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Satellite Earth Stations and Systems (SES); MES providing Low Bit Rate Data Communications (LBRDC) using LEO satellites operating below 1 GHz

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Foreword

This European Telecommunication Standard (ETS) has been produced by the Satellite Earth Stations and Systems (SES) Technical Committee of the European Telecommunications Standards Institute (ETSI).

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1 Scope

This European Telecommunication Standard (ETS) provides specifications for the standardization of the characteristics of Mobile Earth Stations (MESs) with both transmit and receive capabilities in order to limit interference to radiocommunications services.

The Low Earth Orbiting (LEO) satellite networks referred to in this ETS operate under the Mobile Satellite Service (MSS). The MESs operate as part of a LEO satellite network providing Low Bit Rate Data Communications (LBRDC).

The frequency bands under which the MESs operate should be within the following bands:

MES Transmit frequencies and Service allocations		**MES Receive frequencies and Service allocations**	
148 MHz to 149,9 MHz	Mobile-Satellite Service	137 MHz to 137,025 MHz	Mobile-Satellite Service
149,9 MHz to 150,05 MHz	Land Mobile-Satellite Service	137,025 MHz to 137,175 MHz	Mobile-Satellite Service
235 MHz to 322 MHz	Mobile-Satellite Service	137,175 MHz to 137,825 MHz	Mobile-Satellite Service
335,4 MHz to 399,9 MHz	Mobile-Satellite Service	137,825 MHz to 138 MHz	Mobile-Satellite Service
399,9 MHz to 400,05 MHz	Land Mobile-Satellite Service	235 MHz to 322 MHz	Mobile-Satellite Service
		335,4 MHz to 399,9 MHz	Mobile-Satellite Service
		400,15 MHz to 401 MHz	Mobile-Satellite Service

Some LEO satellite networks provide Low Bit Rate Data Communications (LBRDC) using short burst, low duty cycle MES transmissions in order to reduce interference with existing users. The interference levels can also be decreased by modulation techniques: Direct Sequence - Spread Spectrum Multiple Access (DS-SSMA) or Frequency Division Multiple Access (FDMA) using Dynamic Channel Activity Assignment (DCAA) as described in ITU-R Recommendations M 1039 and M 1087.

These MESs generally have the following characteristics:

- the MESs could be either a Based MES (BMES), a Vehicle mounted MES (VMES) or a Portable MES (PMES);

- the MES could consist of a number of modules including suitable interfaces to the user.

The main specifications are contained in two categories related to:

- **unwanted emissions limitation:** to protect terrestrial and space radiocommunications services, and the radio astronomy services from harmful interference;

- **MES control and monitoring functions:** to specify a minimum set of Control and Monitoring Functions (CMFs) to be implemented on each MES in order to minimize the probability that they originate unwanted transmissions that may give rise to harmful interference to other systems.

2 Normative references

This ETS incorporates, by dated or undated references, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] ITU Radio Regulations.

[2] ETS 300 722: "Satellite Earth Stations and Systems (SES); Network Control Facilities for MES providing Low Bit Rate Data Communications (LBRDC) using LEO satellites operating below 1 GHz".

[3] CISPR Publication No 16 (1993): "Specification for radio disturbance and immunity measuring apparatus and methods".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETS, the following definitions apply:

BMES: A MES intended to be installed in a fixed location, and which is powered either by dc or ac mains.

carrier-off state: A MES is in this state when it is not transmitting a signal, i.e. not in the carrier-on state.

carrier-on state: A MES is in this state when it is transmitting a signal in a continuous or non-continuous mode.

control channel: A Control Channel may be either a command to a particular MES or a signal from the satellite containing control information to appropriately enable or disable transmissions from a MES.

