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Radio Equipment and Systems (RES); Short range devices Technical characteristics and test methods for radio equipment to be used in the 25 MHz to 1 000 MHz frequency range with power levels ranging up to 500 mW

ETSI

European Telecommunications Standards Institute

ETSI Secretariat

Postal address: F-06921 Sophia Antipolis CEDEX - FRANCE
Office address: 650 Route des Lucioles - Sophia Antipolis - Valbonne - FRANCE
X.400: c=fr, a=atlas, p=etsi, s=secretariat - **Internet:** secretariat@etsi.fr

Tel.: +33 92 94 42 00 - Fax: +33 93 65 47 16

Contents

Foreword

This Interim European Telecommunication Standard (I-ETS) has been prepared by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI) and having passed through ETSI standards approval procedure, is now published.

This is a general standard based upon CEPT Recommendations T/R 20-03 [1] and T/R 20-04 [2].

All types of modulation for radio devices, except Code Division Multiple Access (CDMA), are covered by this I-ETS.

For regulatory purposes the equipment is divided into four main classes based on frequency range and maximum output power (see table 1), and further divided into classes based on the use inside or outside the Industrial Scientific and Medical (ISM) bands and on the use of the antenna (see table 2).

Table 1

Class	Frequency range MHz	Power level (conducted or radiated) milliWatts (mW)
I	25 to 1 000	10
II	300 to 1 000	25
III	25 to 300	100
IV	300 to 1 000	500

Table 2

Sub-class	Frequency band	Antenna type/connector
a	I.S.M.	Integral
b	Non-I.S.M.	Integral
c	I.S.M.	External socket
d	Non-I.S.M.	External socket

The CEPT Recommendation T/R 01-04 [6] covering Low Power Devices (LPD) is supported by class I.a., from the above tables, see Annex A, Clause A.1.

For non-harmonised parameters, national administrations may impose conditions on the type of modulation, channel/frequency separations, maximum transmitter output power/effective radiated power, equipment marking and the inclusion of an automatic transmitter shut-off facility as a condition of the issue of an individual or general licence, or, as a condition of use under licence exemption. The extreme temperature ranges are fixed and are given in subclause 5.4.1.2.

This I-ETS does not cover requirements for radiated emissions below 25 MHz.

Additional standards or specifications may be required for equipment such as that intended for connection to the Public Switched Telephone Network (PSTN).

Introduction

This I-ETS is intended to specify the minimum performance and the methods of measurement for short range devices as specified in the scope.

When ETSI publishes a standard covering a specific application for short range devices, it will supersede this general standard.

Interference from other services and systems has not been taken into account in this I-ETS.

Included are methods of measurement for equipments fitted with antenna sockets and/or integral antenna. Equipment designed for use with an integral antenna may be supplied with a temporary external/internal or permanent internal 50 ohm connector for the purpose of testing, providing, the characteristics being measured are not expected to be affected.

The performance of the equipment submitted for type testing should be representative of the performance of the corresponding production model. In order to avoid any ambiguity in that assessment, this I-ETS contains instructions for the presentation of equipment for type testing purposes (see subclause 4.1), conditions of testing (see Clause 5).

This I-ETS was drafted on the assumption that:

- "Type test measurements, performed in an accredited test laboratory, shall be accepted by the various National Regulatory Authorities in order to grant type approval, provided the National regulatory requirements are met. In addition national administrations may accept a "certificate of conformity" based on the type test report".

This is in compliance with CEPT Recommendation T/R 71-03 [7].
Clauses 1 and 3 provide a general description on the types of equipment covered by this I-ETS and the definitions and abbreviations used. Clause 4 provides a guide as to the number of samples required in-order that type tests may be carried out, and any markings on the equipment which the applicant should provide.

Clauses 7 and 8 provide the limits of the parameters which are required to be tested. These limits have been chosen to minimise harmful interference to other equipment and services. It also provides details on how the equipment should be tested and the conditions which should be applied.

Clause 9 gives the maximum measurement uncertainty values.

Annex A provides information on specific applications covered by this I-ETS.

Annex B provides specifications concerning radiated measurements.

Annex C contains specifications for adjacent channel power measurement arrangements.

Annex D is a graphic representation of subclause 4.1, referring to the presentation of equipment for testing purposes.

Annex E provides information on the correction curve to be used for pulsed systems.

Annex F provides information on the spectrum analyser specification.

1 Scope

This I-ETS covers the minimum characteristics considered necessary in order to make the best use of the available frequencies.

It does not necessarily include all the characteristics which may be required by a user, nor does it necessarily represent the optimum performance achievable.

It applies to short range devices:

- with an antenna connection and/or with an integral antenna;
- for alarms, telecommand, telemetry, etc., applications;
- with or without speech;
- operating on radio frequencies between 25 MHz and 1 000 MHz, with power levels up to 500 mW, radiated or terminated.

This I-ETS covers fixed stations, mobile stations and portable stations. It applies also to Low Power Devices (LPD), as defined in the CEPT Recommendation T/R 01-04 [6]. In this I-ETS basic requirements are given for the different frequency bands, channel separation etc., where appropriate.

2 Normative references

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

[1] CEPT Recommendation T/R 20-03: "Low power telecommand and telemetry equipment operating on collective frequencies in the ISM frequency bands".

[2] CEPT Recommendation T/R 20-04: "Low power narrow band telecommand and telemetry equipment for use outside the ISM frequency bands".

[3] CCITT Recommendation O.153: "Basic parameters for the measurement of error performance at bit rates below the primary rate".

[4] CISPR Publication 16: "Specifications for radio interference measuring apparatus and measurement methods".

[5] ETR 028: "Radio Equipment and Systems; Uncertainties in the measurement of mobile radio equipment characteristics".

[6] CEPT Recommendation T/R 01-04: "Use of Low Power Devices (LPD) using integral antennas and operating in harmonised frequency bands".

[7] CEPT Recommendation T/R 71-03: "Procedures for type testing and approval for radio equipment intended for non public systems".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purpose of this I-ETS the following definitions apply.

Alarm: the use of radio communication for indicating an alarm condition at a distant location.

Assigned frequency band: the frequency band within which the device is authorised to operate.

Conducted measurements: measurements which are made using a direct 50 ohm connection to the equipment under test.

Fixed station: equipment intended for use in a fixed location.

Full tests: in all cases except where qualified as "limited", tests shall be performed according to this I-ETS.

Integral antenna: an antenna, with or without a connector, designed as an indispensable part of the equipment.

Limited tests: the limited tests, see subclauses 4.1.1 to 4.1.10, are as follows:

- transmitter frequency error, see subclause 7.1;
- transmitter carrier power conducted, see subclause 7.2;
- transmitter effective radiated power, see subclause 7.3;
- transmitter adjacent channel power, see subclause 7.5.

Mobile station: equipment normally fixed in a vehicle.

Portable station: equipment intended to be carried, attached or implanted.

Radiated measurements: measurements which involve the absolute measurement of a radiated field.

Telecommand: the use of radio communication for the transmission of signals to initiate, modify or terminate functions of equipment at a distance.

Telemetry: the use of radio communication for indicating or recording data at a distance.

Wideband: equipment to be used in a non-channelised continuous frequency band covering more than 25 kHz, or to be used in a channelised frequency band with a channel spacing greater than 25 kHz.

3.2 Symbols

For the purposes of this I-ETS the following symbols apply.

E	field strength
NaCl	Sodium chloride
Eo	reference field strength
R	distance
Ro	reference distance
λ	wavelength

3.3 Abbreviations

For the purposes of this I-ETS the following abbreviations apply.

AR1	Alignment Range 1 (see subclauses 4.1.2 and 4.1.3)
AR2	Alignment Range 2 (see subclauses 4.1.2 and 4.1.3)
CDMA	Code Division Multiple Access (spread spectrum)
EMC	Electro-Magnetic Compatibility
ETR	ETSI Technical Report
IF	Intermediate Frequency
ISM	Industrial, Scientific and Medical

NOTE: This I-ETS includes the following designated ISM frequency bands:

- 26,957 MHz - 27,283 MHz;
- 40,660 MHz - 40,700 MHz;
- 433,050 MHz - 434,790 MHz.

RF	Radio Frequency
rms	root-mean-squared
Tx	Transmitter
VSWR	Voltage Standing Wave Ratio

4 General

4.1 Presentation of equipment for testing purposes

Each equipment submitted for type testing shall fulfil the requirements of this standard on all frequencies over which it is intended to operate.

The applicant shall complete the appropriate application form when submitting equipment for type testing.

To simplify and harmonise the type testing procedures between the different test laboratories, measurements shall be performed, according to this I-ETS, on samples of equipment defined in subclauses 4.1.1 to 4.1.12.

The measurements, wherever possible, shall be made by use of a direct connection to the equipment under test (antenna socket or temporary 50 ohm connector) as stated in this I-ETS, in order to ensure that the measurement uncertainties are minimised.

NOTE: These subclauses are intended to give confidence that the requirements set out in this standard have been met without the necessity of performing measurements on all frequencies.

4.1.1 Choice of model for type testing

The applicant shall provide one or more production model(s) of the equipment, as appropriate, for type testing.

If type approval is given on the basis of tests on a preliminary model, the corresponding production models must be identical in all electrical and functional respects with the preliminary model tested.

In the case of portable equipment without an external antenna connector, see subclause 4.1.12.

4.1.2 Definitions of alignment range and switching range

The applicant shall, when submitting equipment for test, state the alignment ranges of the receiver and transmitter.

The alignment range is defined as the frequency range over which the receiver or the transmitter can be programmed and/or realigned to operate, without any physical change to components other than programmable read only memories or crystals (for the receiver or transmitter).

The applicant shall also state the switching range of the receiver and the transmitter (which may differ).

The switching range is the maximum frequency range over which the receiver or the transmitter can be operated without reprogramming or realignment.

4.1.3 Definition of the categories of the alignment range (AR1 and AR2)

The alignment range for the receiver and transmitter, which may be different, falls into one of two categories:

AR1: this corresponds to a limit of less than or equal to 10 % of the highest frequency of the alignment range, which is equal to or less than 500 MHz, or less than or equal to 5 % where the highest alignment frequency is above 500 MHz;

AR2: this corresponds to a limit of greater than 10 % of the highest frequency of the alignment range, which is equal to or less than 500 MHz, or greater than 5 % where the highest alignment frequency is above 500 MHz.

4.1.4 Choice of frequencies

The frequencies for testing shall be chosen by the applicant, in accordance with subclauses 4.1.5 to 4.1.11 and Annex D.

4.1.5 Testing of single frequency equipment of category AR1

Full tests shall be carried out on a frequency within 100 kHz of the centre frequency of the alignment range on one sample of the equipment.

4.1.6 Testing of single frequency equipment of category AR2

Three samples shall be tested. Tests shall be carried out on a total of three frequencies:

- sample one shall be within 100 kHz of the highest frequency of the alignment range;
- sample two shall be within 100 kHz of the lowest frequency of the alignment range;
- sample three shall be within 100 kHz of the centre frequency of the alignment range.

Full tests shall be carried out on all three frequencies.

4.1.7 Testing of two frequencies equipment of category AR1

One sample shall be submitted to enable tests to be carried out on both frequencies.

The upper frequency shall be within 100 kHz of the highest frequency of the switching range. The lower frequency shall be within 100 kHz of the lowest frequency of the switching range. In addition the average of the two frequencies shall be within 100 kHz of the centre frequency of the alignment range.

Full tests shall be carried out on the upper frequency and limited tests on the lower frequency.

