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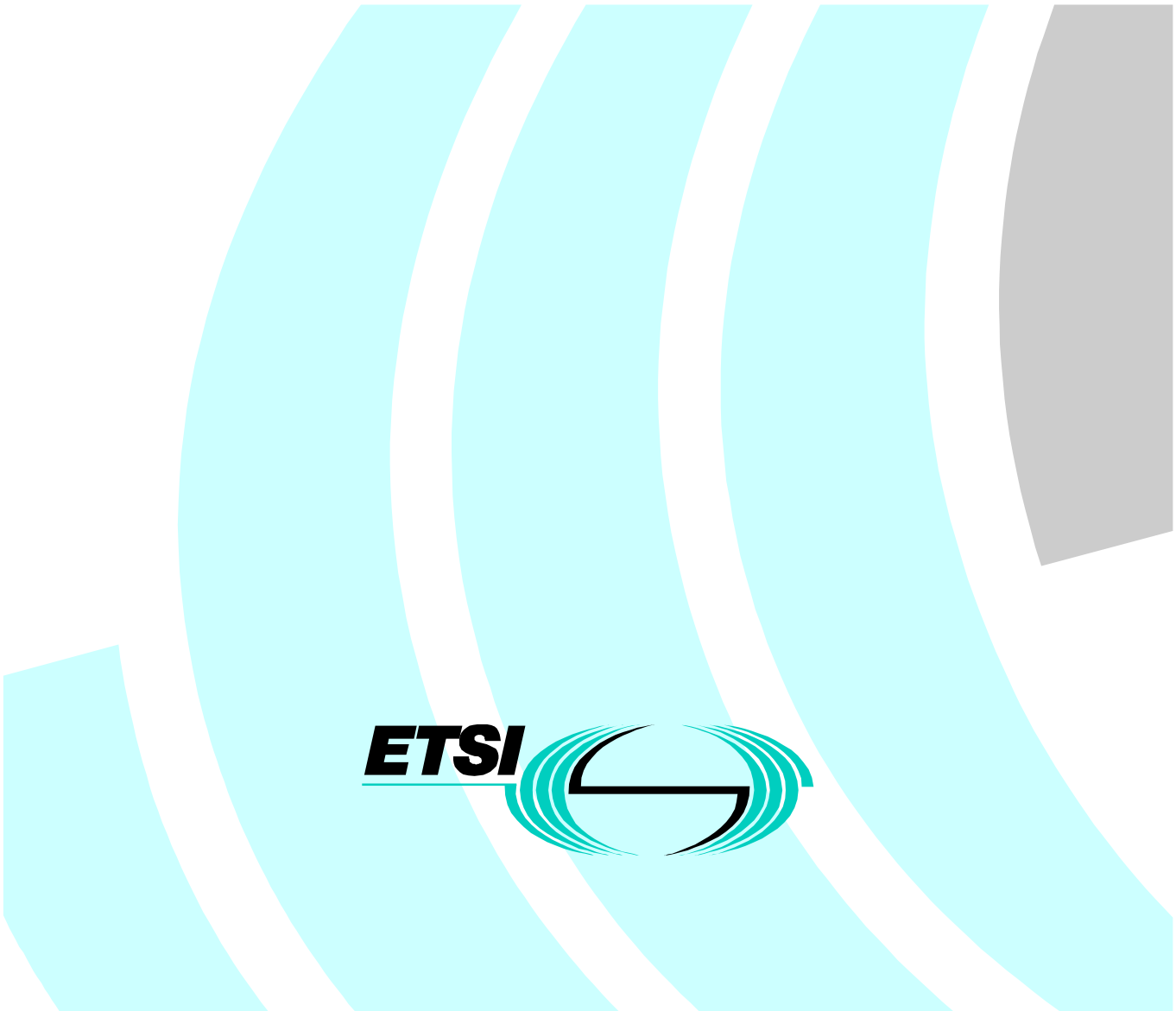
European Standard (Telecommunications series)

Electromagnetic compatibility and Radio spectrum Matters (ERM); General ElectroMagnetic Compatibility (EMC) for radio communications equipment



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Contents

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document has been produced by ETSI in response to a mandate from the European Commission issued under Council Directive 89/336/EEC [1] (as amended) laying down a procedure for the provision of information in the field of technical standards and regulations.

The present document is intended to become a Harmonized Standard, the reference of which will be published in the Official Journal of the European Communities referencing the Council Directive on the approximation of the laws of the Member States relating to electromagnetic compatibility ("the EMC Directive") (89/336/EEC [1] as amended).

Technical specifications relevant to the EMC Directive 89/336/EEC [1] are listed in annex A.

The present document is based on Generic Standards EN 50081-1 [2] and EN 50082-1 [3], and other standards where appropriate, to meet the essential requirements of Council Directive 89/336/EEC [1].

National transposition dates	
Date of adoption of this EN:	5 June 1998
Date of latest announcement of this EN (doa):	30 September 1998
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 March 1999
Date of withdrawal of any conflicting National Standard (dow):	30 September 2001

Introduction

Users of the present document are requested to note that it may become part 1 of a series, as a result of possible future revision(s) to address one or more of the following issues:

a) CEPT ERC is in the process of developing limits for spurious emissions. When these limits are agreed and available, then for reasons of consistency it is planned that the present document will be revised where appropriate, to embody this same information.

b) Fixed service upper microwave equipment is not well covered by this version of the present document as a result of the need for specialised measurements to evaluate some aspects of EMC performance.

c) Ultra high power transmitters (>10kW) require to be tested on site for logistical reasons associated with the power supply feed, the physical size (large), RF power output and heat dissipation. This class of equipment is not well covered by this version of the present document, as a result of the need for specialised measurements to evaluate some aspects of EMC performance.

d) Extremely broadband data systems using spread spectrum or CDMA technology are also not well covered by this version of the present document, as a result of the need for specialised measurements to evaluate some aspects of EMC performance.

Use of the present document in the case where no Harmonized radio product standard and no Harmonized product EMC standard or product family EMC standard exists:

- all technical specifications within the present document are applicable and sufficient to assess the EMC conformity of the product.

Use of the present document in the case where a Harmonized radio product standard exists but no Harmonized product EMC standard or product family EMC standard exists:

- where a Harmonized radio product standard or radio product family standard exists, any technical specifications relevant to the antenna port and the enclosure port contained in that radio product standard take precedence over the corresponding technical specifications in the present document and are to be applied instead (see annex A). All other technical specifications within the present document remain applicable to assess the EMC conformity of the product.

Use of the present document in the case where no standards exist relevant to the radio product:

- all technical specifications within the present document are applicable and sufficient to assess the EMC conformity of the radio product.

Use of the present document in the case where there is a radio product standard which is not Harmonized:

- where technical specifications relevant to the antenna port or enclosure port are contained within such a standard, these specifications can be used to demonstrate EMC conformity of the radio product via article 10.2 or 10.5 of the EMC Directive 89/336/EEC [1].

1 Scope

The present document covers the assessment of radio communication and ancillary equipment in respect of ElectroMagnetic Compatibility (EMC).

The present document may be applied to all categories of radio communications equipment with the exception of broadcast receivers. It does not apply to inductive communications equipment.

Where a relevant Harmonized dedicated product EMC EN or product family Harmonized EMC EN exists, such an EN takes precedence over the present document.

The present document specifies the applicable EMC tests, the methods of measurements, the limits and the minimum performance criteria for radio equipment operating in the frequency range 9 kHz to 3 000 GHz, and any associated ancillary equipment.

The present document contains all of the EMC requirements for radio equipment. However, it does not specify general methods of measurement related to the antenna port.

The present document does not specify requirements for emission above 40 GHz from the antenna port or enclosure port.

For equipment operating at frequencies above 20 GHz, specialized methods of measurement may be found in other standards related to the effective use of the radio spectrum.

The electromagnetic environments encompassed in the present document refer to generic standards EN 50081-1 [2], EN 50082-1 [3], except for the vehicular environment class which refers to ISO 7637-1 [4] and ISO 7637-2 [5].

The EMC requirements have been selected to ensure an adequate level of compatibility for apparatus at residential, commercial, light industrial and vehicular environments. The levels, however, do not cover extreme cases which may occur in any location but with a low probability of occurrence.

The present document may not cover those cases where a potential source of interference producing individually repeated transient phenomena or a continuous phenomena is permanently present, for example a radar or broadcast site in the near vicinity. In such a case it may be necessary to use special protection applied to either the source of interference, or the interfered part, or both.

Certain products such as high power radio transmitters, which cannot be tested in a normal test laboratory environment, can be tested on-site or at the manufacturer's premises. The general basis for the test methods and limits used to assess these products should be in accordance with the present document, where appropriate.

Compliance of radio equipment with the requirements of the present document does not signify compliance with any requirements related to the use of the equipment, for example licensing requirements.

