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Radio Equipment and Systems (RES); Short Range Devices (SRDs) Technical characteristics and test methods for radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz

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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).

Annex A provides normative specifications concerning radiated measurements.

Annexes B through E are graphical representations of RF carrier current limits, H- and E-field strength carrier limits and spurious emission limits.

Annex F is normative describing the calculation for customised antennas.

Annexes G and H are informative annexes describing E-fields, and test fixtures.

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Introduction

This I-ETS is intended to specify the minimum performance and the methods of measurement of Short Range Devices (SRDs) as specified in the scope.

Included are methods of measurement for equipment, such as inductive loop systems, fitted with antenna connector and/or integral antennas. Equipment designed for use with an integral antenna may be supplied with a temporary or permanent internal connector for the purpose of testing, providing the characteristics being measured are not expected to be affected.

This I-ETS will be used by accredited test laboratories for the assessment of the performance of the equipment. Type test measurements will be performed in one of the accredited test laboratories, accepted by the various National Regulatory authorities in order to grant type testing, provided the National regulatory requirements are met. This is in compliance with CEPT Recommendation T/R 71-03 [1].

If equipment, which is available on the market, is required to be checked it should be tested in accordance with the methods of measurement specified in this I-ETS.

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1 Scope

This I-ETS is a general standard for the frequency band 9 kHz to 25 MHz for radio equipment and 9 kHz to 30 MHz for inductive loop systems, which may be superseded by specific standards covering specific applications.

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 SRDs as follows:

- inductive loop systems;

- with an antenna connection and/or with an integral antenna;

- for alarms, identification systems, telecommand, telemetry, etc., applications;

- with or without speech.

All types of modulation for radio devices are covered by this I-ETS.

This I-ETS covers fixed stations, mobile stations and portable stations. If the system includes transponders, these will be measured together with the transmitter.

Two types of measuring methods are defined in this I-ETS due to the varied nature of the types of equipment used in this band. One method measures the RF carrier current, the other measures the H-field.

CEPT Recommendation T/R 01-04 [2], on Low Power Devices (LPDs) using an integral antenna, mentions in the frequency range 9 kHz to 25 MHz two frequency bands, 6,765 to 6,795 MHz and 13,553 to 13,567 MHz, with a field strength limit of 65 dBμV/m measured at 30 m (which is equivalent to 42 dBμA/m at 10 m).

On non-harmonized 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 for the issue of an individual or general licence, or as a condition for use under licence exemption.

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

This I-ETS covers requirements for radiated emissions below 30 MHz.

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 publications are 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 71-03: "Procedures for type testing and approval for radio equipment intended for non-public systems".

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

[3] CCITT Recommendation O.153 (1992): "Basic parameters for the R1 measurement of error performance at bit rates below the primary rate".

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

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

3 Definitions, abbreviations and symbols

3.1 Definitions

For the purposes of this I-ETS the following definitions apply:

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

Artificial antenna: a tuned reduced-radiating dummy load equal to the nominal impedance specified by the applicant.

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

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

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

H-field test antenna: an electrically screened loop or equivalent antenna, with which the magnetic component of the field can be measured.

Identification system: equipment consisting of a transmitter(s), receiver(s) (or a combination of the two) and an antenna(s) to identify a transponder.

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

Magnetic Moment: the product of (Number of coil turns) * (coil area) * (coil current). (Air coils only)

Mobile station: equipment normally installed in a vehicle.

Portable station: equipment intended to be carried.

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.

Transponder: a device, that responds to an interrogation signal.

3.2 Abbreviations

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

EMC	Electro-Magnetic Compatibility
ETR	ETSI Technical Report
IF	Intermediate Frequency
ISM	Industrial, Scientific and Medical
RF	Radio Frequency
Rx	Receiver
Tx	Transmitter
VSWR	Voltage Standing Wave Ratio

3.3 Symbols

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

E	Electrical field strength
Eo	Reference electrical field strength, (see annex A)
f	Frequency
H	Magnetic field strength
Ho	Reference magnetic field strength, (see annex A)
P	Power
R	Distance
Ro	Reference distance, (see annex A)
t	Time

4 General requirements

4.1 Mechanical and electrical design

4.1.1 General

The equipment submitted by the applicant, should 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.

4.1.2 Controls

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

4.1.3 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.