4.1.8 Testing of two frequency equipment of category AR2

Three samples of the equipment shall be tested. Tests shall be carried out on a total of four frequencies:

- sample one, two frequencies shall be measured. The highest frequency shall be within 100 kHz of the centre frequency of the alignment range. The upper frequency shall be within 100 kHz of the highest

frequency of the switching range and the lower frequency shall be within 100 kHz of the lowest frequency of the switching range.

Full tests shall be carried out on the upper frequency and limited tests on the lower frequency;

- sample two, the frequency shall be within 100 kHz of the highest frequency of the alignment range.

  Full tests shall be carried out on this frequency;

- sample three, the frequency shall be within 100 kHz of the lowest frequency of the alignment range.

  Full tests shall be carried out on this frequency.

4.1.9 Testing of multi-frequency equipment (more than two frequencies) of category AR1

One sample of the equipment shall be submitted to enable tests to be carried out on three frequencies.

The centre frequency of the switching range shall be within 100 kHz of the centre frequency of the alignment range. The upper frequency shall be within 100 kHz of the highest frequency of the switching range and the lower frequency shall be within 100 kHz of the lowest frequency of the switching range.

Full tests shall be carried out on the centre frequency and limited tests on the upper and lower frequency.

4.1.10 Testing of multi-frequency equipment (more than two frequencies) of category AR2 (switching range less than alignment range)

Three samples of the equipment shall be tested. Tests shall be carried out on a total of five frequencies:

- sample one, three frequencies shall be measured. The centre frequency of the switching range shall be within 100 kHz of the centre frequency of the alignment range. The upper frequency shall be within 100 kHz of the highest frequency of the switching range and the lower frequency shall be within 100 kHz of the lowest frequency of the switching range.

  Full tests shall be carried out on the centre frequency and limited tests on the upper and lower frequency;

- sample two, the frequency shall be within 100 kHz of the highest frequency of the alignment range;

- full tests shall be carried out on this frequency;

- sample three, the frequency shall be within 100 kHz of the lowest frequency of the alignment range.

  Full tests shall be carried out on this frequency.

4.1.11 Testing of multi-frequency equipment (more than two frequencies) of category AR2 (switching range equals the alignment range)

One sample of the equipment shall be submitted to enable tests to be carried out on three frequencies.

The switching range of the sample shall correspond to the alignment range.

The centre frequency shall be within 100 kHz of the centre frequency of the switching range. The upper frequency shall be within 100 kHz of the highest frequency of the switching range and the lower frequency shall be within 100 kHz of the lowest frequency of the switching range.

Full tests shall be carried out on all three frequencies.

4.1.12 Testing of equipment without a permanent external 50 ohm antenna connector

To facilitate relative measurements, use can be made of a test fixture as described in subclause 6.3 or the equipment can be supplied with a permanent internal or temporary internal/external 50 ohm Radio Frequency (RF) connector.

4.1.12.1 Equipment with a permanent internal 50 ohm RF connector

The way to access a permanent internal 50 ohm RF connector shall be stated by the applicant with the aid of a diagram. The fact that use has been made of the permanent internal 50 ohm RF socket shall be recorded in the test report.

4.1.12.2 Equipment with a temporary 50 ohm RF connector

The applicant shall submit two sets of equipment to the test laboratory, one fitted with a temporary 50 ohm RF connector with the antenna disconnected and the other with the antenna connected. Each equipment shall be used for the appropriate tests.

The way the temporary 50 ohm RF connector is implemented shall be stated by the applicant with the aid of a diagram. The fact that use has been made of the temporary 50 ohm RF connector to facilitate measurements shall be stated in the test report. The addition of a temporary 50 ohm connector should not influence the performance of the equipment under test.

4.2 Mechanical and electrical design

4.2.1 General

The equipment submitted by the manufacturer, or his representative, shall be designed, constructed and manufactured in accordance with sound engineering practice, and with the aim of minimising harmful interference to other equipment and services.

Transmitters and receivers may be individual or combination units, but shall operate with the correct power source.

4.2.2 Controls

Those controls which if maladjusted may increase the interfering potentialities of the equipment shall not be easily accessible to the user.

4.2.3 Transmitter shut-off facility

If the transmitter is equipped with an automatic transmitter shut-off facility, it should be made inoperative for the duration of the test.

4.2.4 Marking (equipment identification)

The equipment shall be marked in a visible place. This marking shall be legible and durable.

The marking shall include as a minimum:

- the name of the applicant or his trade mark;
- the type designation.

4.2.5 Receiver mute or squelch

If the receiver is equipped with a mute, squelch or battery-saving circuit, this circuit shall be made inoperative for the duration of the tests.

4.3 Declarations by the applicant

When submitting equipment for type testing, the applicant shall supply the necessary information according to the appropriate application form.

4.4 Auxiliary test equipment

All necessary test signal sources and setting up information shall accompany the equipment when it is submitted for type testing.

4.5 Interpretation of the measurement results

The interpretation of the results recorded on the appropriate test report form for the measurements described in this I-ETS shall be as follows:

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the standard;

- the measurement uncertainty value for the measurement of each parameter shall be included in the test report;

- the recorded value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in the table of measurement uncertainty (see Clause 9).

5 Test conditions, power sources and ambient temperatures

5.1 Normal and extreme test conditions

Type testing shall be made under normal test conditions, and also, where stated, under extreme test conditions.

The test conditions and procedures shall be as specified in subclauses 5.2 to 5.5.

5.2 External test power source

During type tests the power source of the equipment shall be replaced by an external test power source, capable of producing normal and extreme test voltages as specified in subclauses 5.3.2 and 5.4.2. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible. For the purpose of the tests, the voltage of the external test power source shall be measured at the input terminals of the equipment.

For battery operated equipment the battery shall be removed and the external test power source shall be suitably de-coupled and applied as close to the equipment battery terminals as practicable. For radiated measurements any external power leads should be so arranged so as not to affect the measurements. If necessary, the external test power source may be replaced with the supplied or recommended internal batteries at the required voltage, this shall be stated on the test report. For radiated measurements on portable equipments with integral antenna, fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the applicant.

During tests the external test power source voltages shall be within a tolerance $\leq \pm 1$ % relative to the voltage at the beginning of each test. The value of this tolerance can be critical for certain measurements. Using a smaller tolerance will provide a better uncertainty value for these measurements. If internal batteries are

used, at the end of each test the voltage shall be within a tolerance of <± 5 % relative to the voltage at the beginning of each test.

5.3 Normal test conditions

5.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be any convenient combination of temperature and humidity within the following ranges:

- temperature +15°C to +35°C;

- relative humidity 20 % to 75 %.

When it is impracticable to carry out tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

5.3.2 Normal test power source

5.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of this I-ETS, the nominal voltage shall be the declared voltage, or any of the declared voltages, for which the equipment was designed.

The frequency of the test power source corresponding to the AC mains shall be between 49 Hz and 51 Hz.

5.3.2.2 Regulated lead-acid battery power sources

When the radio equipment is intended for operation from the usual types of regulated lead-acid battery power source the normal test voltage shall be 1,1 multiplied by the nominal voltage of the battery (6 volts, 12 volts etc.).

5.3.2.3 Other power sources

For operation from other power sources or types of battery (primary or secondary), the normal test voltage shall be that declared by the equipment applicant and approved by the test authority. Such values shall be stated in the test report.

5.4 Extreme test conditions

5.4.1 Extreme temperatures

5.4.1.1 Procedure for tests at extreme temperatures

Before measurements are made the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilizing period.

In the case of equipment containing temperature stabilisation circuits designed to operate continuously, the temperature stabilisation circuits shall be switched on for 15 minutes after thermal balance has been obtained, and the equipment shall then meet the specified requirements.

If the thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour, or such period as may be decided by the accredited test laboratory, shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

5.4.1.1.1 Procedure for equipment designed for continuous operation

If the applicant states that the equipment is designed for continuous operation, the test procedure shall be as follows:

- before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on in the transmit condition for a period of half an hour after which the equipment shall meet the specified requirements;

- for tests at the lower extreme temperature the equipment shall be left in the test chamber until thermal balance is attained, then switched to the on condition for a period of one minute after which the equipment shall meet the specified requirements.

5.4.1.1.2 Procedure for equipment designed for intermittent operation

If the applicant states that the equipment is designed for intermittent operation, the test procedure shall be as follows:

- before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained in the oven. The equipment shall then either:

  - transmit on and off according to the applicants declared duty cycle for a period of five minutes;

    or, if the applicants declared "on" period exceeds one minute then:

  - transmit in the on condition for a period not exceeding one minute, followed by a period in the off or standby mode for four minutes;

  after which the equipment shall meet the specified requirements.

- for tests at the lower extreme temperature the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for one minute after which the equipment shall meet the specified requirements when switched on in the transmit mode.

5.4.1.2 Extreme temperature ranges

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in subclause 5.4.1.1, at the upper and lower temperatures of one of the following ranges:

Category I (General):	- 20 °C to + 55 °C;
Category II (Portable equipments):	- 10 °C to + 55 °C.

The test report form shall state which range is used.

5.4.2 Extreme test source voltages

5.4.2.1 Mains voltage

The extreme test voltages for equipment to be connected to an AC mains source shall be the nominal mains voltage ± 10 %.

5.4.2.2 Regulated lead-acid battery power sources

When the radio equipment is intended for operation from the usual type of regulated lead-acid battery power sources the extreme test voltages shall be 1,3 and 0,9 multiplied by the nominal voltage of the battery (6 volts, 12 volts, etc.).

For float charge applications using "gel-cell" type batteries the extreme test voltages shall be 1,15 and 0,85 multiplied by the nominal voltage of the declared battery voltage.

5.4.2.3 Power sources using other types of batteries

The lower extreme test voltages for equipment with power sources using batteries shall be as follows:

- for equipment with a battery indicator, the end point voltage as indicated;

- for equipment without a battery indicator the following end point voltage shall be used:

    - for the Leclanché or the lithium type of battery:
      0,85 multiplied by the nominal voltage of the battery;

    - for the nickel-cadmium type of battery:
      0,9 multiplied the nominal voltage of the battery;

    - for other types of battery the lower extreme test voltage for the discharged condition shall be declared by the equipment applicant.

No upper extreme test voltages apply.

5.4.2.4 Other power sources

For equipment using other power sources, or capable of being operated from a variety of power sources, the extreme test voltages shall be those agreed between the equipment applicant and the accredited test laboratory and shall be recorded in the test report.

6 General conditions

6.1 Normal test signals and test modulation

The test modulating signal is a signal which modulates a carrier and is dependent upon the type of equipment under test and also the measurement to be performed.

6.1.1 Normal test signals for analogue speech

A-M1: a 1 000 Hz tone;

A-M2: a 1 250 Hz tone.

The normal level of the test signals A-M1 and A-M2 shall produce a deviation of 12 % of the channel separation or any lower value as declared by the applicant as the normal operating level.

In the case of amplitude modulation, the modulation ratio shall be 60 %, or any lower value, as declared by the applicant, as the normal operating level.

6.1.2 Normal test signals for data

D-M2: a test signal representing a pseudorandom bit sequence of at least 511 bits in accordance with CCITT Recommendation 0.153 [3]. This sequence shall be continuously repeated. If the sequence cannot be continuously repeated then this and the actual method used shall be stated on the test report.

D-M3: a test signal shall be agreed between the accredited test laboratory and the applicant in the case where selective messages are used and are generated or decoded within the equipment. The agreed test signal may be formatted and may contain error detection and correction.

The normal level of the test signal D-M3 shall produce a deviation of 20 % of the channel separation or any other value as declared by the applicant as the normal operating level.