Compliance with the requirements of the present document does not signify compliance with any safety requirements. However, it is the responsibility of the assessor of the equipment to record in the report any observations regarding the test sample becoming dangerous or unsafe as a result of the application of the tests called for in the present document.

The present document is based on the considerations and guidance given in ETR 238 [14].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, subsequent revisions do apply.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] 89/336/EEC: "Council Directive on the Approximation of the Laws of the Member States Relating to Electromagnetic Compatibility".

[2] EN 50081-1: "Electromagnetic Compatibility; Generic Emission Standard; Part 1: Residential, Commercial and Light Industry".

[3] EN 50082-1: "Electromagnetic Compatibility; Generic Immunity Standard; Part 1: Residential, Commercial and Light Industry".

[4] ISO 7637-1: "Road vehicles, Electrical disturbance by conduction and coupling; Part 1: Passenger cars and light commercial vehicles with nominal 12 V supply voltage - Electrical transient conduction along supply lines only".

[5] ISO 7637-2: "Road vehicles, Electrical disturbance by conduction and coupling; Part 2: Commercial vehicles with nominal 24 V supply voltage - Electrical transient conduction along supply lines only".

[6] EN 55022: "Limits and Methods of Measurement of Radio Disturbance Characteristics of Information Technology Equipment".

[7] CISPR 16-1: "Specification for radio disturbance and immunity measuring apparatus and methods".

[8] EN 61000-4-2: "Electromagnetic Compatibility (EMC); Part 4: Testing and Measurement Techniques; Section 2: Electrostatic Discharge Immunity Test".

[9] EN 61000-4-3: "Electromagnetic Compatibility (EMC); Part 4: Testing and Measurement Techniques; Section 3: Radiated, Radio-Frequency, Electromagnetic Field Immunity Test".

[10] EN 61000-4-4: "Electromagnetic Compatibility (EMC); Part 4: Testing and Measurement Techniques; Section 4: Electrical Fast Transient/Burst Immunity Test".

[11] EN 61000-4-5: "Electromagnetic Compatibility (EMC); Part 4: Testing and Measurement Techniques; Section 5: Surge Immunity Test".

[12] EN 61000-4-6: "Electromagnetic Compatibility (EMC); Part 4: Testing and Measurement Techniques; Section 6: Immunity to Conducted Disturbances, Induced by Radio-Frequency Fields".

[13] EN 61000-4-11: "Electromagnetic Compatibility (EMC); Part 4: Testing and Measurement Techniques; Section 11: Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests".

[14] ETR 238: "CENELEC/ETSI Standardization Programme for the Development of Harmonized Standards Related to Electro-Magnetic Compatibility (EMC) in the Field of Telecommunications".

[15] ITU-R Radio Regulations (1994).

[16] ETS 300 296: "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment using integral antennas intended primarily for analogue speech".

[17] ETS 300 390: "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and using an integral antenna".

[18] ETR 027 (1991): "Radio Equipment and Systems (RES); Methods of measurement for private mobile radio equipment".

[19] ETR 028 (1992): "Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics".

[20] ETS 300 086: "Radio Equipment and Systems (RES); Land mobile group; Technical characteristics and test conditions for radio equipment with an internal or external RF connector intended primarily for analogue speech".

[21] ETS 300 113: "Radio Equipment and Systems (RES); Land mobile service; Technical characteristics and test conditions for radio equipment intended for the transmission of data (and speech) and having an antenna connector".

3 Definitions and abbreviations

3.1 Definitions

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

ancillary equipment: Equipment used in connection with a radio communications equipment is considered as an ancillary equipment if:

- the equipment is intended for use in conjunction with a radio communications equipment to provide additional operational and/or control features, for example to extend control to another position or location; and
- the equipment cannot be used on a stand alone basis to provide user functions independently of a radio communications equipment; and
- the radio communications equipment to which it is connected is capable of providing some intended operation such as transmitting and/or receiving without the ancillary equipment. (i.e. it is not a sub unit of the main equipment essential to the main equipment's basic functions).

integral antenna equipment: Radio communications equipment fitted with an antenna designed to be connected to the equipment without the use of an external connector and considered to be part of the equipment. An integral antenna may be fitted internally or externally to the equipment. In equipment of this type, the enclosure port and the antenna port are identical.

non-integral antenna equipment: Radio communications equipment with a connector or waveguide flange intended for connection to an antenna either directly, or via a feeder or waveguide. In equipment of this type, the antenna port is separate from the enclosure port.

fixed equipment: Equipment intended for installation in a fixed position.

manufacturer (supplier): The legal entity responsible under the terms of the Council Directive 89/336/EEC [1] for placing the product on the market in a member state of the European Union.

port: A particular interface of the specified equipment (apparatus) with the electromagnetic environment. Any connection point on an equipment intended for connection of cables to or from that equipment is considered as a port (see figure 1).

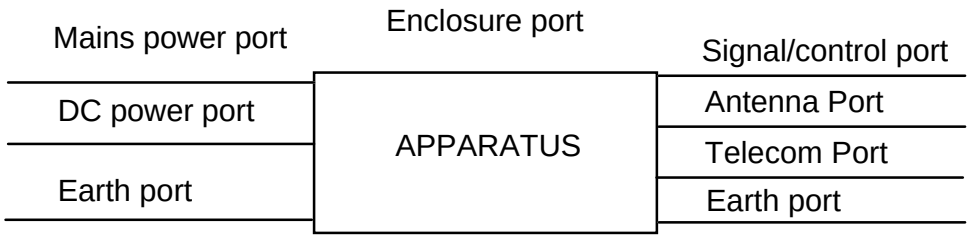

Figure 1: Examples of ports

necessary bandwidth: For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions (ITU-R Radio Regulations [15], clause 146). For application to multi-channel or multi-carier transmitters/transponders, where several carriers may be transmitted simultaneously from a final output amplifier or an active antenna, the necessary bandwidth is taken to be the transmitter or transponder bandwidth.

occupied bandwidth: The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean power of a given emission. Unless otherwise specified by ITU-R for the appropriate class of emission, the value of $\beta/2$ should be taken as 0,5 % (ITU-R Radio Regulations [15]).

telecommunications port: A port intended for direct connection to a telecommunications network.

simplex: Instantaneous one-way communications link (includes semi-duplex mode).

product standard: Functional standard describing frequency management parameters of radio product.

radio communications equipment: Telecommunications equipment which includes one or more radio transmitters and/or receivers and/or parts thereof for use in a fixed, mobile or portable application. It can be operated with ancillary equipment but if so, is not dependent on it for basic functionality.

operating frequency range: The range(s) of continuous radio frequencies covered by the (Equipment Under Test) EUT.

enclosure port: The physical boundary of the equipment onto which an electromagnetic phenomenon may radiate or impinge. In the case of integral antenna equipment, this port is inseparable from the antenna port.

3.2 Abbreviations

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

AC	Alternating Current
AM	Amplitude Modulation
AMN	Artificial Mains Network
B	measurement Bandwidth
BER	Bit Error Ratio
DC	Direct Current
DSB	Double SideBand full carrier
EMC	ElectroMagnetic Compatibility
emf	electromotive force
ESD	Electro Static Discharge
EUT	Equipment Under Test
FER	Frame Erasure Ratio
LISN	Line Impedance Stabilizing Network
PEP	Peak Envelope Power
RF	Radio Frequency
rms	root mean of squares
SSB	Single SideBand suppressed carrier modulation
TDM	Time Division Multiplexed

4 General test conditions

4.1 Test conditions and configurations

The Equipment Under Test (EUT) shall be tested under normal test conditions contained in the relevant product and basic standards or in the information accompanying the equipment, which are within the manufacturer's declared range of humidity, temperature and supply voltage.

The test configuration shall be as close to normal intended use as possible.

The EUT shall be tested in a manner as close as possible to normal intended use, consistent with the requirements of the present document. In order to perform particular tests which could not be performed otherwise, special test software or hardware may be used. However, such special software or hardware shall cause test results which are representative of normal operational conditions.

Where the Radio Frequency (RF) output from the EUT transmitter normally consists of multiple independent radio frequencies, the product may be assessed by considering the characteristics of the individual RF output signals.

If the EUT covers several transmit frequency bands, the EUT shall be tested set to operate at the centre frequency of each of these bands.

Where the EUT is provided with a detachable integral antenna, it shall be tested with the antenna fitted in a manner typical of normal intended use as an integral antenna equipment, unless specified otherwise.

If the EUT is part of a system, or can be connected to ancillary equipment, then the EUT may be tested while connected to the minimum representative configuration of ancillary equipment necessary to exercise the ports.

Ports which in normal operation are connected to ancillary or other equipment through interconnecting cables shall be connected either to such equipment via a representative interconnecting cable, or to a representative termination to simulate the input/output characteristics of the ancillary or other equipment via a representative interconnecting cable. RF input/output ports shall be correctly terminated.

