise structure of the burst and the mapping of data bits into data symbols and transmit waveform are defined in GMR-1 05.004 [3]. The positions of the ramp-up and ramp-down periods relative to the slot boundaries and the maximum effect points of the transmitted symbols from the MES are shown in figure 6.1.

As shown in figure 6.1, the burst has 0,5 symbol of guard time, followed by two symbols of ramp-up. During the ramp-up the MES transmitter transitions from the carrier-off state to the active part of the burst. The active portion of the burst, extending from symbol d_3 to symbol $d_{(39N-3)}$, shall satisfy the average transmit power requirements specified in clause 6.1 and the transmitted symbols within this portion of the burst shall also satisfy the modulation accuracy requirements specified in GMR-1 05.004 [3]. During the ramp-down, the MES transmitter shall reduce the transmit power to at least -35 dBc within 2 symbol periods and shall be at the carrier-off state within 4,5 symbols from the end of the active portion of the burst. The transition from the -35 dBc level to the carrier-off state is termed the "turnoff" period. The dBc measurement is defined relative to the average transmit power during the active portion of the burst.

NOTE: The turnoff period partially overlaps with the ramp-up of the following burst. This overlap does not degrade system performance because the power is already -35 dBc down, and the ramp-up signal does not contain useful information.



NOTE 1: d_i denotes the max effect point of data symbol i. These points are shown with an up-pointing arrow.

NOTE 2: d_{i-j} is the symbol boundary between symbols i and j, as defined in GMR-1 05.004 [3].

NOTE 3: T_s is the symbol period and is equal to 5/117 ms (1/23,4 kHz).

Figure 6.1: Ramp-up and ramp-down in relation to the rest of the burst

6.6 Power control range and accuracy

6.6.1 Approach

The transmit power shall be controlled (backed-off) by specifying a power attenuation setting (PAS) that is in reference to the EIRP power specified by clause 6.1, table 6.1. This PAS shall be expressed in units of dBs. Thus, an MES having a PAS of 0 (0,0 dB) shall have a power output level as specified by clause 6.1, table 6.1. The output power for other PAS values is given by:

$$\text{Output Power (dBW)} = \text{EIRP (dBW, clause 6.1)} - \text{PAS (dB)} \qquad (1)$$

PAS values shall be nonnegative. This PAS is an explicit attenuation that results in an output power that is independent of any previous power setting. For example, if setting PAS equal to 0 for a particular MES produces an output power of +7 dBW, then a PAS of 10 (dB) shall produce a nominal value of -3 dBW.

Observe that this output power, as given by equation 1, is in relation to the actual, non-backed-off EIRP and not necessarily the minimum EIRP, as given by clause 6.1.

6.6.2 Procedures and timing

The value of PAS shall be set in response to the received power control messages (containing PAR and PAN) and signal quality measurements. See GMR-1 05.008 [4] for specification of these procedures.

If the value requested of PAS is not supported by the MES, such as being beyond the specified range or being a non-available step size, then the nearest attenuation value that is supported shall be used. In this case, the value of PAN that is reported shall reflect the actual value of attenuation used, to the nearest coded PAS value.

The timing of the transmit power level changes is defined in GMR-1 05.008 [4].

6.6.3 Range

The minimum PAS range is 0,0 to 18,0 (dB) for handheld terminals, vehicular terminals and fixed terminals. The nominal step size of PAS is 0,4 dB, and step numbers 0 through 60 are defined. Step number $\boldsymbol{n}$ signifies a PAS nominal value of $\boldsymbol{n} \times 0,4$ dB.

6.6.4 Accuracy

The accuracy is specified as applying against the attenuation value, as designated by the PAS setting. A PAS value of 0,0 shall be used as reference for specifying attenuation accuracy. It is, by definition, precise-having zero error. The accuracy of other PAS settings shall be relative and with respect to this value. This accuracy is specified as:

- ±0,4 dB for PAS values from 0,4 dB to 2,0 dB;
- +20 % of PAS for PAS values from 2,4 dB to 14,8 dB;
- -20 % of PAS for PAS values from 2,4 dB to 9,6 dB;
- +3,0 dB for PAS values from 15,2 dB to 24,0 dB;
- -2,0 dB for PAS values from 10,0 dB to 24,0 dB.

These power steps and accuracy are summarized by table 6.5.

Table 6.5: Power steps and accuracy

Step #	PAS nominal value (dB)	PAS minimum value (dB)	PAS maximum value (dB)
0	0,0 (Reference)	0,0	0,0
1	0,4	0,0	0,8
2	0,8	0,4	1,2
3	1,2	0,8	1,6
4	1,6	1,2	2,0
5	2,0	1,6	2,4
6	2,4	1,92	2,88
7	2,8	2,24	3,36
8	3,2	2,56	3,84
9	3,6	2,88	4,32
10	4,0	3,20	4,80
…			
23	9,2	7,36	11,04
24	9,6	7,68	11,52
25	10,0	8,0	12,00
26	10,4	8,4	12,48
…			
36	14,4	12,4	17,28
37	14,8	12,8	17,76
38	15,2	13,2	18,2
39	15,6	13,6	18,6
…			
59	23,6	21,6	26,6
60	24,0	22,0	27,0

The accuracy specification shall be met for any given channel defined in clause 4 and with any fixed temperature and supply voltage within the range of the extreme environmental conditions defined in annex B.