Internally Mounted Equipment (IME) and Externally Mounted Equipment (EME): The EMEs are the modules to be externally mounted as stated by the manufacturer or indicated in the user documentation, the IMEs are the remaining modules intended to be internally mounted Where different specifications apply to IME and EME, this is noted in the relevant text.

nominated bandwidth: The bandwidth of the MES radio frequency transmission is nominated by the terminal manufacturer. The nominated bandwidth is wide enough to encompass all spectral elements of the transmission which have a level greater than the specified unwanted emissions limits. The nominated bandwidth is wide enough to take account of the transmit carrier frequency stability. The nominated bandwidth is within the MSS transmit frequency band within which the MES operates.

PMES: A MES intended to be portable , and which is powered by a stand alone battery, and generally intended to be self-contained and free standing. A PMES would normally consist of a single module, but may consist of several interconnected modules. In some cases different specifications apply to PMES and this is noted in the relevant text.

unwanted emissions: Unwanted emissions are those falling outside the nominated bandwidth.

VMES: A MES intended to be installed on a vehicle. A VMES may consist of one or several interconnected modules as follows:

NOTE: For FDMA / DCAA systems the Nominated Bandwidth does not exceed 25 kHz.

3.2 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

BMES	Based MES
CMF	Control and Monitoring Function
DCAA	Dynamic Channel Activity Assignment
DS-SSMA	Direct Sequence Spread Spectrum Multiple Access
EIRP	Equivalent Isotropically Radiated Power
EME	Externally Mounted Equipment
EUT	Equipment Under Test
FDMA	Frequency Division Multiple Access
IME	Internally Mounted Equipment
MES	Mobile Earth Station
MSS	Mobile Satellite Service
NCF	Network Control Facilities

PMES	Portable MES
RF	Radio Frequency
rms	root mean square
STE	Special Test Equipment
VMES	Vehicle mounted MES

4 Test Report

The test report shall contain:

- the value of the nominated bandwidth, declared by the manufacturer;
- the antenna gain pattern;
- the results of the tests;
- all parameters and operational conditions.

5 Radio Frequency (RF)

Whenever a change of limit between adjacent frequency bands occurs in this subclause, the lower of the two limits shall apply at the transition frequency.

5.1 Unwanted emission outside the bands 148 to 150,05 MHz, 235 to 322 MHz, 335,4 to 399,9 MHz and 399,9 to 400,05 MHz

Purpose:

Protection of other terrestrial services, space radiocommunications services and the radio astronomy services from emissions caused by MESs outside the bands 148 to 150,05 MHz, 235 to 322 MHz, 335,4 to 399,9 MHz and 399,9 to 400,05 MHz.

Specification:

With carrier off the MES unwanted emission shall not exceed 33 dBpW, in any 100 kHz.

The unwanted emissions from the MES outside the uplink bands 148 - 150,05 MHz, 235 to 322 MHz, 335,4 to 399,9 MHz and 399,9 to 400,05 MHz, within which the MES is designed to operate, shall not exceed the limits shown in the following tables.

Table 1: Unwanted emissions outside the operational band 148 to 150,05 MHz

Frequency (MHz)	Maximum EIRP density (dBpW)		Measurement bandwidth
	DS-SSMA	FDMA	
0,1 to 146	54	54	100 kHz
146 to 147,5	70	54	100 kHz
147,5 to 148	70 - 105 (note)	54	100 kHz
150,05 to 151,15	70	54	100 kHz
151,15 to 1 000	54	54	100 kHz
1 000 to 12 750	60	60	1 MHz
NOTE: Linearly interpolated in dBpW vs. frequency			

Table 2: Unwanted emissions outside the operational bands 235 to 322 MHz, 335,5 to 399,9 MHz and 399,9 to 400,05 MHz

Frequency (MHz)	Maximum EIRP density (dBpW)	Measuring bandwidth
0,1 to 30	54	100 kHz
30 to 399,9	54	100 kHz
400,05 to 1 000	54	100 kHz
1 000 to 12 750	60	1 MHz

Verification:

By measurement of unwanted emissions generated by an operating MES.

