ETSI TS 101 376-5-5 V3.3.1 (2012-12)

GEO-Mobile Radio Interface Specifications (Release 3);
Third Generation Satellite Packet Radio Service;
Part 5: Radio interface physical layer specifications;
Sub-part 5: Radio Transmission and Reception;
GMR-1 3G 45.005

Reference

RTS/SES-00328-5-5

Keywords

3G, earth station, GMPRS, GMR, GPRS, GSM, GSO, MES, mobile, MSS, radio, satellite

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Sous-Préfecture de Grasse (06) N° 7803/88

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Contents

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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 will then be republished by ETSI with an identifying change of release date and an increase in version number as follows:

Version 3.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 (Release 3); Third Generation Satellite Packet Radio Service, as identified below:

Part 1: "General specifications":

Part 2: "Service specifications";

Part 3: "Network specifications";

Part 4: "Radio interface protocol specifications";

Part 5: "Radio interface physical layer specifications";

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

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

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

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

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

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

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

Part 6: "Speech coding specifications";

Part 7: "Terminal adaptor specifications".

Introduction

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

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

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

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

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

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

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

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

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

where:

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

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

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

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

- If a GMR specification does not exist, the corresponding GSM or 3GPP specification may or may not apply. The applicability of the GSM and 3GPP specifications is defined in TS 101 376-1-2 [6].

1 Scope

The present document defines the performance requirements for the Mobile Earth Station (MES) radio transceiver for the GMR-1 3G 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.

2 References

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

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

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

2.1 Normative references

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

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

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

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

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

[2] ETSI TS 101 376-5-4: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 4: Modulation; GMR-1 3G 45.004".

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

[4] ETSI EN 301 681: "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 the essential requirements of article 3.2 of the R&TTE Directive".

[5] ETSI TS 101 376-5-5: "GEO-Mobile Radio Interface Specifications (Release 1); Part 5: Radio interface physical layer specifications; Sub-part 5: Radio Transmission and Reception; GMR-1 05.005".

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

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

[7] ETSI EN 301 444: "Satellite Earth Stations and Systems (SES); Harmonized EN for Land Mobile Earth Stations (LMES) operating in the 1,5 GHz and 1,6 GHz bands providing voice and/or data communications covering essential requirements of article 3.2 of the R&TTE directive".

[8] ETSI TS 101 376-5-7: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 7: Radio Subsystem Synchronization; GMR-1 3G 45.010".

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

[10] ETSI EN 302 574-3: "Satellite Earth Stations and Systems (SES); Harmonized Standard for satellite earth stations for MSS operating in the 1 980 MHz to 2 010 MHz (earth-to-space) and 2 170 MHz to 2 200 MHz (space-to- earth) frequency bands; Part 3: User Equipment (UE) for narrowband systems: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

[11] ETSI TS 101 376-5-3: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 5: Radio interface physical layer specifications; Sub-part 3: Channel Coding; GMR-1 3G 45.003".

2.2 Informative references

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

Not applicable.

3 Definitions, abbreviations and symbols

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TS 101 376-1-2 [6] and the following apply:

active transmission: defined as the combination of the ramp-up, ramp-down, and active burst transmission periods

average EIRP: burst EIRP averaged over at least 200 bursts

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

carrier-off state: MES is in this state when it does not transmit any signal and it is more than 20 ms away from any active transmission (i.e. the carrier-off state excludes the carrier-standby state)

carrier-on state: MES is in this state when it transmits a signal (i.e. the carrier-on state corresponds to an active transmission)

carrier-standby state: MES is in this state when it does not transmit any signal but it is within 20 ms of the carrier-on state (i.e. the carrier-standby state occurs for up to 20 ms immediately before, and up to 20 ms immediately after the carrier-on state)

Terminal Type: alphabetic designator defining a terminal, as described in TS 101 376-5-2 [9]

Terminal Type Identifier: numerical identifier defining a terminal, as described in TS 101 376-5-2 [9]

NOTE: Each Terminal Type can have more than one associated Terminal Type Identifier.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TS 101 376-1-1 [1] apply.

3.3 Symbols

For the purposes of the present document, the following symbols apply:

E_b Average energy per bit in the wanted signal
E_s Average energy per symbol in the wanted signal
N_o Average channel noise (the noise power spectral density integrated over the channel bandwidth)
0x Prefix used for Hexadecimal representation of identifiers or numbers

3.4 Terminal Types (informative)

Terminal Types and related Terminal Type Identifiers are defined in TS 101 376-5-2 [9]. The following information is provided for information only and in the event of any conflict the definitions in TS 101 376-5-2 [9] take precedence.

Terminals are defined throughout the present document in terms of Terminal Type Identifiers in Hexadecimal format. Table 3.1. summarizes the relationship between Terminal Types and Terminal Type Identifiers.

Table 3.1: Terminal Types and Identifiers

Terminal Type Identifier (Binary)	Terminal Type Identifier (Hexadecimal)	Terminal Type	Operating Band	Antenna Radiation Pattern Category (see note)	Notes
1 0 0 1 0 0 0	0x48	A	L	B	Fixed
0 0 0 1 0 0 1	0x9	C	L	B	Handheld
0 0 0 1 0 1 0	0xA	C	L	B	Handheld
0 0 0 1 0 1 1	0xB	C	L	B	Handheld
0 0 0 1 1 0 0	0xC	C	L	B	Handheld
0 0 0 1 1 0 1	0xD	D	L	B	Portable - Internal Antenna
0 0 0 1 1 1 0	0xE	D	L	B	Portable - Passive Ext. Antenna
0 0 0 1 1 1 1	0xF	D	L	B	Portable - Active Ext. Antenna
0 0 1 0 0 0 0	0x10	E	S	N	Handheld
0 0 1 0 0 0 1	0x11	E	S	N	Handheld
0 0 1 0 0 1 0	0x12	E	S	N	Handheld
0 0 1 0 1 0 1	0x15	F	S	N	Handheld
0 0 1 1 0 1 0	0x1A	G	S	N	Handheld
0 0 1 1 1 1 1	0x1F	H	S	B	Vehicular
0 1 0 0 0 0 0	0x20	H	S	B	Vehicular
0 1 0 0 1 0 0	0x24	I	S	B	Fixed
0 1 0 0 1 0 1	0x25	I	S	B	Fixed
0 1 0 1 0 0 1	0x29	J	L	N	Handheld
0 1 0 1 1 1 0	0x2E	K	L	N	Handheld
0 1 1 0 0 1 1	0x33	L	L	N	Handheld

Terminal Type Identifier (Binary)	Terminal Type Identifier (Hexadecimal)	Terminal Type	Operating Band	Antenna Radiation Pattern Category (see note)	Notes
0 1 1 1 0 0 0	0x38	M	L	B	Fixed
0 1 1 1 1 0 1	0x3D	N/A	L	N	Handheld - Small
0 1 1 1 1 1 0	0x3E	N/A	L	B	Handheld - Smartphone
0 1 1 1 1 1 1	0x3F	N/A	L	B	Handheld - Rugged
1 0 0 0 0 0 0	0x40	N/A	L	B	Asset Tracking
1 0 0 0 0 0 1	0x41	N/A	L	B	Portable
1 0 0 0 0 1 0	0x42	N/A	L	B	Semi-Fixed
1 0 0 0 0 1 1	0x43	N/A	L	B	Vehicular
1 0 0 0 1 0 0	0x44	N/A	L	B	Maritime - Large
1 0 0 0 1 0 1	0x45	N/A	L	B	Aeronautical
1 0 0 0 1 1 0	0x46	N/A	L	B	Maritime - Small
NOTE: Antenna radiation patterns are categorized as Boresight Oriented (B) or Non-Boresight Oriented (N). Refer to clause 6.2 for more details.					

4 Frequency bands and channel arrangement

GMR-1 operation is defined for L-Band and S-Band LMSS frequency allocations.

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 for circuit switched operation.

MESs operate at S-band frequencies, which are allocated world-wide for land mobile satellite service (LMSS). The combined frequency bands are:

- MES receives (Space-to-Earth): 2 170,0 MHz to 2 200,0 MHz;
- MES transmits (Earth-to-Space): 1 980,0 MHz to 2 020,0 MHz

MESs operate in a subset of these combined S-band frequencies as appropriate for the region of operation.

NOTE 1: In North America, current S-Band frequency allocations are the following subset of the combined frequency bands: Space-to-Earth: 2 180 MHz to 2 200 MHz; Earth-to-Space: 2 000 MHz to 2 020 MHz.

NOTE 2: In Europe, current S-Band frequency allocations are the following subset of the combined frequency bands: Space-to-Earth: 2 170 MHz to 2 200 MHz; Earth-to-space; 1 980 MHz to 2 010 MHz.

For packet switched operation, the FDM scheme may be operated in full duplex with any downlink (forward) RF carrier used with any uplink (return) RF carrier without necessarily having a fixed frequency offset between the two carriers.