6.6.5 Attenuation step size

In addition to the accuracy specified in clause 6.6.4, the following specifications regarding actual attenuation step sizes shall apply to the terminals:

a) for each successive step in the requested PAS (0,40 dB), the actual change in attenuation shall be not less than 0,0 dB and not more than 0,80 dB;

b) for each successive pair of steps in the requested PAS (0,80 dB), the actual change in attenuation shall be not less than 0,4 dB and not more than 1,2 dB.

NOTE: The above specifications also allow for isolated instances of PAS values being skipped for regions where the implemented step size is potentially greater than 0,40 dB (but not exceeding 0,80 dB).

6.7 Adjacent channel interference

Due to the bursty nature of the transmission, interference into adjacent channels is the result of both the modulation process and the power ramping up and down (switching transients).

6.7.1 Interference due to modulation

The average (see definition in note 3) power levels in a measurement bandwidth of 23,4 kHz, centred upon the adjacent channels, shall not exceed the relative values shown in tables 6.6 and 6.7.

Table 6.6: Adjacent channel interference due to modulation for first 4 adjacent channels

Power class	1st adjacent channels, ±31,25 kHz	2nd adjacent channels, ±62,5 kHz	3rd adjacent channels, ±93,75 kHz	4th adjacent channels, ±125,0 kHz
1	-25 dBc	-40 dBc	-53 dBc	-60 dBc
2	-25 dBc	-40 dBc	-53 dBc	-60 dBc
3				
4	-25 dBc	-40 dBc	-53 dBc	-60 dBc
5				
6	-25 dBc	-40 dBc	-53 dBc	-60 dBc
7				
Others				
NOTE: This requirement applies to all adjacent channels that are integrally contained in the band that extends from 2 MHz below the lower end of the transmit band to 2 MHz above the upper end of the transmit band.				

Table 6.7: Adjacent channel interference due to modulation for other adjacent channels

Power class	4th to 8th adjacent channels, ±125 kHz to ±250 kHz (see note 2)	8th to 16th adjacent channels, ±250 kHz to ±500 kHz (see note 2)	16th to 64th adjacent channels, ±500 kHz to ±2 000 kHz (see note 2)	64th and greater adjacent channels, ±2 000 kHz and beyond
1	-60 dBc to -65 dBc	-65 dBc to -70 dBc	-70 dBc to -77 dBc	-77 dBc
2	-60 dBc to -65 dBc	-65 dBc to -70 dBc	-70 dBc to -77 dBc	-77 dBc
3				
4	-60 dBc to -65 dBc	-65 dBc to -70 dBc	-70 dBc to -77 dBc	-77 dBc
5				
6	-60 dBc to -65 dBc	-65 dBc to -70 dBc	-70 dBc to -77 dBc	-77 dBc
7				
Others				
NOTE 1: This requirement applies to all adjacent channels that are integrally contained in the band that extends from 2 MHz below the lower end of the transmit band to 2 MHz above the upper end of the transmit band. NOTE 2: Limits for intermediate adjacent channels are linearly interpolated between the defined limits				

NOTE 1: Adjacent channel power is defined relative to the average power transmitted by the MES in the desired channel.

NOTE 2: The limits in tables 6.6 and 6.7 are compliant with the limits defined in EN 301 681 [10] and ITU-R Recommendation M.1480 [11] for MESs with an EIRP less than or equal to 15 dBW.

The MES is assumed to be receiving a signal from which it may take a frequency reference. The adjacent channel offsets are defined relative to the frequency of the received signal, after accounting for the transmit-to-receive frequency separation.

NOTE 3: Average power shall be measured by averaging the instantaneous power over the middle section of the burst, covering 70 % of the active portion of the burst. This average shall further be averaged over at least 200 bursts for the first, second, and third adjacent channels, and over at least 50 bursts for the fourth and all other adjacent channels beyond.

The above requirements shall be satisfied over the extreme set of environmental conditions specified in annex B. If the MES is operated outside the range of extreme environmental conditions, the average power in the first, second, third, fourth, and beyond adjacent channels shall not exceed -19 dBc, -34 dBc, -47 dBc, and -54 dBc, respectively, relative to the power in the desired channel.

6.7.2 Interference due to switching transients

The peak power in a measurement bandwidth of 23,4 kHz centred on the adjacent channels observed during a sequence of 200 complete burst activities of the MES shall be as shown in table 6.8.

Table 6.8: Adjacent channel interference due to switching transients

Power class	1st adjacent channels, ±31,25 kHz	2nd adjacent channels, ±62,5 kHz	3rd adjacent channels, ±93,75 kHz	4th adjacent channels and beyond
1	-18 dBc	-33 dBc	-46 dBc	-53 dBc
2	-18 dBc	-33 dBc	-46 dBc	-53 dBc
3				
4	-18 dBc	-33 dBc	-46 dBc	-53 dBc
5				
6	-18 dBc	-33 dBc	-46 dBc	-53 dBc
7				
Others				

NOTE: Adjacent channel power is defined relative to the average power transmitted by the MES in the desired channel.