6.2 Artificial antenna

Where applicable, tests shall be carried out using an artificial antenna which shall be a substantially non-reactive non-radiating load of 50 ohm connected to the antenna connector. The Voltage Standing Wave Ratio (VSWR) at the 50 ohm connector shall not be greater than 1,2:1 over the frequency range of the measurement.

6.3 Test fixture

With equipment intended for use with an integral antenna, and not equipped with a 50 ohm RF output connector, the applicant may supply a test fixture (see also subclause 4.1.12).

This test fixture is a radio frequency coupling device for coupling the integral antenna to a 50 ohm radio frequency terminal at the working frequencies of the equipment under test. This allows certain measurements to be performed using conducted measuring methods, however, only relative measurements may be performed.

In addition, the test fixture shall provide:

- a connection to an external power supply;
- an audio interface either by direct connection or by an acoustic coupler.

The performance characteristics of the test fixture shall be agreed upon with the accredited test laboratory and shall conform to the following basic parameters:

- the circuitry associated with the RF coupling shall contain no active or non-linear devices;
- the coupling loss shall not influence the measuring results;
- the coupling loss shall be independent of the position of the test fixture and be unaffected by the proximity of surrounding objects or people;
- the coupling loss shall be reproducible when the equipment under test is removed and replaced;
- the coupling loss shall remain substantially constant when the environmental conditions are varied.

6.4 Test sites and general arrangements for radiated measurements

For guidance on radiation test sites see Annex B. Detailed descriptions of the radiated measurement arrangements are included in this annex.

6.5 Modes of operation of the transmitter

For the purpose of the measurements according to this I-ETS, there should preferably be a facility to operate the transmitter in an unmodulated state. The method of achieving an unmodulated carrier frequency, or special types of modulation patterns, may also be decided by agreement between the applicant and the accredited test laboratory. It shall be described in the test report. It may involve suitable temporary internal modifications of the equipment under test. If it is not possible to provide an unmodulated carrier then this must be stated in the test report.

For purposes of type testing, the normal test signal (see subclause 6.1) shall be applied to the input of the transmitter under test with the normal input device disconnected (e.g. microphone).

6.6 Measuring receiver

The term measuring receiver refers to either a selective voltmeter or a spectrum analyser. The bandwidth of the measuring receiver is given in table 3.

Table 3

Frequency being measured: f	Measuring receiver bandwidth
f < 150 kHz	200 Hz
150 kHz ≤ f < 30 MHz	9 kHz
30 MHz ≤ f < 1 000 MHz	120 kHz
1 000 MHz ≤ f	1 MHz

7 Methods of measurement and limits for transmitter parameters

Where the transmitter is designed with an adjustable carrier power, then all transmitter parameters shall be measured using the highest power level, as declared by the applicant. The equipment shall then be set to the lowest carrier power setting, as declared by the applicant, and the measurements for spurious emissions shall be repeated (see subclause 7.7).

When making transmitter tests on equipment designed for intermittent operation the duty cycle of the transmitter, as declared by the applicant on the application form, must not be exceeded. The actual duty cycle used shall be stated on the test report form.

If the equipment is supplied with both a permanent external 50 ohm RF connector and an integral antenna then full tests shall be carried out using the external connector and in addition:

- effective radiated power (radiated) (see subclause 7.3);
- spurious emission (see subclause 7.7);

tests shall be carried out with the integral antenna.

The frequency error measurement (subclause 7.1) is not mandatory if the adjacent channel power measurement (subclause 7.5) under extreme conditions is measured. The applicant shall state on the application form the measurement to be applied to the equipment submitted for testing. The submitted equipment shall fulfil the requirements of the stated measurement.

7.1 Frequency error

This measurement is made if the equipment is capable of producing an unmodulated carrier. If the equipment is not capable of producing an unmodulated carrier, then the adjacent channel power (see subclause 7.5) shall also be measured under extreme test conditions (see subclause 5.4) and the limits in subclause 7.5.3 shall be met.

7.1.1 Definition

The frequency error of the transmitter is the difference between the measured unmodulated carrier frequency and the nominal frequency stated by the applicant.

7.1.2 Method of measurement

The carrier frequency shall be measured (in the absence of modulation) with the transmitter connected to an artificial antenna. A transmitter without a 50 ohm output connector may be placed in the test fixture (see subclause 6.3) connected to an artificial antenna. The measurement shall be made under normal test conditions (see subclause 5.3) and extreme test conditions (see subclause 5.4) (extreme temperature and supply voltage simultaneously).

7.1.3 Limits

The frequency error shall not exceed the values given in table 4 under normal, extreme or any intermediate set of conditions.

Table 4

Frequency separation (kHz)	Frequency error limit (kHz)				
	< 47 MHz	47 to 137 MHz	> 137 to 300 MHz	> 300 to 500 MHz	> 500 to 1 000 MHz
10/12,5	± 0,60	± 1	± 1(b) ± 1,50(m) ± 2(p)	± 1(b) ± 1,50(m) ± 2,5(p)	No value specified
20/25	± 0,60	± 1,35	± 2	± 2(mb) ± 2,50(p)	± 2,50(mb) ± 3(p)

KEY:

b = fixed station (base)
m = mobile station
p = portable station

7.2 Carrier power (conducted)

If the equipment is designed to operate with different carrier powers, the rated power for each level or range levels shall be declared by the applicant.

These measurements shall be performed at the highest power level at which the transmitter is intended to operate.

7.2.1 Definition

The carrier power is the average power delivered to the artificial antenna (see subclause 6.2) during one radio frequency cycle in the absence of modulation.

When it is not possible to measure the power in the absence of modulation this fact shall be stated in the test report.

7.2.2 Method of measurement

This method applies only to fixed and mobile equipment with a permanent external antenna connector.

In the case of pulse modulation equipment where it is not possible to make the measurement in the absence of modulation, the measurement shall be carried out by the use of a measuring receiver with bandwidth as stated in subclause 6.6 and quasi-peak detector set in accordance with the specification of CISPR Publication 16 [4] Section One for the bands C and D.

The transmitter shall be connected to an artificial antenna (see subclause 6.2) and the carrier or mean power delivered to this artificial antenna shall be measured under normal test conditions (see subclause 5.3).

The measurement shall be repeated under extreme test conditions (see subclauses 5.4.1 and 5.4.2 applied simultaneously).

7.2.3 Limits

Under normal and extreme test conditions (see subclauses 5.3 and 5.4) the carrier output power (conducted) shall not exceed the maximum value given in table 5.

Table 5

Class	Frequency range MHz	Power level milliWatts (mW)
I	25 to 1 000	10
II	300 to 1 000	25
III	25 to 300	100
IV	300 to 1 000	500

7.3 Effective radiated power (radiated)

This measurement applies to equipment with an integral antenna and to portable equipment with an antenna connector and equipped with an antenna as declared by the applicant.

If the equipment is designed to operate with different carrier powers, the rated power for each level or range levels shall be declared by the applicant.

These measurements shall be performed at the highest power level at which the transmitter is intended to operate.

7.3.1 Definition

The effective radiated power is the power radiated in the direction of the maximum level under specified conditions of measurements, in the absence of modulation.

When it is not possible to measure the power in the absence of modulation this fact shall be stated in the test report.

7.3.2 Methods of measurement

On a test site, selected from Annex B, the equipment shall be placed at the specified height on a support, as specified in Annex B, and in the position closest to normal use as declared by the applicant.

The test antenna shall be oriented initially for vertical polarisation and shall be chosen to correspond to the frequency of the transmitter.

The output of the test antenna shall be connected to the measuring receiver.

In case of pulse modulation equipment where it is not possible to make the measurement in the absence of modulation, the measurement shall be carried out by the use of a measuring receiver with bandwidth as stated in subclause 6.6 and quasi-peak detector set in accordance with the specification of CISPR Publication 16 [4] Section One for the bands C and D.

The transmitter shall be switched on, if possible, without modulation and the measuring receiver shall be tuned to the frequency of the transmitter under test.

The test antenna shall be raised and lowered through the specified range of height until a maximum signal level is detected by the measuring receiver.

The transmitter shall then be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver.

The test antenna shall be raised and lowered again through the specified range of height until a maximum signal level is detected by the measuring receiver.

The maximum signal level detected by the measuring receiver shall be noted.

The transmitter shall be replaced by a substitution antenna as defined in Annex B, subclause B.2.3.

The substitution antenna shall be orientated for vertical polarisation and the length of the substitution antenna shall be adjusted to correspond to the frequency of the transmitter.

The substitution antenna shall be connected to a calibrated signal generator.

If necessary, the input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver.

The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received.

The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the transmitter radiated power was measured, corrected for the change of input attenuator setting of the measuring receiver.

The input level to the substitution antenna shall be recorded as power level, corrected for any change of input attenuator setting of the measuring receiver.

The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarisation.

The measure of the effective radiated power is the larger of the two levels recorded, at the input to the substitution antenna, corrected for gain of the substitution antenna if necessary.

7.3.3 Limits

The effective radiated power shall not exceed the maximum value given in table 6.

Table 6

Class	Frequency range MHz	Power level milliWatts (mW)
I	25 to 1 000	10
II	300 to 1 000	25
III	25 to 300	100
IV	300 to 1 000	500

The measurement shall be carried out under normal test conditions only (see subclause 5.3).

7.4 Response of the transmitter to modulation frequencies

These measurements are not applicable for wideband equipment.

7.4.1 Frequency deviation

This measurement is only applicable for analogue speech (angle modulation).

7.4.1.1 Definition

The frequency deviation is the maximum difference between the instantaneous frequency of the frequency or phase modulated radio frequency signal and the carrier frequency in the absence of modulation.

7.4.1.2 Analogue signals within the audio bandwidth

7.4.1.2.1 Method of measurement

The transmitter shall be connected to the artificial antenna (see subclause 6.2). A transmitter without a 50 ohm output connector shall be placed in the test fixture (see subclause 6.3) connected to an artificial antenna. The frequency deviation shall be measured by means of a deviation meter capable of measuring the maximum permissible frequency deviation, including that due to any harmonics and intermodulation products which may be produced in the transmitter. The deviation meter bandwidth must be suitable to accommodate the highest modulation frequency and to achieve the required dynamic range.

The modulation frequency shall be varied between 300 Hz and 3 000 Hz for equipment operating with

20 kHz or 25 kHz channel separations and between 300 Hz and 2 550 Hz for equipment operating with 10 kHz or 12,5 kHz channel separations. The level of the test signal shall be 20 dB above the level of the normal test signal A-M1 (see subclause 6.1.1), or 10 dB above in case of a transmitter with an integrated microphone.

The maximum (positive or negative) frequency deviation shall be recorded.

7.4.1.2.2 Limits

The maximum frequency deviation for transmitters equipped with speech facilities shall not exceed the values given in table 7.

Table 7

Channel separation	Maximum permissible frequency deviation
10 kHz	± 2 kHz
12,5 kHz	± 2,5 kHz
20 kHz	± 4 kHz
25 kHz	± 5 kHz

7.4.1.3 Analogue signals above the audio bandwidth

7.4.1.3.1 Method of measurement

The transmitter shall be connected to the artificial antenna (see subclause 6.2). A transmitter without a 50 ohm output connector shall be placed in the test fixture (see subclause 6.3) connected to an artificial antenna. The frequency deviation shall be measured by means of a deviation meter capable of measuring the maximum permissible frequency deviation, including that due to any harmonics and intermodulation

products which may be produced in the transmitter. The deviation meter bandwidth must be suitable to accommodate the highest modulation frequency and to achieve the required dynamic range.

