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Electromagnetic compatibility requirements and test methods for radio telecommunication terminal equipment

Recommendation ITU-T K.116

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Electromagnetic compatibility requirements and test methods for radio telecommunication terminal equipment

Summary

Recommendation ITU-T K.116 establishes the essential electromagnetic compatibility (EMC) requirements for radio telecommunication terminal equipment and ancillary accessories. This Recommendation specifies the emission and immunity requirements for radio telecommunication terminal equipment and ancillary equipment. It also describes test conditions for emission and immunity testing. Performance assessment and criteria for immunity tests are also specified.

History

Edition	Recommendation	Approval	Study Group	
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Keywords

EMC, radio telecommunication terminal equipment.

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Introduction

Radio telecommunication terminal equipment is developed rapidly and it is necessary to establish the essential electromagnetic compatibility (EMC) requirements for radio terminal equipment to reduce the potential emission issues and interference cases.

The equipment should conform to the requirements laid out in this Recommendation and should be used in its intended electromagnetic (EM) environment in accordance with the manufacturer's instructions:

– it should not generate electromagnetic disturbances at a level which may interfere with the intended operation of other equipment;

– it should have an adequate level of intrinsic immunity to electromagnetic disturbances to operate as intended.

Recommendation ITU-T K.116

Electromagnetic compatibility requirements and test methods for radio telecommunication terminal equipment

1 Scope

This Recommendation defines the essential electromagnetic compatibility (EMC) requirements for radio telecommunication terminal equipment and ancillary accessories; such as mobile terminals, the devices developed under the standards of Bluetooth, and wireless fidelity (Wi-Fi). This Recommendation also describes the test conditions for emission and immunity testing. Methods of measurement and limits for emissions, test methods and levels, performance assessment, and performance criteria for immunity tests are also specified. If there is an ITU-R provision, it takes precedence to this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[IEC CISPR 25] IEC CISPR 25 (2008), *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*.

[IEC CISPR 32] IEC CISPR 32 (2015), *Electromagnetic compatibility of multimedia equipment – Emission requirements*.

[IEC 61000-3-2] IEC 61000-3-2 (2014), *Electromagnetic compatibility (EMC) Part 3-2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*.

[IEC 61000-3-3] IEC 61000-3-3 (2013), *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*.

[IEC 61000-3-11] IEC 61000-3-11 (2000), *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*.

[IEC 61000-3-12] IEC 61000-3-12 (2012), *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase*.

[IEC 61000-4-2] IEC 61000-4-2 (2008), *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*.

[IEC 61000-4-3] IEC 61000-4-3 (2010), *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*.

[IEC 61000-4-4] IEC 61000-4-4 (2012), *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*.

[IEC 61000-4-5] IEC 61000-4-5 (2014), *Electromagnetic compatibility (EMC) – Part 4-5: Testing and Measurement Techniques – Surge Immunity Test*.

[IEC 61000-4-6] IEC 61000-4-6 (2013), *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*.

[IEC 61000-4-11] IEC 61000-4-11 (2004), *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity test*.

[ISO 7637-2] ISO 7637-2 (2004), *Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 ancillary equipment [b-ETSI EN 301 489-1]: Equipment (apparatus), used in connection with a receiver or transmitter.

NOTE – It is considered as an ancillary equipment (apparatus) if:

– the equipment is intended for use in conjunction with a receiver or transmitter to provide additional operational and/or control features to the radio equipment, (e.g., 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 receiver or transmitter; and

– the receiver or transmitter, 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 basic functions).

3.1.2 portable equipment [b-ETSI EN 301 489-1]: Radio and/or ancillary equipment intended for portable (e.g., handheld) operation, powered by its own integral battery.

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 radio telecommunication terminal equipment: The communications equipment (apparatus) at either end of a wireless communications link, used to accomplish the mission of communication.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current

ACK Acknowledgement

AMN Artificial Mains Networks

AN Artificial Network

ARQ Automatic Retransmission request

CDN Coupling and Decoupling Network

DC Direct Current

EM Electromagnetic

EMC Electromagnetic Compatibility

EUT Equipment Under Test

NACK Not Acknowledgement

RF Radio Frequency

Wi-Fi Wireless Fidelity

5 Conventions

None.

6 Test conditions

6.1 General

The equipment shall be tested under normal test conditions according to the relevant product and basic standards or the information accompanying the equipment, which are within the manufacturer's declared range of humidity, temperature and supply voltage. The test conditions shall be recorded in the test report.

The test configuration and mode of operation shall represent the intended use and shall be recorded in the test report.

6.2 Arrangements for test signals

Adequate measures shall be taken to avoid the effect of immunity test signals on both the measuring equipment and the signal sources for the wanted signals located outside the test environment.

6.2.1 Arrangements for test signals at the input of transmitters

The signal source providing the transmitter under test with the modulation signal for the normal test modulation shall be located outside the test environment, unless the transmitter is modulated by its own internal source.

The transmitter shall be modulated with normal test modulation, by an internal or external signal source capable of delivering the normal test modulation.

6.2.2 Arrangements for test signals at the output of transmitters

The measuring equipment for the wanted radio frequency (RF) output signal from the transmitter under test shall be located outside the test environment. For transmitters with an integral antenna, the wanted RF output signal to establish a communication link shall be delivered from the equipment under test (EUT) to an antenna located within the test environment. This antenna shall be connected to the external measuring equipment by a coaxial cable.