If the EUT has a large number of ports, then a sufficient number shall be selected to simulate actual operational conditions and to ensure that all the different types of termination are tested.

Ports which are not connected to cables during normal intended operation, for example service connectors, programming connectors or temporary connectors, shall not be connected to any cables for the purpose of EMC testing. Where cables have to be connected to these ports, or interconnecting cables have to be extended in length in order to exercise the EUT, precautions shall be taken to ensure that the evaluation of the EUT is not affected by the addition to or extension of these cables.

The test conditions, test configurations and modes of operation of the EUT shall be recorded in the test report.

4.2 Arrangements for test signals and EUT stimulating signals

For non-integral antenna radio communications equipment using other than coaxial means of connecting to the antenna port (e.g. 600 Ω balanced twin or waveguide), a suitable screened transmission line shall be used to connect the EUT to the measuring equipment.

4.2.1 Arrangements for test signals at the input to the transmitter

The transmitter shall be modulated with normal test modulation by an internal or external signal source capable of producing the appropriate drive signal (see subclause 4.5.2).

4.2.2 Arrangements for test signals at the output from the transmitter

For integral antenna radio communications equipment, the wanted signal to establish a communication link shall be delivered from the equipment to an antenna located within the test environment. The measuring equipment for the wanted signal shall be located outside of the test environment.

For non-integral antenna radio communications equipment, the wanted signal to establish a communication link shall be delivered from the antenna connector by an appropriate screened cable or waveguide. The measuring equipment for the wanted signal shall be located outside of the test environment.

Adequate measures shall be taken to avoid any effect of the interfering signal on the measuring equipment.

4.2.3 Arrangements for test signals at the input to the receiver

For integral antenna radio communications equipment, the wanted input signal to establish a communication link, shall be presented to the equipment from an antenna located within the test environment. Unless specified otherwise in the present document, it shall be at a level 40 dB above that which just supports normal link performance (or less, as declared by the manufacturer), measured while the power amplifiers generating the EMC disturbance are switched on but without excitation. This level of the wanted input signal is expected to represent a normal operational signal level and should be sufficient to prevent broad band noise from the power amplifiers generating the EMC disturbance from influencing the measurement. The source of the wanted input signal shall be located outside of the test environment.

NOTE: It may be necessary to fit a notch filter which is tuned to the frequency of the communications link to the interfering test signal source in order to lower the noise floor sufficiently to allow valid measurements to be made.

For non-integral antenna radio communications equipment, the wanted input signal to establish a communication link shall be presented to the antenna connector by an appropriate screened transmission line. The source of the wanted input signal shall be located outside of the test environment. Unless specified otherwise in the present document, it shall be at a nominal level of 40 dB above that which just supports normal link performance (or less, as declared by the manufacturer), measured while the power amplifiers generating the EMC disturbance are switched on but without excitation.

Test signal sources which are applied to the receiver shall present a correct impedance to the receiver input. This requirement shall be met irrespective of whether one or more signals are applied to the receiver simultaneously.

4.2.4 Arrangements for test signals at the output from the receiver

For speech equipment, the audio frequency output of the receiver should be coupled via an electrically non-conductive acoustic tube to an audio distortion meter or other measuring equipment located outside of the test environment. Where it is not practical to use this technique, then other means of connecting the receiver output to an audio distortion meter or other suitable measuring equipment shall be provided. A description of the test system shall be recorded in the test report. Precautions shall be taken to ensure that any effect on the measuring equipment is minimized.

For non-speech equipment, the output of the receiver should be coupled via an electrically non-conductive means to the test equipment located outside of the test environment. If the receiver has a connector providing the receiver output, then it shall be connected to a cable as used in normal operation of the EUT, connected to test equipment outside of the test environment. This test equipment may be supplied by the manufacturer. Precautions shall be taken to ensure that any effect on the measuring equipment is minimized. A description of the test system shall be recorded in the test report.

4.2.5 Arrangements for the application of interfering (immunity) test signals

These are detailed in the relevant standards referred to in the present document.

4.3 Exclusion bands

Frequencies on which radio communications equipment is intended to operate are generally excluded from immunity tests with either conducted or radiated RF test signals. Frequencies on which transmitters are intended to operate, also out-of-band emission frequencies, are additionally excluded from EMC emission measurements.

There shall be no frequency exclusion band applied to EMC emission measurements of receivers, or ancillaries.

The RF test exclusions are referred to as "exclusion bands" and are elaborated below for the various cases.

4.3.1 Transmitter exclusion bands for EMC emission measurements

Exclusion bands shall not be applied when measuring transmitters in standby mode.

The exclusion band for typical different classes of transmitters is elaborated in table 1.

Application of the transmitter exclusion band avoids measuring emissions which, although not located at the transmitter nominal frequency, are due to modulation (when present), or due to the shape factor of the filter in the measuring device.

Table 1: Transmitter exclusion bands for emission measurements

Category of EUT	Width of exclusion band (notes 1 and 2)	Centre of exclusion band
Channelized equipment with $F_n < 0,05\ F_c$.	$5\ F_n + F_s$	F_c
Non-channelized equipment, including direct sequence spread-spectrum equipment, or equipment with $Fn > 0,05\ F_c$	$1,1\ F_n + F_s$	F_c
Frequency hopping equipment	$4\ F_n + F_h + F_s$	F_{ch}

Where:
F_n is the necessary bandwidth of the wanted class of emission.
F_s is the skirt bandwidth = 20 B.
B (the measurement bandwidth) is defined as:
1 kHz in the frequency range 9 kHz to 150 kHz;
9 - 10 kHz in the frequency range 150 kHz to 30 MHz;
100 - 120 kHz in the frequency range 30 MHz to 1 GHz;
1 MHz in the frequency range > 1 GHz.

F_h is the hopping frequency range.
F_c is the centre of transmitter necessary bandwidth (as defined in ITU-R Radio Regulations 1-18, clause 146 [15]).
F_{ch} is the centre frequency of transmitter hopping range.

NOTE 1: The extension of the exclusion bandwidth for transmitters to include 20 times the measurement bandwidth is needed to accommodate the skirt bandwidth (F_s) of the filters used in the measurement equipment. Narrower measurement bandwidths may be used. The exclusion band and measurement bandwidth shall be recorded in the test report.
NOTE 2: For equipment operating on frequencies below 30 MHz, the exclusion band shall be extended at each end by 5 % of the centre frequency.

4.3.2 Transmitter exclusion bands for immunity testing

The exclusion band extends from the centre frequency minus twice the occupied bandwidth, to the centre frequency plus twice the occupied bandwidth.

For Time Division Multiplexed (TDM) equipment, the transmitter exclusion band for immunity testing is equal to the receiver exclusion band for immunity testing.

4.3.3 Receiver exclusion bands for immunity testing

The exclusion band is the relevant operating frequency band, extended at each end by ±5 % of the centre frequency.

4.4 Test conditions for EMC emission measurements

The measurement shall be made in the operational mode producing the largest emission in the frequency band being investigated consistent with normal applications.

An attempt shall be made to maximize the detected radiated emission, for example by moving the cables of the equipment.

Where appropriate, a single tone or a bit stream shall be used to modulate the transmitter. The manufacturer shall define the modulation with the highest emission in transmit mode.

Where the EUT has multiple operating bands, it shall be set to operate at the centre frequency of each band. Where the EUT has one or more wide operating frequency bands, there shall be at least one test per decade of frequency coverage provided by the EUT. The actual test frequencies selected shall be recorded in the test report.

4.5 Test conditions for EMC immunity tests

The measurement shall be made in the mode of operation as required in subclause 4.5.1.

For the immunity tests of ancillary equipment without separate pass/fail criteria, the receiver, transmitter or transceiver coupled to the ancillary equipment shall be used to judge whether the ancillary equipment passes or fails.

4.5.1 Mode of operation

For the immunity tests of transmitters, the transmitter shall be operated at its maximum rated RF output Peak Envelope Power (PEP), or at a level not less than -6 dB relative to that power level in the event of declared thermal limitations. The transmitter shall be modulated with normal test modulation (subclause 4.5.2). Where possible, a continuous communication link shall be established (subclause 5.2) at the start of the test, and the performance criteria in subclause 6.2.1 shall apply. Where the equipment does not support a continuous communications link, the performance criteria in subclause 6.2.2 shall apply.

For the immunity tests of receivers, the wanted input signal coupled to the receiver shall be modulated with normal test modulation (subclause 4.5.2). Where possible, a continuous communication link shall be established (subclause 5.2) at the start of the test, and the performance criteria in subclause 6.2.1 shall apply. Where the equipment does not support a continuous communications link, the performance criteria in subclause 6.2.2 shall apply.