4.2 RF carrier spacing and designation

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

The 40 MHz of S-band spectrum in Earth-to-Space direction is divided into 1 280 carriers with carrier spacing of 31,250 kHz. The 30 MHz of S-Band spectrum in Space-to-Earth direction is divided into 960 carriers with carrier spacing of 31,250 kHz.

Absolute Radio Frequency Channel Numbers (ARFCN), N, are assigned to each carrier pair and take the values from 1 through 1 087 ($1 \leq N \leq 1\ 087$) when operating in L-Band.

ARFCNs, N, are numbered from 1 through 1 280 ($1 \leq N \leq 1\ 280$) when operating in S-Band for Earth-to-Space and from 1 through 960 ($1 \leq N \leq 960$) when operating in S-Band for Space-to-Earth.

The centre frequency of the carriers in kHz corresponding to an ARFCN is given by the expressions in table 4.1 for L-band and in table 4.1a for S-band.

Table 4.1: ARFCNs for L-Band

	Carrier centre frequencies (kHz)	ARFCN
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	$1 \leq N \leq 1\ 087$

Table 4.1a: ARFCNs for S-Band

	Carrier centre frequencies (kHz)	ARFCN
Mobile earth station receive	2 170 000,00 + 15,625 + 31,25 x (N_{RX} - 1)	$1 \leq N_{RX} \leq 960$
Mobile earth station transmit	1 980 000,00 + 15,625 + 31,25 x (N_{TX} - 1)	$1 \leq N_{TX} \leq 1\ 280$

The ARFCN and centre frequency of the carriers are given in table 4.2 for L-band and table 4.2a for S-band Space-to-Earth and table 4.2b for S-band Earth-to-Space. The RF channels are spaced at 31,25 kHz intervals, which provides 32 carriers per MHz.

Table 4.2: ARFCN and frequencies for L-Band

MES-RX centre frequencies (kHz)	MES-TX centre frequencies (kHz)	ARFCN (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

Table 4.2a: Receive ARFCNs and frequencies for S-Band

MES-RX centre frequency (kHz)	RX ARFCN (N_{RX})
2 170 015,625	1
2 170 046,875	2
...	...
2 199 984,375	960

Table 4.2b: Transmit ARFCNs and frequencies for S-Band

MES-TX centre frequency (kHz)	TX ARFCN (N_{TX})
1 980 015,625	1
1 980 046,875	2
...	...
2 009 984,375	960
...	...
2 019 984,375	1 280

The packet services use nominal transmission bandwidths that are multiples of the 31,25 kHz basic transmission bandwidth. These different transmission bandwidths defined over the sub bands are used to support transmission symbol rates that are multiples of the basic symbol rate of 23,4 ksps. A 3-bit bandwidth suffix is added to the AFRCN to indicate the bandwidth and transmission rate of the modulated carrier. The association of transmission bandwidths to transmission rates is given in table 4.3.

If the transmission bandwidth is an even multiple of 31,25 kHz, then the carrier frequency shall be shifted by +15,625 kHz.

Table 4.3: Transmission bandwidth and associated transmission symbol rates

Bandwidth suffix	Transmission bandwidth (kHz)	Transmission Symbol rate (ksps)
000	Reserved	Reserved
001	31,25	23,4
010	62,50	46,8
011	Reserved	Reserved
100	125,00	93,6
101	156,25	117,0
110	312,5	234,0
111	Reserved	Reserved

4.3 RF carrier used for synchronization and spot beam selection

MES synchronization to the BCCH carrier is defined in TS 101 376-5-6 [3] and TS 101 376-5-7 [8].

4.4 Frequency assignment to spot beams

L-band RF or S-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

Same as clause 5.1 in TS 101 376-5-5 (Release 1) [5].

5.1.1 Definition of operating conditions

Same as clause 5.1.1 in TS 101 376-5-5 (Release 1) [5] for MESs operating in the L-band. For MESs operating in the S-Band an appropriate S-band carrier frequency (fc) shall be applied to define Doppler frequency.

5.1.2 Frequency and timing stability requirement

Same as clause 5.1.2 in TS 101 376-5-5 (Release 1) [5].

5.1.3 Frequency and timing stability requirements for packet data

In the tests of this clause, the MES shall be receiving the logical channel specified in tables 5.1 or 5.2 and shall be transmitting a PDCH or DCH channel. In all test cases, AWGN shall be used.

The rms frequency and symbol timing error of the transmitted signal from the MES shall not exceed the values given, when the unit is receiving the channels defined with the E_s/N_o values listed in tables 5.1 (for MESs supporting FCCH) and 5.2 (for MESs supporting FCCH3).

Table 5.1: Frequency and timing stability requirements

Received logical channel	Operational condition (see note)	E_s/N_o (dB)	RMS Frequency Error (Hz)	RMS timing error (μs)
DCH (at 23,4 ksps)	Steady State	3	10	0,9
PDCH (at 23,4 ksps)	Steady State	5	10	0,9
PDCH (at 46,8 ksps)	Steady State	5	10	0,9
PDCH (at 93,6 ksps)	Steady State	5	10	0,9
PDCH (at 117,0 ksps)	Steady State	5	10	0,9
PDCH (at 234,0 ksps)	Steady State	5	10	0,9
NOTE: The Steady State operational condition is defined in TS 101 376-5-5 (Release 1) [5].				

Table 5.2: Frequency and timing stability requirements

Received logical channel	Operational condition (see note 1)	RMS Frequency Error (Hz) (see note 2)	RMS timing error (μs) (see note 2)
DC12	Steady State	10	2,0
PNB3(1,3)	Steady State	20	3,0
PNB3(1,6)	Steady State	20	3,0
PNB(1,6)	Steady State	10	1,5
PNB3(2,6)	Steady State	10	1,5
PNB3(5,3)	Steady State	10	1,5
PNB3(5,12)	Steady State	10	1,5
PNB3(10,3)	Steady State	10	1,0
NOTE 1: The Steady State operational condition is defined in TS 101 376-5-5 (Release 1) [5]. NOTE 2: These requirements apply at the sensitivity levels defined in clause 7.4.			

5.2 Frequency switching time

Depending on the Terminal Type Identifier as follows:

- Terminal Type Identifiers (0x9, 0xA, 0xB, 0xC, 0xD, 0xE, 0xF, and 0x48): 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-standby conditions defined in clause 6.4a.

- All other Terminal Type Identifiers: MESs shall be capable of switching (1) from any transmit frequency to any other transmit frequency, or (2) from any receive frequency to any other receive frequency in less than 2,0 ms, while maintaining the frequency stability defined in clause 5.1. MESs operating in Half-Duplex mode shall be capable of switching (1) from any transmit frequency to any receive frequency, or (2) from any receive frequency to any transmit frequency in less than 1,0 ms while maintaining the frequency stability defined in clause 5.1. The same minimum switching time specifications shall apply when changing transmitted symbol rates. During frequency switching, the MES transmit level shall correspond to the carrier-off and carrier-standby conditions defined in clauses 6.4 and 6.4a.

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

For full duplex operation, the transmit (receive) to receive (transmit) frequency switching time is not applicable. In addition, the MES shall be capable of switching from any transmit frequency to any other transmit frequency with the same specification as the receiver frequency switching.

5.3 MES time alignment accuracy

Same as clause 5.3 in TS 101 376-5-5 (Release 1) [5].

6 Transmitter characteristics

6.1 Power output characteristics and power class

The EIRP specifications in tables 6.1 to 6.5 are defined as follows:

- For terminals with Terminal Type Identifiers (0x10, 0x11, 0x12, 0x15, 0x29, 0x2E, 0x33, 0x3D-0x40), the EIRP is defined as the 90th percentile of the gain distribution (i.e. 10 % of the solid angles in the defined pattern have higher gain) associated with the antenna. See clause 6.2.

- For all other terminals, the EIRP is defined at boresight (i.e. maximum gain) for the antenna. Same as clause 6.1 in TS 101 376-5-5 (Release 1) [5] with the additional specifications for Terminal Types for packet mode operation.

Table 6.1 defines the Nominal EIRP (EIRP_nom) for each Terminal Type. This value provides the basis for the EIRP requirements that follow. For terminals with Terminal Type Identifiers (0x9-0xC) see TS 101 376-5-5 (Release 1) [5].

Table 6.1: Nominal EIRP for Each Terminal Type

Terminal Type Identifier	EIRP_nom (dBW), PAS = 0 dB (see note)
0x48	13,1
0xD	9,0
0xE, 0xF	16,0
0x10-0x12	-1,0
0x15	0,0
0x1A	2,0
0x1F, 0x20	5,0
0x24, 0x25	13,0
0x29	-6,3
0x2E	-1,3
0x33	1,0
0x38	12,0
0x3D	-5,0
0x3E	1,5
0x3F	1,5
0x40	1,5
0x41	10,2
0x42	15,0
0x43	18,0
0x44	18,0
0x45	17,0
0x46	15,0
NOTE: Power Attenuation Setting (PAS) is defined in TS 101 376-5-6 [3].	