All RF tests in this subclause shall be carried out at ambient environmental conditions of the test laboratory and for a nominal power supply voltage.

All tests with carrier on shall be undertaken with the transmitter operating at full power and with the maximum transmit burst rate where applicable.

To enable the performance tests to be carried out, the use of Special Test Equipment (STE), supplied by the manufacturer, may be necessary. Since this test equipment will be specific for the particular system, it is not possible to provide detailed specifications in the ETS.

However, the following baseline is provided:

- if the MES requires to receive a modulated carrier from the satellite in order to transmit, then special test arrangements are required to simulate the satellite signal, thus enabling the MES to transmit allowing measurement of transmission parameters;

- any specification of these special test arrangements which may have direct or indirect effects on any requirement or recommendation of this ETS shall be clearly stated by the manufacturer.

Test procedure:

The full system shall be tested according to the test procedure given in annex B.

5.2 Maximum unwanted emission within the bands 148 to 150,05 MHz, 235 to 322 MHz, 335,4 to 399,9 MHz and 399,9 to 400,05 MHz

Purpose:

Protection of other terrestrial and space radiocommunications services operating in the above frequency bands.

Specification:

For each transmit band 148 to 150,05 MHz, 235 to 322 MHz 335,4 to 399,9 MHz and 399,9 to 400,05 MHz, within which the MES is designed to operate, the unwanted emissions EIRP in any 4 kHz band within that transmit band shall not exceed the following limits:

- when carrier-off: 34 dBpW in any 4 kHz;

- when carrier-on: limits given in table 3.

Table 3: Unwanted emissions EIRP within the operational bands but outside the nominated bandwidth

Offset from the edge of the nominated bandwidth	Maximum EIRP density (dBpW/4 kHz)	
	DS-SSMA	FDMA
0 to 50 % of the nominated bandwidth	90 - 56 (note)	70
50 % to 250 % of the nominated bandwidth	56	65
NOTE: Linearly interpolated in dBpW vs. frequency		

Verification:

Conformance shall be determined by direct measurement.

The conditions (environment, power, STE etc.) set out in the verification section of subclause 5.1 in this ETS shall apply.

5.3 Maximum EIRP emission density in the nominated bandwidth

Purpose:

Protection of other services which use the same frequency band.

Specification:

The EIRP density in any 4 kHz band radiated from the MES shall not exceed the following limit:

130 dBpW for FDMA;
106 dBpW for DS-SSMA.

Verification:

Conformance shall be either:

- calculated for equipment with antenna connector (conducted);
- measurement of maximum RF power at the antenna connector;
- measurement of transmit antenna gain pattern; or

- measured for equipment with integral antenna (radiated).

The conditions (environment, power, STE etc.) set out in the verification section of subclause 5.1 in this ETS shall apply.

Test procedure:

The test procedure shall be in accordance:

- with annex B clause B.5 for conducted measurement;
- with annex B clause B.4 for radiated measurement.

The antenna gain pattern will be provided by the manufacturer and shall be included in the test report.

5.4 Protection of the radio astronomy service from emissions produced by the MES in the bands 150,05 to 153 MHz, 322 to 328,6 MHz and 406,1 to 410 MHz

Purpose:

Protection of the radio astronomy observations taking place in the frequency bands 150,05 to 153 MHz, 322 to 328,6 MHz and 406,1 to 410 MHz.

Specification:

The MES shall provide means of suppressing transmission in order to reduce unwanted emissions in the adjacent bands 150,05 to 153 MHz, 322 to 328,6 MHz and 406,1 to 410 MHz.

Verification:

By documentary evidence and demonstration.

It shall be demonstrated that the transmitting MES can suppress transmissions producing unwanted emissions falling in the bands 150,05 to 153 MHz, 322 to 328,6 MHz and 406,1 to 410 MHz, when it has received a disable command or other indication that the radio astronomy service is required to be protected, and that transmissions remain suppressed until an appropriate enable command or indication has been received.