4.1.4 Marking (equipment identification)

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

The marking shall be in accordance with the requirements of the National Regulatory Authority and should include as a minimum:

- the name of the manufacturer or his trade mark;

- the type designation.

4.1.5 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.

4.2 Declarations by the applicant

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

The performance of the equipment submitted for type testing shall be representative of the performance of the corresponding production model.

4.3 Auxiliary test equipment

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

4.4 Interpretation of the measurement results

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

- the measured value relating to the corresponding limit shall be used to decide whether an equipment meets the requirements of the I-ETS;

- 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 (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 5.4.

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 power supply may be replaced with its own internal batteries at the required voltage; this shall be stated on the test report. For radiated measurements on portable equipment with integral antenna, fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the applicant.

If the equipment is powered from an external source, the test voltage shall be that measured at the point of connection of the power cable to the equipment.

During tests the test power source voltages shall be within a tolerance < ± 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 with 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 (e.g. 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 laboratory. 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 a half 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 on 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 applicant's 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.

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):	- 10°C to + 55°C;
Category III (Equipment for normal indoor use):	0°C to + 55°C.

NOTE: The term "Equipment for normal indoor use" is taken to mean the minimum indoor temperature is equal to or greater than 5°C.

The test report shall state which range is used. The user's manual should include the temperature range used for type testing.

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.).

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 voltages 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 or equipment incorporating a low power detection circuit, 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. Modulation test signals only apply to products with an external modulation connector. For equipment without an external modulation connector, normal operating modulation shall be used.

6.1.1 Normal test signals for analogue speech

A-M1: a 1 000 Hz tone;

A-M2: a 1 250 Hz tone.

The level of the test signals A-M1 and A-M2 shall be adjusted to produce a deviation of 12 % of the channel separation or if a deviation of 12 % cannot be achieved, the maximum deviation as declared by the applicant.

In the case of amplitude modulation, the modulation depth shall be 60 % or if 60 % cannot be achieved the maximum modulation depth as declared by the applicant.

6.1.2 Normal test signals for data

D-M2: a test signal representing a pseudo-random 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, 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 case selective messages are used and are generated or decoded within the equipment.

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

A tuned reduced radiating load connected to the antenna connector shall be equal to the nominal load of the equipment specified by the applicant.

6.3 Test fixture

A test fixture shall be supplied by the applicant to enable extreme temperature measurements to be made, where applicable. The test fixture shall couple to the generated electromagnetic field from the equipment under test without disturbing the operation of the said device. The test fixture shall be provided with a 50 ohm standard connector, where the generated field can be sampled.

The test fixture shall be fully described by the applicant.

The test laboratory shall calibrate the test fixture by carrying out the required field measurements at normal temperatures at the prescribed test site and then by repeating the same measurements on the equipment under test using the test fixture for all identified frequency components.

The test fixture is only required for extreme temperature measurements and shall be calibrated only with the equipment under test.

6.4 Test sites and general arrangements for radiated measurements

For guidance on radiation test sites and detailed descriptions of radiated measurement arrangements see annex A.

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, and 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 shall be stated in the test report.

When an input to the transmitter is available for the purpose of type testing, the normal test signal 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 a selective voltmeter or a spectrum analyser. The bandwidth of the measuring receiver shall be according to CISPR 16-1 [4]. Signals below 135 kHz shall be measured using the peak detector of the measuring receiver; above 135 kHz the quasi-peak detector shall be applied, see table 1.

Table 1

Frequency: (f)	Detector type:	Bandwidth:
9 kHz ≤ f < 30 kHz	Peak	200 - 300 Hz
30 kHz ≤ f < 135 kHz	Peak	9 - 10 kHz
135 kHz ≤ f < 30 MHz	Quasi Peak	9 -10 kHz
30 MHz ≤ f ≤ 1000 MHz	Quasi Peak	100 - 120 kHz

6.7 Pulse modulated signal below 135 kHz

For pulse modulated signals, measurements in the band 9 kHz to 135 kHz, using a peak detector on the measuring receiver (see subclause 6.6), the level shall be calculated as follows:

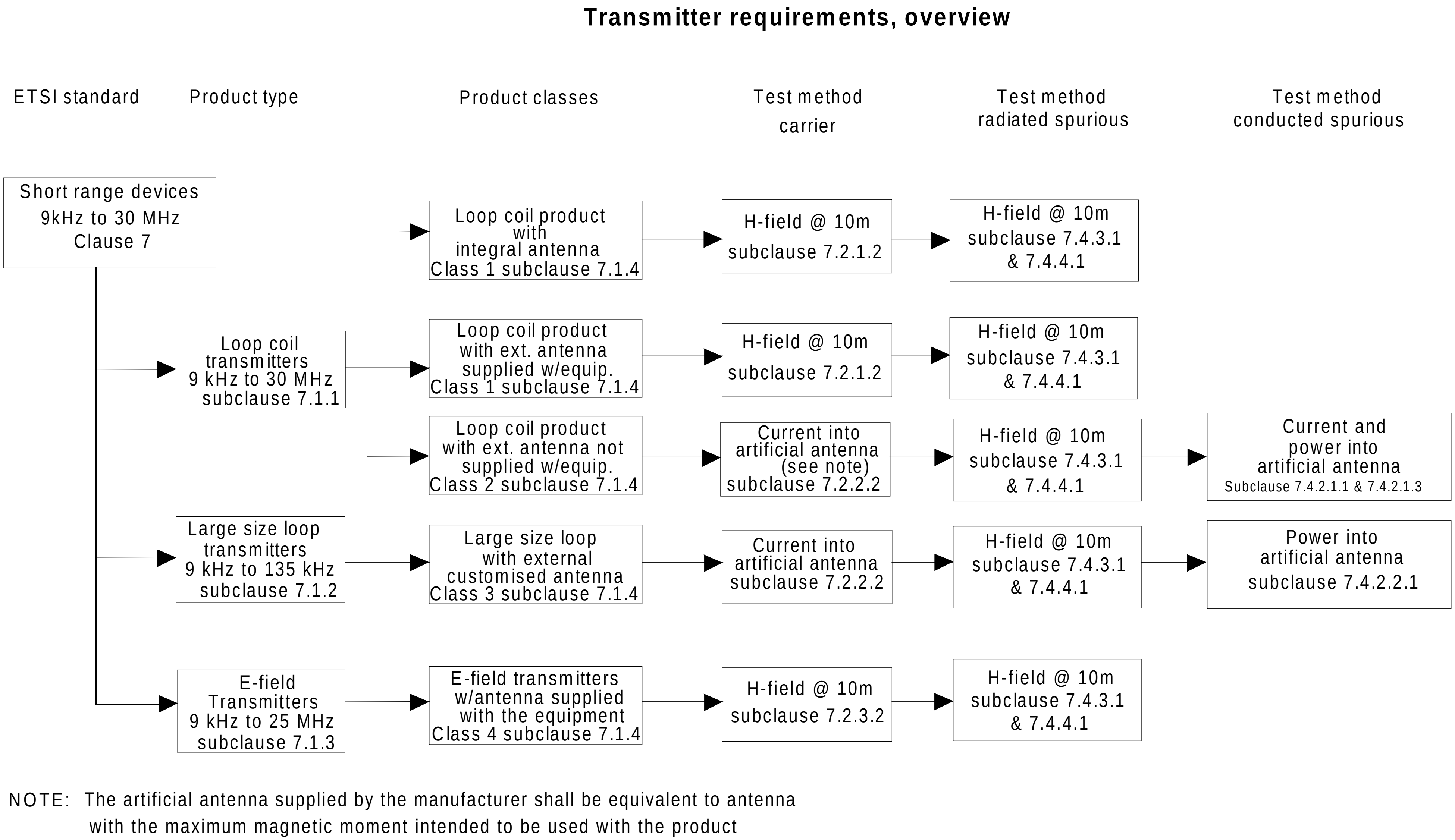
for t_{on} < 25 ms:	$L = M_{peak} - 6$	dB;
for 25 ms ≤ t_{on} < 100 ms:	$L = M_{peak} + 10 \log t_{on}/100$	dB;
for t_{on} ≥ 100 ms:	$L = M_{peak}$	dB;

where:

L = the relevant limit applicable (see clause 7);

M_{peak} = measured peak value;

t_{on} = the total time in a 100 ms window that the equipment is transmitting.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Power into artificial antenna subclause 7.4.2.2.1
NOTE: The artificial antenna supplied by the manufacturer shall be equivalent to antenna with the maximum magnetic moment intended to be used with the product

Figure 1

7 Transmitter requirements

Where the transmitter is designed with an adjustable carrier power, all parameters shall be measured using the highest output level as declared by the applicant. The equipment shall then be adjusted to the lowest setting, as declared by the applicant, and the spurious emissions measurement shall be repeated (see subclause 7.4).