For transmitters with a removable antenna, the wanted RF output signal to establish a communication link shall be delivered from the antenna connector to the external measuring equipment by a shielded transmission line, such as a coaxial cable. Adequate measures shall be

taken to minimize the effect of unwanted common mode currents on the external conductor of the transmission line at the point of entry to the transmitter.

The level of the wanted RF output signal in transmit mode of operation shall be set to the maximum rated RF power for the EUT, modulated with the normal test modulation.

The manufacturer may provide a suitable companion receiver that can be used to receive messages or to set up a communication link.

6.2.3 Arrangements for test signals at the input of receivers

The signal source providing the receiver under test with the wanted RF input signal shall be located outside the test environment.

The signal source shall be modulated with normal test modulation.

For receivers with an integral antenna, the wanted RF input signal to establish a communication link shall be presented to the EUT from an antenna located within the test environment. This antenna shall be connected to the external RF signal source by a coaxial cable.

For receivers with a removable antenna, the wanted RF input signal to establish a communication link shall be presented to the antenna connector of the EUT by a shielded transmission line, such as a coaxial cable. The transmission line shall be connected to the external RF signal source. Adequate measures shall be taken to minimize the effect of unwanted common mode currents on the external conductor of the shielded transmission line at the point of entry to the receiver.

The level of the wanted RF input signal shall be set to be approximately 40 dB above the minimum level necessary to achieve a receiver performance which meets the relevant specified performance criteria, measured while the power amplifiers generating the electromagnetic (EM) disturbance are switched on, but without excitation. This increased level of the wanted RF input signal is expected to represent a normal operation signal level and should be sufficient to avoid the road band noise from the power amplifiers generating the EM disturbance from influencing the measurement.

6.2.4 Arrangements for test signals at the output of receivers

The measuring equipment for the output signal from the receiver under test shall be located outside the test environment.

For receivers with an analogue speech output, the audio output from the acoustic transducer should be coupled via an electrically non-conductive acoustic tube to an external audio distortion meter or other appropriate measuring equipment outside of the test environment. Where it is not practical to use an electrically non-conductive acoustic tube, then other means of connecting the receiver output signal to the external audio distortion meter or other measuring equipment shall be provided and recorded in the test report.

For receivers with a non-speech output, the output signal shall be coupled via an electrically non-conductive means to the external measuring equipment outside the test environment (e.g., a camera to read a display). If the receiver has an output connector or port providing the wanted output signal, then this port shall be used via a cable, consistent with the standard cable used in normal operation, connected to the external measuring equipment outside the test environment.

The measuring equipment may be supplied by the manufacturer.

Precautions shall be taken to ensure that any effect on the test due to the coupling means is minimized.

6.2.5 Arrangements for testing transmitter and receiver together (as a system)

Transmitters and receivers may be tested for immunity as a system when combined as a transceiver or the combined equipment is of a size which allows simultaneous testing. In this case, the

transceiver or transmitter and receiver shall be located inside the test environment and shall be exposed simultaneously to the immunity test signals.

For transceivers or transmitters and receivers operating at the same frequency, the wanted output signal of the transmitter may be used via a suitable attenuator and applied to the input of the receiver as the wanted input signal.

The manufacturer may provide a suitable companion transceiver or transmitter and receiver that can be used to send and receive messages or to set up a communication link. Both the EUT and the companion equipment shall transmit the normal test modulation. Further, the output of the radio EUT shall be monitored by the test system.

6.3 RF exclusion band of radio communications equipment

The RF exclusion band applies to radio equipment with an operating frequency up to 2.7 GHz, or for equipment operating above 2.7 GHz, but whose RF bandwidth extends to a frequency below 2.7 GHz.

For equipment operating at frequencies above 2.7 GHz and whose RF bandwidth does not extend to a frequency below 2.7 GHz, there is no exclusion band.

This exclusion band is always product dependent. The frequencies on which the transmitter part of the EUT is intended to operate shall be excluded from radiated emission measurements when performed in transmit mode of operation.

There shall be no frequency exclusion band applied to emission measurements of the receiver part of transceivers or the stand alone receiver under test, and/or associated ancillary equipment.

The exclusion band for immunity testing shall be calculated as follows:

- lower limit of exclusion band = lowest allocated band edge frequency −5%;
- upper limit of exclusion band = highest allocated band edge frequency +5%.

Using the 2,450 MHz band as an example:

- lower limit of exclusion band = 2 400 – 120 = 2 280 MHz;
- upper limit of exclusion band = 2 483.5 + 124.175 = 2 607.675 MHz;
- thus the exclusion band for 2.45 GHz equipment falling within the scope of this Recommendation extends from 2 280 MHz to 2 607.675 MHz.

6.4 Narrow band responses of receivers or receivers which are part of transceivers

Responses on receivers or the receiver part of (duplex) transceivers occurring during the immunity tests at discrete frequencies which are narrow band responses (spurious responses), are identified by the following method.

If during the test the immunity RF test signal (see clauses 11.2 and 11.5) causes non-compliance of the receiver with the specified performance criteria (see clause 6), it is necessary to establish whether this non-compliance is due to a narrow band response or a wideband phenomenon. Therefore, the frequency of the test signal is increased by an amount equal to twice the nominal 6 dB bandwidth of the IF filter immediately preceding the demodulator of the receiver, or if appropriate, the bandwidth over which the apparatus is intended to operate, as declared by the manufacturer. The test is repeated with the frequency of the test signal decreased by the same amount.