The modulation frequency shall be varied between 3 kHz for equipment operating with 20 kHz or

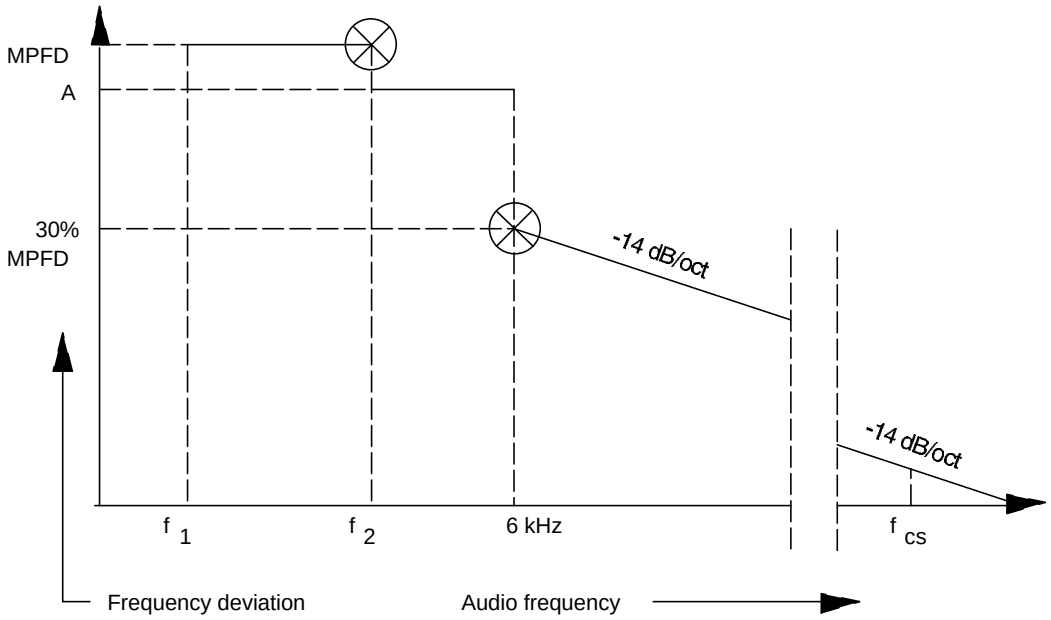
25 kHz channel separations or 2,55 kHz for equipment operating with 10 kHz or 12,5 kHz channel separations and the frequency equal to the channel separation with a level of the normal test signal A-M1 (see subclause 6.1.1).

The maximum (positive or negative) frequency deviation shall be recorded.

7.4.1.3.2 Limits

The frequency deviation at a modulation frequencies below 6 kHz, shall not exceed the frequency deviation at a modulation frequency of 3 kHz/2,55 kHz. At 6 kHz the deviation shall be not more than 30,0 % of the maximum permissible frequency deviation (see table 7).

The frequency deviation at modulation frequencies between 6 kHz and a frequency equal to the channel separation for which the equipment is intended shall not exceed the value given by a linear representation of the frequency deviation (dB) relative to the modulation frequency, starting at the 6 kHz limit and having a slope of - 14 dB per octave. These limits are illustrated in figure 1.



Abbreviations:

f_1: lowest appropriate frequency.
f_2: 3,0 kHz (for 20 kHz or 25 kHz channel separation), or
2,55 kHz (for 10 kHz or 12,5 kHz channel separation).
MPFD: maximum permissible frequency deviation, see subclause 7.4.1.2.2.
A: measured frequency deviation at f_2.
f_{cs}: frequency equal to channel separation.

Figure 1

7.4.2 Modulation depth

This measurement is only applicable for analogue speech (amplitude modulation).

7.4.2.1 Definition

The modulation depth is the ratio of the difference between the maximum and minimum amplitude of the wave to the sum of these amplitudes.

7.4.2.2 Analogue signals within the audio bandwidth

7.4.2.2.1 Method of measurement

The transmitter shall be connected to the artificial antenna (see subclause 6.2). A transmitter without a 50 ohm output connector shall be placed in the test fixture (see subclause 6.3) connected to an artificial antenna. The modulation depth shall be measured by means of a modulation depth meter. The modulation depth meter must be suitable to cover the required dynamic range.

The modulation frequency shall be varied between 300 Hz and 3 000 Hz for equipment operating with 20 kHz or 25 kHz channel separations and between 300 Hz and 2 550 Hz for equipment operating with 10 kHz or 12,5 kHz channel separations. The level of the test signal shall be the level which produces a modulation depth of 60 % or any lower value as declared by the applicant, using A-M2 (see subclause 6.1.1). The level of the test signal shall then be increased by 20 dB, or 10 dB in the case of a transmitter with an integrated microphone. At each test frequency, the resulting modulation depth shall be recorded.

7.4.2.2.2 Limits

The maximum modulation depth is 100 % for frequencies within the audio bandwidth.

7.4.2.3 Analogue signals above the audio bandwidth

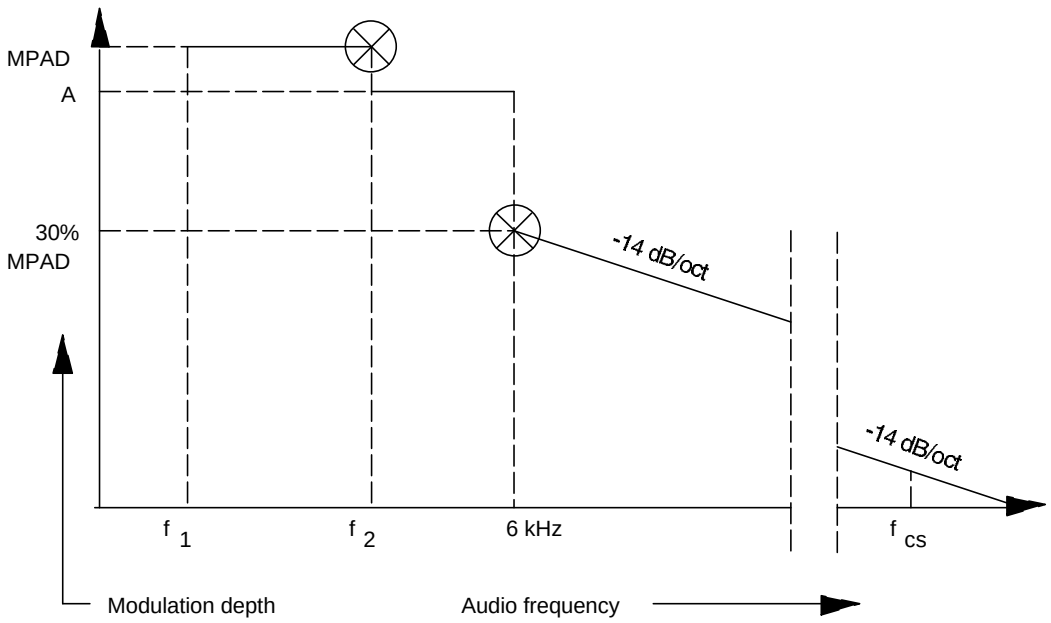
7.4.2.3.1 Method of measurement

The transmitter shall be connected to the artificial antenna (see subclause 6.2). A transmitter without a 50 ohm output connector shall be placed in the test fixture (see subclause 6.3) connected to an artificial antenna. The modulation depth shall be measured by means of a modulation depth meter. The modulation depth meter must be suitable to cover the required dynamic range.

The modulation frequency shall be varied between 3 kHz for equipment operating with 20 kHz or 25 kHz channel separations or 2,55 kHz for equipment operating with 10 kHz or 12,5 kHz channel separations and the frequency equal to the channel separation for which the equipment is intended to operate. The level of the test signal shall be the level which produces a modulation depth of 60 % or any lower value as declared by the applicant, using A-M2 (see subclause 6.1.1). The level of the test signal shall then be increased by 20 dB, or 10 dB in the case of a transmitter with integrated microphone. At each test frequency, the resulting modulation depth shall be recorded.

7.4.2.3.2 Limits

The modulation depth at modulation frequencies between the audio bandwidth and 6 kHz shall not exceed the modulation depth measured at the audio bandwidth. At 6 kHz the modulation depth shall be not more than 30 %. The modulation depth at modulation frequencies between 6 kHz and a frequency equal to the channel separation for which the equipment is intended to operate shall not exceed the value given by a linear representation of the modulation depth (dB) relative to the modulation frequency, starting at the 6 kHz limit and having a slope of -14 dB per octave. These limits are illustrated in figure 2.



Abbreviations:

f_1: lowest appropriate frequency.
f_2: 3,0 kHz (for 20 kHz or 25 kHz channel separation), or
2,55 kHz (for 10 kHz or 12,5 kHz channel separation).
MPAD: maximum permissible modulation depth, see subclause 7.4.2.2.2
A: measured modulation depth at f_2
f_{cs}: frequency equal to channel separation.

Figure 2

7.5 Adjacent channel power

These measurements are not applicable for wide band equipment. For wide band equipment, the range of modulation bandwidth shall be measured (see subclause 7.6).

7.5.1 Definition

For devices with specified channel bandwidth the adjacent channel power is that part of the total power output of a transmitter under defined conditions of modulation, which falls within a specified passband centred on the nominal frequency of either of the adjacent channels. This power is the sum of the mean power produced by the modulation, hum and noise of the transmitter.

7.5.2 Method of measurement

When using the test fixture for this measurement, it is important to ensure that direct radiation from the transmitter to the receiver does not affect the results.

7.5.2.1 Method of measurement using a power measuring receiver

The adjacent channel power shall be measured with a power measuring receiver which conforms with the requirements given in Annex C.

When using the test fixture (see subclause 6.3) for this measurement, it is important to ensure that direct radiation from the transmitter to the power measuring receiver does not affect the result or the loss introduced by the test fixture.

a) The transmitter under test shall be connected via the test load to a power measuring receiver calibrated to measure rms power level. The level at the receiver input shall be within its allowed limit. The transmitter shall be operated at the maximum operational carrier power level under normal conditions.

b) The tuning of the power measuring receiver shall be adjusted away from the carrier so that its -6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal frequency of the carrier as given in table 8.

Table 8

Channel separation (kHz)	Displacement (kHz)
10	5,75
12,5	8,25
20	13
25	17

The same result may be obtained by tuning the power measuring receiver (point 0 in figure C.1, of the power measuring filter shape) to the nominal frequency of the adjacent channel, if it has been suitably calibrated.

c) The transmitter shall be modulated as follows:

- equipment for analogue speech and angle modulation shall be modulated with test signal A-M2 (see subclause 6.1.1) at a level 20 dB above the level of the normal test signal, or 10 dB in case of a transmitter with an integrated microphone;

- equipment for analogue speech and amplitude modulation shall be modulated with a test signal A-M2 (see subclause 6.1.1) at a level which is 20 dB higher than the level that is required to produce a modulation depth of 60 %;

- equipment using data streams shall be modulated with the test modulation D-M2 (see subclause 6.1.2) at the agreed deviation;

- equipment for messages shall be modulated with the test modulation D-M3 (see subclause 6.1.2) repeated continuously at the agreed deviation.

d) The absolute value of the adjacent channel power shall be recorded.

e) Steps b) to d) shall be repeated with the power measuring receiver tuned to the other side of the carrier.

7.5.3 Limits

The measurement shall be made under normal conditions and, if applicable, under extreme conditions (see Clause 7).

The adjacent channel power shall not exceed the maximum values given in table 9.

Table 9

	Channel separation < 20 kHz	Channel separation ≥ 20 kHz
Normal test conditions	10 µW	200 nW
Extreme test conditions	32 µW	640 nW

7.6 Range of modulation bandwidth for wide band equipment (>25 kHz)

7.6.1 Definition

The range of modulation bandwidth includes all associated side bands above the appropriate spurious level and the frequency error under extreme test conditions.