6 MES Control and Monitoring Functions (CMFs)

This clause defines a minimum set of CMFs which shall be implemented on MESs in order to minimize the probability that they originate unwanted emissions that may give rise to harmful interference to other systems.

There shall be a CMF at each MES, associated to separate NCFs as described in ETS 300 722 [2].

6.1 Monitoring functions

6.1.1 Processor monitoring

Purpose:

To ensure that the MES can suppress transmissions in the event of a processor sub-system failure.

Specification:

The MES shall incorporate a processor monitoring function for each of its processors involved in the manipulation of traffic and in CMFs.

The processor monitoring function shall detect failure of the processor hardware and software.

No later than 1 second after any fault condition occurs, the transmissions shall be suppressed (carrier-off) until the processor monitoring function has determined that all fault conditions have been cleared.

Verification:

Compliance shall be verified by documentary evidence.

The manufacturer shall declare all fault conditions which cause transmission shutdown.

6.1.2 Transmit frequency generation sub-system

Purpose:

To verify the correct operation of the transmit frequency generation sub-system and to inhibit transmissions, should the sub-system fail.

Specification:

The MES shall monitor the operation of its transmit frequency generation sub-system.

The failure of the transmit frequency generation sub-system for a cumulative period of transmission longer than 5 seconds shall result in transmissions being suppressed (carrier-off) until all fault conditions have been cleared.

Verification:

Compliance shall be verified by documentary evidence.

The manufacturer shall declare all fault conditions which cause transmission shutdown.

6.2 Power-on

Purpose:

To demonstrate that the MES achieves a controlled non-transmitting state (carrier-off) following the POWER-ON.

Specification:

Following POWER-ON no transmission shall occur from the MES (carrier-off). Following POWER-ON the MES shall remain within a non-transmitting state (carrier-off) until a control channel is received.

Verification:

Compliance shall be verified by documentary evidence and demonstration. Transmission shall not occur until an appropriate control channel is received by the MES.

6.3 Network control reception and authorization

6.3.1 Control channel(s) reception

Purpose:

To ensure that the MES cannot transmit unless it receives a control channel.

Specification:

1) Without reception of a control channel, it shall not be possible to initiate message transmission (carrier-off).

2) After having lost the control channel for a period of time longer than 30 seconds the MES shall suppress transmission (carrier-off).

Verification:

The MES shall be situated in an environment that ensures that the receipt of control channels and receipt of NCF commands is entirely under control of the test laboratory.

It shall be demonstrated that it is not possible for a MES to initiate message transmission until a control channel is received by the MES.

It shall be demonstrated that a transmitting MES suppresses transmissions (carrier-off) after having lost a control channel for a period of time longer than 30 seconds, and the MES transmissions shall remain suppressed until a control channel is received.

6.3.2 Network control commands

Purpose:

These requirements ensure that the MES shall be capable of:

- receiving and implementing commands from the NCF through its correct reception of the control channel(s);

- retaining a unique identification in the network and transmitting it upon reception of a dedicated request.

Specification:

The MES shall hold, in non-volatile memory, the unique identification codes of the terminal itself within the MES network.

The MES shall be enabled or disabled through its control channels.

The MES shall be capable of receiving and acting upon the control messages that are addressed to it which contain transmitter enabling and disabling information. The MES shall be capable of transmitting its identification code upon reception of a dedicated command addressed to the MES.

Verification:

The method of setting and storing the MES identification codes shall be verified by documentary evidence.

The other requirements shall be verified by documentary evidence and demonstration showing that the MES is capable of receiving appropriate signals from the NCF to implement enables, disables and identification functions.

The manufacturer shall provide the test house with a test procedure to demonstrate the implementation of enable, disable and identification functions.

7 Compliance with RF specifications under conditions of shock and vibration

Purpose:

To ensure that in-band unwanted emission parameters of the MES remain within specification when the MES is subjected to mechanical shock or vibration.