If the receiver is then in either or both frequency offset cases in compliance with the specified performance criteria, the response is considered as a narrow band response.

If the receiver still does not comply with the specified performance criteria, this may be due to the fact that the offset has made the frequency of the unwanted signal correspond to the frequency of

another narrow band response. Under these circumstances the procedure is repeated with an increase and decrease of the frequency of the test signal adjusted two and a half times the bandwidth referred to above.

If the receiver still does not comply with the specified performance criteria in either or both frequency offset cases, the phenomena is considered wide band and therefore an EMC problem and the equipment fails the test.

For immunity tests, narrow band responses shall be disregarded.

6.5 Normal test modulation

For the purpose of EMC tests, the transmitter under test shall be modulated according to the normal test modulation specified in the relevant product standard dealing with the particular type of radio equipment.

For the purpose of EMC tests, the receiver under test shall be provided with a wanted RF input signal modulated according to the normal test modulation specified in the relevant product standard dealing with the particular type of radio equipment.

The modulated test signal shall represent normal intended use, and may contain data formatting, error detection and correction information.

7 Performance assessment

7.1 General

The manufacturer shall, at the time of submission of the equipment for test, supply the following information to be recorded in the test report:

- the primary functions of the radio terminal equipment to be assessed during and after the EM stress;
- the intended functions of the radio terminal equipment which shall be in accordance with the documentation accompanying the equipment;
- the user control functions and stored data that are required for normal operation and the method to be used to assess whether these have been lost after the EM stress;
- the type of modulation, the characteristics of the transmission used for testing (random bit stream, message format, etc.), and the necessary test equipment delivered to enable the assessment of the EUT;
- the ancillary equipment to be combined with the radio terminal equipment for testing (where applicable);
- an exhaustive list of ports, with the maximum cable lengths allowed, classified as either power or telecommunication/signal/control. Power ports shall further be classified as alternating current (AC) or direct current (DC) power;
- the bandwidth of the IF filter immediately preceding the demodulator;
- the method to be used to verify that a communication link is established and maintained (if appropriate);
- the operating frequency bands over which the equipment is intended to operate;
- any equipment thermal limitation which prevent continuous testing of the EUT;
- the environment(s) in which the equipment is intended to be used.
- test conditions (clause 6);
- performance assessment (clause 7);
- performance criteria (clause 8).

The following information should be included, if applicable for the equipment for test:

- the operating frequency range(s) of the equipment and, where applicable, band(s) of operation;
- the type of the equipment, for example: standalone or plug-in radio terminal device;
- the host equipment to be combined with the radio terminal equipment for testing;
- the minimum performance level under the application of EM stress (see Table 1);
- the normal test modulation, the format, the type of error correction and any control signals e.g., acknowledgement (ACK)/not acknowledgement (NACK), or automatic retransmission request (ARQ).

7.2 Equipment which can provide a continuous communication link

For radio equipment of non-specialized nature or for radio equipment tested in combination with ancillary equipment, the normal test modulation, test arrangements, etc., shall apply.

7.3 Equipment which does not provide a continuous communication link

For radio equipment which does not provide a continuous communication link and/or ancillary equipment intended to be tested on a standalone basis, the manufacturer shall specify the permissible minimum level of performance or degradation of performance during and/or after the EM stress.

The manufacturer shall furthermore define the test method(s) for the assessment of the actual level of performance or degradation of performance during and/or after the EM stress. Under these circumstances the manufacturer shall additionally provide the following information also for inclusion in the test report:

- the primary functions of the relevant type of EUT during and after EM stress;
- the intended functions of the relevant type of EUT which shall be in accordance with the documentation accompanying the equipment;
- suitable pass/fail criteria for the relevant type of EUT;
- the method of monitoring the actual level of performance and/or the actual degradation of performance of the EUT.

The assessment of the actual performance or its degradation which is carried out during and/or after the EM stress, shall be simple, but at the same time give adequate proof that the primary functions of the equipment are operational.

7.4 Ancillary equipment

At the manufacturer's discretion, ancillary equipment may be tested and assessed:

- applying the provisions of this Recommendation:
  - separately to the ancillary equipment; or
  - to the combination of ancillary and radio equipment;
- applying another appropriate EMC recommendation or standard.

In each case, compliance enables the ancillary equipment to be used with different receivers, transmitters or transceivers.

7.5 Equipment classification

For the purpose of the EMC performance assessment in this Recommendation, the radio terminal equipment and/or associated ancillary EUT shall be classified into one of the following three classes:

- equipment for fixed use (e.g., mobile terminal connected with the AC/DC charger); or
- equipment for vehicular use (e.g., mobile terminal connected with vehicular charger); or
- equipment for portable use (powered by its own integral battery, e.g., Bluetooth earphone).

This classification determines the extent of applicable EMC tests. However, the following instructions shall also apply to multiple use radio and/or ancillary equipment:

- radio and/or ancillary equipment for portable use or combinations thereof declared as capable of being powered for intended use by the main battery of a vehicle shall additionally be considered as equipment for vehicular use;
- radio and/or ancillary equipment for portable or vehicular use or combinations thereof declared as capable of being powered for intended use by an AC mains or DC network shall additionally be considered as equipment for fixed use.

Subsequently, for multiple use radio and/or ancillary equipment, more than one set of equipment test requirements listed in Tables 2 and 3 has to be taken into account.