Where an assigned frequency band has been subdivided into channels with bandwidths greater than 25 kHz, then spurious emission limits shall apply to any frequency within the assigned frequency band, but excluding frequencies in the wanted channel.

7.6.2 Method of measurement

In case of equipment with integral antenna, the equipment shall be placed in the test fixture (see subclause 6.3). The RF output of the equipment or the test fixture shall be connected to a spectrum analyser via a 50 ohm connector.

The transmitter shall be operated at the carrier power measured under normal test conditions in subclause 7.2 or 7.3. The attenuator shall be adjusted to an appropriate level displayed on the spectrum analyser screen.

The transmitter shall be modulated by the normal test signal (see subclause 6.1).

The output power of the transmitter, with or without a test fixture, shall be measured using a spectrum analyser resolution bandwidth large enough to accept all major modulation side bands. The power level calibration of the spectrum analyser shall then be related to the power level measured in subclause 7.2 or 7.3. The calculated relation will be used to calculate absolute levels of RF power.

The spectrum analyser shall then be adjusted so that 1 MHz below the lowest frequency of the assigned band to 1 MHz above the highest frequency of the assigned band is displayed. The resolution bandwidth shall be set to 100 Hz and the video bandwidth to 10 kHz.

The spectrum analyser shall be put in "Maximum hold" mode and the measurement shall be made under normal test conditions (see subclause 5.3) and repeated under extreme test conditions (subclauses 5.4.1 and 5.4.2 applied simultaneously) with the spectrum analyser still in the "maximum hold" mode.

The frequencies of the upper and lower points, where the displayed power envelope of modulation including frequency drift, equals the appropriate spurious emission level (subclause 7.7.5) is recorded as the modulation bandwidth.

7.6.3 Limits

The permitted range of modulation bandwidth must be within the limits of the assigned frequency band.

7.7 Spurious emissions

In the case of pulse modulation equipment where it is not possible to make the measurement in the absence of modulation, the measurement shall be carried out by the use of a measuring receiver with bandwidth as stated in subclause 6.6 and quasi-peak detector set in accordance with the specification of CISPR Publication 16 [4] Section One for the bands C and D. For measurements above 1 000 MHz the peak value shall be measured using a spectrum analyser. Any spurious emissions measured above 1 000 MHz shall be corrected using the calibration factor determined in Annex E.

7.7.1 Definition

Spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with normal test modulation. The level of spurious emissions shall be measured as:

either,

a.i) their power level in a specified load (conducted spurious emission);

and,

a.ii) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation);

or,

b) their effective radiated power when radiated by the cabinet and the integral antenna, in the case of portable equipment fitted with such an antenna and no external RF connector.

7.7.2 Method of measuring the power level in a specified load, subclause 7.7.1 a.i)

This method applies only to equipment with an external antenna connector.

The transmitter shall be connected to a 50 ohm power attenuator. The output of the power attenuator shall be connected to a measuring receiver. The transmitter shall be switched on with modulation, in the case of pulse modulation, and without modulation, for other types of modulation. If an unmodulated carrier cannot be obtained then the measurements shall be made with the transmitter modulated by the normal test signal D-M3 (see subclause 6.1.2) in which case this fact shall be recorded in the test report.

The measuring receiver, (see subclause 6.6) shall be tuned over the frequency range 9 kHz to 4 GHz for equipment operating on frequencies below 470 MHz, or over the frequency range of 9 kHz to 12,75 GHz for equipment operating on frequencies above 470 MHz. For an accurate measurement, it can be useful to add to the measuring receiver a device such as a RF preselector, in order to avoid harmonic components being introduced by the mixer.

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, except for the channel on which the transmitter is intended to operate and the adjacent channels.

The measurements shall be repeated with the transmitter on stand-by.

7.7.3 Method of measuring the effective radiated power, subclause 7.7.1 a.ii)

This method applies only to equipment with an external antenna connector.

On a test site, selected from Annex B, the equipment shall be placed at the specified height on a non-conducting support and in the position closest to normal use as declared by the applicant.

The transmitter antenna connector shall be connected to an artificial antenna (see subclause 6.2). The test antenna shall be orientated for vertical polarisation and the length of the test antenna shall be chosen to correspond to the instantaneous frequency of the measuring receiver. The output of the test antenna shall be connected to a measuring receiver.

The transmitter shall be switched on with modulation, in the case of pulse modulation, and without modulation, for other types of modulation. If an unmodulated carrier cannot be obtained then the measurements shall be made with the transmitter modulated by the normal test signal D-M3 (see subclause 6.1.2) in which case this fact shall be recorded in the test report.

The measuring receiver shall be tuned over the frequency range 25 MHz to 4 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

At each frequency at which a spurious component is detected, the test antenna shall be raised and lowered through the specified range of heights until a maximum signal level is detected on the measuring receiver.

The transmitter shall then be rotated through 360^{o} in the horizontal plane, until the maximum signal level is detected by the measuring receiver.

The maximum signal level detected by the measuring receiver shall be noted.

The transmitter shall be replaced by a substitution antenna as defined in subclauses B.1.2 and B.2.3.

The substitution antenna shall be orientated for vertical polarisation and calibrated for the frequency of the spurious component detected.

The substitution antenna shall be connected to a calibrated signal generator.

The frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected. The input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver, if necessary.

The test antenna shall be raised and lowered through the specified range of heights to ensure that the maximum signal is received.

When a test site according to Clause B.3 is used, there is no need to vary the height of the antenna.

The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for any change of input attenuator setting of the measuring receiver.

The input level to the substitution antenna shall be recorded as a power level, corrected for any change of input attenuator setting of the measuring receiver.

The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarisation.

The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the substitution antenna if necessary.

If applicable, the measurements shall be repeated with the transmitter on standby.

7.7.4 Method of measuring the effective radiated power, subclause 7.7.1 b)

This method applies only to equipment without an external antenna connector. The method of measurement shall be performed according to subclause 7.7.3, except that the transmitter output shall be connected to the integral antenna and not to an artificial antenna.

7.7.5 Limits

The power of any spurious emission, conducted or radiated, shall not exceed the following values given in table 10.

Table 10

State	47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other frequencies below 1 000 MHz	Frequencies above 1 000 MHz
Operating	4 nW	250 nW	1 µW
Standby	2 nW	2 nW	20 nW

8 Methods of measurement and limits for receiver parameters

8.1 Spurious radiation

8.1.1 Definition

Spurious radiations from the receiver are components at any frequency, radiated by the equipment and antenna.

The level of spurious radiations shall be measured by:

either,

a.i) their power level in a specified load (conducted spurious emission);

and,

a.ii) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation);

or,

b) their effective radiated power when radiated by the cabinet and the integral antenna, in the case of portable equipment fitted with such an antenna and no external RF connector.

8.1.2 Method of measuring the power level in a specified load, subclause 8.1.1 a.i)

This method applies only to equipment with an external antenna connector.

The receiver shall be connected to a 50 ohm attenuator.

The output of the attenuator shall be connected to a measuring receiver. The receiver shall be switched on, and the measuring receiver shall be tuned over the frequency range 9 kHz to 4 GHz for equipment operating on frequencies below 470 MHz, or over the frequency range of 9 kHz to 12,75 GHz for equipment operating on frequencies above 470 MHz.

At each frequency at which a spurious component is detected, the power level shall be recorded as the spurious level delivered into the specified load.

8.1.3 Method of measuring the effective radiated power, subclause 8.1.1 a.ii)

This method applies only to equipment with an external antenna socket.

On a test site, selected from Annex B, the equipment shall be placed at the specified height on a non-conducting support and in the position closest to normal use as declared by the applicant. The receiver antenna connector shall be connected to an artificial antenna, (see subclause 6.2).

The test antenna shall be orientated for vertical polarisation and the length of the test antenna shall be chosen to correspond to the instantaneous frequency of the measuring receiver. The output of the test antenna shall be connected to a measuring receiver. The receiver shall be switched on and the measuring receiver shall be tuned over the frequency range 25 MHz to 4 GHz. At each frequency at which a spurious component is detected, the test antenna shall be raised and lowered through the specified range of height until a maximum signal level is detected by the measuring receiver. When a test site according to Clause B.3 is used there is no need to vary the height of the antenna. The receiver shall then be rotated through 360^{o} in the horizontal plane until the maximum signal level is detected by the measuring receiver. The maximum signal level detected by the measuring receiver shall be noted.

The receiver shall be replaced by a substitution antenna as defined in subclauses B.1.3 and B.2.3.

The substitution antenna shall be orientated for vertical polarisation and calibrated for the frequency of the spurious component detected.

The substitution antenna shall be connected to a calibrated signal generator.

The frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected.

The input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver, if necessary.

The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received. The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for any change of input attenuator setting of the measuring receiver. The input level to the substitution antenna shall be recorded as power level, corrected for any change of input attenuator setting of the measuring receiver.

The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarisation.

The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the substitution antenna if necessary.

8.1.4 Method of measuring the effective radiated power, subclause 8.1.1 b)

This method applies only to equipment without an external antenna connector.

The method of measurement shall be performed according to subclause 8.1.3, except that the receiver input shall be connected to the integral antenna and not to an artificial antenna.

8.1.5 Limits

The power of any spurious emission, radiated or conducted, shall not exceed the values given below:

Receiver: 2 nW below 1 000 MHz
20 nW above 1 000 MHz

9 Measurement uncertainty

The accumulated measurement uncertainties of the test system in use for the parameters to be measured should not exceed those given below, this is in order to insure that the measurements remain within an acceptable standard.

RF frequency	± $1x10^{-7}$
RF power, conducted	± 0,75 dB
Maximum frequency deviation	
- within 300 Hz and 6 kHz of audio frequency	± 5 %
- within 6 kHz and 25 kHz of audio frequency	± 3 dB
Adjacent channel power	± 3 dB
Conducted emission of transmitter, valid up to 12,75 GHz	± 4 dB
Conducted emission of receivers	± 3 dB
Radiated emission of transmitter, valid up to 4 GHz	± 6 dB
Radiated emission of receiver, valid up to 4 GHz	± 6 dB
Temperature	± 1° C
Humidity	± 5 %

For the test methods according to this I-ETS the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in the ETR 028 [5].

Annex A (informative): Defined applications using I-ETS 300 220

A.1 Application: Low power devices

A.1.1 General

Annex A covers Low Power Devices (LPD) as recommended by The European Conference of Postal and Telecommunications Administrations Recommendation T/R 01-04 [6] and adopted by the European Radiocommunications Committee.

A.1.2 Definition

Non-public radio devices with integral antenna which radiates in one of the specified frequency bands up to a power level of 10 milliWatts, working on a non-interference and non-protected basis and which does not require frequency planning.

A.1.3 Technical parameters

Table A.1: Technical parameters

Subclause	Parameter	Limit	Measuring method
A.1.3.1	Frequency error	subclause 7.1.3 NOTE 1	subclause 7.1.2
A.1.3.2	Power	10 mW erp	subclause 7.3
A.1.3.3	Permitted operating frequency bands	NOTE 2	subclause 7.6
A.1.3.3	Bandwidth	Any bandwidth may be used provided that the occupied bandwidth of emission does not exceed the permitted operating frequency band.	
A.1.3.4	Modulation	Any type of modulation may be used.	
A.1.3.5	Extreme Temperature Range: (subclause 5.4.1.2)	Category I: - 20°C to + 55°C Category II: - 10°C to + 55°C	
A.1.3.6	Spurious emissions		
	Transmitter:	Limits: subclause 7.7.5, table 10	subclause 7.7
	Receiver:	Limits: subclause 8.1.5	subclause 8.1
NOTE 1: Frequency error is not specified in CEPT T/R 01-04 [6]. For bandwidths greater than 25 kHz subclause A.1.3.3 applies. NOTE 2: The frequency bands may change. The latest version of CEPT T/R 01-04 [6], should be used as the reference document.			