The MES is assumed to be receiving a signal from which it may take a frequency reference. The adjacent channel offsets are defined relative to the frequency of the received signal, after accounting for the transmit-to-receive frequency separation.

The interference effects due to switching transients are measured in the time domain and the specifications assume the following measurement conditions: zero frequency scan, measurement bandwidth of 23,4 kHz, peak hold, and video bandwidth of 100 kHz (video bandwidth should be at least 3 times the measurement bandwidth). Peak power measurement shall be performed without any triggering on the burst envelope, unlike the average power measurement in clause 6.7.1, where only the power in the middle of the burst is observed.

6.8 Unwanted emissions

6.8.1 Unwanted emissions in the carrier-on state

For an MES in the carrier-on state, the maximum EIRP density of the unwanted emissions from the MES outside the band 1 626,5 MHz to 1 660,5 MHz shall not exceed the carrier-on limits defined in table 3 of EN 301 681 [10]. The unwanted emissions shall also not exceed the carrier-on limits defined in tables 1 and 2A of ITU-R Recommendation M.1480 [11]. Where there is a discrepancy between the ETSI and the ITU-R limits, the more stringent limit shall apply.

6.8.2 Unwanted emissions in the carrier-off state

For an MES in the carrier-off state, the maximum EIRP density of the unwanted emissions from the MES shall not exceed the carrier-off limits defined in table 5 of EN 301 681 [10]. The unwanted emissions shall also not exceed the carrier-off limits defined in ITU-R Recommendation M.1480 [11]. Where there is a discrepancy between the ETSI and the ITU-R limits, the more stringent limit shall apply.

7 Receiver characteristics

7.1 Receive antenna pattern

The receive antenna radiation pattern for the handheld MES, with the antenna fully deployed and with no conducting objects in the vicinity of the unit, shall have a 2 dB beamwidth of at least 90°. The axial ratio of the radiated wave shall be less than 5 dB over the frequency range at 20° elevation and less than 2 dB over the frequency range at zenith.

7.2 Receive polarization

Receive polarization shall be left-hand circularly polarized.

7.3 Receiver figure of merit

The gain/temperature (G/T) ratio of the handheld MES in the direction of peak antenna gain under clear sky conditions, with the antenna fully deployed and with no conducting objects in the vicinity of the unit, shall be -24 dB/K, minimum, at 20 °C.

When the antenna is in the stowed position, the average (see definition below) G/T ratio of the handheld MES, under clear sky conditions and with no conducting objects in the vicinity of the unit, shall be -38 dB/K, minimum.

Average G/T shall be calculated by (a) measuring G/T in the direction of peak antenna gain and (b) subtracting from that G/T the difference of the peak antenna gain minus the average antenna gain. Average antenna gain shall be obtained by averaging the antenna gain over all azimuth angles and all directions with elevation greater than 20°. Zero elevation plane is the plane perpendicular to the peak gain direction.

7.4 Receiver sensitivity

For ease of measurement, the receiver sensitivity is defined at the antenna connector of the MES. However, a variety of antenna gains and antenna noise temperatures may be utilized. Thus, the receiver input power is specified as the power that would be required for a 0 dBi noiseless antenna and is then corrected with the term A_f, which depends on the gain and noise temperature of the actual antenna used. This relationship is derived in annex A.

7.4.1 Receiver BER in static conditions

Under static channel conditions, the MES receiver shall meet or exceed the uncoded bit error rate (BER) requirements in table 7.1 at 20°C for the following burst types: NT3, NT6 and NT9.

Table 7.1: BER requirements in static conditions

Power class	Receive signal strength at the antenna connector	G/T	BER (%)
1	(-125,4 + A_f) dBm	-24	3,5
2	(-125,4 + A_f) dBm	-24	3,5
3			
4	(-127,4 + A_f) dBm	-22	3,5
5			
6	(-131,4 + A_f) dBm	-18	3,5
7			
Others			

NOTE: An E_b/N_0 of 2,5 dB was used in deriving the power level according to equation A.7 in annex A.

The term A_f, given in the following equation, is the correction that needs to be added when an antenna of gain G_a and noise temperature T_{ant} is used. This term becomes zero when $G_a = 0\ dBi$ and $T_{ant} = 0K$.

$$A_f = 10 \times \log(10^{G_a/10} - 10^{\frac{G/T}{10}} \times T_{ant})$$

For example, power class one with an antenna gain of 3,5 dB and an antenna noise temperature of 150 K gives:

$$A_f = 10 \times \log\left(10^{3,5/10} - 10^{-24/10} \times 150\right)$$

$$A_f = 2{,}15\ dB$$

The BER performance under the channel conditions given shall be met over the extreme set of environmental conditions defined in annex B, when the power into the antenna connector is increased by 1,5 dB relative to the levels defined in table 7.1.