4.5.2 Normal test modulation

For analogue speech equipment:

- the receiver input signal shall be set to the nominal operating frequency, modulated with a sinusoidal audio frequency of 1 kHz with modulation index as specified by the manufacturer to represent normal operation;

- Double SideBand (DSB) full carrier transmitters shall be modulated with a sinusoidal audio frequency signal of 1 kHz. The level of this audio signal shall be set to obtain at least 60 % modulation depth of the RF output signal;

- Single SideBand (SSB) suppressed carrier modulation transmitters shall be modulated with a sinusoidal audio frequency signal of 1 kHz (see subclause 4.5.1);
- angle modulated transmitters shall be modulated with a sinusoidal audio frequency signal of 1 kHz. The level of this audio signal shall be set to obtain a deviation of 60 % peak system deviation of the RF output signal;
- in the case of angle modulated equipment employing audio sidetone, an audio breakthrough test may be performed as a substitute for the above tests. The reference level for the audio breakthrough test shall be taken with a 1 kHz sinusoidal audio signal and a deviation of 60 % peak system deviation. For receivers, this modulation shall be applied to the wanted signal. For transmitters, this modulation shall be applied to the RF output signal. After the reference level has been found, the 1 kHz modulation shall be removed for the duration of the audio breakthrough test.

For other equipment (digitized speech, data, specific response, etc.):

- the receiver wanted input signal shall be set to the nominal frequency of the receiver, modulated with a test signal specified by the manufacturer which represents normal operation;
- the transmitter shall be modulated with a test signal which represents normal operation as specified by the manufacturer;
- the manufacturer may supply the test modulation/demodulation equipment;
- the test signal generator (modulation) shall be able to produce a continuous stream of data or a repetitive message as appropriate;
- in the case of data equipment, the test instrumentation shall be able to produce:
  - a readout of Bit Error Ratio (BER) or Frame Erasure Ratio (FER) of a continuous data stream; or
  - a repetitive readout of message acceptance or an indication of bulk data throughput rate in the case of error-corrected systems.

5 Performance assessment

5.1 General

The manufacturer shall supply the following information concerning the EUT, to be recorded in the test report:

- the primary user functions of the EUT to be tested during and after the EMC testing;
- the intended functions of the EUT which shall be in accordance with its user documentation;
- the type of modulation and characteristics of the transmission used for testing (random bit stream, message format, etc.);
- the ancillary equipment to be combined with the radio equipment for testing, if any;
- the method to be used to verify that a communications link is established and maintained;
- the user control functions (including volume control if appropriate) and stored data that are required for normal operation and the method to be used to assess whether these have been lost after EMC stress;
- an exhaustive list of ports, classified as power, telecom, antenna or signal/control, and the maximum lengths of cables that may be connected. Power ports shall further be classified as Alternative Current (AC) or Direct Current (DC) power;
- a list of service connectors or programming connectors;
- the bandwidth of the filter immediately preceding the demodulator in the receiver;

- details of the operating frequency range of the EUT;
- in the case of non-integral antenna equipment, details of all antennas supplied by the manufacturer for use with it;
- details of the mechanism for manual recovery of normal operation shall be provided in the user documentation;
- the EUT software version used during the test.

5.2 EUTs which can provide a continuous communications link

If the EUT permits the establishment of a continuous communications link, the test modulation, test arrangement etc. as required in clause 4 shall apply.

5.3 EUTs which can only provide a discontinuous communications link

If the EUT does not permit a continuous communications link to be established, or in the case of ancillary equipment tested on a stand alone basis, the manufacturer shall define the method of test to determine the acceptable level of performance or degradation of performance during and/or after the test. The manufacturer shall provide the following:

- the pass/fail criteria for the EUT;
- the method of observing the performance of the EUT.

The assessment of performance to be carried out during and/or after the tests shall be simple, but at the same time give adequate proof that the primary functions of the EUT are operational.

5.4 EUT classification

Portable equipment, or combinations of equipment, declared as capable of being powered for intended use by the main battery of a vehicle shall additionally be considered as equipment intended for vehicular use.

Portable or mobile equipment or combinations of equipment declared as capable of being powered for intended use by ac mains shall additionally be considered as equipment intended for fixed use.

5.5 Ancillary equipment - methods of assessing compliance

At the manufacturer's discretion an ancillary equipment may be:

- declared compliant separately from a receiver, transmitter or transceiver with all the applicable immunity and EMC emission measurement clauses of the present document; or
- declared compliant with another appropriate Harmonized EMC standard; or
- tested whilst connected to a receiver, transmitter or transceiver, in which case compliance shall be demonstrated with the appropriate clauses of the present document.

6 Performance criteria

The EUT shall meet the minimum performance criteria specified in subclauses 6.1 and 6.2 as appropriate.

6.1 General

The EUT shall meet the performance criteria given in table 2 including the associated notes 1 and 2.

Where the EUT is a transmitter only, tests shall be repeated with the EUT in standby mode (where this mode exists) to ensure that unintentional transmission does not occur.

Where the EUT is a transceiver, the transmitter shall not operate unintentionally during the test, under any circumstances.

The performance criteria A, B and C as indicated in table 2 shall be used in the following manner:

- performance criteria A for immunity tests with phenomena of a continuous nature;
- performance criteria B for immunity tests with phenomena of a transient nature or where called for in specific subclauses of the present document;
- performance criteria C for immunity tests with power interruptions exceeding a certain period of time (see subclause 9.4).

Table 2: Performance criteria

Criteria	During test	After test
A	Operate as intended Degradation of performance (note 1) No loss of function	Operate as intended No degradation of performance (note 2) No loss of function
B	Loss of function (one or more)	Operate as intended No degradation of performance (note 2) Functions self-recoverable
C	Loss of function (one or more)	Operate as intended No degradation of performance (note 2) Functions recoverable by the operator (note 3)

NOTE 1: Degradation of performance during the test is understood as a degradation to a level not below a minimum performance level specified by the manufacturer for the use of the apparatus as intended. In some cases the specified minimum performance level may be replaced by a permissible degradation of performance.
If the minimum performance level or the permissible performance degradation is not specified by the manufacturer then either of these may be derived from the product description and documentation (including leaflets and advertising) and what the user may reasonably expect from the apparatus if used as intended.

NOTE 2: No degradation of performance after the test is understood as no degradation below a minimum performance level specified by the manufacturer for the use of the apparatus as intended. In some cases the specified minimum performance level may be replaced by a permissible degradation of performance. After the test no change of actual operating data or user retrievable data is allowed.
If the minimum performance level or the permissible performance degradation is not specified by the manufacturer then either of these may be derived from the product description and documentation (including leaflets and advertising) and what the user may reasonably expect from the apparatus if used as intended.

NOTE 3: The EUT should provide an indication of the need for manual operation to recover normal functionality of the product following EMC stress. For example, a lamp or buzzer may be used. Where this is provided, full details of the necessary recovery action and diagnostics provided by the EUT shall be recorded in the user documentation.

6.2 Assessment of receiver immunity

6.2.1 EUTs capable of establishing a continuous communications link

The establishment of the communications link at the start of the test, the maintenance of the communications link and the assessment of the recovered signal information, e.g. an audio signal, shall be used as the performance criteria to ensure that the essential functions of the EUT are evaluated during and after the test.

6.2.2 EUTs only capable of establishing a discontinuous communications link

If the EUT does not permit a continuous communications link to be established, or in the case of ancillary equipment being tested on a stand alone basis, the manufacturer shall declare, for inclusion in the test report, the acceptable level of performance or degradation of performance during and/or after testing. The performance specification shall be included in the product description and documentation.

The performance criteria specified by the manufacturer shall provide at least the same degree of immunity protection as specified in subclause 6.1.

6.2.3 Assessment of receiver responses, wideband and narrowband

6.2.3.1 Wideband phenomena:

- EUTs operating below 1 MHz:
    - where any response causing the EUT to not meet criteria A is found over a frequency range greater than 50 times the necessary bandwidth of the radio service in which the EUT is intended to operate, this is considered to be a wideband EMC immunity response and it is deemed to fail the test. At the manufacturer's option, the test may be repeated at offsets equal to twice and 2,5 times the declared bandwidth of the filter immediately preceding the demodulator. If in either of these two latter cases the phenomenon is not present, then the EUT shall be deemed not to fail the test. The option used to evaluate the EUT shall be recorded in the test report.
- EUTs operating above 1 MHz:
    - where any response causing the EUT to not meet criteria A is found over a frequency range greater than 10 times the necessary bandwidth of the radio service in which the EUT is intended to operate, this is considered to be a wideband EMC immunity response and it is deemed to fail the test. At the manufacturer's option, the test may be repeated at offsets equal to twice and 2,5 times the declared bandwidth of the filter immediately preceding the demodulator. If in either of these two latter cases the phenomenon is not present, then the EUT shall be deemed not to fail the test. The option used to evaluate the EUT shall be recorded in the test report.