Additionally, radio equipment when integrated within a host equipment shall meet the requirements of this Recommendation. The arrangements for the performance assessment of host dependant equipment and plug-in cards are within Annex A.

8 Performance criteria

The performance criteria are:

- performance criteria A for immunity tests with phenomena of a continuous nature;
- performance criteria B for immunity tests with phenomena of a transient nature;
- performance criteria C for immunity tests with power interruptions exceeding a certain time.

The equipment shall meet the minimum performance criteria as specified in the following clauses.

Table 1 – Performance criteria

Criteria	During test	After test
A	Shall operate as intended. May show degradation of performance (Note 1). Shall be no loss of function. Shall be no unintentional transmissions.	Shall operate as intended. Shall be no degradation of performance (Note 2). Shall be no loss of function. Shall be no loss of stored data or user programmable functions.
B	May show loss of function (one or more). May show degradation of performance (Note 1). No unintentional transmissions.	Functions shall be self-recoverable. Shall operate as intended after recovering. Shall be no degradation of performance (Note 2). Shall be no loss of stored data or user programmable functions.
C	May be loss of function (one or more).	Functions shall be recoverable by the operator. Shall operate as intended after recovering. Shall be no degradation of performance (Note 2).

Table 1 – Performance criteria

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.

If an equipment is of such nature, that the performance criteria described in the following clauses are not appropriate, then the manufacturer shall declare, for inclusion in the test report, its own specification for an acceptable level of performance or degradation of performance during and/or after testing, as required by this Recommendation.

The performance criteria specified by the manufacturer shall give the same degree of immunity protection as called for in the following clauses.

8.1 Performance criteria for continuous phenomena

The performance criteria A shall apply.

Tests shall be repeated with the EUT in standby mode (if applicable) to ensure that unintentional transmission does not occur.

Where the EUT is a transceiver, under no circumstances shall the transmitter operate unintentionally during the test.

In systems using acknowledgement signals, it is recognized that an ACK or NACK transmission may occur, and steps should be taken to ensure that any transmission resulting from the application of the test is correctly interpreted.

8.2 Performance criteria for transient phenomena

The performance criteria B shall apply, except for voltage dips of 100 ms and voltage interruptions of 5000 ms duration, for which performance criteria C shall apply.

Tests shall be repeated with the EUT in standby mode (if applicable) to ensure that unintentional transmission does not occur.

Where the EUT is a transceiver, under no circumstances, shall the transmitter operate unintentionally during the test.

In systems using acknowledgement signals, it is recognized that an ACK or NACK transmission may occur, and steps should be taken to ensure that any transmission resulting from the application of the test is correctly interpreted.

8.3 Performance criteria for ancillary equipment tested on a standalone basis

If ancillary equipment is intended to be tested on a standalone basis, then the performance criteria described in clauses 8.1 and 8.2 are not appropriate and the manufacturer shall declare, for inclusion in the test report, his own specification for an acceptable level of performance or degradation of performance during and/or after the immunity tests. The performance specification shall be included in the product description and documentation. The related specifications set out in clause 7.3 also have to be taken into account.

The performance criteria specified by the manufacturer shall give the same degree of immunity protection as called for in clauses 8.1 and 8.2.

9 Applicability overview tables

The applicability overview (Tables 2 and 3) gives a comprehensive overview about all EMC tests specified in this Recommendation for radio and/or associated ancillary equipment.

The applicability of EMC tests specified in this Recommendation depends on the actual type of radio and/or associated ancillary EUT. All tests are port-related EMC tests.

9.1 Emission

Table 2 – Emission applicability

Phenomenon	Application	Equipment test requirement			Reference clause in this Recommendation	Reference standard
		Radio and ancillary equipment for fixed use	Radio and ancillary equipment for vehicular use (connected to vehicular DC supplies)	Radio and ancillary equipment for portable use (powered by integral battery)		
Radiated emission	Enclosure of ancillary equipment	applicable for standalone testing	applicable for standalone testing	applicable for standalone testing	10.2	IEC CISPR 32
Conducted emission	DC power input/output port	applicable	applicable	not applicable	10.3	IEC CISPR 32
Conducted emission	AC mains input/output port	applicable	not applicable	not applicable	10.4	IEC CISPR 32
Harmonic current emissions	AC mains input port	applicable	not applicable	not applicable	10.5	IEC 61000-3-2
Voltage fluctuations and flicker	AC mains input port	applicable	not applicable	not applicable	10.6	IEC 61000-3-3
Conducted emission	Telecommunication port	applicable	not applicable	not applicable	10.7	IEC CISPR 32

9.2 Immunity

Table 3 – Immunity applicability

Phenomenon	Application	Equipment test requirement			Reference clause in this Recommendation	Reference standard
		Radio and ancillary equipment for fixed use	Radio and ancillary equipment for vehicular use (connected to vehicular DC supplies)	Radio and ancillary equipment for portable use (powered by integral battery)		
RF electro-magnetic field (80 MHz to 1 000 MHz and 1 400 MHz to 2 700 MHz)	Enclosure	applicable	applicable	applicable	11.2	IEC 61000-4-3
Electrostatic discharge	Enclosure	applicable	applicable	applicable	11.3	IEC 61000-4-2
Fast transients common mode	Signal, telecommunication and control ports, DC and AC power input ports	applicable	not applicable	not applicable	11.4	IEC 61000-4-4
RF common mode 0.15 MHz to 80 MHz	Signal, telecommunication and control ports, DC and AC power input ports	applicable	applicable	not applicable	11.5	IEC 61000-4-6
Transients and surges, vehicular environment	DC power input ports	not applicable	applicable	not applicable	11.6	ISO 7637-2
Voltage dips and interruptions	AC mains power input ports	applicable	not applicable	not applicable	11.7	IEC 61000-4-11
Surges, common and differential mode	AC power input ports, telecommunication ports	applicable	not applicable	not applicable	11.8	IEC 61000-4-5