7.4.2 Receiver BER in Rician fading

The MES receiver shall meet or exceed the uncoded BER requirements in table 7.2 at 20°C in Rician channels with (a) K = 9 dB, f_d = 10 Hz, and (b) K = 12 dB, f_d = 200 Hz. Parameters K and f_d are defined in annex C of the present document. This requirement applies for the following burst types: NT3, NT6 and NT9.

Table 7.2: BER requirements in Rician fading

Power class	Receive signal strength at the antenna connector	G/T	BER (%)
1	(-122,9 + A_f) dBm	-24	2,0
2	(-122,9 + A_f) dBm	-24	2,0
3			
4	(-124,9 + A_f) dBm	-22	2,0
5			
6	(-128,9 + A_f) dBm	-18	2,0
7			
Others			

The term A_f is defined in clause 7.4.1.

The BER performance under the channel conditions given shall be met over the extreme set of environmental conditions defined in annex B, when the power into the antenna connector is increased by 1,5 dB relative to the levels defined in table 7.2.

7.4.3 FER of logical channels

The coded frame error rate (FER) of the logical channels in table 7.3 shall not exceed the values in this table for the E_s/N_0 values and channel models given in that table. A frame shall be considered to be in error if the corresponding CRC fails. Channel models 1, 2, and 3 are (a) a static channel (b) a Rician fading channel with K = 9 dB and fd = 10 Hz, and (c) a Rician fading channel with K = 12 dB and fd = 200 Hz, respectively. All tests shall be conducted in the steady-state operational conditions (OC_1), defined in clause 5.1, under normal environmental conditions. The E_s/N_0 values may be mapped into power levels into the antenna port for each type of MES using the formulas in annex A.

E_s/N_0 is defined as the ratio of the average signal energy in a period of 1/23 400 s to the noise power spectral density per Hz. Note that this definition applies particularly to the BACH channel, where the definition of a symbol is ambiguous otherwise.

Table 7.3: FER of logical channels

Logical channel	Max. FER Allowed	E_s/N_0 (dB) at input of baseband demodulator		
		Channel 1: (Static)	Channel 2: (R_9_10)	Channel 3: (R_12_200)
FACCH3	5%	-0,5	0,5	0,0
FACCH6	5%	5,3	8,0	8,0
FACCH9	5%	5,3	8,0	8,0
SACCH6	5%	5,3	8,0	8,0
SACCH9	5%	5,3	8,0	8,0
SDCCH	5%	-0,5	0,5	0,0
AGCH/PCH/CBCH	5%	5,3	8,3	7,3
BCCH	5%	5,3	8,3	7,3
BACH	5%	-8,5	-5,5	-5,5
TACCH/GBCH	5%	6,0	8,0	7,7
PCH (state selection active)	1%	7,0	N/A	N/A

The TCH-3 and TACCH FER shall be met when:

a) the MES is receiving both a TCH-3 and a TACCH, as in the case of a Terminal-to-Terminal (TtT) call;

b) the TACCH channel is under condition OC_1, defined in clause 5.1 of the present document, and TCH-3 is under condition OC_3-FS30. This scenario emulates the case of a TtT call where the receiving terminal is stationary but the transmitting terminal is moving.

With respect to the PCH and BACH FER:

- The frame error rates quoted in table 7.3 shall apply to all active pages or alerts, which may occur at any paging or alerting opportunity, and which may not necessarily be present in every paging or alerting opportunity.

- Performance shall be conditioned on the presence of BCCH and FCCH at signal (transmitted carrier) levels equal to the pages and alerts and with frame structure as defined in GMR-1 05.002 [8].

- The MES shall begin to correctly interpret and act upon received error-free pages not more than 30 s after the MES has been presented with PCH signals meeting the requirement of table 7.3 (Channel 1) without manual intervention.

- The MES shall begin to correctly interpret and act upon error-free alerting messages not more than 30 s after the MES has been presented with BACH signals meeting the requirement of table 7.3 (Channel 1) without manual intervention.

The FER performance above shall be met over the extreme set of environmental conditions defined in annex B when the power into the antenna connector is increased by 1,5 dB relative to the levels defined in table 7.3.

7.5 Receiver selectivity

Receiver selectivity is a measure of a receiver's ability to operate in the presence of a single modulated interferer at some power level and at some defined frequency spacing from the received signal. The interferer shall be modulated as defined in GMR-1 05.004 [3] with random data.

Under the interference conditions in table 7.4, the receiver shall perform as defined in the static sensitivity requirement with 0,5 dB greater signal power.

Table 7.4: Receiver selectivity interference conditions

Case	Interference level relative to sensitivity	Interference frequency offset
1	+15 dB	31,25 kHz
2	+25 dB	93,75 kHz
3	+45 dB	>500 kHz

This clause specifies the intended performance, not necessarily the measuring technique for this parameter. An alternate measuring technique may be used that results in demonstrably equivalent performance.

7.6 Receiver intermodulation

Receiver intermodulation requirements define the ability of the receiver to operate in the presence of two interferers that are spaced in frequency such that their first intermodulation product coincides with the desired signal, i.e. the interferers are spaced at some frequency from the desired signal, and at twice that spacing. The interferers shall be applied at the antenna connector on the MES.