Specification:

This specification applies, if required by the manufacturer.

The VMES shall be designed so that the in-band unwanted emission limits set out in subclause 5.2 continue to be met after the VMES has been subjected to the mechanical shocks and vibrations set out in annex A, clause A.1.

Verification:

After the VMES has been subjected to the appropriate mechanical shocks and vibrations tests, for its intended application, verification procedure given in subclause 5.2 shall be applied. The tests in subclause 5.2 needs only to be performed once. The test conditions given in annex A shall apply.

8 NCFs for MES networks

Relevant information is contained in ETS 300 722 [2].

Annex A (normative): Environmental and test conditions

A.1 Environmental conditions

The following requirements specify various environmental conditions to which this ETS refers:

a) wind loading: relative wind speeds up to 200 km/h;

b) vibration: random vibration; 5 to 20 Hz at 0,005 g^2/Hz;
20 to 150 Hz at -3 dB/octave (0,5 g rms);

c) mechanical shock: half sine wave shock with a peak of 20 g and a duration of 11 ms;

d) induced acceleration: maximum tangential of linear acceleration of up to 2 g;

e) rate of turn: 10°/s.

All requirements are applicable to VMES.

Requirements a), d) and e) do not apply to PMES.

Requirement a) does not apply to the IME of VMES.

The above requirements are not applicable to the BMES.

A.2 Test conditions

The following requirements specify various test conditions to which this ETS refers:

a) wind loading: relative wind speeds up to 200 km/h;

b) vibration: random vibration; 5 to 20 Hz at 0,005 g^2/Hz;
20 to 150 Hz at -3 dB/octave (0,5 g rms).

Vibration is to be performed for a period of 2 hours in each of 3 mutually perpendicular axes.

c) mechanical shock: half sine wave shock with a peak of 20 g and a duration of 11 ms. A total of 18 shocks shall be performed (6 shocks in each of 3 mutually perpendicular axes);

d) induced acceleration: maximum tangential of linear acceleration of up to 2 g;

e) rate of turn: 10°/s.

All requirements are applicable to VMES.

Requirements a), d) and e) do not apply to PMES.

Requirement a) does not apply to the IME of VMES.

The above requirements are not applicable to the BMES.

Annex B (normative): Test procedures

B.1 Introduction

This annex describes the measurement procedure for both wanted and unwanted emissions generated by an MES terminal under operating conditions (as specified in subclauses 5.1, 5.2 and 5.3).

The level of unwanted emissions shall be measured as either:

a) conducted measurement from 0,1 MHz up to 12,750 GHz; and
b) radiated measurement from 30 MHz up to 4 GHz; or
c) radiated measurement for equipment with integral antenna from 30 MHz up to 4 GHz.

B.2 Equipment Under Test (EUT)

For the purpose of the test, the MES terminal comprises, for VMES:

- the EME;

- the IME;

- a connection cable between IME and EME units;

- the necessary power supply cables and any other cable ensuring a proper functioning of the terminal.

For PMES, the MES terminal comprises:

- for a single module PMES, the module itself with any deployable parts in their normal operating configuration;

- for a multiple module PMES, all such modules with all necessary interconnecting cables of lengths as normally supplied by the manufacturer; again any deployable parts should be in their normal operating configuration.

B.3 Special Test Equipment (STE)

In order to measure the system radiation under operation (transmitting) conditions, proper arrangements shall be made available (by the manufacturers) to put the MES terminal in its normal operating mode (in particular in the normal transmit mode with maximum transmit burst rate and with maximum transmitter power). This may require the use of STE provided by the manufacturer (see subclause 5.1).

B.4 Radiated measurement

B.4.1 Measuring apparatus

In order to carry out the test, the following elements are required, as a minimum:

- a set of calibrated reference antennas covering the frequency range of interest;

- the necessary post reference antenna pre-amplification and amplification devices;

- spectrum analyser(s) with sweep/store capability covering the frequency range of interest.