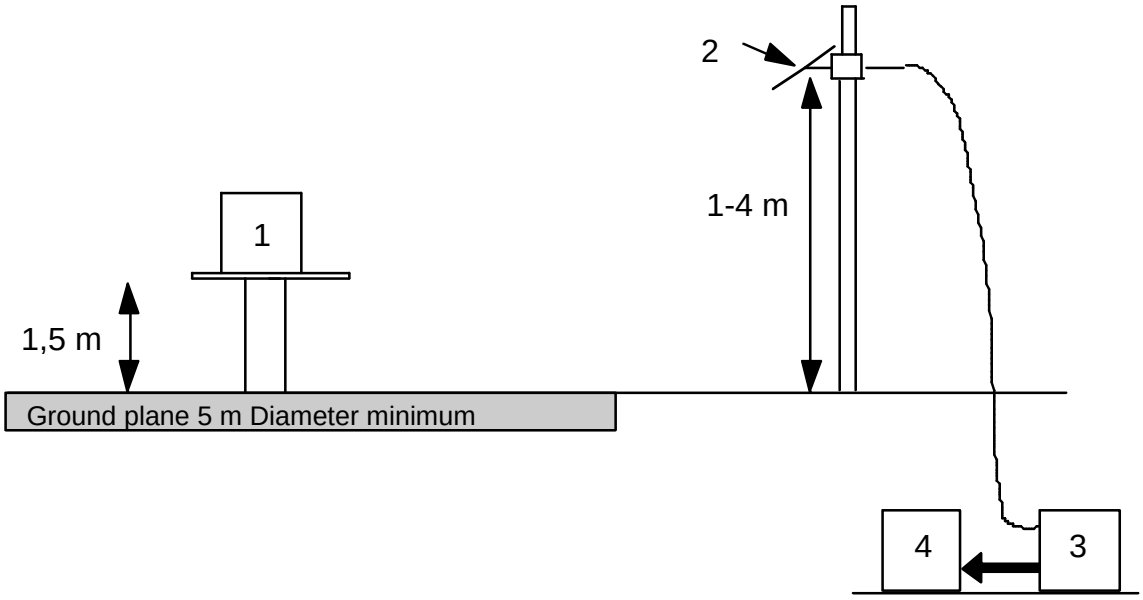
Annex B (normative): Radiated measurements

B.1 Test sites and general arrangements for measurements involving the use of radiated fields

B.1.1 Outdoor test site

The outdoor test site shall be on a reasonably level surface or ground. At one point on the site, a ground plane of at least 5 m diameter shall be provided. In the middle of this ground plane, a non-conducting support, capable of rotation through 360^{o} in the horizontal plane, shall be used to support the test sample in its standard position, at 1,5 m above the ground plane. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of $\lambda/2$ or 3 m whichever is the greater. The distance actually used shall be recorded with the results of the tests carried out on the site.

Sufficient precautions shall be taken to ensure that reflections from extraneous objects adjacent to the site do not degrade the measurements results.



Key:

1. Equipment under test
2. Test antenna
3. High pass filter (may not be necessary)
4. Spectrum analyser or measuring receiver

Figure B.1

B.1.1.1 Test support for body worn equipment

For equipment intended to be worn close the body and operating on frequencies below 50 MHz, but excluding hand-held equipment, the non-conducting support shall be replaced with the simulated man.

The simulated man shall consist of a plastic tube, filled with salt water (9 grams NaCl per litre). The tube shall have a length of 1,5 m and an internal diameter of 10 cm ± 0,5 cm. The upper end of the tube is closed by a metal plate with a diameter of 15 cm, which is in contact with the water. To meet the requirements made on equipment with rigid outside antenna that this antenna has to be in a vertical position during the measurement, the metal plate must, if necessary, be prepared in such a way that a second hinged metal plate of 10 cm x 15 cm can be fastened to its narrow side. It must be possible to change the supporting point of the hinged metal plate as far as the centre.

The position of the hinged metal plate shall be adjusted within 0° to 90° with respect to the lower metal plate.

The sample shall be fastened in such a way that:

a) the centre of its largest area rests on the revolving metal plate; and

b) this centre, on its part, is located above the centre of the lower metal plate by changing the supporting point of the revolving plate.

In the case of samples, whose largest area is smaller than 10 cm x 15 cm, the centre of the sample shall (deviating from point a) above) be so changed in its longitudinal axis that the antenna base is at the edge outside the metal plate.

B.1.1.2 Standard position

The standard position in all test sites, except for equipment which is intended to be worn on a person, shall be as follows:

- for equipment with an integral antenna; it shall be placed in the position closest to normal use as declared by the applicant;

- for equipment with a rigid external antenna; the antenna shall be vertical;

- for equipment with non-rigid external antenna, the antenna shall be extended vertically upwards by a non-conducting support.

B.1.2 Test antenna

The test antenna is used to detect the radiation from both the test sample and the substitution antenna, when the site is used for radiation measurements.

This antenna is mounted on a support such as to allow the antenna to be used in either horizontal or vertical polarisation and for the height of its centre above ground to be varied over the range 1 m to 4 m. Preferably a test antenna with pronounced directivity should be used. The size of the test antenna along the measurement axis shall not exceed 20 % of the measuring distance.

For receiver and transmitter radiation measurements, the test antenna is connected to a measuring receiver, capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input. For receiver radiated sensitivity measurements the test antenna is connected to a signal generator.

B.1.3 Substitution antenna

When measuring in the frequency range up to 1 GHz the substitution antenna shall be a $\lambda/2$ dipole, resonant at the operating frequency, or a shortened dipole, calibrated to the $\lambda/2$ dipole. When measuring in the

frequency range above 4 GHz a horn radiator shall be used. For measurements between 1 GHz and 4 GHz either a λ/2 dipole or a horn radiator may be used. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the volume centre of the sample when its antenna is mounted inside the cabinet, or the point where an external antenna is connected to the cabinet.

The distance between the lower extremity of the dipole and the ground shall not be less than 0,3 m.

The substitution antenna shall be connected to a calibrated signal generator when the site is used for spurious radiation measurements and transmitter effective radiated power measurements. The substitution antenna shall be connected to a calibrated measuring receiver when the site is used for the measurement of receiver sensitivity.

The signal generator and the receiver shall operate at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

NOTE: The gain of a horn antenna is generally ≥expressed relative to an isotropic radiator.

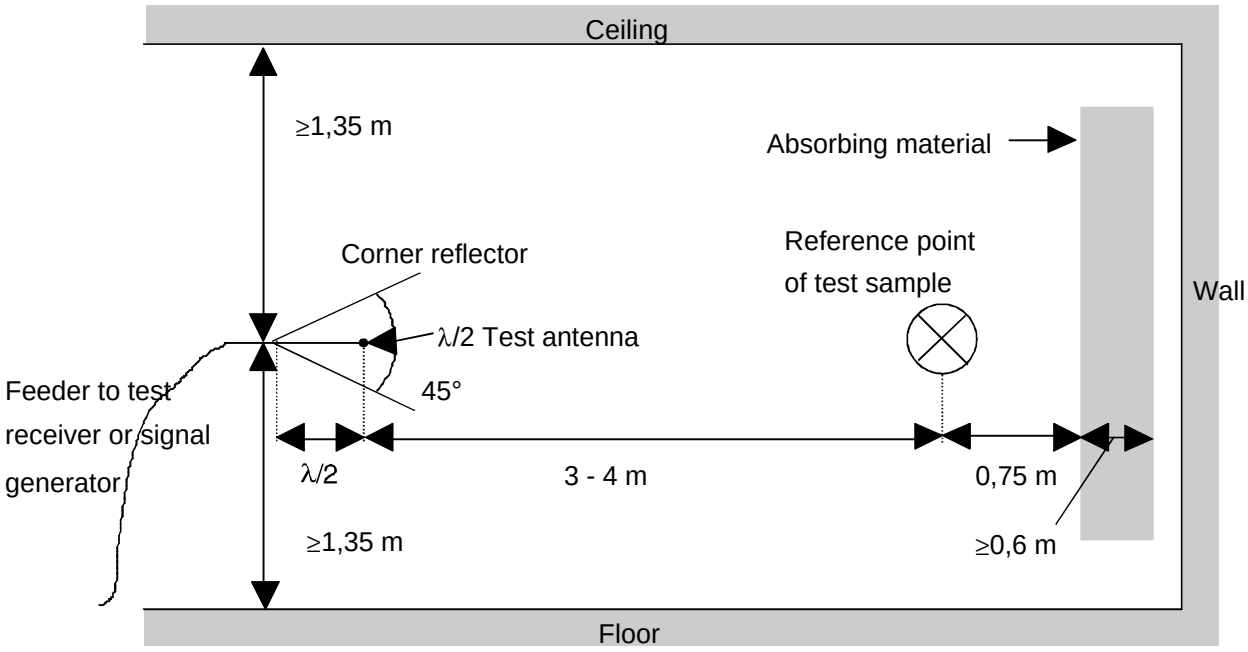


Figure B.2: Indoor site arrangement (shown for horizontal polarisation)

B.1.4 Optional additional indoor site

When the frequency of the signals being measured is greater than 80 MHz, use may be made of an indoor test site. If this alternative site is used, this shall be recorded in the test report.

The measurement site may be a laboratory room with a minimum area of 6 m by 7 m and at least 2,7 m in height.

Apart from the measuring apparatus and the operator, the room shall be as free as possible from reflecting objects other than the walls, floor and ceiling.

The potential reflections from the wall behind the equipment under test are reduced by placing a barrier of absorbent material in front of it. The corner reflector around the test antenna is used to reduce the effect of reflections from the opposite wall and from the floor and ceiling, in the case of horizontally polarised measurements. Similarly, the corner reflector reduces the effects of reflections from the side walls for vertically polarised measurements. For the lower part of the frequency range (below approximately 175 MHz) no corner reflector or absorbent barrier is needed. For practical reasons, the λ/2 antenna in figure B.2 may be replaced by an antenna of constant length, provided that this length is between λ/4 and λ at the frequency

of measurement, and the sensitivity of the measuring system is sufficient. In the same way the distance of $\lambda/2$ to the apex may be varied.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method. To ensure that errors are not caused by the propagation path approaching the point at which phase cancellation between the direct and the remaining reflected signals occurs, the substitution antenna shall be moved through a distance of ± 0,1 m in the direction of the test antenna as well as in the two directions perpendicular to this first direction.

If these changes of distance cause a signal change of greater than 2 dB, the test sample should be re-sited until a change of less than 2 dB is obtained.

B.2 Guidance on the use of radiation test sites

For measurements involving the use of radiated fields, use may be made of a test site in conformity with the requirements of Clause B.1 of this annex. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

B.2.1 Measuring distance

Evidence indicates that the measuring distance is not critical and does not significantly affect the measuring results, provided that the distance is not less than $\lambda/2$ at the frequency of measurement, and that the precautions described in this annex are observed. Measuring distances of 3 m, 5 m, 10 m and 30 m are in common use in European test laboratories.

B.2.2 Test antenna

Different types of test antenna may be used, since performing substitution measurements reduces the effect of the errors on the measuring results.

Height variation of the test antenna over a range of 1 m to 4 m is essential in order to find the point at which the radiation is a maximum.