6.1.1 Average EIRP - Extreme Conditions

- The Maximum Average EIRP under Extreme Conditions shall be less than (EIRP_nom + 1,8) dBW.

- The Minimum Average EIRP under Extreme Conditions shall be greater than (EIRP_nom - 2,0) dBW.

6.1.2 Average EIRP - Normal Conditions

- The Maximum Average EIRP under Normal Conditions shall be less than (EIRP_nom + 1,8) dBW.

- The Minimum Average EIRP under Normal Conditions shall be greater than (EIRP_nom - 1,0) dBW.

6.1.3 Single Burst EIRP

The single burst EIRP shall satisfy the following:

a) Each of the bursts in the first five frames of each transmit activity that are not preceded in the past 60 seconds by a transmit activity of at least ten bursts long shall satisfy:

   1) The Maximum EIRP shall be less than (EIRP_nom + 1,8) dBW.

   2) The Minimum EIRP shall be greater than (EIRP_nom - 4,0) dBW.

b) Each of the remaining bursts shall satisfy:

   3) The Maximum EIRP shall be less than (EIRP_nom + 1,8) dBW.

   4) The Minimum EIRP shall be greater than (EIRP_nom - 3,0) dBW.

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

6.1.4 Access Burst EIRP

For terminals with Terminal Type Identifiers (0x48, 0xD, 0xE) the EIRP of RACH bursts shall satisfy:

- The Maximum EIRP shall be less than 11,8 dBW.
- The Minimum EIRP shall be greater than 4,3 dBW.

For terminals with all other Terminal Type Identifiers and EIRP_nom below 5 dBW, the EIRP of RACH or RACH3 bursts shall satisfy:

- The Maximum EIRP shall be less than (EIRP_nom + 1,8) dBW.
- The Minimum EIRP shall be greater than (EIRP_nom - 4,0) dBW.

For terminals with all other Terminal Type Identifiers the EIRP of RACH or RACH3 bursts shall satisfy:

- The Maximum EIRP shall be less than 6,8 dBW.
- The Minimum EIRP shall be greater than 1,0 dBW.

For terminals with all Terminal Type Identifiers the EIRP of PRACH or PRACH3 bursts (if used) shall satisfy:

- The Maximum EIRP shall be less than (EIRP_nom + 1,8) dBW.
- The Minimum EIRP shall be greater than (EIRP_nom - 4,0) dBW.

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

6.2 Antenna radiation pattern

Same as clause 6.2 of TS 101 376-5-5 (Release 1) [5] with the addition of the following text.

Antenna radiation patterns are categorized as follows.

- Boresight Oriented: The antenna pattern has a distinct gain peak (boresight), and the gain tends to reduce monotonically as a function of the angular offset from boresight in the main lobe. Other lobes in the pattern have significantly lower peak gain. This category includes terminals with Terminal Type Identifiers (0x9-0xF, 0x1A, 0x1F, 0x20, 0x24, 0x25, 0x38, 0x48, 0x41-0x46). Clause 6.2.1 defines the specifications for these terminals.
- Non-Boresight Oriented: The antenna pattern is irregular and consists of numerous peaks and valleys throughout the solid angles over which the terminal is used. This category includes terminals with Terminal Type Identifiers (0x10, 0x11, 0x12, 0x15, 0x29, 0x2E, 0x33, 0x3D-0x40). Clause 6.2.2 defines the specifications for these terminals.

6.2.1 Boresight Oriented Radiation Patterns

The antenna for the various packet terminals have the following gains when fully deployed with no conduction objects in the vicinity of the MES antenna. These apply to measurements made using polarizations identified in table 6.4.

Table 6.2: Minimum Transmit Antenna Gain

Terminal Type Identifier	Antenna gain (dBi)
0x48	12,0
0x9-0xC	Same as handheld MES. See TS 101 376-5-5 (Release 1) [5]
0xD	8,5
0xE, 0xF	15,0
0x1A	2
0x1F, 0x20	2
0x24, 0x25	13
0x38	12

6.2.2 Non-Boresight Oriented Radiation Patterns

These terminals can have antenna patterns with significant peaks and valleys. To characterize the performance of the antenna, the Cumulative Density Function (CDF) of the gain pattern shall be measured in free space with the phone vertical to the ground and no conducting objects in the vicinity of the unit.

Equidistant solid angle gain measurements (5° or less apart) shall be made for elevation angles of -40 degrees to +90 degrees and 360 degrees in azimuth. (That is, each gain measurement represents the average gain over a solid angle.) Gain is defined for signals polarized as defined in clause 6.3. For the cases of linear polarization, gain shall be measured in orthogonal polarizations, and combined to derive an equivalent gain. The gain CDF shall be based on samples expressed in dB units. For performance purposes the minimum gain will be defined as the 10 % point on the CDF curve and the maximum gain shall be defined as the 90 % point on the CDF curve. The average performance will also be specified.

Table 6.3: Minimum Gain for Non-Boresight Oriented Antennas

Terminal Type Identifier	Minimum gain (dBi) (10 % CDF)	Average gain (dBi)	Maximum gain (dBi) (90 % CDF)
0x10-0x12, 0x15, 0x1A, 0x29, 0x2E, 0x33, 0x3D-0x3F	-6,9	-2,9	-0,3

6.3 Transmit polarization

The transmit polarization shall be either circular or linear as defined in table 6.4.

Table: 6.4: Transmit antenna polarization

Terminal Type Identifier	Polarization
0x48	Left-Hand Circular
0x9-0xC	Left-Hand Circular
0xD	Left-Hand Circular
0xE, 0xF	Left-Hand Circular
0x10-0x12	Linear
0x15	Linear
0x1A	Circular
0x1F, 0x20	Circular
0x24, 0x25	Circular
0x29	Linear
0x2E	Circular
0x33	Circular
0x38	Circular
0x3D	Linear
0x3E-0x46	Left-Hand Circular

For terminals with Terminal Type Identifier (0x9, 0xA, 0xB, 0xC, 0xE, 0x48, 0x1A, 0x1F, 0x20, 0x24, 0x25, 0x2E, 0x33, or 0x38), the axial ratio of radiated wave over the operational frequency range shall be better than 2 dB at boresight and better than 5 dB over the 3 dB coverage of the antenna.

For terminals with Terminal Type Identifier (0xD or 0xF), the axial ratio of radiated wave over the operational frequency range shall be better than 4 dB at boresight and better than 5 dB over the 3 dB coverage of the antenna.

6.4 Carrier-off conditions

The maximum EIRP from an MES in the carrier-off state shall be less than -30 dBm within any 31,25 kHz channel.

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

6.4a Carrier-standby conditions

The maximum EIRP from an MES in the carrier-standby state shall be less than -8 dBm within any 31,25 kHz channel.

This requirement shall be met under the extreme environmental conditions defined in annex B.