The interferers shall be:

- a sinusoid (carrier) 800 kHz from the desired channel with a level of -75 dBm;
- a modulated (see definition below) signal 1 600 kHz from the desired channel with a level of -75 dBm.

Under each of these conditions, the receiver shall perform as defined in the static sensitivity requirement with 3 dB greater signal power.

The modulated signal shall be continuous, and it shall be modulated with random data with the method and parameters defined in GMR-1 05.004 [3].

7.7 Receiver blocking characteristics

Receiver blocking characterizes the ability of the receiver to receive the desired signal in the presence of other signals that can be located anywhere over a wide portion of the spectrum. Receiver blocking is specified separately for in-band and out-of-band signals.

In-band signals are signals in the 1 505 MHz to 1 579 MHz band, i.e. signals in the MSS and neighbouring bands. Out-of-band signals are signals outside this band.

The receiver will perform as defined in the sensitivity requirement when these two signals are applied at its input:

- a desired signal with power 3 dB greater than that defined in the static sensitivity section;
- a continuous, static sine wave signal at the level in table 7.5 and at frequencies that are integer multiples of 31,25 kHz.

Table 7.5: Receiver blocking requirement

Band of blocking signal	Frequency range	Level	Distance from desired signal (kHz)
In-band	1 505 MHz - 1 579 MHz	-70 dBm	>1 600 kHz
Out-of-band	0,1 kHz - 1 505 MHz or 1 579 MHz - 12 750 MHz	-35 dBm	N/A

The requirement in table 7.6 shall be relaxed at a set of frequencies called spurious response frequencies. The number and level of spurious response frequencies is defined in table 7.6.

Table 7.6: Spurious response requirement

Band of spurious response	Frequency range	Max. number of frequencies	Level
In-band	1 505 MHz - 1 579 MHz	Six	-100 dBm
Out-of-band	0,1 kHz - 1 505 MHz or 1 579 MHz - 12 750 MHz	Twelve	-55 dBm
Out-of-band	0,1 kHz - 1 505 MHz or 1 579 MHz - 12 750 MHz	Four (in addition to the above)	-70 dBm

7.8 Receive signal strength

The MES shall be capable of generating relative receive signal strength (relative RSS) for use in the beam selection and power control functions described in GMR-1 05.008 [4]. This clause defines the range and accuracy with which relative RSS shall be generated.

Relative RSS is defined as the difference in the signal strength of two received signals. Relative RSS error is the difference between the actual relative signal strength of two incident waves and the relative RSS reported by the MES receiver.

The relative RSS error at the MES when:

a) the ambient temperature is fixed, anywhere within the extreme temperature range defined in annex B;

b) the radiated input waves of the two carriers have fixed power, anywhere in a range defined by the static sensitivity limit and a level 20 dB above it;

c) the difference in power between the two incident waves is less than 10 dB;

d) the two received signals carry BCCH logical channels, and their carrier frequencies vary within the receive LMSS band;

e) the power flux density on the CICH channels is -133 dBW/m^2 or less;

shall be less than ±3 dB. The above requirement is motivated by the beam selection procedures described in GMR-1 03.022 [2] and GMR-1 05.008 [4]. The above measurements shall be performed with a received signal and bursts corresponding to BCCH logical channels.

In addition, the relative RSS error at the MES when:

a) the ambient temperature is fixed, anywhere within the normal temperature range defined in annex B;

b) the radiated input waves of the two carriers have fixed power, anywhere in a range defined by the static sensitivity limit and a level 20 dB above it;

c) the difference in power between the two incident waves is less than 10 dB;

d) the carrier frequencies of the two received signals are the same, but lie anywhere within the MES receive band;

shall be less than ±1 dB. The same measurements performed over the extreme set of environmental conditions defined in annex B shall result in an error of less than ±2 dB.

This requirement is motivated by the power control procedures described in GMR-1 05.008 [4]. The difference in the two requirements is that in the latter, (i) the two signals whose power is being compared have the same frequency, although this frequency can be anywhere in the receive band, and (ii) the two signals are not restricted to carrying BCCH logical channels.

The above measurements shall be performed with a GMR-1-modulated received signal and bursts corresponding to the logical channel.

Note that the specifications in this clause are stated in terms of radiated input signals because they are intended to include antenna effects. The actual measurements may be performed in a two-stage process where the antenna and the rest of the receivers are characterized separately.

8 GPS receiver characteristics

8.1 General

The GPS receiver shall acquire and track GPS Standard Positioning Service (SPS) signals under the conditions discussed in this clause. Signals from all GPS satellites in view (up to eight) shall be acquired and tracked; this tracking will allow the receiver to determine its location.