6.2.3.2 Narrowband phenomena:

- EUTs operating below 1 MHz:
    - where any response causing the EUT to not meet criteria A is found over a frequency range less than 50 times the necessary bandwidth of the radio service in which it is intended to operate, this is considered to be a receiver spurious response. All such narrowband responses shall be recorded in the test report. If any responses of this type are found, this shall constitute failure of the test unless the manufacturer declares the complete list of narrowband spurious response frequencies in the user documentation. In such cases, this list shall additionally be included as an annex to the test report.

- EUTs operating above 1 MHz:

  - where any response causing the EUT to not meet criteria A is found over a frequency range less than 10 times the necessary bandwidth of the radio service in which it is intended to operate, this is considered to be a receiver spurious response. All such narrowband responses shall be recorded in the test report. If any responses of this type are found, this shall constitute failure of the test unless the manufacturer declares the complete list of narrowband spurious response frequencies in the user documentation. In such cases, this list shall additionally be included as an annex to the test report.

7 Applicability overview tables

7.1 Emission measurements

Table 3: Emission measurements applicability (note 2)

Application	Equipment test requirement			Reference subclause in the present document	Reference document
	Radio and ancillary equipment for fixed use	Radio and ancillary equipment for vehicular use	Radio and ancillary equipment for portable use		
Enclosure port (radio) (note 1)	applicable	applicable	applicable	8.4	
Enclosure port (stand alone ancillary)	applicable for ancillary equipment not integrated into receivers, transmitters or transceivers	applicable for ancillary equipment not integrated into receivers, transmitters or transceivers	applicable for ancillary equipment not integrated into receivers, transmitters or transceivers	8.3	EN 55022 [6]
DC power in/out ports	applicable	applicable	not applicable	8.2	EN 55022 [6]CIS PR 16-1 [7]
Antenna ports (note 1)	applicable	applicable	applicable	8.4 or 8.5	
AC mains ports	applicable	not applicable	not applicable	8.1	EN 55022 [6]
NOTE 1: These parameters are normally covered in standards relating to the use of the radio spectrum. In such a case, the intended use of the present document is described in the introduction. NOTE 2: It may be determined from consideration of the electrical characteristics and/or intended operational environment of a particular EUT that some tests are technically inappropriate. In such a case, the decision and justification not to test these parameters shall be recorded in the test report. Decisions on the applicability of individual tests shall be based on information contained in user documentation and/or installation instructions, and consideration of the technical design.					

7.2 EMC Immunity tests

Table 4: Immunity tests applicability (note 2)

Phenomena	Application	Equipment test requirement			Reference, sub-clause in the present document	Reference document
		Radio and ancillary equipment for fixed use	Radio and ancillary equipment for vehicular use	Radio and ancillary equipment for portable use		
RF electro magnetic field (80 -1 000 MHz)	Enclosure port (note 1)	applicable	applicable	applicable	9.1 9.3	EN 61000-4-3 [9]
Electrostatic discharge	Enclosure port	applicable	applicable	applicable	9.1 9.3	EN 61000-4-2 [8]
Fast transients common mode	Signal/control ports, DC and AC power input ports, antenna ports (cable), telecom ports	applicable	not applicable	not applicable	9.2 9.4 9.5 9.6 9.8	EN 61000-4-4 [10]
RF common mode 0,15 - 80 MHz	Signal and control ports, DC and AC power input ports, antenna ports (cable), telecom ports	applicable	not applicable	not applicable	9.2 9.4 9.5 9.6 9.8	EN 61000-4-6 [12]
Transient and surges, vehicular environment	DC power input ports	not applicable	applicable	not applicable	9.7	ISO 7637-1 [4], ISO 7637-2 [5]
Voltage dips and interruptions	AC mains power input ports	applicable	not applicable	not applicable	9.4	EN 61000-4-11 [13]
Conducted RF differential mode	Antenna ports (cable) receive mode (note 1)	applicable	applicable	applicable	9.2	
Surges, differential mode	AC mains input/output ports, telecom ports	applicable	not applicable	not applicable	9.1 9.4	EN 61000-4-5 [11]
Surges, common mode	AC mains and DC power input ports, telecom ports	applicable	not applicable	not applicable	9.4 9.6 9.8	EN 61000-4-5 [11]

NOTE 1: These parameters are normally covered in standards relating to the use of the radio spectrum. In such a case, the intended use of the present document is described in the introduction.

NOTE 2: It may be determined from consideration of the electrical characteristics and/or intended operational environment of a particular EUT that some tests are technically inappropriate. In such a case, the decision and justification not to test these parameters shall be recorded in the test report. Decisions on the applicability of individual tests shall be based on information contained in user documentation and/or installation instructions, and consideration of the technical design.

8 Methods of measurement and limits for EMC emissions

The individual measurements called up in the tables in this clause shall be performed in accordance with the standards specified in each case, using the test limits indicated. Any deviations from this principle are elaborated in the text.

The measurements shall be performed in receive, standby and transmit modes of operation unless indicated otherwise in the tables.

Transmitters in the transmit mode of operation are subject to frequency exclusion bands as in subclause 4.3.1. The applicability of tests to specific classes of equipment is elaborated in subclause 7.1.

NOTE: It is intended that the present document will be used as described in the Introduction to avoid "double testing".

8.1 Emissions from the AC mains power input/output port

8.1.1 Definition

This test assesses the ability of ancillary equipment and/or radio communications equipment to limit its internal noise from being present on the AC mains power ports.

8.1.2 Method of measurement

The conducted measurement technique, using the method from EN 55022 [6] shall be used.

In the case of AC output ports, the port shall be connected via a Line Impedance Stabilizing Network (LISN) to a load drawing the rated current of the source.

In the case where the AC output port is intended to be directly connected (or via a switch or circuit breaker) to the AC power input port of the EUT, the AC output port need not be tested.

NOTE: In EN 55022 [6] the term Artificial Mains Network (AMN) is used instead of LISN.

8.1.3 Limits

The EUT shall meet the limits of table 5 (including the average limit and the quasi-peak limit).

The measurement frequency range extends from 150 kHz to 30 MHz, apart from the transmitter exclusion band for emission measurements when measured in transmit mode, where appropriate.

Table 5: Limits

Environmental phenomena	Frequency range	Units	Test limits	Basic standard	Remarks
Conducted RF EMC emission	0,15 to 0,5 MHz	dBµV	66 to 56 quasi peak 56 to 46 average	EN 55022 [6] CISPR 16-1 [7]	(note)
Conducted RF EMC emission	> 0,5 to 5 MHz	dBµV	56 quasi peak 46 average	EN 55022 [6] CISPR 16-1 [7]	
Conducted RF EMC emission	> 5 to 30 MHz	dBµV	60 quasi peak 50 average	EN 55022 [6] CISPR 16-1 [7]	
NOTE: The limit decreases linearly with the logarithm of frequency in the range 0,15 MHz to 0,50 MHz.					

8.2 Emissions from the DC power input/output port

This test applies to DC power input/output ports which may be connected to cables longer than 3 m. Where the manufacturer specifies an AC to DC power supply converter which shall always be used to power the EUT via interconnecting cables shorter than 3 m, emissions shall be measured at the AC port of the adaptor and not on the DC port of the EUT (see subclause 8.1).

8.2.1 Definition

This test assesses the ability of ancillary equipment and/or radio communications equipment to limit its internal noise from being present on the DC power ports.

8.2.2 Method of measurement

The conducted measurement technique, using the method from EN 55022 [6] shall be used.

The measurement receiver shall be in accordance with the requirements of CISPR 16-1 [7].

EUTs intended to be supplied with both DC leads floating or with one lead grounded shall be tested under both conditions.

DC output ports shall be connected via a LISN to a load drawing the rated current of the source.

A measuring receiver shall be connected to each LISN measurement port in turn and the conducted emission measurement recorded.

In the case where the DC output port is directly connected (or via a switch or circuit breaker) to the DC power input port of the EUT, the DC output port need not be tested.

8.2.3 Limits

The equipment shall meet the limits of table 6.

The measurement frequency range extends from 150 kHz to 30 MHz, apart from the transmitter exclusion band for emission measurements when measured in transmit mode.

Table 6: Limits

Environmental phenomena	Frequency range	Units	Test limits	Basic standard	Remarks
Conducted RF EMC emission	0,15 to 0,5 MHz	dBµV	66 to 56 quasi peak 56 to 46 average	EN 55022 [6] CISPR 16-1 [7]	(note)
Conducted RF EMC emission	> 0,5 to 5 MHz	dBµV	56 quasi peak 46 average	EN 55022 [6] CISPR 16-1 [7]	
Conducted RF EMC emission	> 5 to 30 MHz	dBµV	60 quasi peak 50 average	EN 55022 [6] CISPR 16-1 [7]	
NOTE: The limit decreases linearly with the logarithm of frequency in the range 0,15 MHz to 0,50 MHz.					