10 Methods of measurement and limits for EMC emissions

10.1 Test configurations

This clause defines the configurations for emission tests as follows:

– measurements shall be made in the operational mode producing the largest emission in the frequency band being investigated consistent with normal applications;

– the equipment shall be tested under normal test conditions;

– the test configuration shall be as close to normal/typical intended use as possible;

– where radio equipment is provided with an integral antenna, it shall be tested with the antenna fitted in a manner typical of normal intended use, unless declared as a removable antenna;
– if the equipment is part of a system, or can be connected to ancillary equipment, then it shall be acceptable to test the equipment while connected to the minimum configuration of ancillary equipment necessary to exercise the ports;
– if the equipment has a large number of ports, then a sufficient number shall be selected to simulate actual operation conditions and to ensure that all the different types of termination are covered;
– the test conditions, test configuration and mode of operation shall be recorded in the test report;
– ports which in normal operation are connected shall be connected to an ancillary equipment or to a representative piece of cable correctly terminated to simulate the input/output characteristics of the ancillary equipment, RF input/output ports shall be correctly terminated;
– ports that are not connected to cables during normal operation, (e.g., service connectors, programming connectors, 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 or extension of these cables.

10.2 Radiated emission

This test is only applicable to ancillary equipment not incorporated in the radio terminal equipment and intended to be measured on a stand-alone basis, as declared by the manufacturer.

This test shall be performed on a representative configuration of the ancillary equipment.

10.2.1 Definition

This test assesses the ability of ancillary equipment to limit their unwanted emissions from being radiated from the enclosure.

10.2.2 Test method

The radiated emission test method should be in accordance with [IEC CISPR 32].

10.2.3 Limits

The ancillary equipment should meet the class B limits given in [IEC CISPR 32].

10.3 Conducted emission DC power input/output port

This test is applicable for radio equipment and ancillary equipment for fixed use that may have DC cables longer than 3 m (see clause 7.1 – manufacturer's declaration) and for vehicular use irrespective of cable length.

If the DC power cable of the radio and/or the ancillary equipment is less than or equal to 3 m in length, and intended only for direct connection to a dedicated AC to DC power supply, then the measurement shall be performed only on the AC power input of that power supply as specified in clause 10.4. If the DC power cable is longer than 3 m, then the measurement shall additionally be performed on the DC power port of the radio and/or ancillary equipment.

If the DC power cable between the mobile radio and/or ancillary equipment and the dedicated DC/DC power converter is less than or equal to 3 m in length, then the measurement can be limited to the DC power input port of that power converter only. If this DC power cable is longer than 3 m,

then the measurement shall additionally be performed on the DC power port of the mobile radio and/or ancillary equipment.

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

10.3.1 Definition

This test assesses the ability of the EUT to limit its internal noise from being present on the DC power input/output ports.

10.3.2 Test method

The test method shall be in accordance with [IEC CISPR 32], for radio and ancillary equipment for fixed use, the artificial mains networks (AMN) as specified in [IEC CISPR 32] shall be used and be connected to a DC power source. For mobile radio and ancillary equipment intended to be connected to the vehicle's onboard DC mains, an artificial network (AN) as specified in [IEC CISPR 25] shall be used and be connected to a DC power source.

The measurement frequency range extends from 150 kHz to 30 MHz. When the EUT is a transmitter operating at frequencies below 30 MHz, then the exclusion band for transmitters applies (see clause 6.3) for measurements in the transmit mode of operation.

In the case of emission measurement on DC output ports, the relevant port shall be connected via an AMN/AN to a load drawing the rated current of the source.

10.3.3 Limits

The equipment shall meet the limits defined in Table 4 including the average limit and the quasi-peak limit when using, respectively, an average detector receiver and a quasi-peak detector receiver and measured in accordance with the method described in clause 10.3.2 above. If the average limit is met when using a quasi-peak detector, the equipment shall be deemed to meet both limits and measurement with the average detector receiver is not necessary.

Table 4 – Limits for conducted emissions

Frequency range	Quasi-peak	Average
0.15 – 0.5 MHz	66 to 56 dBµV	56 to 46 dBµV
> 0.5 – 5 MHz	56 dBµV	46 dBµV
> 5 – 30 MHz	60 dBµV	50 dBµV
NOTE – The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz.		

10.4 Conducted emissions AC mains power input/output port

This test is applicable for radio equipment and/or ancillary equipment for fixed use powered by the AC mains.

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

10.4.1 Definition

This test assesses the ability of the EUT to limit its internal noise from being present on the AC mains power input/output ports.

10.4.2 Test method

The test method shall be in accordance with [IEC CISPR 32] and the AMNs shall be connected to the AC mains power source.

The measurement frequency range extends from 150 kHz to 30 MHz. When the EUT is a transmitter operating at frequencies below 30 MHz, then the exclusion band for transmitters applies (see clause 6.3) for measurements in the transmit mode of operation.