8.2 Satellite signals

The GPS Civil/Acquisition (C/A-Code) signals broadcast on the L1 frequency (1 575,42 MHz) will be employed. These signals are BPSK-modulated and have nominal bandwidths (null-to-null) of 2,046 MHz and power levels incident on the earth that vary between -130 dBmic and -123 dBmic (dB relative to one mW into an isotropic circularly polarized antenna). Their frequencies are stable to within better than one part in 10^{12}, and the maximum Doppler shift seen at a stationary receiver is less than 5 kHz. Signals are continuous and BPSK-modulated at a 1,023 MHz rate, with content and all parameters defined in the GPS Interface Control Document [9].

8.3 Antenna

The GPS antenna shall be capable of receiving the right-hand circularly polarized (RHCP) GPS signals on 1 575,42 MHz. The GPS antenna shall have a peak gain of at least 0 dBic in a direction that is at greater than 55° elevation from the horizontal.

The GPS antenna shall have a beamwidth of at least 160° in one plane (arbitrary orientation) and at least 100° in a second plane perpendicular to the first. The GPS antenna shall have a gain of at least -6 dBic throughout the specified beamwidth.

In the case of a handheld MES, these requirements shall be met when the handset is in a "normal dialling" position. This means that the smallest angle between the direction of peak gain and the horizontal plane shall be no less than 55°.

NOTE: The "normal dialling" position is with the handheld MES in free space at an angle of 45° to the horizontal with the keypad facing upwards. The antenna shall be in an extended position.

8.4 Receiver sensitivity

Receiver sensitivity is the ability of the receiver to process weak signals, and it is measured in terms of the minimum signal levels at the receiver input that are required for the receiver to acquire and track GPS signals.

The receiver shall acquire GPS signals with levels greater than -134 dBm and shall track signals with levels greater than -142 dBm.

8.5 Interference resistance

The GPS receiver shall track GPS signals when subjected to interference with characteristics as noted in the following clauses. Additionally, it shall acquire GPS signals when the interference is reduced by 10 dB relative to the levels used in the tracking tests. The GPS signal level shall be set to -130 dBm, when these tests are conducted.

8.5.1 In-band interference

In-band interference shall be a continuous (100 % duty cycle) CW (unmodulated) signal with power of -110 dBm located anywhere in the 10 MHz band centred on L1.

8.5.2 Adjacent-band interference

Adjacent-band interference shall be a continuous (100 % duty cycle) narrowband signal located in the bands around the GPS L1 signal with total power no greater than that shown in figure 8.1.

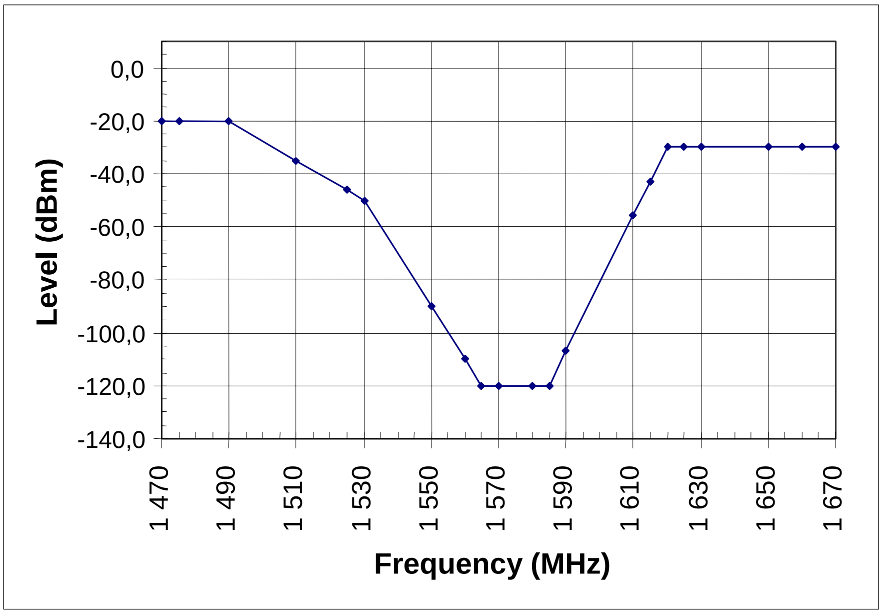


Figure 8.1: Out-of-band interference mask

8.5.3 Self-interference

The GPS receiver shall maintain its sensitivity performance when the GMR-1 receiver and all other MES elements, except the transmitter, are operating. The GPS receiver may not function during the periods that the GMR-1 transmitter is active. The GMR-1 transmitter shall be defined to be active when it bursts in each frame.

8.6 Accuracy

Overall position determination accuracy shall be comparable with that obtained from commercially available, low-cost GPS receivers.

8.7 Environmental conditions

The above specifications shall be met over the extreme environmental conditions defined in annex B of the present document.

Annex A (informative): Antenna factor equation

A.1 Introduction

This annex derives the antenna factor equation used in clause 7.4 that specifies the receiver sensitivity. The first step is to find the receiver input power in terms of the required E_b/N_0 at the demodulator input and the receiver noise temperature. The second step computes the receiver temperature in terms of the G/T specification and the antenna gain and noise temperature.