8.3 Emissions from the enclosure port of stand alone ancillary equipment

This test is applicable to ancillary equipment not integrated into a receiver, transmitter, or transceiver.

This test shall be performed on a representative configuration of the equipment, or a representative configuration of the combination of radio and ancillary equipment.

8.3.1 Definition

This test assesses the ability of ancillary equipment to limit any radiated emission from its enclosure.

8.3.2 Method of measurement

The test method shall be in accordance with EN 55022 [6].

8.3.3 Limits

The limits shall be according to EN 55022 [6] shown in table 7 (10 m measuring distance).

Table 7: Limits

Frequency range	Limit (quasi-peak)
30 to 230 MHz	30 dBµV/m
> 230 to 1 000 MHz	37 dBµV/m

8.4 Emissions from the enclosure port of non-integral antenna equipment, and antenna input/output port of integral antenna equipment

8.4.1 Definition

This test assesses the ability of non-integral antenna radio communications equipment to limit internal noise (spurious emissions) from being radiated from its enclosure port.

In the case of integral antenna communications equipment, this test assesses its ability to limit spurious emissions from being radiated by the antenna port, this being identical with the enclosure port for this class of equipment.

8.4.2 Method of measurement

For radiated measurements, either the substitution or direct power measurements may be used, whichever is suitable for the frequency range under consideration.

Guidance can be obtained from ETS 300 296 [16], ETS 300 390 [17], ETR 027 [18], ETS 300 086 [20], ETS 300 113 [21], ETR 028 [19] or CISPR 16-1 [7]. The test method shall be recorded in the test report.

The measuring receiver shall be tuned over the measurement frequency range and, at each frequency at which a spurious component is detected, the power level shall be measured. The measurements shall be repeated with the EUT in standby mode and receive mode. Emission measurements of a level lower than 10 dB below the limits given in table 8 need not be recorded.

The transmitter (if appropriate) shall be modulated with normal test modulation (see subclause 4.5.2) during the test. The exclusion band as defined in subclause 4.3.1 shall be applied.

For non-integral antenna transmitters, the antenna port shall be terminated in a suitable non-radiating load during the test.

Where spectrum analysers or similar instruments are used to perform the measurements, the video (post detector) bandwidth shall be equal to or greater than the measurement bandwidth B.

8.4.3 Limits

The equipment shall meet the limits of table 8.

Table 8: Limits

Environmental phenomena	Test Frequency range	Units	Test limits Rx, Tx Standby	Test limits, Tx active mode	Remarks
Spurious radiated RF EMC Emissions	30 to 230 MHz	dBm Peak	-57 (2 nW)	-36 (250 nW) or -80 dB PEP, whichever is the higher level	B = 100 kHz to 120 kHz (note 1)
Spurious radiated RF EMC Emissions	230 MHz to 1 GHz	dBm Peak	-50 (10 nW)	-36 (250 nW) or -80 dB PEP, whichever is the higher level	B = 100 kHz to 120 kHz (note 2)
Spurious radiated RF EMC Emissions	> 1 to 12,75 GHz	dBm peak	-47 (20 nW)	-30 (1 µW) or -74 dB PEP, whichever is the higher level	B = 1 MHz (note 4)
Spurious radiated RF EMC Emissions	> 12,75 to 40 GHz	dBm Peak	-47 (20 nW)	-30 (1 µW) or -74 dB PEP, whichever is the higher level	B = 1 MHz (notes 3 and 4)

NOTE 1: For transmitters intended for installation less than 10 m distance from domestic broadcast receivers, a limit of -54 dBm (4 nW) peak applies in active mode in the bands 47 MHz to 74 MHz, 87,5 MHz to 118 MHz and 174 MHz to 230 MHz.
NOTE 2: For transmitters intended for installation less than 10 m distance from domestic broadcast receivers, a limit of -54 dBm (4 nW) peak applies in active mode in the band 470 MHz to 862 MHz.
NOTE 3: Applicable only to radio assemblies or subassemblies which contain an antenna as an integral part of their mechanical structure.
NOTE 4: Testing shall initially be performed up to 4 GHz or $2 \times F_C$, whichever is the higher. If any spurious emissions exceeding -10 dB with respect to the specified limit are detected above 1,5 GHz, then the test shall continue to 12,75 GHz or $2 \times F_C$, whichever is the higher.

8.5 Emissions from the antenna input/output port (spurious emissions) of non-integral antenna equipment

In the frequency range 30 MHz to 4 GHz, the conducted emissions requirements of this subclause may be replaced by radiated requirements of the EUT and all declared antennas, in accordance with subclause 8.4.

8.5.1 Definition

This test assesses the ability of non-integral antenna radio communications equipment to limit the levels of spurious emission conducted from its antenna port.

8.5.2 Method of measurement

The antenna port shall be correctly terminated with a non-radiating power attenuator of adequate power absorption capability. The output of the power attenuator shall be connected to a measuring receiver. The measuring receiver (or spectrum analyser) shall comply with the bandwidth (B) requirements in table 9. A peak detector shall be used.

The measuring receiver shall be tuned over the measurement frequency range and at each frequency at which a spurious component is detected, the power level shall be recorded as the conducted spurious emission level delivered into the specified load. The measurements shall be repeated with the EUT in standby mode and receive mode. Emission measurements of a level lower than 10 dB below the limits given in table 9 need not be recorded.

Guidance can be obtained from ETS 300 296 [16], ETS 300 390 [17], ETR 027 [18], ETS 300 086 [20], ETS 300 113 [21], ETR 028 [19] or CISPR 16-1 [7]. The test method shall be recorded in the test report.

Where spectrum analysers or similar instruments are used to perform the measurements, the video (post detector) bandwidth shall be equal to or greater than the measurement bandwidth B.

For transmitters, the exclusion band as defined in subclause 4.3.1 shall be applied during the test.

If the EUT is only intended for connection to waveguide longer than two wavelengths of the cut-off frequency, the test shall be limited to frequencies above 0,7 times the cut-off frequency.

In the event that the manufacturer supplies a range of antennas for use with the EUT, details of those tested shall be included in the test report.

8.5.3 Limits

The equipment shall meet the limits in table 9.

The attenuation of the non-radiating power attenuator from the antenna port to the measurement port shall be taken into consideration when assessing compliance.

If the equipment is only intended to be connected to specific antennas supplied by the manufacturer which have a reduced radiation efficiency at frequencies corresponding to those of emissions measured as being outside the allowed conducted limit, the manufacturer's declaration of antenna performance shall be considered. If the gain characteristic of the antenna is declared by the manufacturer, and it indicates gain at the spurious emission frequency sufficiently far below 0 dBi that the antenna radiation caused by the conducted spurious emission would be below the limit allowed for a radiated spurious emission, then the level of the conducted spurious emission shall be considered as acceptable.

This may be expressed as a formula:

Where: Measured conducted spurious emission at frequency f is of level x dBm, and

Declared antenna gain at frequency f is g dBi;

Then: Equivalent power radiated from antenna would be (x + g) dBm = h dBm.

Result: If this is within the limit allowed in table 9 for frequency f, then the level of that conducted spurious emission shall be considered as acceptable, even if level x is above the limit allowed in table 9.

EXAMPLE: A transmitter in Tx active mode has a conducted spurious emission of -24 dBm at 1,5 GHz.

This is above the limit allowed for a conducted spurious emission at 1,5 GHz, see table 9.

But the antenna gain at this frequency is declared to be only -30 dBi.

Therefore the equivalent power radiated by the antenna would be only -54 dBm at 1,5 GHz.

This is within the limit allowed for a radiated spurious emission at 1,5 GHz, see table 8.

Therefore in this case, the level of the conducted emission is considered as acceptable.

In the event that the manufacturer declares more than one type of applicable antenna, then the consideration of antenna performance referred to above shall be limited to the type giving the greatest gain at the frequency of the spurious emission.

Table 9: Limits

Environmental phenomena	Frequency range	Units	Test limits Rx, Tx Standby	Test limits Tx active mode	Remarks
Spurious conducted RF Emissions	9 to 150 kHz	dBm (nW) Peak	-57 (2 nW)	-36 (250 nW) or -70 dB PEP, whichever is the higher level	B = 1 kHz
Spurious conducted RF Emissions	> 150 kHz to 30 MHz	dBm (nW) Peak	-57 (2 nW)	-36 (250 nW) or -70 dB PEP, whichever is the higher level	B = 9 to10 kHz
Spurious conducted RF Emissions	> 30 MHz to 1 GHz	dBm (nW) Peak	-57 (2 nW)	-36 (250 nW) or -80 dB PEP, whichever is the higher level	B = 100 kHz to 120 kHz (note 2)
Spurious conducted RF Emissions	> 1 to 12,75 GHz	dBm (nW) Peak	-47 (20 nW)	-30 (1 µW) or -74 dB PEP, whichever is the higher level	B = 1 MHz (note 1)
Spurious conducted RF Emissions	> 12,75 to 40 GHz	dBm (nW) Peak	-47 (20 nW)	-30 (1 µW) or -74 dB PEP, whichever is the higher level	B = 1 MHz (note 1)
NOTE 1: Testing should initially be performed up to 4 GHz or $2 \times F_C$, whichever is the higher. If any spurious emissions exceeding -10 dB with respect to the specified limit are detected above 1,5 GHz, then the test shall continue to 12,75 GHz or $2 \times F_C$, whichever is the higher.					
NOTE 2: For transmitters intended for installation less than 10 m distance from domestic broadcast receivers, a limit of -54 dBm (4 nW) peak applies in the bands 47 MHz to 74 MHz, 87,5 MHz to 118 MHz, 174 MHz to 230 MHz and 470 MHz to 862 MHz.					