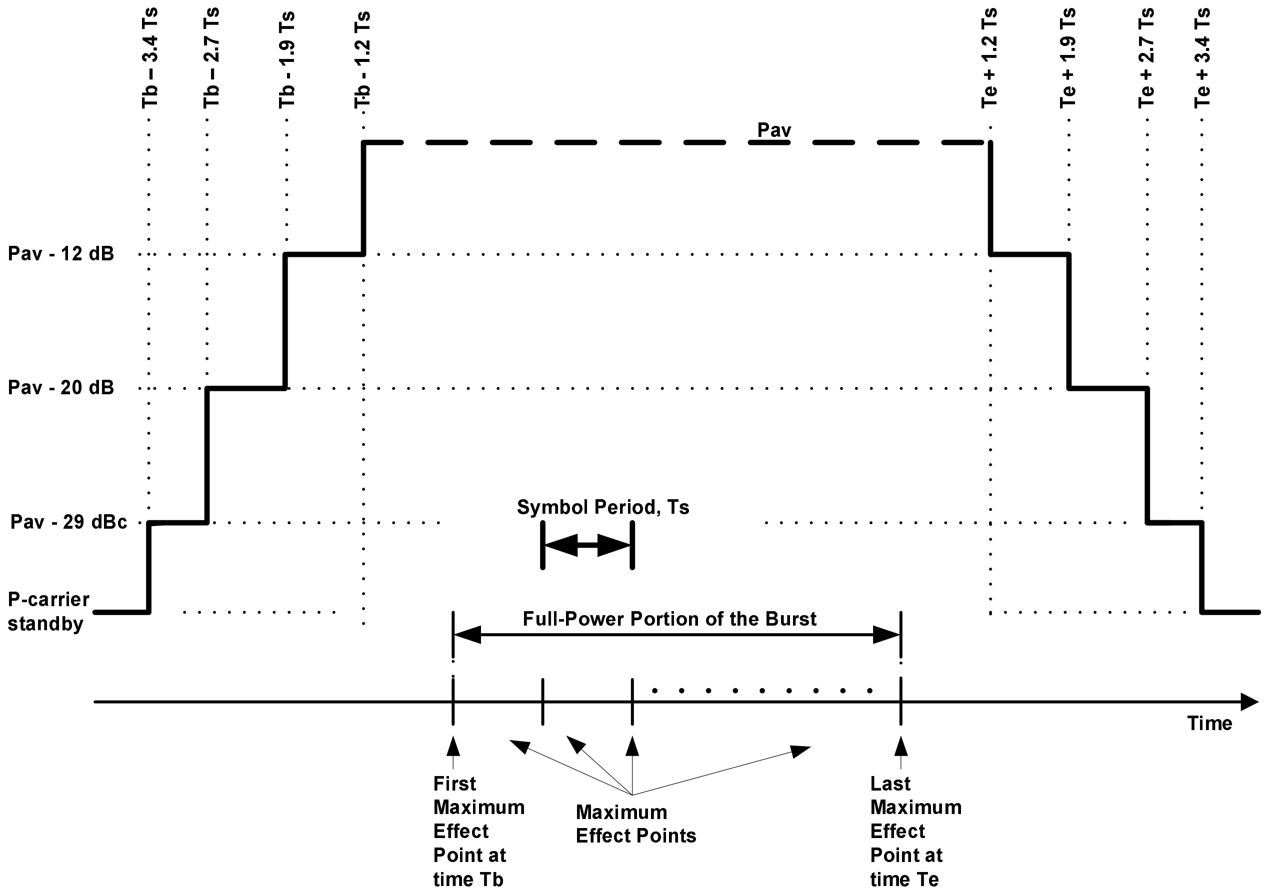
6.5 Droop, ramp-up and ramp-down

The transition from the carrier standby 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 structure of bursts and the mapping of data bits into data symbols and transmit waveform are defined in TS 101 376-5-4 [2]. The term Maximum Effect Point defines the peak of the waveform transmitted to convey each symbol. The Maximum Effect Points occur at the midpoint of the period associated with each symbol (as defined in TS 101 376-5-2 [9]). For example, in a burst that contains an initial Guard Period with duration of 5 'half symbols', the first Maximum Effect Point will occur half a symbol period after the Guard Period, i.e. 3 symbol periods after the start of the associated timeslot. The positions in time of the ramp up and ramp down periods relative to the Maximum Effect Points are shown in figure 6.1.

During the Full-Power Portion of the Burst (from the first Maximum Effect Point until the last Maximum Effect Point), the transmitted waveform shall not droop more than 1 dB relative to Pav, i.e. the average power throughout the Full-Power Portion of the Burst. To be specific, the power difference between any two portions of each burst (e.g. the start and the end) shall be less than 2 dB. Droop is defined as a change (either positive or negative) in average (over several symbols) transmitted power during a burst. Note that instantaneous changes in power in excess of the 1 dB will occur due to the particular bits being transmitted and the envelope variation associated with the modulation. These instantaneous changes do not constitute droop.

Two approaches to verification of this requirement are envisaged: Either (a) direct measurement of droop by suitable test equipment, or (b) recording and analyzing burst power profiles. The power that is used to determine the droop for approach-(b) shall be averaged over periods not exceeding 500 us.

Outside of the Full-Power Portion of the Burst, the average power profile transmitted from an MES shall lie below the defined levels (in figure 6.1) relative to Pav. Random symbols should be present throughout the transmitted bursts, and the present document applies to the actual waveform generated, i.e. not a filtered version of the waveform such as that seen at the output of a receiver matched filter.



NOTE: T_S is the symbol period and is equal to 1/(23,4 x m) msec.

Figure 6.1: Ramp-up and ramp-down of a burst

6.6 Power control range and accuracy

6.6.1 Approach

Same as clause 6.6.1 in TS 101 376-5-5 (Release 1) [5].

6.6.2 Procedures and timing

Same as clause 6.6.2 in TS 101 376-5-5 (Release 1) [5].

6.6.3 Range

Same as clause 6.6.3 in TS 101 376-5-5 (Release 1) [5].

6.6.4 Accuracy

Same as clause 6.6.4 in TS 101 376-5-5 (Release 1) [5].

6.6.5 Attenuation step size

Same as clause 6.6.5 in TS 101 376-5-5 (Release 1) [5].

6.6.6 Initial power level P_{init}

The definition and the usage of the initial power level, P_{init}, is given in TS 101 376-5-6 [3]. The P_{init} for each terminal type shall be 0 in terms of the associated PAS (Power Attenuation Setting).

6.7 Adjacent channel interference

Same as clause 6.7 in TS 101 376-5-5 (Release 1) [5] with the following additional text:

- A factor "m" defines the transmitted signal symbol rate. "m" is equal to the ratio of the signal's transmit symbol rate to 23 400 symbols/sec.

6.7.1 Interference due to modulation

For terminals with Terminal Type Identifiers: 0x48, 0x9-0xF, 0x24, 0x25, 0x38, and 0x41-0x46:

Terminals with Maximum EIRP less than or equal to 15 dBW shall meet the following requirements:

Same as clause 6.7.1 in TS 101 376-5-5 (Release 1) [5] with the following additional text:

- The interference shall be less than the levels given in table 6.5 as seen by a matched filter with a bandwidth of m × 23,4 kHz. The channel centres for measurement are also scaled by the factor "m", as given in table 6.5.
- The level of interference shall be measured as the average during the transmission of fewer than 200 bursts.

Table 6.5: Adjacent channel interference due to modulation

1st Adjacent channels, ±m x 31,25 kHz	2nd Adjacent channels, ±m x 62,5 kHz	3rd Adjacent channels, ±m x 93,75 kHz	4th Adjacent channels and Beyond (see note 1)	Terminal Type Identifier/s
-25 dBc	-40 dBc	-53 dBc	-60 dBc	0x9-oxC, 0x48, 0x41-0x46
-25 dBc	-40 dBc	-53 dBc	-60 dBc	0xD-0xF (see note 2)
-25 + ΔI dBc	-40 + ΔI dBc	-53 + ΔI dBc	-60 + ΔI dBc	0x24, 0x25 (see note 3)
-25 + ΔM dBc	-40 + ΔM dBc	-53 + ΔM dBc	-60 + ΔM dBc	0x38 (see note 4)
NOTE1: 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: The total energy in any adjacent voice carrier bandwidth (23,4 kHz) due to terminals with Terminal Type Identifier 0D, 0E, or 0F connected to an external antenna capable of 15 dBW EIRP shall be at most -35 dBc. The first adjacent voice carrier will be located at ±(m+1) x 15,625 kHz. NOTE 3: ΔI equals -7 dB for a 31,25 kHz carrier; -4 dB for a 62,5 kHz carrier; 0 dB for a 156,25 kHz carrier, and 0 dB for a 312,5 kHz carrier transmitted by terminals with Terminal Type Identifier 24 or 25. NOTE 4: ΔM equals -6 dB for a 31,25 kHz carrier; -3 dB for a 62,5 kHz carrier, -1 dB for a 156,25 kHz carrier, and 0 dB for a 312,5 kHz carrier transmitted by terminals with Terminal Type Identifier 38.				

For L-band the transmitter shall also meet the following requirements:

- For terminals with Maximum EIRP less than or equal to 15 dBW, the unwanted emissions within the band 1 626,5 MHz to 1 660,5 MHz shall not exceed the carrier-on limits defined in clause 4.2.2 of EN 301 681 [4]. In the event of any conflict the more stringent limit shall apply.

- For terminals with Maximum EIRP greater than 15 dBW, the unwanted emissions within the band 1 626,5 MHz to 1 660,5 MHz shall not exceed the carrier-on limits defined in clause 4.2.2 of EN 301 444 [7]. In the event of any conflict the more stringent limit shall apply.

For S-band the transmitter shall also meet the following requirements:

- For terminals operating in the band 1 980 MHz to 2 010 MHz, the unwanted emissions within the band 1 980 MHz to 2 010 MHz shall not exceed the carrier-on limits defined in clause 4.2.3 of EN 302 574-3 [10]. In the event of any conflict the more stringent limit shall apply.

- MES designed to operate in other bands should comply with the relevant emissions limits for that band.

For terminals with Terminal Type Identifiers: 0x10-0x12, 0x15, 0x1A, 0x1F, 0x20, 0x29, 0x2E, 0x33, 0x3D-0x40:

The EIRP shall not exceed the higher of:

a) The relative levels defined below, OR

b) The absolute level -55 dBW/30 kHz.

These requirements apply to all 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.

All power levels refer to EIRP during active transmission. The levels may be averaged to reduce the variance of the power estimates.

Within the 1st and 2nd adjacent channels, the levels defined in table 6.6 shall not be exceeded. The defined levels are relative to the signal power in the band, as seen by a matched filter with bandwidth (m × 23,4) kHz. The interference shall be less that the levels defined in table 6.6 as seen by a matched filter with the defined center frequencies, and also with bandwidth (m × 23,4) kHz.