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, shall not be exceeded. The actual duty cycle used shall be stated on the test report.

7.1 Transmitter definitions

Transmitters are divided into classes based on their radiated field and antenna type to be used. Transmitters type tested without an antenna may allow the customer to use his own loop antenna design based on the manufacturers design guidelines. The user's manual shall include the guidelines for the design of the antennas.

7.1.1 The inductive loop coil transmitters

These transmitters are characterised by:

- loop coil antenna area, $A < 30\ m^2$;

- antenna coil with one or multiple turns.

7.1.2 The large size loop transmitters

These transmitters are characterised by:

- large loop antenna area $A > 30\ m^2$;

- large loop antenna with one turn only;

- 9 kHz to 135 kHz only.

7.1.3 Other transmitters

These transmitters are characterised as E-field transmitters.

7.1.4 Product classes

The product classes are:

Class 1: inductive loop coil transmitter, type tested with an integral antenna;

NOTE 1: The transmitter carrier and spurious are limited by the maximum generated H-field, (see subclause 7.2.1.3 and subclauses 7.4.3.2 and 7.4.4.2 respectively).

Class 2: inductive loop coil transmitter, type tested without an antenna;

NOTE 2: This class of equipment is intended for use with customised antennas only. Where a manufacturer provides a range of standard antennas the equipment will be type tested as class 1 equipment, with the antenna attached. The transmitter carrier and spurious are limited by the maximum output loop current, (see subclause 7.2.2.3 and subclauses 7.4.2.1.2, 7.4.2.1.4, 7.4.3.2 and 7.4.4.2 respectively).

Class 3: large size inductive loop transmitter, type tested without an antenna;

NOTE 3: The transmitter carrier and spurious are limited by the maximum output loop current, (see subclauses 7.2.2.3 and subclauses 7.4.2.1.2, 7.4.2.1.4, 7.4.3.2 and 7.4.4.2 respectively).

Class 4: E-field transmitter, type tested with each type of antenna to be used.

NOTE 4: The transmitter carrier and spurious are limited by the maximum generated E-field, measured as the equivalent H-field, (see subclause 7.2.3.3 and subclauses 7.4.3.2 and 7.4.4.2 respectively).

For transmitter requirement overview see figure 1.

7.2 Transmitter carrier output levels

7.2.1 H-field (Class 1)

7.2.1.1 Definition

In the case of a transmitter with an integral antenna the H-field is measured in the direction of maximum field strength under specified conditions of measurement.

7.2.1.2 Methods of measurement

The H-field produced by the equipment shall be measured at a distance of 10 m on an open field test site (see annex A). The equipment under test shall operate where possible, without modulation. Where this is not possible, e.g. for pulsed equipment, it shall be stated in the test report.

For pulsed systems the field strength in the frequency range 9 kHz to 135 kHz is calculated using the formula in subclause 6.7:

where:

L = field strength limit in the applicable frequency range as defined in table 2; and

M_{peak} = measured peak field strength.

The reading should be reduced by 51,5 dB for measuring equipment calibrated in dBµV and converted to dBµV/m.

7.2.1.3 Limits

The maximum levels presented in this I-ETS are the required field strengths to allow satisfactory operation of inductive systems. These levels were determined after careful analysis within ETSI of proposals by ETSI members. Exceptionally, some National Administrations may have a need for SRDs to apply lower field strengths at particular frequencies in the bands indicated, in order to protect existing primary services. In order to take account of these requirements a level is indicated which shall be the minimum value of the limit to be applied at those particular frequencies.

Maximum field strength under normal and extreme conditions are given in table 2.

Table 2: H-field limits

Frequency range (MHz)	H-field strength limit (H_f) dBµA/m at 10 m
For loop coil antennas with area ≥ 0,16 m^2	
0,009 ≤ f < 0,03	72 or according to NOTE
0,03 ≤ f < 0,135	72 at 0,03 MHz descending 3,5 dB/oct or according to NOTE
0,135 ≤ f < 4,78	38 at 0,135 MHz descending 3,5 dB/oct
4,78 ≤ f < 30	20
6,765 ≤ f ≤ 6,795 (ISM) 13,553 ≤ f ≤ 13,567 (ISM) 26,957 ≤ f ≤ 27,283 (ISM)	42
For loop coil antennas < 0,05 m^2	
0,009 ≤ f < 0,03	62 or according to NOTE
0,03 ≤ f < 0,135	62 at 0,03 MHz descending 3,5 dB/oct or according to NOTE
For loop coil antennas with area between 0,05 m^2 and 0,16 m^2	
0,009 ≤ f < 0,135	H_f table values for loop coils ≥ 0,16 m^2 + 10 *log(area/0,16 m^2) or according to NOTE

NOTE: The minimum limit to be applied at particular frequencies to protect existing services within these indicated bands is 42 dBµA/m at 10 m.