9 Test methods and levels for EMC immunity

The individual tests specified in the tables of this clause, shall be performed in accordance with the standard specified in each case, using the test levels indicated. Any deviations from this principle are elaborated in the text.

The tests shall be performed in receive, standby and transmit modes of operation as supported by the EUT, unless indicated otherwise.

Decisions on the applicability of individual tests shall be based on information contained in user documentation and/or installation instructions, and consideration of the technical design of the EUT.

9.1 Immunity of antenna port and enclosure port of integral antenna radio equipment

In the case of integral antenna equipment, the antenna port is identical to, and inseparable from the enclosure port. Both are simultaneously exposed to EMC phenomena. However, for accurate evaluation of the performance of these ports, different tests are required to assess functionality.

The performance shall be evaluated according to subclauses 9.1.1 or 9.1.2, depending on the operating frequency of the EUT.

9.1.1 EUTs operating at frequencies up to 2 GHz

Electro Static Discharge (ESD) tests according to EN 61000-4-2 [8] shall be applied at levels ±2, ±4 and ±8 kV (air) and ±2 and ±4 kV (contact), applying performance criteria B.

The following steps shall be performed in sequence:

1) the operating frequency of the EUT shall be set to the centre of the operating frequency range. Where the EUT has more than one operating frequency range, the following tests shall be repeated for each range;

2) a wanted signal shall be applied at a level 10 dB above that which just supports normal link performance, or at a level defined by the manufacturer;

3) for receivers, an interfering test signal shall be applied at 30 mV/m or at a level 80 dB above the wanted signal, whichever is the greater but without exceeding 3 V/m. This shall be swept over the frequency range 80 MHz to 1 GHz. The necessary forward power for the required test field strength can be calculated from the knowledge of the input power and the field strength recorded during the calibration of the field at other field strengths as defined in EN 61000-4-3 [9]. The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz. The frequency exclusion band of subclause 4.3.3 shall apply:

   - the radio link performance shall be assessed against criteria A;

   - the receiver response performance for narrowband and wideband phenomena shall be assessed in accordance with subclause 6.2.3.

4) for all EUTs, an interfering test signal at 3 V/m shall be applied. This shall be swept over the frequency range 80 MHz to 1 GHz. The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz. The frequency exclusion bands of subclause 4.3 shall apply:

   - for receivers, the test at 3 V/m shall only be used to evaluate those aspects of receiver performance not related to the radio link, against performance criteria A (for link performance assessment, see (3) above);

   - for transmitters in transmit and standby modes, performance shall be assessed against criteria A.

9.1.2 EUTs operating at frequencies on or above 2 GHz

ESD tests according to EN 61000-4-2 [8] shall be applied at levels ±2, ±4 and ±8 kV (air) and ±2 and ±4 kV (contact), applying performance criteria B.

The following steps shall be performed in sequence:

1) the operating frequency of the EUT shall be set to the centre of the operating frequency range. Where the EUT has more than one operating frequency range, the following tests shall be repeated for each range;

2) a wanted signal shall be applied at a level 10 dB above that which just supports normal link performance, or at a level defined by the manufacturer;

3) for all EUTs, an interfering test signal at 3 V/m shall be applied. This shall be swept over the frequency range 80 MHz to 1 GHz. The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz;

   - all primary user functions shall be assessed against criteria A;

   - the receiver response performance for narrowband and wideband phenomena shall be assessed in accordance with subclause 6.2.3.

9.2 Immunity of antenna port of non-integral antenna radio equipment

In the case of non-integral antenna radio equipment, the antenna port is separate from the enclosure port.

9.2.1 Test levels and performance criteria

Table 10: Test levels and performance criteria

Phenomena	Units	Test Levels	Basic Standard	Performance Criteria	Remarks
Conducted RF common mode	MHz V(RMS unmod elecromotive force (emf)) % Amplitude Modulation (AM)	0,15 to 80 3 80	EN 61000-4-6 [12]	A (inside the Rx exclusion band, B applies)	(notes 1, 2 and 4)
Conducted RF differential mode				A	Follow subclause 9.2.1.1 or 9.2.1.2 (notes 3 & 5)
Fast transients common mode	kV peak Tr/Th ns Rep frequency kHz	0,5 5/50 5	EN 61000-4-4 [10]	B	(notes 2 and 4)
NOTE 1: The test method shall be the current clamp injection method in accordance with EN 61000-4-6 [10]. The exclusion band of subclause 4.3.3 shall be applied and narrowband responses (spurious responses) shall be disregarded in the measurement (see subclause 6.2.3). NOTE 2: Applicable only to ports interfacing with cables whose total length may exceed 3 m. NOTE 3: Applicable to receivers. NOTE 4: Applicable only to co-axial ports. NOTE 5: Measurements shall not be performed on receivers operating on or above 2 GHz, see subclause 9.2.1.2.					

The performance shall be evaluated according to subclause 9.2.1.1 or subclause 9.2.1.2, depending on the operating frequency of the EUT.

9.2.1.1 Conducted RF differential mode testing: receivers operating below 2 GHz

The following steps shall be performed in sequence:

1) the frequency of the EUT shall be set to the centre of its operating range. Where it has more than one operating range, the following tests shall be repeated for each range;

2) a wanted signal shall be applied at a level 10 dB above that which just supports normal link performance, or at a level defined by the manufacturer;

3) an interfering test signal shall be applied and swept over the frequency range 80 MHz to 1 GHz. It shall be at a level 80 dB above the wanted signal, but without exceeding + 100 dBµV emf. The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz. The frequency exclusion band of subclause 4.3.3 shall apply. Alternatively, the manufacturer may specify that the test shall be performed as in subclause 9.1.1 step (3) with a representative antenna fitted.

The receiver response performance for narrowband and wideband phenomena shall be assessed in accordance with subclause 6.2.3.

9.2.1.2 Conducted RF differential mode testing: receivers operating on or above 2 GHz

This test is considered technically inappropriate to this class of equipment and shall not be performed.

Justification:

- in service, the interfering signals reaching the antenna port would typically be offset by only ±5 % from the operating frequency, and would thus lie within the exclusion band normally applied for this test;

- fixed radio equipment with carrier frequencies on or above 2 GHz normally has directional antennas.

9.3 Immunity of the enclosure port of non-integral antenna radio equipment and all classes of ancillary equipment

Table 11: Test levels and performance criteria

Phenomena	Units	Test levels	Basic standard	Performance criteria	Remarks
Radio Frequency electromagnetic Field	MHz V/m root mean of squares rms % AM	80 to 1 000 3 80	EN 61000-4-3 [9]	A (inside the receiver frequency exclusion band, B applies)	(notes 1 and 2)
ESD	kV kV	±2, ±4 and ±8 (air) ±2 and ±4 (contact)	EN 61000-4-2 [8]	B	

NOTE 1: The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz.
NOTE 2: The receiver response performance for narrowband and wideband phenomena shall be assessed in accordance with subclause 6.2.3.

9.4 Immunity of the AC mains power input/output port

Table 12: Test levels and performance criteria

Phenomena	Units	Test Levels	Basic Standard	Performance Criteria	Remarks
Conducted RF common mode	MHz V (RMS unmod emf) % AM	0,15 to 80 3 80	EN 61000-4-6 [12]	A (inside the receiver frequency exclusion band, "B" applies)	(notes 1, 2 and 4)
Fast transients common mode	kV peak Tr/Th ns Rep frequency kHz	1,0 5/50 5	EN 61000-4-4 [10]	B	(note 2)
Surges common mode (line to ground)	kV peak Tr/Th µs	1,0 1,2/50 (8/20)	EN 61000-4-5 [11]	B	(note 3)
Surges differential mode (line to line)	kV peak Tr/Th µs	0,5 1,2/50 (8/20)	EN 61000-4-5 [11]	B	(note 3)
Voltage dips	% reduction ms	30 10	EN 61000-4-11 [13]	B	(note 3)
	% reduction ms	60 100	EN 61000-4-11 [13]	B	(note 3)
Power interruptions	% reduction ms	> 95 5 000	EN 61000-4-11 [13]	C	(note 3)

NOTE 1: This test should be performed using the intrusive or direct connection method, where appropriate, see EN 61000-4-6 [12]. The test method may be the current clamp injection method in accordance with EN 61000-4-6 [12]. Narrowband responses (spurious responses) found during testing shall be disregarded in the measurement (see subclause 6.2.3).
NOTE 2: Applicable to all input ports, and to output ports interfacing with cables whose total length may exceed 3 m.
NOTE 3: Applicable only to input ports.
NOTE 4: The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz.