Outside the 2nd adjacent channel, the relative levels defined in table 6.7 shall not be exceeded.

Table 6.6: Adjacent channel interference due to modulation

	1st Adjacent Channel Center Frequencies	**2nd Adjacent Channel Center Frequencies**
Upper Channel Band relative to Signal Carrier Frequency, fc	fc + (m x 31,25 kHz)	fc + 2 x (m x 31,25 kHz)
Lower Channel Band relative to Signal Carrier Frequency, fc	fc - (m x 31,25 kHz)	fc - 2 x (m x 31,25 kHz)
Maximum EIRP (dBc)	-25 dBc	-35 dBc

Table 6.7: Adjacent channel interference due to modulation

Frequency Offset from Carrier Center (kHz) (see note 1)	**EIRP (dBc) (see notes 2, 3, 4)**	**Measurement Bandwidth (kHz)**
±2,5 x m x 31,25	-34-m(dB)	30
±MAX(4,5 x m x 31,25, 200)	-44-m(dB)	30
±2 000	-54-m(dB)	30
Edge of band	-54-m(dB)	30

NOTE 1: Measurements shall span defined bands, starting and ending with the edges of the measured band coinciding with the measurement band edges. For example, the lowest channel between '+600 kHz' and the 'Edge of band' would be centered at 615 kHz (given the 30 kHz Measurement Bandwidth).

NOTE 2: EIRP(dBc) refers to the EIRP within the defined Measurement Bandwidth relative to the total Signal Power, i.e. in the band:

[fc - 0,5 x (m x 31,25 kHz) to fc + 0,5 x (m x 31,25 kHz)].

NOTE 3: Linearly interpolated in dB vs. Frequency Offset.

NOTE 4: Value of m(dB) is $10 \times LOG_{10}(m)$.

6.7.2 Interference due to switching transients

For terminal with Terminal Type Identifiers 0x48, 0x9-0xF, 0x24, 0x25, and 0x38, same as clause 6.7.2 in TS 101 376-5-5 (Release 1) [5] with the following additional text:

Table 6.8: Adjacent channel interference due to switching transients

Terminal Type Identifier	1st Adjacent channels, ±m x 31,25 kHz	2nd Adjacent channels, ±m x 62,5 kHz	3rd Adjacent channels, ±m x 93,75 kHz	4th Adjacent channels and beyond (see note)
0x48, 0x9-0xF, 0x24, 0x25, 0x38	-18 dBc	-33 dBc	-46 dBc	-53 dBc
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.				

6.8 Unwanted emissions

6.8.1 Unwanted emissions in the carrier-on state and carrier-standby state (L-band)

This clause applies to MES operating in L-band.

Terminals with Maximum EIRP less than or equal to 15 dBW shall meet the following requirements:

- For an MES in the carrier-on state, or in the carrier-standby 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 clause 4.2.1 of EN 301 681 [4].

Terminals with Maximum EIRP greater than 15 dBW shall meet the following requirements:

- For an MES in the carrier-on state, or in the carrier-standby 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 clause 4.2.1 of EN 301 444 [7].

6.8.2 Unwanted emissions in the carrier-off state (L-band)

This clause applies to MES operating in L-band.

Terminals with Maximum EIRP less than or equal to 15 dBW shall meet the following requirements:

- 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 clause 4.2.3 of EN 301 681 [4].

Terminals with Maximum EIRP greater than 15 dBW shall meet the following requirements:

- 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 clause 4.2.1 of EN 301 444 [7]. In addition, the EIRP in any 3 kHz band within the 1 626,5 MHz to 1 660,5 MHz band shall not exceed -63 dBW.

6.8.3 Unwanted emissions in the carrier-on state and carrier-standby state (S-Band)

This clause applies to MES operating in S-band.

MESs designed to operate in the band 1 980 MHz to 2 010 MHz shall meet the following requirements:

- For an MES in the carrier-on state, or in the carrier-standby state, the maximum EIRP density of the unwanted emissions from the MES outside the band 1 980 MHz to 2 010 MHz shall not exceed the carrier-on limits defined in clause 4.2.2. of EN 302 574-3 [10].

MES designed to operate in other bands should comply with the relevant emissions limits for that band.

6.8.4 Unwanted emissions in the carrier-off state (S-band)

This clause applies to MES operating in S-band.

MESs designed to operate in the band 1 980 MHz to 2 010 MHz shall meet the following requirements:

- 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 clause 4.2.4. of EN 302 574-3 [10].

MES designed to operate in other bands should comply with the relevant emissions limits for that band.

7 Receiver characteristics

7.1 Receive antenna pattern

Same as clause 7.1 in TS 101 376-5-5 (Release 1) [5] with the following addition.

The antenna for the various packet terminals have the following gains when fully deployed and with no conduction objects in the vicinity of the MES antenna.

As described for the transmitter, antenna radiation patterns are categorized as Boresight Oriented, or Non-Boresight Oriented.

7.1.1 Boresight Oriented Radiation Patterns

Table 7.1: Receive Antenna Gain

Terminal Type Identifier	Antenna gain (dBi)
0x48	12,0
0x9-0xC	Same as handheld MES. See TS 101 376-5-5 (Release 1) [5]
0xD	8,5
0xE, 0xF	15,0
0x1A	2
0x1F, 0x20	2
0x24, 0x25	13
0x38	12

7.1.2 Non-Boresight Oriented Radiation Patterns

The CDF of the gain pattern shall be defined as for the transmitted signal (see clause 6.2), with the exception that gain is measured with respect to an appropriately polarized reference signal. For MESs with terminal type 0x10-0x12, the reference signal shall be Left-Hand Circularly Polarized.

Table 7.1a: Antenna characteristics

Minimum gain (dBi) (10 % CDF)	Average gain (dBi)	Maximum gain (dBi) (90 % CDF)
-13,8	-7,5	-2,8

7.2 Receive polarization

The receive polarization shall be either circular or linear as defined in table 7.1b. The circular polarization is the same as clause 7.2 of TS 101 376-5-5 (Release 1) [5].

Table: 7.1b: Receive antenna polarization

Terminal Type Identifier	Polarization
0x48	Circular
0x9-0xC	Circular
0xD	Circular
0xE, 0xF	Circular
0x10-0x12	Linear
0x15	Linear
0x1A	Left-Hand Circular
0x1F, 0x20	Left-Hand Circular
0x24, 0x25	Left-Hand Circular
0x29	Linear
0x2E	Circular
0x33	Circular
0x38	Circular
0x3D	Linear
0x3E-0x46	Left-Hand Circular

For terminals with Terminal Type Identifier:

- (0x9-0xC, 0xE, 0x48, 0x1A, 0x1F, 0x20, 0x24, 0x25, 0x2E, 0x33, or 0x38); the axial ratio of radiated wave over the operational frequency range shall be better than 2 dB at boresight and better than 5 dB over the 3 dB coverage of the antenna.

- (0xD or 0xF); the axial ratio of radiated wave over the operational frequency range shall be better than 4 dB at boresight and better than 5 dB over the 3 dB coverage of the antenna.

7.3 Receiver figure of merit

Same as clause 7.3 in TS 101 376-5-5 (Release 1) [5] with the following additional text.

The Gain/Temperature (G/T) ratio of the various packet data terminals in the direction of the peak antenna gain under clear sky conditions, with the antenna fully deployed and with no conducting objects in the vicinity of the unit, at 20 °C, will exceed the following G/T values at elevations over 20 degrees.

For terminals with Boresight Oriented antennas, the G/T is defined in the direction of peak gain. For non-Boresight Oriented antennas, the G/T is defined over the 10^{th} percentile of highest gain as defined in clause 6.2.2.

Table 7.2: Gain/Temperature (G/T) ratio

Terminal Type Identifier	G/T [dB/K]
0x48	-16,2
0x9-0xC	Same as handheld MES. See TS 101 376-5-5 (Release 1) [5]
0xD	-18,0
0xE, 0xF	-18,0
0x10-0x12	-31,8
0x15	-29
0x1A	-27
0x1F, 0x20	-27
0x24, 0x25	-17
0x29	-31
0x2E	-26
0x33	-26
0x38	-17
0x3D	-31
0x3E	-26
0x3F	-26
0x40	-26
0x41	-18
0x42	-13
0x43	-13
0x44	-15,5
0x45	-13
0x46	-17,5
NOTE 1: With passive external antenna. NOTE 2: For an S-Band antenna, and terminal types 0x3D to 0x3F, this value will be exceeded for 10 % of cases for elevation angles from -40 to 90 degrees and all azimuth directions.	

7.4 Receiver sensitivity

Same as clause 7.4 in TS 101 376-5-5 (Release 1) [5] with the following additional text.