A.2 Input power computation

From the definition of E_b/N_0 we have:

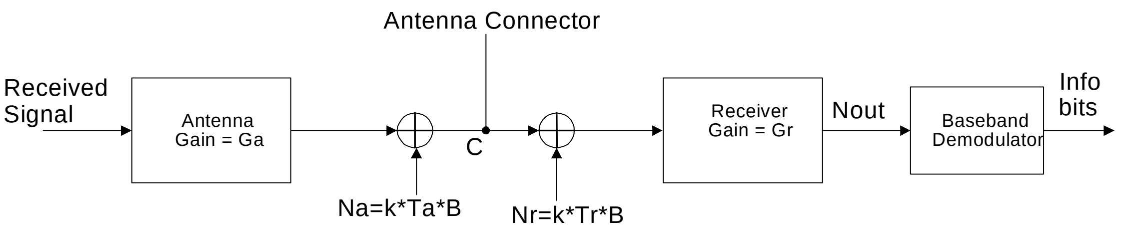
$$\frac{E_b}{N_o} = \frac{C / R_b}{k \times T_r} \qquad \text{(A.1)}$$

where C is the signal power, R_b is the information bit rate, T_r, is the receiver noise temperature, and k is Boltzmann's constant. From this equation we get C, as:

$$C = (E_b/N_0)\ k\ T_r\ R_b \qquad \text{(A.2)}$$

All quantities on the right side of this equation, except T_r, are known, which we will derive through the G/T specification and the antenna gain and temperature.

Figure A.1 shows the noise model of the unit. The terminal is modelled with an antenna of gain G_a and temperature T_a, followed by a receiver of noise temperature, T_r. The gain of the receiver for this calculation is irrelevant since it does not impact the signal-to-noise ratio seen by the demodulator. Note that, in this model, the antenna noise temperature is referred to the antenna *output*, whereas the receiver noise is referred to the receiver *input*. This is consistent with common practice.



N_a	is the antenna noise power in bandwidth B
k	is Boltzman's constant
T_a	is the antenna noise temperature
N_r	is the receiver noise power in bandwidth B
T_r	is the receiver noise temperature
C	is the signal at the antenna connector

Figure A.1: Receiver noise model

From figure A.1 it is clear that the G/T figure of the complete terminal is:

$$\left(\frac{G}{T}\right)_{spec} = \frac{G_a}{T_a + T_r} \tag{A.3}$$

from which we express the temperature of the receiver as:

$$T_r = \frac{G_a}{\left(\frac{G}{T}\right)_{spec}} - T_a \tag{A.4}$$

For convenience, we compute T_r for the nominal antenna case of G = 1 and T_a = 0 and then compute a factor that shall be added (in dB scale) to this temperature, which depends on the actual antenna gain and temperature. Denoting the receiver temperature for this nominal case as T_{ro}, we have:

$$T_{ro} = \frac{1}{\left(\frac{G}{T}\right)_{spec}} \tag{A.5}$$

from which we define:

$$A_f = \frac{T_r}{T_{ro}} = G_a - \left(\frac{G}{T}\right)_{spec} \times T_a \tag{A.6}$$

Using the expression for A_f, equation (A.2) above becomes:

$$C = (E_b / N_0) \times k \times T_{ro} \times A_f \times R_b = (E_b / N_0) \times k \times A_f \times R_b / (G / T)_{spec} \tag{A.7}$$

For the nominal case, i.e. when A_f = 1, and with $E_b/N_0 = 5\ dB$, G/T = -24 dB/K, R_b = 46,8 kbit/s, the receiver input power derived from (7) equals -122,9 dBm. Hence,

$$= -122{,}9 dBm + A_f\,(dB) \tag{A.8}$$

The quantity A_f defines the amount by which the receiver temperature can be increased relative to the nominal case of G_a = 1 and T_a = 0, while maintaining the same terminal G/T. The expression in clause 7.4 is simply the same as that of equation (A.6), with quantities A_f, G_a, and (G/T)spec, expressed in dB.

Annex B (normative): Environmental conditions

B.1 General

This normative annex specifies the environmental requirements of GMR-1 Mobile Earth Stations. All GMR-1 requirements shall be met under normal temperature conditions and over the voltage and vibration conditions specified in this annex. A subset of the GMR-1 requirements shall be met over the extreme temperature range. The specification of each parameter indicates whether the specification shall be met over extreme conditions and what the required values are under these conditions (in general, some of the requirements may be relaxed relative to the ones for normal temperature range). If a parameter is specified without any reference to extreme temperature conditions, then its requirement shall be met only over the normal temperature conditions.

B.2 Temperature

Normal temperature range shall be defined as temperature from +15 C to +35°C and relative humidity of 25 % to 75 %.

Extreme temperature range shall be defined as temperature from -10°C to +55°C and relative humidity of 25 % to 75 %.

Outside this temperature range the MES, if powered on, will not make ineffective use of the radio frequency spectrum. In no case shall the MES exceed the transmitted levels as defined in the present document for extreme operation.

B.3 Voltage

The MES shall fulfil all the requirements defined in the present document in the full voltage range defined by the manufacturer. The full voltage range shall extend, as a minimum, from 90 % to 110 % of the nominal supply voltage. In cases where the MES is powered by external accessories, such as car kits or desktop chargers, the supply voltage of the accessory shall meet the specifications of the MES manufacturer.