For emission measurements on AC output ports of the EUT, the relevant port shall be connected via an AMN to a load drawing the rated current of the source. In the case where the AC output port is directly connected (or via a circuit breaker) to the AC power input port of the EUT, the AC power output port need not to be tested.

10.4.3 Limits

The equipment shall meet the limits below including the average limit and the quasi-peak limit when using, respectively, an average detector receiver and a quasi-peak detector receiver and measured in accordance with the method described in clause 10.4.2 above. If the average limit is met when using a quasi-peak detector, the equipment shall be deemed to meet both limits, and measurement with the average detector receiver is not necessary.

The equipment shall meet the class B limits given in [IEC CISPR 32].

10.5 Harmonic current emissions (AC mains input port)

The appropriate requirements of [IEC 61000-3-2] for harmonic current emission apply for equipment covered by the scope of this Recommendation with an input current up and including 16 A per phase. For equipment with an input current greater than 16 A per phase, [IEC 61000-3-12] applies.

10.6 Voltage fluctuations and flicker (AC mains input port)

The appropriate requirements of [IEC 61000-3-3] for voltage fluctuations and flicker apply for equipment covered by the scope of this Recommendation with an input current up to and including 16 A per phase. For equipment with an input current of greater than 16 A per phase, [IEC 61000-3-11] applies.

10.7 Telecommunication ports

This test is applicable for radio equipment and/or ancillary equipment for fixed use which have telecommunication ports.

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

10.7.1 Definition

This test assesses the EUT unwanted emission present at the telecommunication ports.

10.7.2 Test method

The test method shall be in accordance with [IEC CISPR 32].

The measurement frequency range extends from 150 kHz to 30 MHz. When the EUT is a transmitter operating at frequencies below 30 MHz, then the exclusion band for transmitters applies (see clause 6.3) for measurements in the transmit mode of operation.

10.7.3 Limits

The telecommunication ports shall meet the class B limits given in [IEC CISPR 32].

11 Test methods and levels for immunity tests

11.1 Test configurations

This clause defines the configurations for immunity tests as follows:

– the radio equipment shall be tested under normal test conditions;

– the test configuration shall be as close to normal intended use as possible;

– if the equipment is part of a system, or can be connected to ancillary equipment, then it shall be acceptable to test the equipment while connected to the minimum configuration of ancillary equipment necessary to exercise the ports;

– where radio equipment is provided with an integral antenna, it shall be tested with the antenna fitted in a manner typical of normal intended use, unless declared as a removable antenna;

– for the immunity tests of ancillary equipment, without a separate pass/fail criteria, the receiver or transmitter coupled to the ancillary equipment, shall be used to judge whether the ancillary equipment passes or fails;

– if the equipment has a large number of ports, then a sufficient number shall be selected to simulate actual operation conditions and to ensure that all the different types of termination are tested;

– the test conditions, test configuration and mode of operation shall be recorded in the test report;

– ports which in normal operation are connected shall be connected to an ancillary equipment or to a representative piece of cable correctly terminated to simulate the input/output characteristics of the ancillary equipment, RF input/output ports shall be correctly terminated;

– ports which are not connected to cables during normal operation, (e.g., service connectors, programming connectors, 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 or extension of these cables.

11.2 RF electromagnetic field (80 MHz to 1 000 MHz and 1 400 MHz to 2 700 MHz)

This test is applicable for radio equipment and associated ancillary equipment.

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

11.2.1 Definition

This test assesses the ability of EUT to operate as intended in the presence of an RF EM field disturbance at the enclosure.

11.2.2 Test method and level

The test method shall be in accordance with [IEC 61000-4-3].

The following requirements and evaluation of test results shall apply:

– the test level shall be 3 V/m (measured unmodulated). The test signal shall be amplitude modulated to a depth of 80% by a sinusoidal audio signal of 1 kHz. If the wanted signal is modulated at 1000 Hz, then an audio signal of 400 Hz shall be used;

– for receivers and transmitters the stepped frequency increments shall be 1% frequency increment of the momentary used frequency;
– the test shall be performed over the frequency range 80 MHz to 1 000 MHz and 1 400 MHz to 2 700 MHz with the exception of the exclusion band for transmitters, receivers and duplex transceivers (see clause 6), as appropriate;
– responses on receivers occurring at discrete frequencies, which are narrow band responses, shall be disregarded from the test (see clause 6);
– the frequencies selected and used during the test shall be recorded in the test report.

11.2.3 Performance criteria

For transmitters, the performance criteria for continuous phenomena for transmitters shall apply (see clause 8.1). For receivers, the performance criteria for continuous phenomena for receivers shall apply (see clause 8.1).

For ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter in which case the corresponding performance criteria above shall apply.

11.3 Electrostatic discharge

This test is applicable for radio equipment and associated ancillary equipment.

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

11.3.1 Definition

This test assesses the ability of the EUT to operate as intended in the event of an electrostatic discharge.

11.3.2 Test method and level

The test method shall be in accordance with [IEC 61000-4-2].

For radio equipment and ancillary equipment, the following requirements and evaluation of test results shall apply.

The test severity level for contact discharge shall be 4 kV and for air discharge 8 kV. All other details, including intermediate test levels, are contained within [IEC 61000-4-2].

Electrostatic discharges shall be applied to all exposed surfaces of the EUT except where the user documentation specifically indicates a requirement for appropriate protective measures (see [IEC 61000-4-2]).