For a graphical representation see annex B.

7.2.2 RF carrier current (Classes 2 and 3)

7.2.2.1 Definition

The RF carrier current is defined as the current delivered to an artificial load under specified conditions of measurement.

7.2.2.2 Methods of measurement

The transmitter shall be connected to an artificial antenna, see subclause 6.2. The RF current delivered to this artificial antenna during a transmission duty cycle shall be measured using a calibrated current test fixture up to 30 MHz connected to a selective voltmeter.

For pulsed systems operating below 135 kHz, RF carrier current is calculated according to subclause 6.7:

where:

L = RF carrier current;

M_{peak} = measured peak RF current.

The measurements shall be made under normal and extreme test conditions, see subclause 5.4.

7.2.2.3 Limits

7.2.2.3.1 Class 2:

a) RF carrier current:

the measured value of RF carrier current shall be within 1,5 dB of the value declared by the applicant, without exceeding the declared value.

b) equivalent H-field:

maximum field strength is given in table 2.

The H-field is not required to be measured, in order to obtain the initial type testing, however, if equipment is subsequently required to be tested, then measurements shall be made, with the customised antenna fitted, in accordance with subclause 7.2.1.2 and shall not exceed the limits as stated in subclause 7.2.1.3.

The type testing will be to a specific maximum RF carrier current, as declared by the manufacturer on the appropriate application form. This will allow the manufacturer to supply customised antenna based on the minimum antenna factor, for a given maximum RF current, obtained from annex H, figure H.1. Customer designed antennas shall be approved by the manufacturer or the manufacturer's representative.

A detailed explanation on the relationship between the RF carrier current, antenna factor (N*A) and the equivalent generated H-field is given in annex H. The antenna factor is equal to the number of coil turns (N) and the area (A) of the antenna coil.

7.2.2.3.2 Class 3

The maximum RF carrier current for Large size loop transmitters is given in table 3

Table 3: RF carrier current

Frequency range kHz	RF carrier current dBµA
9 < 30	126,2
30 - 135	126,2 at 30 kHz descending 3,5 dB/oct

See annex C for a graphical representation.

7.2.3 Radiated E-field (Class 4)

7.2.3.1 Definition

A transmitter with an integral antenna. The radiated E-field is defined as the E-field in the direction of maximum field strength under the specified conditions of measurement.

7.2.3.2 Methods of measurement

The transmitter radiated E-field, is based on the equivalent measured H-field, measured at 10 m. For a detailed explanation of the relationship between E-field and H-field, see annex G.

For pulsed systems operating below 135 kHz, equivalent H-field is calculated according to subclause 6.7:

where:

L = equivalent H-field;

M_{peak} = measured equivalent peak H-field.

7.2.3.3 Limits

In the frequency range 9 kHz to 4,78 MHz, the limits of Hef follow the H-fields limits, Hf, as given in subclause 7.2.1.3, table 2 with an additional correction factor C. The factor given below is specific for a 10 m measuring distance.

The limit Hef = Hf + C;

where:

$$C = 20*\log (f_c / 4,78*10^6) \quad \text{dB;}$$

and where:

f_c is the carrier frequency in Hz.

For a graphical representation of the correction factor C see annex D.

In the frequency range 4,78 MHz - 25 MHz limits are identical to the limits in subclause 7.2.1.3, table 2 without any correction factor.

7.3 Operating frequencies

The frequency ranges shall be stated by the applicant.

7.3.1 Definition

The permitted range of operating frequencies includes all frequencies on which the equipment submitted for type testing may operate within an assigned frequency band.

7.3.2 Frequency error

The frequency error shall only be measured when an unmodulated signal can be obtained.

7.3.2.1 Definition

The frequency error of the transmitter system is the difference between the operating carrier frequency and the nominal frequency declared by the applicant.