Radiated sensitivity (see annex D) can specify a terminal's required error rate performance. That is, by defining a flux density (dBm/m^2) at a receive antenna, a specified error rate shall be met. Radiated Sensitivity can be defined as a combination of terminal G/T and Es/No as shown in figure 7.1.

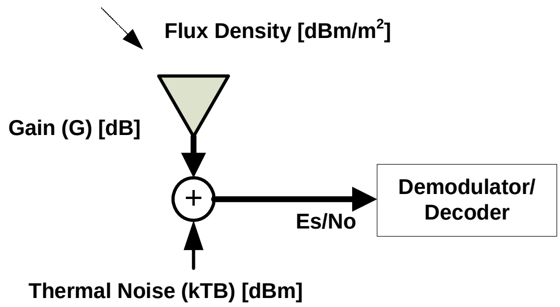


Figure 7.1: Radiated Sensitivity, G/T, and Es/No

NOTE: Compliance to these requirements may be tested using a combination of antenna characterization (G and Tant) and conducted sensitivity evaluation.

7.4.1 Receiver BER in static conditions

Same as clause 7.4.1 of TS 101 376-5-5 (Release 1) [5] with the following additional text:

1) Data terminals with Terminal Type Identifiers 0x9-0xC, and 0x48 shall meet or exceed the coded bit error rate (BER) requirements in table 7.3a at 20 °C for the channel types supported as per TS 101 376-5-2 [9].

2) Data terminals with Terminal Type Identifiers 0xD, 0xE, and 0xF shall meet or exceed the frame error rate (FER) requirements in table 7.3b at 20 °C for the channel types supported as per TS 101 376-5-2 [9].

3) Data terminals with Terminal Type Identifiers 0x10-0x12, 0x15, 0x1A, 0x1F, 0x20, 0x24, 0x25, 0x29, 0x2E, 0x33, 0x38, and 0x3D-0x46 shall meet or exceed the frame error rate (FER) requirements in table 7.3c at 20 °C for the channel types supported as per TS 101 376-5-2 [9].

Table 7.3a: BER in static conditions

Power Class	C/No at antenna connector (dB/Hz)	G/T (dB/K) (see note 1)	BER	User data rate (kbps) (see note 2)	Convolutional coding constraint length	Coding rate	Data terminal type identifier/s, and burst type
1	53,1	-24	$1,0 \times 10^{-6}$	47,2	9	3/5	(0xA-0xC), PNB(2,6)
1	54,2	-24	$1,0 \times 10^{-6}$	56,0	9	7/10	(0xA-0xC), PNB(2,6)
1	55,4	-24	$1,0 \times 10^{-6}$	64,0	9	4/5	(0xA-0xC), PNB(2,6)
8	58,8	-16,2	$1,0 \times 10^{-6}$	116,8	7	3/4	0x48, PNB(4,3)
8	57,8	-16,2	$1,0 \times 10^{-6}$	97,6	7	5/8	0x48, PNB(4,3)
8	56,2	-16,2	$1,0 \times 10^{-6}$	78,4	7	1/2	0x48, PNB(4,3)
8	59,8	-16,2	$1,0 \times 10^{-6}$	148,8	7	3/4	0x48, PNB(5,3)
8	58,8	-16,2	$1,0 \times 10^{-6}$	124,8	7	5/8	0x48, PNB(5,3)
8	57,2	-16,2	$1,0 \times 10^{-6}$	99,2	7	1/2	0x48, PNB(5,3)

NOTE 1: This G/T value applies for elevations over 20 degrees.
NOTE 2: This includes 16 bits of CRC.

Table 7.3b: FER in static conditions

Power Class	C/No at antenna connector (dB/Hz)	G/T (dB/K) (see notes 1 and 2)	FER	User data rate (kbps) (see note 3)	FEC/ Modulation	Coding rate	Data Terminal Type Identifier/s, and burst type
9	67,06	-18	$1,0 \times 10^{-4}$	444	LDPC/32 APSK	0,818	(0xD-0xF) PNB2(5,12)
9	66,13	-18	$1,0 \times 10^{-4}$	415,6	LDPC/32 APSK	0,765	(0xD-0xF) PNB2(5,12)
9	63,96	-18	$1,0 \times 10^{-4}$	355,2	LDPC/16 APSK	0,818	(0xD-0xF) PNB2(5,12)
9	61,75	-18	$1,0 \times 10^{-4}$	296	LDPC/16 APSK	0,681	(0xD-0xF) PNB2(5,12)
9	58,68	-18	$1,0 \times 10^{-4}$	199,6	LDPC/π/4-QPSK	0,919	(0xD-0xF) PNB2(5,12)
9	56,78	-18	$1,0 \times 10^{-4}$	177,6	LDPC/π/4-QPSK	0,818	(0xD-0xF) PNB2(5,12)
9	55,04	-18	$1,0 \times 10^{-4}$	148	LDPC/π/4-CQPSK	0,681	(0xD-0xF) PNB2(5,12)
9	53,21	-18	$1,0 \times 10^{-4}$	110,4	LDPC/π/4-CQPSK	0,508	(0xD-0xF) PNB2(5,12)
9	67,28	-18	$1,0 \times 10^{-4}$	382,4	LDPC/32 APSK	0,798	(0xD-0xF) PNB2(5,3)
9	66,46	-18	$1,0 \times 10^{-4}$	358,4	LDPC/32 APSK	0,748	(0xD-0xF) PNB2(5,3)
9	64,18	-18	$1,0 \times 10^{-4}$	305,6	LDPC/16 APSK	0,797	(0xD-0xF) PNB2(5,3)
9	62,13	-18	$1,0 \times 10^{-4}$	254,4	LDPC/16 APSK	0,664	(0xD-0xF) PNB2(5,3)
9	59,10	-18	$1,0 \times 10^{-4}$	171,2	LDPC/π/4-QPSK	0,894	(0xD-0xF) PNB2(5,3)
9	57,28	-18	$1,0 \times 10^{-4}$	152,0	LDPC/π/4-QPSK	0,793	(0xD-0xF) PNB2(5,3)
9	55,58	-18	$1,0 \times 10^{-4}$	126,4	LDPC/π/4-CQPSK	0,660	(0xD-0xF) PNB2(5,3)
9	53,93	-18	$1,0 \times 10^{-4}$	97,6	LDPC/π/4-CQPSK	0,509	(0xD-0xF) PNB2(5,3)

NOTE 1: This G/T value applies for elevations over 20 degrees.
NOTE 2: With passive external antenna the G/T is -11 dB/K.
NOTE 3: This includes 8 bits of CRC.

Table 7.3c: FER in static conditions

FER (%)	User data rate (kbps) (see note 1)	FEC/ Modulation (see note 2)	Coding rate	Burst type	Es/No (dB)
1	2,45	Voice - Conv., Type 1, π/4-QPSK	0,54	PNB3(1,3)	3,6
1	4,0	Voice - Conv., Type 1, π/4-QPSK	0,8	PNB3(1,3)	6,9
1	4,0	Voice - Conv., Type 2, π/4-QPSK	0,8	PNB3(1,3)	7,1
1	2,45	Voice - Conv., Type 1, π/2-BPSK	0,53	PNB3(1,6)	-0,1
1	4,0	Voice - Conv., Type 1, π/4-QPSK	0,41	PNB3(1,6)	2,2
1	2,60	Data - Conv., Type 1, π/4-QPSK	0,54	PNB3(1,3)	3,6
1	4,0	Data - Conv., Type 1, π/4-QPSK	0,82	PNB3(1,3)	6,9
1	4,0	Data - Conv., Type 2, π/4-QPSK	0,82	PNB3(1,3)	7,1
1	2,60	Data - Conv., Type 1, π/2-BPSK	0,53	PNB3(1,6)	-0,1
1	4,0	Data - Conv., Type 1, π/4-QPSK	0,4	PNB3(1,6)	2,3
0,1	21	Conv. K = 9 π/4-QPSK	0,6	PNB(1,6)	5,6
0,1	25	Conv. K = 9 π/4-QPSK	0,7	PNB(1,6)	6,5
0,1	29	Conv. K = 9 π/4-QPSK	0,8	PNB(1,6)	7,6
0,1	47	Turbo π/4-QPSK	0,6	PNB3(2,6)	4,6
0,1	56	Turbo π/4-QPSK	0,7	PNB3(2,6)	5,9
0,1	64	Turbo π/4-QPSK	0,8	PNB3(2,6)	7,4
0,1	96	Turbo π/4-QPSK	0,5	PNB3(5,3)	3,1
0,1	120	Turbo π/4-QPSK	0,63	PNB3(5,3)	4,5
0,1	144	Turbo π/4-QPSK	0,75	PNB3(5,3)	6,1
0,1	160	Turbo π/4-QPSK	0,83	PNB3(5,3)	7,3
0,1	256	Turbo 16-APSK	0,67	PNB3(5,3)	11,9
0,1	111	Turbo π/4-QPSK	0,5	PNB3(5,12)	2,5
0,1	139	Turbo π/4-QPSK	0,63	PNB3(5,12)	4,1
0,1	166	Turbo π/4-QPSK	0,75	PNB3(5,12)	5,8
0,1	186	Turbo π/4-QPSK	0,83	PNB3(5,12)	7,0
0,1	222	Turbo 16-APSK	0,50	PNB3(5,12)	9,2
0,1	259	Turbo 16-APSK	0,58	PNB3(5,12)	10,1
0,1	296	Turbo 16-APSK	0,67	PNB3(5,12)	11,7
0,1	261	Turbo π/4-QPSK	0,61	PNB3(10,3)	4,1
0,1	590	Turbo 16-APSK	0,69	PNB3(10,3)	12,1
NOTE 1: This includes 16 bits of CRC for packet data channels and 5 bits of CRC for DCH voice channels. NOTE 2: See TS 101 376-5-3 [11] for detailed FEC/Modulation descriptions.					