11.3.3 Performance criteria

For transmitters, the performance criteria for transient phenomena for transmitters shall apply (see clause 8.2). For receivers, the performance criteria for continuous phenomena for receivers shall apply (see clause 8.2).

For ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter in which case the corresponding performance criteria above shall apply.

11.4 Fast transients common mode

The test shall be performed on AC mains power input port (if any) of radio equipment and associated ancillary equipment.

This test shall be additionally performed on signal ports, telecommunication ports, control ports, and DC power ports, of radio and associated equipment, if the cables may be longer than 3 m.

Where this test is not carried out on any port because the manufacturer declares that it is not intended to be used with cables longer than 3 m, a list of ports, which were not tested for this reason shall be included in the test report.

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

11.4.1 Definition

This test assesses the ability of EUT to operate as intended in the event of fast transients present on one of the input/output ports.

11.4.2 Test method and level

The test method shall be in accordance with [IEC 61000-4-4]. The following requirements and evaluation of test results shall apply:

– the test level for signal ports, telecommunication ports, and control ports shall be 0.5 kV open circuit voltage at a repetition rate of 5 kHz as given in [IEC 61000-4-4];

– the test level for DC power input ports shall be 0.5 kV open circuit voltage as given in [IEC 61000-4-4];

– the test level for AC mains power input ports shall be 1 kV open circuit voltage as given in [IEC 61000-4-4].

11.4.3 Performance criteria

For transmitters, the performance criteria for transient phenomena for transmitters shall apply (see clause 8.2). For receivers, the performance criteria for continuous phenomena for receivers shall apply (see clause 8.2).

For ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter in which case the corresponding performance criteria above shall apply.

11.5 Radio frequency, common mode

This test shall be performed on the AC mains power port (if any) of radio equipment and ancillary equipment.

This test shall be additionally performed on signal ports, telecommunication ports, control ports, and DC power ports, which may have cables longer than 3 m.

Where this test is not carried out on any port because the manufacturer declares that it is not intended to be used with cables longer than 3 m, a list of ports, which were not tested for this reason, shall be included in the test report.

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

11.5.1 Definition

This test assesses the ability of the EUT to operate as intended in the presence of a RF EM disturbance on the input/output ports.

11.5.2 Test method and level

The test method shall be in accordance with [IEC 61000-4-6].

The following requirements and evaluation of test results shall apply:

– the test level shall be severity level 2 as given in [IEC 61000-4-6] corresponding to 3 V rms unmodulated. The test signal shall then be amplitude modulated to a depth of 80% by a sinusoidal audio signal of 1 000 Hz, If the wanted signal is modulated at 1 000 Hz, then the test signal of 400 Hz shall be used;

– the test shall be performed over the frequency range 150 kHz – 80 MHz with the exception of an exclusion band for transmitters, and for receivers and duplex transceivers (see clause 6);

– for receivers and transmitters the stepped frequency increments shall be 1% frequency increment of the momentary frequency in the frequency range 150 kHz – 80 MHz;

– the injection method to be used shall be selected according to [IEC 61000-4-6];

– responses on receivers or receiver parts of transceivers occurring at discrete frequencies which are narrow band responses (spurious responses), are disregarded from the test, (see clause 7);

– the frequencies selected during the test and the test method used shall be recorded in the test report.

11.5.3 Performance criteria

For transmitters, the performance criteria for continuous phenomena for transmitters shall apply (see clause 8.1). For receivers, the performance criteria for continuous phenomena for receivers shall apply (see clause 8.1).

For ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter, in which case the corresponding performance criteria above shall apply.

11.6 Transients and surges, vehicular environment

The tests are applicable to radio and ancillary equipment intended for vehicular use.

These tests shall be performed on nominal 12 V and 24 V DC power input ports of mobile radio and ancillary equipment, which are also intended for mobile use in vehicles.

These tests shall be performed on a representative configuration of the mobile radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

11.6.1 Definition

These tests assess the ability of EUT to operate as intended in the event of transients and surges present on their DC power input ports in a vehicular environment.

11.6.2 Test method and level

The test method shall be in accordance with [ISO 7637-2] for 12 V DC and 24 V DC powered equipment.

11.6.2.1 Test requirements for 12 V and 24 V DC powered equipment

The test method shall be in accordance with [ISO 7637-2], applying pulses 1, 2a, 2b, 3a, 3b, and 4, using immunity test level III. For the purpose of EMC testing, it is sufficient to apply pulses 1, 2a, 2b and 4, 10 times each, and apply the test pulses 3a and 3b for 20 minutes each.

11.6.3 Performance criteria

For transmitters, pulse 3a and 3b the performance criteria for continuous phenomena for transmitters shall apply (see clause 8.1). For pulse 1, 1a, 1b, 2 and 4 the performance criteria for

transient phenomena for transmitters shall apply (see clause 8.2), with the exception that a communications link need not be maintained during the EM stress and may have to be re-established.

For receivers, pulse 3a and 3b the performance criteria for continuous phenomena for receivers shall apply (see clause 8.1). For pulse 1, 1a, 1b, 2 and 4 the performance criteria for transient phenomena for receivers shall apply (see clause 8.2), with the exception that a communications link need not be maintained during the EM stress and may have to be re-established.

For ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter in which case the corresponding performance criteria above shall apply.

11.7 Voltage dips and interruptions

The tests shall be performed on AC mains power input port (if any) of radio equipment and associated ancillary equipment.