Height variation of the test antenna may not be necessary at the lower frequencies below approximately 100 MHz.

B.2.3 Substitution antenna

Variations in the measuring results may occur with the use of different types of substitution antenna at the lower frequencies below approximately 80 MHz. Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used should be included with the results of the tests carried out on the test site. Correction factors shall be taken into account when shortened dipole antennas are used.

B.2.4 Artificial antenna

The dimensions of the artificial antenna used during radiated measurements should be small in relation to the sample under test.

Where possible, a direct connection should be used between the artificial antenna and the test sample. In cases where it is necessary to use a connecting cable, precautions should be taken to reduce the radiation from this cable by, for example, the use of ferrite cores or double screened cables.

B.2.5 Auxiliary cables

The position of auxiliary cables (power supply and microphone cables etc.) which are not adequately decoupled, may cause variations in the measurement results. In order to get reproducible results, cables and wires of auxiliaries should be arranged vertically downwards (through a hole in the non conducting support).

B.3 Further optional alternative indoor test site using an anechoic chamber

For radiation measurements, when test frequency of the signals being measured is greater than 30 MHz, use may be made of an indoor test site being a well-shielded anechoic chamber simulating a free space environment. If such a chamber is used, this shall be recorded in the test report.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method, Clause B.1. In the range 30 MHz to 100 MHz, some additional calibration may be necessary.

An example of a typical measurement site may be an electrically shielded anechoic chamber being 10 m long, 5 m broad and 5 m high. Walls and ceiling should be coated with RF absorbers of 1 m height. The base should be covered with absorbing material 1 m thick, and a wooden floor, able to carry test equipment and operators. A measuring distance of 3 m to 5 m in the long middle axis of the chamber can be used for measurements up to 12,75 GHz. The construction of the anechoic chamber is described in the following clauses.

B.3.1 Example of the construction of a shielded anechoic chamber

Free-field measurements can be simulated in a shielded measuring chamber where the walls are coated with RF absorbers. Figure B.3 shows the requirements for shielding loss and wall return loss of such a room. As dimensions and characteristics of usual absorber materials are critical below 100 MHz (height of absorbers < 1 m, reflection attenuation < 20 dB) such a room is more suitable for measurements above 100 MHz. Figure B.4 shows the construction of an anechoic shielded measuring chamber having a base area of 5 m by 10 m and a height of 5 m.

Ceilings and walls are coated with pyramidal formed RF absorbers approximately 1 m high. The base is covered with absorbers which form a non-conducting sub-floor, or with special ground floor absorbers. The available internal dimensions of the room are 3 m x 8 m x 3 m, so that a maximum measuring distance of 5 m length in the middle axis of this room is available.

At 100 MHz the measuring distance can be extended up to a maximum of 2λ.

The floor absorbers reduce floor reflections so that the antenna height need not be changed and floor reflection influences need not be considered.

All measuring results can therefore be checked with simple calculations and the measurement uncertainties have the smallest possible values due to the simple measuring configuration.

B.3.2 Influence of parasitic reflections in anechoic chambers

For free-space propagation in the far field condition the correlation E=Eo (Ro/R) is valid for the dependence of the field strength E on the distance R, whereby Eo is the reference field strength in the reference distance Ro.

It is useful to use this correlation for comparison measurements, as all constants are eliminated with the ratio and neither cable attenuation, nor antenna mismatch, or antenna dimensions are of importance.

Deviations from the ideal curve can be seen easily if the logarithm of the above equation is used, because the ideal correlation of field strength and distance can then be shown as a straight line and the deviations occurring in practice are clearly visible. This indirect method shows the disturbances due to reflections more readily and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in Clause B.3 at low frequencies up to 100 MHz, there are no far field conditions and therefore reflections are stronger so that careful calibration is necessary. In the medium frequency range from 100 MHz to 1 GHz the dependence of the field strength on the distance meets the expectations very well. In the frequency range of 1 GHz to 12,75 GHz, because more refections will occur, the dependence of the field strength on the distance will not correlate so closely.

B.3.3 Calibration of the shielded RF anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 12,75 GHz.

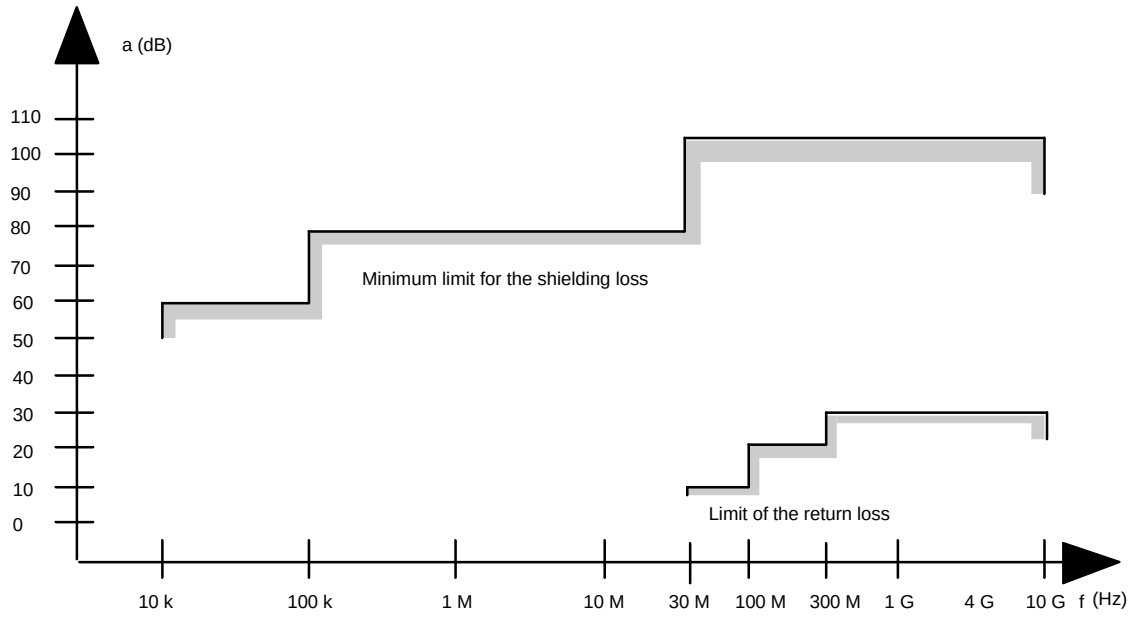


Figure B.3: Specification for shielding and reflections

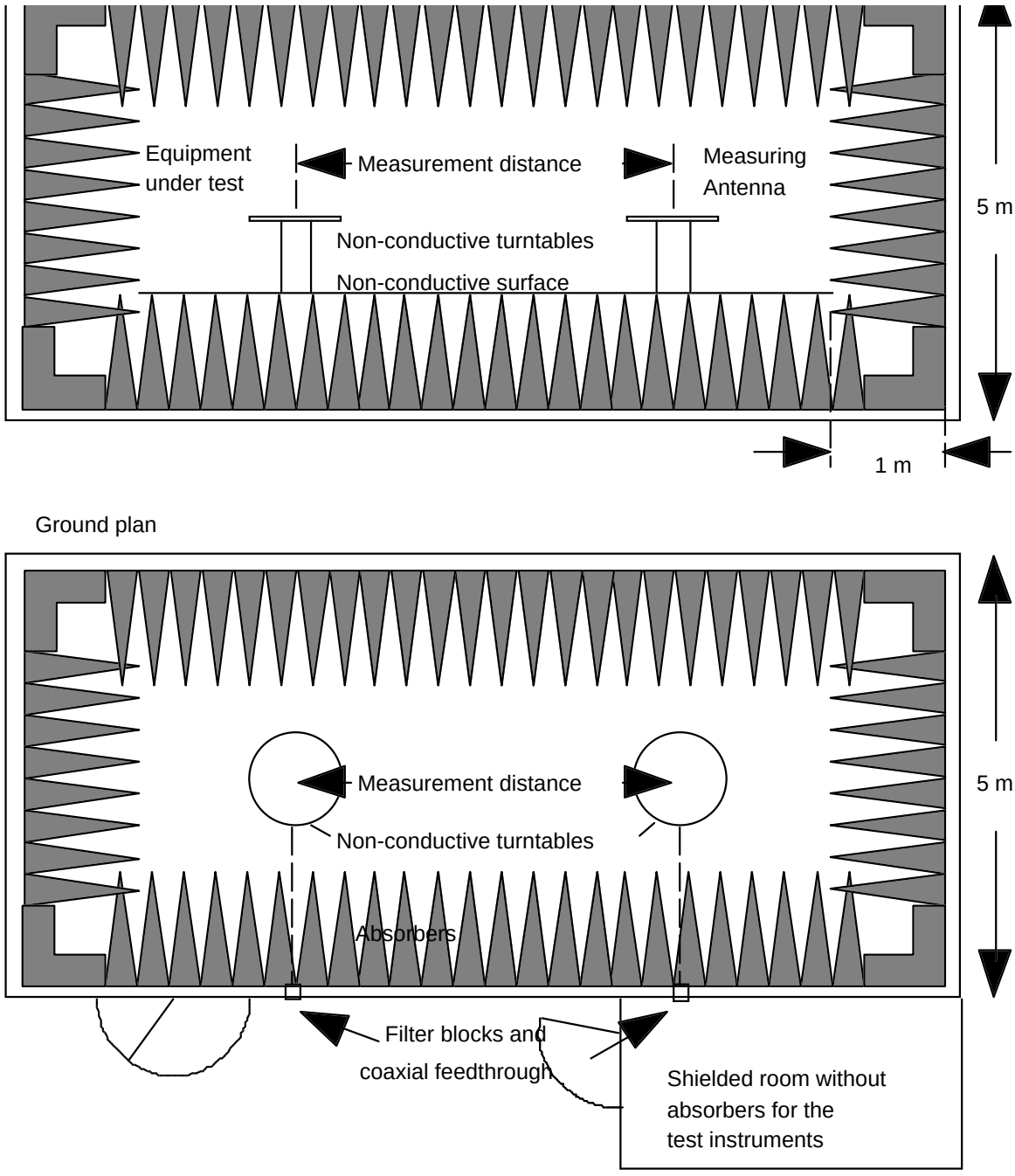


Figure B.4: Example of construction of an anechoic shielded chamber

Annex C (normative): Specifications for adjacent channel power measurement arrangements

C.1 Power measuring receiver specification

The power measuring receiver consists of a mixer, an Intermediate Frequency (IF) filter, and oscillator, an amplifier, a variable attenuator and an rms value indicator. Instead of the variable attenuator with the rms value indicator it is also possible to use an rms voltmeter calibrated in dB as the rms value indicator. The technical characteristics of the power measuring receiver are given in subclauses C.1.1 to C.1.4.

C.1.1 IF filter

The IF filter shall be within the limits of the selectivity characteristic of figure C.1.