7.4.2 Receiver BER in Rician fading (A/Gb mode only)

Same as clause 7.4.2 in TS 101 376-5-5 (Release 1) [5].

7.4.3 FER of logical channels (A/Gb mode only)

Same as clause 7.4.3 in TS 101 376-5-5 (Release 1) [5].

7.4.4 FER of PUI (A/Gb mode only)

The Frame Error Rate (FER) of the PUI over PDTCH and extended PUI over PDTCH2 shall not exceed the values specified in table 7.3d for the given E_s/N_0 values in a static channel. A PUI and extended PUI frame shall be considered to be in error if there are any decoded PUI and extended PUI bits in error. All tests shall be conducted in the steady-state operational conditions (OC_1), defined in clause 5.1 of TS 101 376-5-5 (Release 1) [5] 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 of TS 101 376-5-5 (Release 1) [5].

Table 7.3d: PUI and Extended PUI FER Requirement

Max. FER Allowed	E_s/N_0 (dB) at input of baseband demodulator
0,01 %	3,5

7.4.5 FER of PUI and ULMAP (Iu mode only)

The Frame Error Rate (FER) of the PUI and ULMAP shall not exceed the values specified in tables 7.3e and 7.3f, respectively, for the given Es/No values in a static channel. A frame shall be considered in error if there are any decoded bits in error. All tests shall be conducted in the steady-state operational conditions (OC_1), defined in clause 5.1 of TS 101 376-5-5 (Release 1) [5] under normal environmental conditions.

Table 7.3e: PUI FER Requirement

Burst	Max. FER Allowed	E_s/N_0 (dB) at input of baseband demodulator
PNB(1,6)/PKAB(1,6)	0,01 %	5,1
PNB3(2,6)/PKAB3(2,6)	0,01 %	3,8
PNB3(5,3)/PKAB3(5,3)	0,01 %	3,4
PNB3(5,12)/PKAB3(5,12)	0,01 %	3,4
PNB3(10,3)/PKAB3(10,3)	0,01 %	3,1

Table 7.3f: ULMAP FER Requirement

Burst	Max. FER Allowed	E_s/N_0 (dB) at input of baseband demodulator
PNB3(5,3)/PKAB3(5,3)	0,01 %	3,1
PNB3(5,12)	0,01 %	3,1
PNB3(10,3)/PKAB(10,3)	0,01 %	3,1

7.4.6 FER of Common Control Channels (system using FCCH3)

The Frame Error Rate (FER) of the BCCH, GBCH3, PCH, BCCH, AGCH shall not exceed the values specified in table 7.4 for the given Es/No values in a static channel when FCCH3 is used in system. As defined in TS 101 376-5-2 [9], if FCCH3 used, then DC12 burst is used to carry BCCH, GBCH3, PCH, and AGCH, A frame shall be considered in error if there are any decoded bits in error. All tests shall be conducted in the steady-state operational conditions (OC_1), defined in clause 5.1 of TS 101 376-5-5 (Release 1) [5] under normal environmental conditions.

Table 7.4: Common Control Channel FER Requirement

Channel	Max. FER Allowed	E_s/N_0 (dB) at input of baseband demodulator
BCCH	5 %	-0,5
PCH	5 %	-0,5
AGCH	5 %	-0,5
GBCH3	5 %	-0,5
CBCH	5 %	-0,5
BACH	5 %	-10,5

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 will be modulated as defined in TS 101 376-5-4 [2] with random data, and a symbol rate of 23,4 ksym/sec.

Under the interference conditions in table 7.5, the receiver performs as defined in the static sensitivity requirement with 0,5 dB greater signal power.

Table 7.5: Receiver Selectivity Interference Conditions

Interference level relative to sensitivity	Interference frequency offset
+15 dB	m × 31,25 kHz
+25 dB	m × 93,75 kHz
+45 dB	> 500 kHz

Where "m" defines the bandwidth of the received signal in units of 31,25 kHz channels.

The interference level shall be relative to the sensitivity of the interfering bearer. The sensitivity shall be that for a DC6 burst as defined in TS 101 376-5-2 [9] in static conditions.

7.6 Receiver intermodulation

Same as clause 7.6 in TS 101 376-5-5 (Release 1) [5].

7.7 Receiver blocking characteristics

7.7.1 L-Band

This clause applies to MES operating in L-band.

Same as clause 7.7 in TS 101 376-5-5 (Release 1) [5].

7.7.2 S-Band

This clause applies to MES operating in S-band.

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 2 150 MHz to 2 220 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 clause 7.4.1 (receiver static sensitivity);
- a continuous, static sine wave signal at the level in table 7.6 and at frequencies that are integer multiples of 31,25 kHz.

Table 7.6: Receiver blocking requirement

Band of blocking signal	Frequency range	Level	Distance from desired signal (kHz)
In-band	2 150 MHz to 2 220 MHz	-70 dBm	>1 600 kHz
Out-of-band	0,1 kHz tp 2 150 MHz or 2 220 MHz to 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 7.7.

Table 7.7: Spurious response requirement

Band of spurious response	Frequency range	Max. number of frequencies	Level
In-band	2 150 MHz to 2 220 MHz	Six	-100 dBm
Out-of-band	0,1 kHz - 2 150 MHz or 2 220 MHz to 12 750 MHz	Twelve (see note)	-55 dBm
Out-of-band	0,1 kHz to 2 150 MHz or 2 220 MHz to 12 750 MHz	Four (see note)	-70 dBm
NOTE: These two sets of out-of-band spurious responses are separate allowances: a lower level response does not also count as a higher level response.			

7.8 Receive signal strength

The MES shall be capable of generating relative receive signal strength (relative RSS) measurements. Relative RSS is the difference between two Receive Signal Strength Indication (RSSI) estimates. This clause defines the range and accuracy with which relative RSS shall be generated.

Relative RSS provides an estimate of the power difference between two signals. The specification (3 cases) is stated in the form of two signals with defined power difference, where the MES shall correctly identify which of the signals has higher power. All measurements are based on RSSI estimates. The compared values may be based on the average of up to 5 individual RSSI measurements per bearer.

Case 1: Extreme temperature range with channel separation over whole band: Under the following conditions:

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

b) two radiated source bearers with a 3 dB power difference shall be present;

c) the power of each bearer shall lie anywhere between the static sensitivity limit (for the lower power bearer) and a level 20 dB above the static sensitivity limit (for the higher power bearer);

d) the two source bearers carry DC12 bursts, and their carrier frequencies lie anywhere within the receive band, with no constraint on the frequency difference.

The MES shall identify the bearer with higher power as having higher RSSI.

Case 2: Normal temperature range with channel separation over a limited band: Under the following conditions:

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

b) two radiated source bearers with a 1 dB power difference shall be present;

c) the power of each bearer shall lie anywhere between the static sensitivity limit (for the lower power bearer) and a level 20 dB above the static sensitivity limit (for the higher power bearer);

d) the two source bearers carry DC12 bursts, and their carrier frequencies could lie anywhere within the receive band;

e) the two source bearers shall differ in carrier frequency by up to 156,25 kHz.

The MES shall identify the bearer with higher power as having higher RSSI.

Case 3: Extreme temperature range with channel separation over a limited band: Under the following conditions:

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

b) two radiated source bearers with a 2 dB power difference shall be present;

c) the power of each bearer shall lie anywhere between the static sensitivity limit (for the lower power bearer) and a level 20 dB above the static sensitivity limit (for the higher power bearer);

d) the two source bearers carry DC12 bursts, and their carrier frequencies could lie anywhere within the receive band;

e) the two source bearers shall differ in carrier frequency by up to 156,25 kHz.

The MES shall identify the bearer with higher power as having higher RSSI.

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

NOTE: 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.

7.9 Erroneous frame Indication Performance

For an MES receiving a valid PDCH signal with a random USF not equal to an allocated USF, the probability of the MES detecting USF equal to the allocated USF shall not be more than 1e-05. This requirement shall be met for all input Es/No levels up to 3,5 dB.