These tests shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

11.7.1 Definition

These tests assess the ability of the EUT to operate as intended in the event of voltage dips and interruptions present on the AC mains power input ports.

11.7.2 Test method and level

The following requirements and evaluation of test results shall apply.

The test method shall be in accordance with [IEC 61000-4-11].

The test levels shall be:

– voltage dip: 0% residual voltage for 0.5 cycle;

– voltage dip: 0% residual voltage for 1 cycle;

– voltage dip: 70% residual voltage for 25 cycles;

– voltage interruption: 0% residual voltage for 250 cycles.

11.7.3 Performance criteria

For a voltage dip, the following performance criteria apply:

– for transmitters, the performance criteria for transient phenomena for transmitters shall apply (see clause 8.2). For receivers the performance criteria for transient phenomena for receivers shall apply (see clause 8.2);

– for ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter, in which case the corresponding performance criteria above shall apply.

For a voltage interruption the following performance criteria apply:

– in the case where the equipment is fitted with or connected to a battery backup, the performance criteria for transient phenomena for transmitters or for receivers shall apply (see clause 8.2);

– in the case where the equipment is powered solely from the AC mains supply (without the use of a parallel battery backup), volatile user data may have been lost and if applicable the

communication link need not be maintained and lost functions should be recoverable by user or operator;

– no unintentional responses shall occur at the end of the test;

– in the event of loss of function(s) or in the event of loss of user stored data, this fact shall be recorded in the test report;

– for ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter in which case the corresponding performance criteria above shall apply.

11.8 Surges

This test shall be performed on AC mains power input port (if any) of radio equipment and associated ancillary equipment.

This test shall be additionally performed on telecommunication ports, if any.

These tests shall be performed on a representative configuration of the radio equipment, the associated ancillary equipment, or a representative configuration of the combination of radio and ancillary equipment.

11.8.1 Definition

These tests assess the ability of the EUT to operate as intended in the event of surges being present on the AC mains power input ports and telecommunication ports.

11.8.2 Test method and level

The test method shall be in accordance with [IEC 61000-4-5].

The requirements and evaluation of test results given in clause 11.8.2.1 (telecommunication ports, outdoor cables), clause 11.8.2.2 (telecommunication ports, indoor cables) and clause 11.8.2.3 (mains ports) shall apply, but no test shall be required where normal functioning cannot be achieved, because of the impact of the coupling and decoupling net (CDN) on the EUT.

11.8.2.1 Test method for telecommunication ports directly connected to outdoor cables

The test level for telecommunications ports, intended to be directly connected to the telecommunications network via outdoor cables, shall be 1 kV line to ground as given in [IEC 61000-4-5]. In this case the total output impedance of the surge generator shall be in accordance with the basic standard [IEC 61000-4-5].

The test generator shall provide the 1.2/50 µs pulse as defined in [IEC 61000-4-5].

11.8.2.2 Test method for telecommunication ports connected to indoor cables

The test level for telecommunications ports, intended to be connected to indoor cables (longer than 10 m) shall be 0.5 kV line to ground. In this case, the total output impedance of the surge generator shall be in accordance with the basic standard [IEC 61000-4-5].

The test generator shall provide the 1.2/50 µs pulse as defined in [IEC 61000-4-5].

11.8.2.3 Test method for mains ports

The test level for AC mains power input ports shall be 2 kV line to ground, and 1 kV line to line, with the output impedance of the surge generator, as given in the [IEC 61000-4-5].

The test generator shall provide the 1.2/50 µs pulse, as defined in [IEC 61000-4-5].

11.8.3 Performance criteria

For transmitters, the performance criteria for transient phenomena for transmitters shall apply (see clause 8.2). For receivers, the performance criteria for transient phenomena for receivers shall apply (see clause 8.1).

For ancillary equipment, the pass/failure criteria supplied by the manufacturer (see clause 8.3) shall apply, unless the ancillary equipment is tested in connection with a receiver or transmitter in which case the corresponding performance criteria above shall apply.

Annex A

Arrangements for the performance assessment of host dependant equipment and plug-in cards

(This annex forms an integral part of this Recommendation.)

For equipment parts for which integration with a host equipment is necessary in order to offer functionality, two alternative approaches defined in clauses 6.2.1 and 6.2.2 may be used. The manufacturer shall declare which alternative shall be used.

A.1 Alternative A: composite equipment

A combination of the radio equipment part and a specific type of host equipment may be used for assessment according to the present document.

Where a specific combination of host equipment and a radio equipment part is tested as a composite system for compliance, repeat testing shall not be required for:

- those other combinations of hosts and radio equipment parts which are based on substantially similar host models in the circumstance that the variations in mechanical and electrical properties between such host models are unlikely to significantly influence the intrinsic immunity and unwanted emissions of the radio equipment part;
- the radio equipment part which cannot be used without mechanical, electrical, or software modification in variations of host equipment different from those represented by the units for which compliance to this Recommendation has been demonstrated.

For all other combinations, each combination shall be tested separately.

A.2 Alternative B: use of a test jig or host

Where the radio equipment part is intended for use with a variety of host systems, the manufacturer shall supply a suitable test configuration consisting of either a host system intended for normal use or a test jig that is representative of the range of host systems in which the device may be used. The test jig shall allow the radio equipment part to be powered and stimulated in a way similar to the way it would be powered and stimulated when connected to or inserted into host equipment.

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