7.3.2.2 Methods of measurement

The transmitter shall be connected to an artificial antenna. The measurement shall be made under normal test conditions (subclause 5.3) and extreme test conditions (subclause 5.4). The carrier frequency shall be measured in the absence of modulation. For multi-carrier systems a single carrier shall be selected.

7.3.2.3 Limits

The maximum frequency error measured shall be used to determine the range of operating frequencies (see subclause 7.3.3.3). Where an unmodulated carrier cannot be produced the frequency error shall be assumed to be zero.

7.3.3 Modulation bandwidth

7.3.3.1 Definition

The modulation bandwidth of the transmitter is a measure for attenuation of the modulation products at a certain offset from the nominal carrier frequency under defined conditions of modulation.

7.3.3.2 Methods of measurement

The transmitter shall be operated at the carrier level determined in subclause 7.2 under normal test conditions (subclause 5.3). The signal to be measured shall be applied to the input of a measuring receiver at the appropriate level. The transmitter shall be modulated according to subclause 6.1 at the input level specified by the applicant. The spectrum analyser shall be adjusted to a bandwidth of 100 Hz and frequency span that is appropriate for measuring the bandwidth at which the level is - 30 dB relative to the carrier level measured in subclause 7.2.

Additionally where the transmitter has a speech facility, the test shall be repeated using normal test modulation according to subclause 6.1 but with a 20 dB increased input level. The largest bandwidth measured shall be recorded.

7.3.3.3 Limit

The largest bandwidth measured shall be used to determine the range of operating frequencies.

The permitted range of operating frequencies will be determined as follows:

lower Limit = $f_l + (f_b/2) + f_d$ kHz;

higher Limit = $f_h - (f_b/2) - f_d$ kHz;

where:

fb = modulation bandwidth in kHz as determined in subclause 7.3.3.2;

fd = frequency error as determined in subclause 7.3.2.2;

fh = highest frequency of the assigned frequency band;

fl = lowest frequency of the assigned frequency band.

For unmodulated systems the modulation bandwidth is assumed to be zero.

7.4 Spurious emissions

7.4.1 Definition

Spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with normal test modulation (subclause 6.1). The level of spurious emissions shall be measured at normal conditions (subclause 5.3) as either:

1) a) their power or current level in an artificial antenna (conducted spurious emission); and

   b) their effective radiated power or field strength when radiated by the cabinet and structure of the equipment (cabinet radiation);

or,

2) their effective radiated power or field strength 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.

7.4.2 Conducted spurious emissions, subclause 7.4.1 1 a

7.4.2.1 Class 2

7.4.2.1.1 Methods of measurement (< 30 MHz)

The transmitter shall be connected to an artificial antenna according to subclause 6.2. The measuring receiver shall be connected to the output of the artificial antenna and the current measured.

7.4.2.1.2 Limits

The spurious current limit is calculated by the following formula:

$I_S = I_C + H_S - H_C$;

where:

I_S is the calculated conducted spurious limit;

H_S is the generated H-field spurious limit, see subclause 7.4.3.2;

I_C is the measured RF carrier current, see subclause 7.2.2.3.1 a);

H_C is the generated H-field limit, see subclause 7.2.1.3.

7.4.2.1.3 Methods of measurement (≥ 30 MHz)

The transmitter shall be connected to an artificial antenna according to subclause 6.2. The spurious components are measured by means of a selective voltmeter connected to the output of the artificial antenna.

7.4.2.1.4 Limits

The power of any conducted spurious emission shall not exceed the values given in table 4.

Table 4

State	47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other Frequencies between 30 to 1000 MHz
Operating	4 nW	250 nW
Standby	2 nW	2 nW

7.4.2.2 Class 3

7.4.2.2.1 Methods of measurement

Spurious emissions shall be measured as the power level of any discrete signal delivered into a nominal non-reactive load. This may be done by connecting the transmitter output through an attenuator to a measuring receiver.

The transmitter shall be switched on with normal modulation and the measurements shall be made, in the frequency range 135 kHz - 1 GHz.

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

7.4.2.2.2 Limits

The power of any conducted spurious emission below 30 MHz shall not exceed the values given in table 5.

The power of any conducted spurious emission at, or above, 30 MHz shall not exceed the values given in table 4.