For an MES receiving a valid PDCH3 signal with a random USF not equal to an allocated USF, the probability of the MES detecting USF equal to the allocated USF shall not be more than 1e-05. This requirement shall be met for all input Es/No levels up to 2,5 dB.

7.10 Maximum Received Power Level

The receiver shall meet the BCCH sensitivity error rate performance requirements in the following scenario:

- A BCCH signal is received.
- Interfering PNB3(5,12) interferers (or equivalent) are placed in contiguous adjacent channels on either side of the BCCH bearer, extending to at least 2 MHz above and below the BCCH bearer.
- All signals shall have the same Power Spectral Density.
- The flux density of the bearers (both signal and interferer) shall be -54 dBm/MHz/m^2.

8 GPS receiver characteristics

Same as clause 8 in TS 101 376-5-5 (Release 1) [5].

Annex A (informative): Antenna factor equation

Same as annex A in TS 101 376-5-5 (Release 1) [5].

Annex B (normative): Environmental conditions

Same as annex B in TS 101 376-5-5 (Release 1) [5].

Annex C (normative): Channel model

Same as annex C in TS 101 376-5-5 (Release 1) [5].

Annex D (informative): Derivation of receiver sensitivity specifications

D.1 Introduction

This annex describes the derivation of the sensitivity specifications used elsewhere in the present document. The purpose is to clearly define the meaning of the specification and the calculations used in the derivation.

The system requirements define transmissions at several symbol rates and different coding rates, which provide a specification for the E_s/N_o at the input to the demodulator that is required to achieve an Error Rate specification.

D.2 Definitions

Three definitions of the receiver sensitivity are defined as follows, using the terms defined in table D.2.1.

Table D.2.1: Definition of Terms - Sensitivity

Symbol	Definition
$T_s = T$	System Noise Temperature (referred to the antenna connector)
T_{ant}	Noise Temperature of Antenna
T_{amb}	Ambient Temperature (e.g. 290 K)
SR	Symbol Rate
CR	Code Rate
R_b	Information bit rate
E_b/N_o	Energy per information bit related to noise Power Spectral Density
E_s/N_o	Energy per symbol related to noise Power Spectral Density
C/N_o	Signal Power related to noise Power Spectral Density
G/T	Receiver Figure of Merit: Ratio of Antenna Gain to noise temperature in receiver chain (T_s)
G	Antenna Gain (dBi)
λ	Wavelength of carrier
f_c	Carrier frequency
A_e	Effective Area of antenna
T_{cond}	Temperature of receive chain in test configuration
k	Boltzmann's Constant = 1,38 x 10^{-23} J/K
c	Speed of light in a vacuum = 2,998 x 10^{8} m/s

D.2.1 Integral sensitivity

The integral sensitivity is the conducted power collected by the receiver antenna that achieves the desired BER assuming the antenna remains connected to the receiver. The integral sensitivity is specified in dBm.

The integral sensitivity may be considered to be that conducted power incident at the input of the receiver that has been collected by the antenna at the radiated sensitivity specification, considering the performance parameters of the antenna.

The integral sensitivity may be calculated from the definition and specification of G/T. The system noise temperature of the receiver may be calculated from the following formula expressed in logarithmic form:

$$G/T = G - 10\log(T_S)$$

The integral sensitivity is defined as the product of the system noise floor (kT_S) and the required C/N_o.

$$Integral\ \ Sensitivity(dB) = 10\log(kT_S) + (C/N_0)$$

The (C/N_o) may then be expanded to give:

$$Integral\ \ Sensitivity(dB) = 10\log(kT_S) + (E_b / N_0) + 10\log(R_b)$$

$$Integral\ Sensitivity\ (dB) = 10\log(kT_S R_b) + (E_b / N_0)$$

$$= 10\log(kTsSR) + (E_s / N_o)$$

D.2.2 Radiated sensitivity

The radiated sensitivity is the radiated power flux density incident at the receiver antenna that achieves the desired error rate. The radiated sensitivity is specified in dBm/m^2.

The radiated sensitivity is calculated from the integral sensitivity and including the effective area of the receive antenna as follows:

$$Radiated\ Sensitivity = Integral\ Sensitivity - 10\log(A_e)$$

Using the definition of effective antenna area:

$$A_e = \frac{G_l \lambda^2}{4\pi}$$

where G_l is the gain of the antenna relative to an isotropic radiator in linear form, and the formula for integral sensitivity derived above, the Radiated Sensitivity can be expressed as follows:

$$Radiated\ \ Sensitivity = 10\log\left(\frac{4\pi k T_s R_b}{\lambda^2}\right) + (E_b / N_0) - G$$

$$= 10\log\left(\frac{4\pi k T_s (SR) c^2}{f_c^{\ 2}}\right) + (E_s / N_0) - G$$

where G is the gain G_l expressed in logarithmic form (dBi).

D.2.3 Conducted sensitivity

The conducted sensitivity is the conducted power incident at the receiver connector, with the receive antenna disconnected, assuming a signal source at the ambient temperature has been impedance matched (to 50 Ω) to the receiver. The conducted sensitivity is specified in dBm. (Note that conducted sensitivity verification for specific terminals is based on actual losses in the test and antenna signal paths, i.e. the losses may differ.)

The calculation of conducted sensitivity is similar to the integral sensitivity, with a noise temperature that considers the signal source, such that:

$$T_{cond} = T_S - T_{ant} + T_{amb}$$

where T_{cond} = Noise Temperature of Conducted System (referred to the connector).

All temperatures are expressed in Kelvin (K).

$$\therefore Conducted\ \ Sensitivity(dB) = 10\log(kT_{cond} R_b) + (E_b / N_0)$$

$$= 10\log(kT_{cond}(SR)) + (E_s / N_0)$$

D.3 Parameters

Table D.3.1 provides an example of the parameters used in the calculations that are common to all modulation rates and coding schemes for a hypothetical implementation of a terminal with Terminal Type Identifier = 48. Note that only requirement relates to radiated sensitivity, and that trades can be made between parameters in this table in any particular implementation.

Table D.3.1: Example parameters for terminal with Terminal Type Identifier 48

Parameter	Symbol	Value	Derivation
G/T	G/T	-16,2 dB/K	The present document
Antenna Gain	G	12 dBi	The present document
Boltzmann Constant	k	1,38 x 10^{-23} J/K	Physical Constant
Free Space Wavelength	λ	0,194 m	Calculated using frequency at the centre of the Rx band
Effective Antenna Area	A_e	-13,22 dB m^2	Calculated from antenna gain and wavelength
Antenna Noise Temperature	T_{ant}	150 K	Antenna Specification
System Noise Temperature	T_s	660,7 K	Calculated from G/T and antenna gain
System Noise Floor	$10\log(kT_s)$	-170,4 dBm/Hz	Calculated
Conducted Noise Temperature	T_{cond}	800,7 K	Calculated with Tamb at 290 K
Conducted Noise Floor	$10\log(kT_{cond})$	-169,6 dBm/Hz	Calculated

D.4 Calculations

The following tables present example calculations that can be applied to any terminal for any burst type, modulation, coding and transmitted symbol rate.

Table D.4.1 defines the general form.

Table D.4.1: General Form

Input Parameters	Value
Transmission Symbol Rate [ksps]	SR
Coding Rate	CR
Target Signal-to-Noise Ratio for defined Error Rate [dB]	Clause 7.4
Antenna Temperature [K]	Tant
G/T [dB/K]	Clause 7.3
G [dBi]	Clause 7.2
Carrier Frequency [GHz]	Clause 4
Derived Performance	
C/N_0 [dB]	$E_s/N_o + 10\log(SR)$
Integral Sensitivity [dBm]	$30+10\log(k.T_s.SR)) + E_s/N_o$
Radiated Sensitivity [dBm/m^2]	$30+10\log(4.pi.k.T_s.f^2/c^2) + E_s/N_o - G$
Conducted Sensitivity [dBm]	$30+10\log(k(T_s-T_{ant}+T_{amb})(SR)) + E_s/N_o$

Table D.4.2 provides an example, using the following case:

- Terminal Type Identifier = 10 (S-Band Handheld).
- PNB3(5,3), Code Rate = 0,5.

Table D.4.2: Example

Input Parameters	**Value**
Transmission Symbol Rate [ksps]	117
Coding Rate	0,5
Target Signal-to-Noise Ratio (Es/No) for defined Error Rate [dB]	3,1
T_{ant} [K]	150
T_{amb} [K]	290
G/T [dB/K]	-30
G [dBi]	-1
Carrier Frequency [GHz]	2,185
Derived Performance	
C/N_0 [dB]	53,8
Integral Sensitivity [dBm]	-115,8
Radiated Sensitivity [dBm/m^2]	-86,6
Conducted Sensitivity [dBm]	-115,1

Annex E (informative): Bibliography

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History

Document history		
V3.1.1	July 2009	Publication
V3.2.1	February 2011	Publication
V3.3.1	December 2012	Publication