9.5 Immunity of the signal/control input/output port

Table 13: Test levels and performance criteria

Phenomena	Units	Test Levels	Basic Standard	Performance Criteria	Remarks
Conducted RF common mode	MHz V (RMS unmod emf) % AM	0,15 to 80 3 80	EN 61000-4-6 [12]	A (inside the receiver frequency exclusion band, "B" applies)	(notes 1, 2 and 3)
Fast transients common mode	kV peak Tr/Th ns Rep frequency kHz	0,5 5/50 5	EN 61000-4-4 [10]	B	(note 3)
NOTE 1: This test should be performed using the intrusive or direct connection method, where appropriate, see EN 61000-4-6 [12]. The test method may be the current clamp injection method in accordance with EN 61000-4-6 [12]. Narrowband responses (spurious responses) found during testing shall be disregarded in the measurement (see subclause 6.2.3). NOTE 2: The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz. NOTE 3: These tests shall be performed on ports which may have cables longer than 3 m.					

9.6 Immunity of the telecommunication port

Table 14: Test levels and performance criteria

Phenomena	Units	Test Levels	Basic Standard	Performance Criteria	Remarks
Conducted RF common mode	MHz V (RMS unmod emf) % AM	0,15 to 80 3 80	EN 61000-4-6 [12]	A (inside the receiver frequency exclusion band, B applies)	(notes 1 and 2)
Fast transients common mode	kV peak Tr/Th ns Rep frequency kHz	0,5 5/50 5	EN 61000-4-4 [10]	B	
Surges differential mode	kV Tr/Th µs	0,5 1,2/50	EN 61000-4-5 [11]	B	
Surges common mode (line to ground)	kV Tr/Th µs	0,5 1,2/50	EN 61000-4-5 [11]	B	
NOTE 1: This test should be performed using the intrusive or direct connection method, where appropriate, see EN 61000-4-6 [12]. The test method may be the current clamp injection method in accordance with EN 61000-4-6 [12]. Narrowband responses (spurious responses) found during testing shall be disregarded in the measurement (see subclause 6.2.3). NOTE 2: The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz.					

9.7 Immunity of the DC power port (vehicle supply)

These tests shall be performed on 12 V and 24 V DC power input ports of ancillary and/or radio communications equipment intended for vehicular use.

9.7.1 Definition

These tests assess the ability of ancillary and/or radio communications equipment to operate as intended in the event of transients and surges present on the DC power input ports in a vehicular environment.

9.7.2 Method of measurement

The test method shall be in accordance with ISO 7637-1 [4] applicable to 12 V DC operated EUTs and ISO 7637-2 [5] applicable to 24 V DC operated EUTs except that the following requirements and evaluation of test results shall apply.

EUTs designed to operate at both 12 V DC and 24 V DC without component change, module change or adjustment shall be tested according to subclause 9.7.5 and in addition, the pulse 4 test of subclause 9.7.4 table 15 shall be performed.

EUTs designed to operate at both 12 V DC and 24 V DC but with component change, module change or adjustment shall be tested according to subclauses 9.7.4 and 9.7.5.

9.7.3 Performance criteria

Performance criteria B shall apply.

9.7.4 Immunity levels: 12 V DC powered equipment

Where the EUT is intended to be directly connected to the 12 V main vehicle battery, the pulses in table 15 shall apply.

Table 15: 12 V equipment directly powered from main battery, test levels

ISO 7637-1 [4] Pulse	level	Pulse qty	characteristics	test time
3a	II			5 minutes
3b	II			5 minutes
4	II	5	Vs = -5 V Va = -2,5 V t6 = 25 ms t8 = 5 s t = 5 ms	

Where the EUT does not require a direct connection to the 12 V main vehicle battery, the pulses in table 16 shall apply, in addition to the pulses in table 15.

Table 16: 12 V equipment, extra tests where direct connection to main vehicle battery is not required

ISO 7637-1 [4] Pulse	Level	Pulse qty	characteristics
1	II	10	t1 = 2,5 s
2	II	10	t1 = 2,5 s

Where the pulses in table 16 are not applied because the manufacturer declares that the equipment requires direct connection to the vehicle battery, this shall be recorded in the test report.

9.7.5 Immunity levels: 24 V DC powered equipment

Where the EUT is intended to be directly connected to the 24 V main vehicle battery, the pulses in table 17 shall apply:

Table 17: 24 V equipment directly powered from main battery, test levels

ISO 7637-2 [5] Pulse	level	Pulse qty	characteristics	test time
3a	II			5 minutes
3b	II			5 minutes
4	II	5	Vs = -10 V Va = -5 V t6 = 25 ms t8 = 5 s tf = 5 ms	

Where the EUT does not require a direct connection to the 24 V main vehicle battery, the pulses in table 18 shall apply, in addition to the pulses in table 17.

Table 18: 24 V equipment, extra tests where direct connection to main vehicle battery is not required

ISO 7637-2 [5] Pulse	Level	Pulse qty	characteristics
1a	II	10	t1 = 2,5 s Ri = 25 Ω
1b	II	10	t1 = 2,5 s Ri = 100 Ω
2	II	10	t1 = 2,5 s

Where the pulses in table 18 are not applied because the manufacturer declares that the equipment requires direct connection to the vehicle battery, this shall be recorded in the test report.

9.8 Immunity of the DC power port (non-vehicle supply)

Table 19: Test levels and performance criteria

Phenomena	Units	Test Levels	Basic Standard	Performance Criteria	Remarks
Conducted RF Common Mode	MHz V (RMS unmod emf) % AM	0,15 to 80 3 80	EN 61000-4-6 [12]	A (inside the receiver frequency exclusion band, 'B' applies)	(notes 1, 2 and 4)
Fast Transients Common Mode	kV peak Tr/Th ns Rep frequency kHz	0,5 5/50 5	EN 61000-4-4 [10]	B	(note 2)
Surges Common Mode (Line to Ground)	kV Tr/Th µs	1,0 1,2/50	EN 61000-4-5 [11]	B	(note 3)

NOTE 1: This test should be performed using the intrusive or direct connection method, where appropriate, see EN 61000-4-6 [12]. The test method may be the current clamp injection method in accordance with EN 61000-4-6 [12]. Narrowband responses (spurious responses) found during testing shall be disregarded in the measurement (see subclause 6.2.3).
NOTE 2: Applicable to all input ports, and to output ports interfacing with cables whose total length may exceed 3 m.
NOTE 3: Applicable only to input ports whose cable length may exceed 10 m.
NOTE 4: The test signal shall be amplitude modulated to a depth of 80 % by a sinusoidal audio signal of 1 kHz unless this coincides with the wanted audio tone, in which case the modulation shall be at 400 Hz.

10 Measurement uncertainty

For parameters addressed in ETR 028 [19], the test report shall contain a declaration of the actual measurement uncertainty associated with the measurements.

Annex A (normative): Clauses and/or subclauses of the present document relevant for compliance with the essential requirements of EC Council Directives

Table A.1: Clauses and/or subclauses of the present document relevant for compliance with the essential requirements of EC Council Directives

Clause/ subclause Number	Title	Corresponding Article of Council Directive 89/336/EEC	Qualifying Remarks
8	Methods of measurement and limits for EMC emissions		
8.1	Emissions from the AC mains power input/output port	4(a)	
8.2	Emissions from the DC power input/output port	4(a)	
8.3	Emissions from the enclosure port of stand alone ancillary equipment	4(a)	
8.4	Emissions from the enclosure port of non-integral antenna equipment, and antenna input/output port of integral antenna equipment	4(a)	
8.5	Emissions from the antenna input/output port (spurious emissions) of non-integral antenna equipment	4(a)	
9	Test methods and levels for EMC immunity		
9.1	Immunity of antenna port and enclosure port of integral antenna radio equipment	4(b)	
9.2	Immunity of antenna port of non-integral antenna radio equipment	4(b)	
9.3	Immunity of the enclosure port of non-integral antenna radio equipment and all classes of ancillary equipment	4(b)	
9.4	Immunity of the AC mains power input/output port	4(b)	
9.5	Immunity of the signal/control input/output port	4(b)	
9.6	Immunity of the telecommunication port	4(b)	
9.7	Immunity of the DC power port (vehicle supply)	4(b)	
9.8	Immunity of the DC power port (non-vehicle supply)	4(b)	

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