Outside this voltage range the MES, if powered on, will not make ineffective use of the RF spectrum. In no case shall the MES exceed the transmitted levels, as defined in the present document, for extreme operation. In particular, the MES shall inhibit all RF transmissions when the power supply is below the manufacturer-declared shutdown voltage.

B.4 Vibration

The MES shall fulfil all the requirements when vibrated at the following frequency/amplitudes:

Frequency	ASD (Acceleration Spectral Density)
10 Hz to 200 Hz	1,0 m^2/s^3
200 Hz to 2 000 Hz	0,3 m^2/s^3

Outside the specified frequency range, the MES, if powered on, will not make ineffective use of the radio frequency spectrum. In no case shall the MES exceed the transmitted levels, as defined in the present document, for extreme operation.

Annex C (informative): Channel model

C.1 General

The Rician fading model is generally accepted as a valid representation of the fast signal fading (that is, excluding shadowing) encountered in mobile satellite links. This model has a direct signal component, plus a multipath-generated component, which is generally modelled as a Rayleigh fading process. The direct signal component represents signal received through a line of sight (LoS) path from the transmitter, and it has a constant (time-invariant) magnitude and a constant Doppler shift relative to the signal observed by a stationary receiver. The multipath component is the result of many reflected rays arriving into the receiver antenna from many angles. The angle of arrival of the multipath components is typically assumed to be uniformly distributed around the circle, and as a result, this component has Doppler content from $-f_d$ to f_d Hz, where f_d is the Doppler when the receiver is moving in the direction of the transmitter.

C.2 Channel model

Figure C.1 shows the channel model block diagram. The input signal is multiplied by a fixed gain and then by a complex Rayleigh fading gain to form the multipath portion of the signal path. This portion is then added to the direct signal component to form a Rician fading signal. The noise samples, which have been appropriately scaled to produce the required E_b/N_0, are subsequently added to the sum of the direct path and the multipath signal components. Note that only power from the direct path is counted in computing the energy per bit, which in turn determines the scaling of the noise samples.

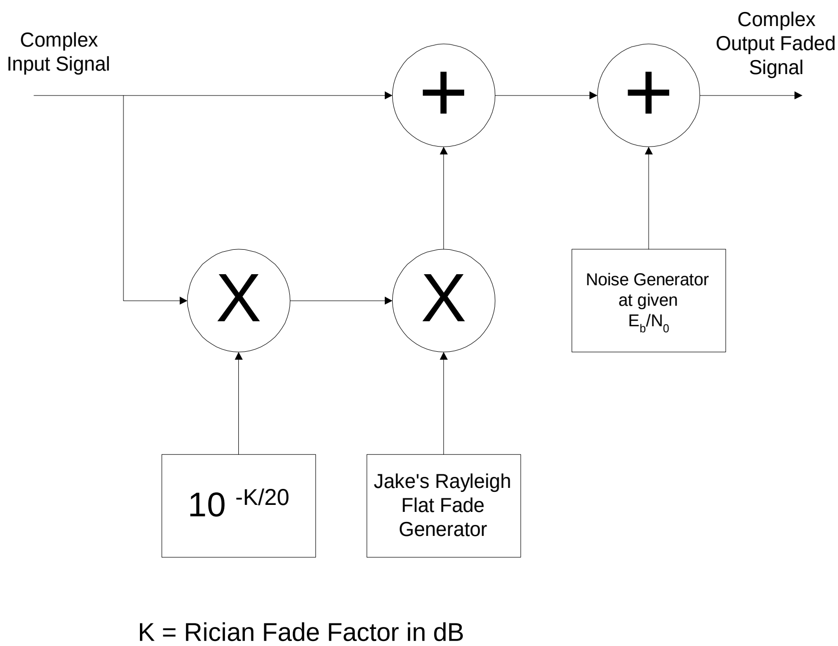


Figure C.1: Block diagram of the GMR-1 channel model

The ratio of the direct signal power to the total multipath power is the Rician K-factor.

The coherent summation of many multipath components, which are of roughly equal strength and randomly phased with respect to one another, yields the classical Doppler spectrum for a Rayleigh fading process, which when added to the direct path signal, forms the Rician fading.

The Rician spectrum for linear (i.e. not in dB scale) Rician factor K_l is given by:

$$S(f) = \frac{1}{K_l \cdot \pi \cdot f_d \sqrt{1 - \left(\frac{f}{f_d}\right)^2}} + \delta(f) \qquad \text{for } -f_d < f < f_d$$

$$\text{else } S(f) = 0$$

Note that the total power of this signal is $1 + 1/K_l$ and that the power of the direct component is 1, in keeping with the convention that only direct path power is counted in the calculation of E_b/N_0.

The Rayleigh fading generator is based on the well-known Jake's model [6] in which an ensemble of sinusoidal waveforms are added together to simulate the coherent sum of scattered rays with different Doppler shifts arriving from different directions at the receiver.

History

Document history		
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