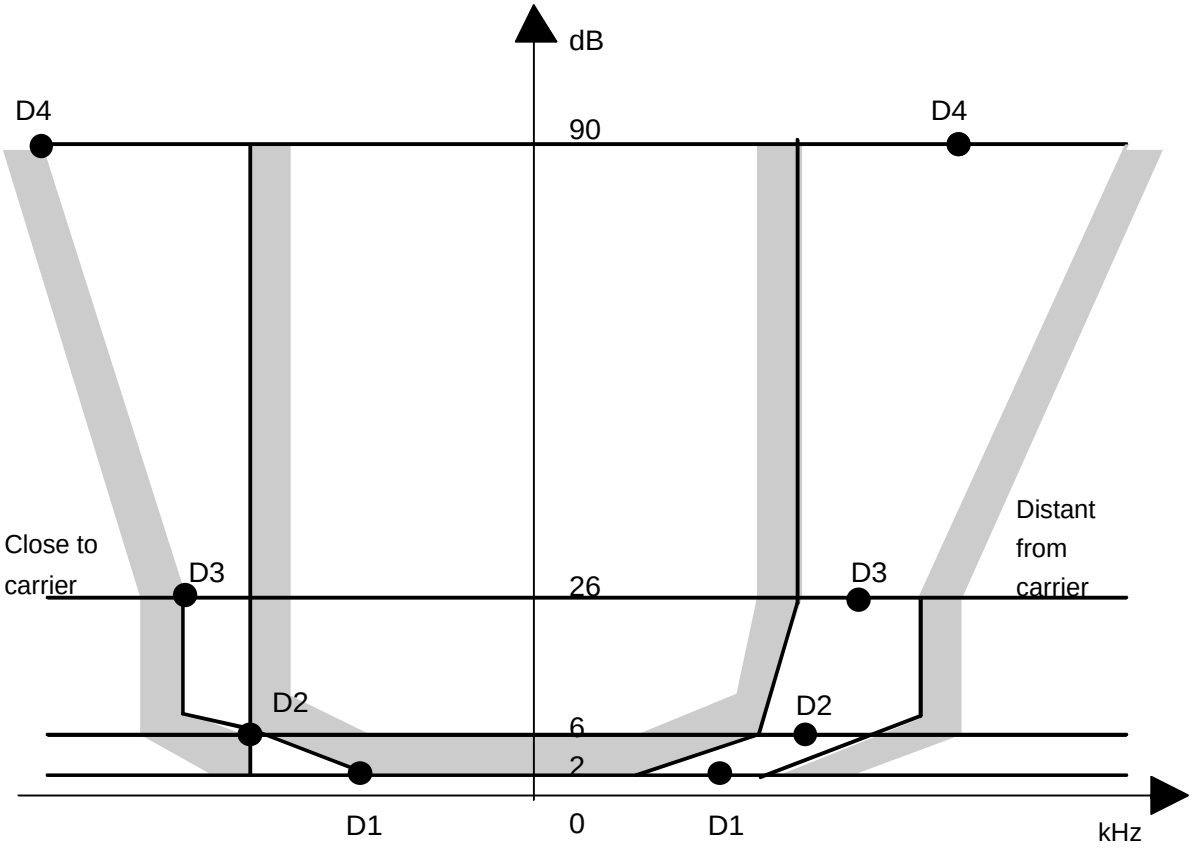


Figure C.1

Depending on the channel separation, the selectivity characteristic shall keep the following frequency separations from the nominal centre frequency of the adjacent channel.

Table C.1: Selectivity characteristic

Channel separation (kHz)	Frequency separation of filter curve from nominal centre frequency of adjacent channel (kHz)			
	D1	D2	D3	D4
10/12,5	3,0	4,25	5,5	9,5
20	4,0	7,0	8,25	12,25
25	5,0	8,0	9,25	13,25

Depending on the channel separation, the attenuation points shall not exceed the tolerances given in table C.2 and table C.3.

Table C.2: Attenuation points close to carrier

Channel separation (kHz)	Tolerance range (kHz)			
	D1	D2	D3	D4
10/12,5	+ 1,35	± 0,1	- 1,35	- 5,35
20	+ 3,1	± 0,1	- 1,35	- 5,35
25	+ 3,1	± 0,1	- 1,35	- 5,35

Table C.3: Attenuation points distant from the carrier

Channel separation (kHz)	Tolerance range (kHz)			
	D1	D2	D3	D4
10/12,5	± 2,0	± 2,0	± 2,0	+ 2,0 - 6,0
20	± 3,0	± 3,0	± 3,0	+ 3,0 - 7,0
25	± 3,5	± 3,5	± 3,5	+ 3,5 - 7,5

The minimum attenuation of the filter outside the 90 dB attenuation points shall be equal to or greater than 90 dB.

C.1.2 Variable attenuator

The variable attenuator shall have a minimum range of 80 dB and a resolution of 1 dB.

C.1.3 rms value indicator

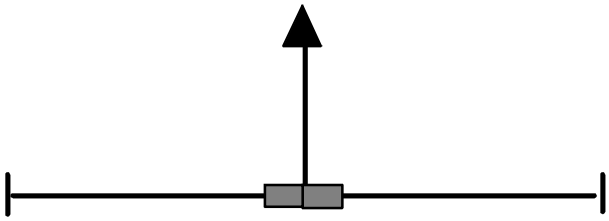
The instrument shall accurately indicate non-sinusoidal signals in a ratio of up to 10:1 between peak value and rms value.

C.1.4 Oscillator and amplifier

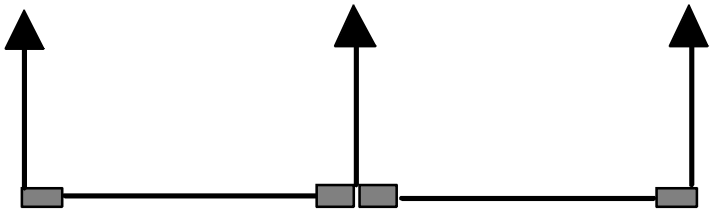
The oscillator and the amplifier shall be designed in such a way that the measurement of the adjacent channel power of a low-noise unmodulated transmitter, whose self-noise has a negligible influence on the measurement result, yields a measured value of ≤ - 90 dB for channel separations of 20 kHz and 25 kHz and of ≤ - 80 dB for a channel separation of 10 kHz and 12,5 kHz, referred to the carrier of the oscillator.

Annex D (informative): Graphic representation of the selection of equipment and frequencies for testing of single and multi-frequency equipment

SINGLE FREQUENCY EQUIPMENT

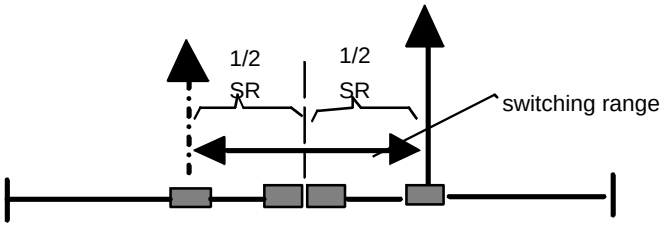


Equipment of category AR1 see subclause 4.1.5

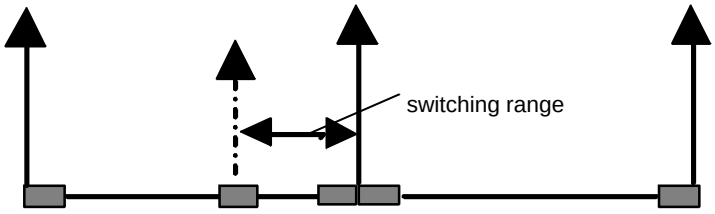


Equipment of category AR2 see subclause 4.1.6

TWO FREQUENCY EQUIPMENT



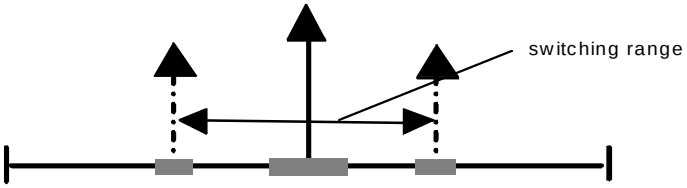
Equipment of category AR1 see subclause 4.1.7



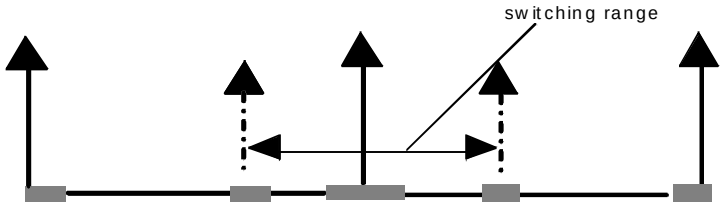
Equipment of category AR2 see subclause 4.1.8

Figure D.1: Single/two frequency equipment

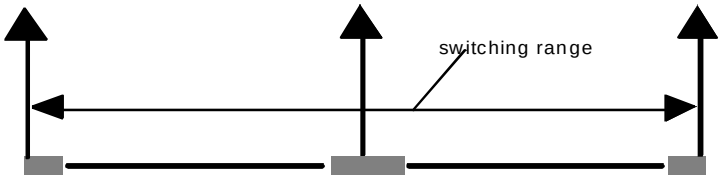
MULTI FREQUENCY EQUIPMENT



Equipment of category AR1 see subclause 4.1.9



Equipment of category AR2 see subclause 4.1.10



Equipment of category AR2 see subclause 4.1.11
AR = SR

Legend:

AR1 - First category of alignment range, see subclause 4.1.3.
AR2 - Second category of alignment range, see subclause 4.1.3.
Limited test, see subclause 3.1.
Full test, see subclause 3.1.
100 kHz range in which the test shall be carried out.

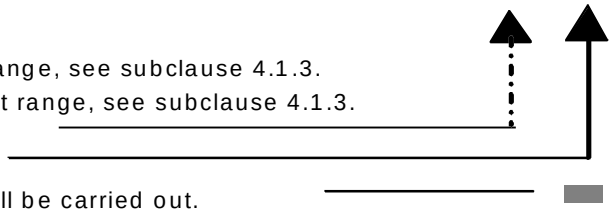


Figure D.2: ulti frequency equipment

Annex E (normative): Correction factor for pulsed systems

E.1 Introduction

For frequencies below 1 000 MHz any spurious signal shall be measured using a measuring receiver with a CISPR quasi-peak detector.

For measurements above 1 000 MHz the peak value shall be measured using a spectrum analyser. Any spurious emission measured above 1 000 MHz shall be corrected using the correction factor, as determined below.

E.2 Method of measurement

The carrier power shall be measured according to subclause 7.2, or effective radiated power according to subclause 7.3. The level measured shall be noted. If the measuring receiver has a peak setting then switch to the peak setting. If the measuring receiver does not have a peak detector, replace the receiver with a measuring receiver with a peak detector. If a spectrum analyser is used, set the bandwidth to 100 kHz. Note the measured peak value.

The correction factor (CF) is equal to

$$\frac{\text{Peak Value}}{\text{Quasi-peak Value}} \qquad \text{(Numeric values)}$$

The corrected value for spurious frequencies above 1 000 MHz is equal to

$$\frac{\text{Measured Peak value}}{\text{Correction Factor}} \qquad \text{(Numeric values)}$$

E.3 Limit

The corrected value shall be equal to or less than the limits stated in subclause 7.7.5.

Annex F (normative): Technical performance of the spectrum analyser

The specification shall include the following requirements:

it shall be possible, using a resolution bandwidth of 1 kHz, to measure the amplitude of a signal or noise at a level 3 dB or more above the noise level of the spectrum analyser, as displayed on the screen, to an accuracy of ± 2 dB in the presence of a signal separated in frequency by:

a) 10 kHz, at a level 90 dB above that of the signal to be measured for 25 kHz and 20 kHz channel separations; and

b) 6,25 kHz, at a level 80 dB above that of the signal to be measured for a 12,5 kHz channel separation; and

c) 5 kHz at a level 80 dB above that of the signal to be measured for a 10 kHz channel separation.

The reading accuracy of the frequency marker shall be within ± 2 % of the channel separation.

The accuracy of relative amplitude measurements shall be within ± 1 dB.

It shall be possible to adjust the spectrum analyser to allow the separation, on the display, of two components with a frequency difference of 1 kHz.

History

Document history	
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