Table 5

State	135 to 1 000 kHz	1 000 kHz to 30 MHz
Operating	1 µW	250 nW
Standby	2 nW	2 nW

7.4.3 Field strength, subclause 7.4.1 1 b and 2

7.4.3.1 Methods of measurement (< 30 MHz)

This applies to all Classes.

The field strength shall be measured for frequencies below 30 MHz. The equipment under test shall be measured at a distance of 10 m on an outdoor test site. The test antenna shall be a calibrated shielded magnetic field antenna. The equipment under test and test antenna shall be arranged as stated in annex A, clause A.1.

For Classes 2 and 3 the transmitter antenna connector of the equipment under test shall be connected to an artificial antenna (see subclause 6.2) and the output connector terminated.

The equipment under test shall be switched on with normal modulation. The characteristics of the modulation signal used shall be stated on the test report. The measuring receiver shall be tuned over the frequency range 9 kHz to 30 MHz, except for the frequency band on which the transmitter is intended to operate.

At each frequency at which a spurious signal is detected the equipment under test and the test antenna shall be rotated until maximum field strength is indicated on the measuring receiver. This level shall be noted.

If the transmitter can be operated in the standby mode, then the measurements shall be repeated in the standby mode.

Reduce reading by 51,5 dB for measuring equipment calibrated in dBµV or dBµV/m.

7.4.3.2 Limits

Radiated emissions below 30 MHz shall not exceed the generated H-field dBµA/m at 10 metres given in table 6.

Table 6

State	Frequency 9 kHz ≤ f < 4,78 MHz	Frequency 4,78 MHz ≤ f < 30 MHz
Transmit	24,5 dBµA/m descending 3 dB/oct	-2,8 dBµA/m
Standby	3,5 dBµA/m descending 3 dB/oct	-23,7 dBµA/m

For a graphical representation see annex E.

7.4.4 Effective radiated power, subclause 7.4.1 1 b and 2

7.4.4.1 Methods of measurement (≥ 30 MHz)

This method applies to all Classes.

On a test site, selected from annex A, 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.

For Classes 2 and 3 the transmitter antenna connector shall be connected to an artificial antenna (see subclause 6.2).

The test antenna shall be oriented for vertical polarisation. The output of the test antenna shall be connected to a measuring receiver.

The transmitter shall be switched on with normal modulation, and the measuring receiver shall be tuned over the frequency range 30 to 1 000 MHz.

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

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 annex A, clause A.3 is used, there is no need to vary the height of the antenna.

The input signal to the substitution antenna shall be adjusted until an equal or a known related level to that detected from the transmitter is obtained on the measuring receiver.

The input signal to the substitution antenna shall be recorded as a power level and 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 oriented 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 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.

If standby mode is available, the measurements shall be repeated in that mode.

7.4.4.2 Limits

The power of any radiated emission shall not exceed the values given in table 7.

Table 7

State	47 MHz to 74 MHz 87,5 MHz to 118 MHz 174 MHz to 230 MHz 470 MHz to 862 MHz	Other frequencies between 30 to 1 1 000 MHz
Operating	4 nW	250 nW
Standby	2 nW	2 nW

8 Receiver requirement

8.1 Receiver spurious radiation

These requirements do not apply to receivers used in combination with permanently co-located transmitters continuously transmitting. Co-located is defined as < 3 m. In these cases the receivers will be tested together with the transmitter in operating mode (see subclause 7.4).

8.1.1 Definition

Spurious radiation from receivers are emissions radiated from the antenna, the chassis and case of the receiver. It is specified as the radiated power of a discrete signal.

8.1.2 Methods of measurement

1) For radiation below 30 MHz see subclause 7.4.3.1.

2) For radiation at or above 30 MHz see subclause 7.4.4.1.

Reduce reading by 51,5 dB for measuring equipment calibrated in dBmV or dBmV/m.

8.1.3 Limits

8.1.3.1 Radiated emissions below 30 MHz:

The spurious components below 30 MHz shall not exceed the generated H-field dBµA/m values at 10 metres according to table 8.

Table 8

Frequency 9 kHz ≤ f < 4,78 MHz	**Frequency 4,78 MHz ≤ f < 30 MHz**
3,5 dBµA/m descending 3 dB/oct	- 23,7 dBµA/m

For a graphical representation see annex E.

8.1.3.2 Radiated emissions above 30 MHz:

The measured values shall not exceed 2 nW.