For the apparatus utilized, it shall be verified that:

- the response of the apparatus, including any antenna and associated amplification system, to a constant amplitude sine wave signal remain within ±1 dB of calibration across the frequency range of interest;

- the screening performance of the measuring apparatus shall be such that when the measuring antenna/post-antenna equipment is removed, and the input to the measuring apparatus is screened, the measured power density shall fall to a value at least 60 dB below the measured value (see CISPR Publication No 16 [3], section 6.2).

B.4.2 Test set-up

The tests shall be carried out at ambient environmental conditions and for a nominal power supply voltage.

For VMES, the EME and the IME shall be installed with a separation of about 0,5 m. Between the two pieces of equipment, the maximum length connection cable specified by the manufacturer shall be installed. The height of the cable shall be between 0,5 m and 1 m. The cable shall be maintained in that position by non-metallic means. The EME shall be set, in its normal operating configuration on a non-metallic table at a height between 0,5 m and 1 m. The IME shall be set on a non-metallic table at a height between 0,5 m and 1 m. Any associated equipment, e.g. portable computer or data terminal if required for operation of the MES, shall be placed next to, and at the same height as the IME.

For PMES and BMES, the equipment shall be arranged in its normal operating configuration as recommended by the manufacturer on a non-metallic table at a height between 0,5 m and 1 m.

The measuring antenna shall be installed in the horizontal plane of the radiating part of the MES. Each antenna shall be positioned to be outside the near field of other antenna.

In addition, it shall be verified that the test site is suitable with respect to the ambient noise power density which shall be at least 6 dB lower than the lowest specification value being measured.

B.4.3 Measuring procedure

The EUT shall be switched on and the STE (if used) activated. The measuring equipment shall be set to an appropriate measuring bandwidth and the measured EIRP given in the specified bandwidth.

The measuring antenna shall be placed at an appropriate distance from the EUT. Measurements shall be made around the EUT to detect unwanted emissions. A suitable test procedure follows.

Testing should first be performed in angular steps of 90° while varying the height of the measuring antenna between 1 m and 4 m. For those directions and frequencies, or frequency bands, where unwanted emissions are detected that are near to the specified limits, additional tests shall be performed for each detected emission by varying the height of the measuring antenna between 1 m and 4 m and rotating the EUT through 360° to maximize the emission value.

These measurements shall be carried out with the measuring antenna in both planes (vertical and horizontal) of polarization to ensure that the values of measured EIRP obtained are maximized.

The received power density shall be measured over the frequency range of interest in measurement ranges appropriate to the test equipment being used. The precise knowledge of distance between the EUT and the reference antenna, the reference antenna gain and the amplification/attenuation characteristics of the post reference antenna network allow the determination of the unwanted EIRP density radiated by the EUT.

B.5 Conducted measurement

B.5.1 Measuring apparatus

In order to carry out the test, the following elements are required, as a minimum:

- calibrated coaxial cables covering the frequency range of interest;

- the necessary pre-amplification devices;

- spectrum analyser(s) with sweep/store capability covering the frequency range of interest.

For the apparatus utilized, it shall be verified that:

- the response of the apparatus, including any associated amplification system, to a constant amplitude sine wave signal remain within ±1 dB of calibration across the frequency range of interest;

- the spectrum analyser has been recently calibrated.

B.5.2 Test set-up

The tests shall be carried out at ambient environmental conditions and for a nominal power supply voltage.

Conducted emissions shall be measured as the power level of any signal delivered into a 50 Ω load. This is performed by connecting the EUT transmitter output through an attenuator to a spectrum analyser.

B.5.3 Measuring procedure

The EUT shall be switched on and the STE (if used) activated. The spectrum analyser shall be set to an appropriate measuring bandwidth and the measured EIRP given in the specified bandwidth.

The EUT maximum antenna gain shall be taken into account.

History

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