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
Conducted emission of transmitter, valid up to 1 GHz	± 3 dB
Conducted emission of receivers	± 3 dB
Radiated emission of transmitter, valid up to 1 GHz (Substitution method)	± 3 dB
Radiated emission of transmitter, valid up to 1 GHz (Direct measurement, using calibrated antennas)	± 6 dB
Radiated emission of receiver, valid up to 1 GHz (Substitution method)	± 2 dB
Radiated emission of receiver, valid up to 1 GHz (Direct measurement, using calibrated antennas)	± 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 (normative): Radiated measurements

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

A.1.1 Outdoor test site

The outdoor test site shall be on a reasonably level surface or ground. For measurements at frequencies below 30 MHz a non-conducting ground plane shall be used. For measurements at frequencies 30 MHz and above, a conducting ground plane of at least 5 m diameter shall be provided at one point on the site. In the middle of this ground plane, a non-conducting support, capable of rotation through 360o in the horizontal plane, shall be used to support the test sample in its standard position, at 1 m above the ground plane, with the exception of equipment with floor standing antenna. For this equipment, the antenna shall be raised, on a non-conducting support, 100 mm above the turntable, the point(s) of contact being consistent with normal use. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of 10 m. 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.

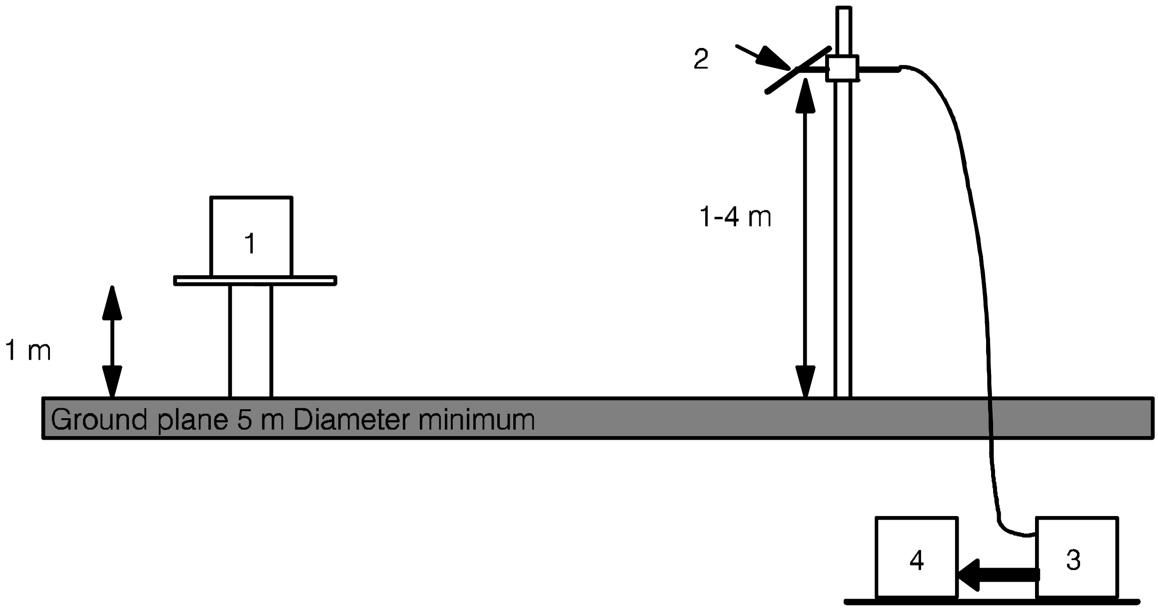

Figure A.1

A.1.1.1 Test support for body worn equipment

For equipment intended to be worn close the body, 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 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, this antenna has to be in a vertical position during the measurement and the metal plate shall, 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 shall 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:

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

2) 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 a sample, whose largest area is smaller than 10 cm x 15 cm, the centre of the sample shall (deviating from point 1) above) be so changed in its longitudinal axis so that the antenna base is at the edge outside the metal plate.

A.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 manufacturer;

- 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.

A.1.2 Test antenna

A.1.2.1 Below 30 MHz

A calibrated loop antenna shall be used to detect the field strength from the test sample. The antenna shall be supported in the vertical plane and be rotated about a vertical axis. The lowest point of the loop shall be 1 m above ground level.

A.1.2.2 Above 30 MHz

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. Where necessary, it is used as a transmitting antenna, when the site is used for the measurement of receiver characteristics.

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.

A.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. 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.

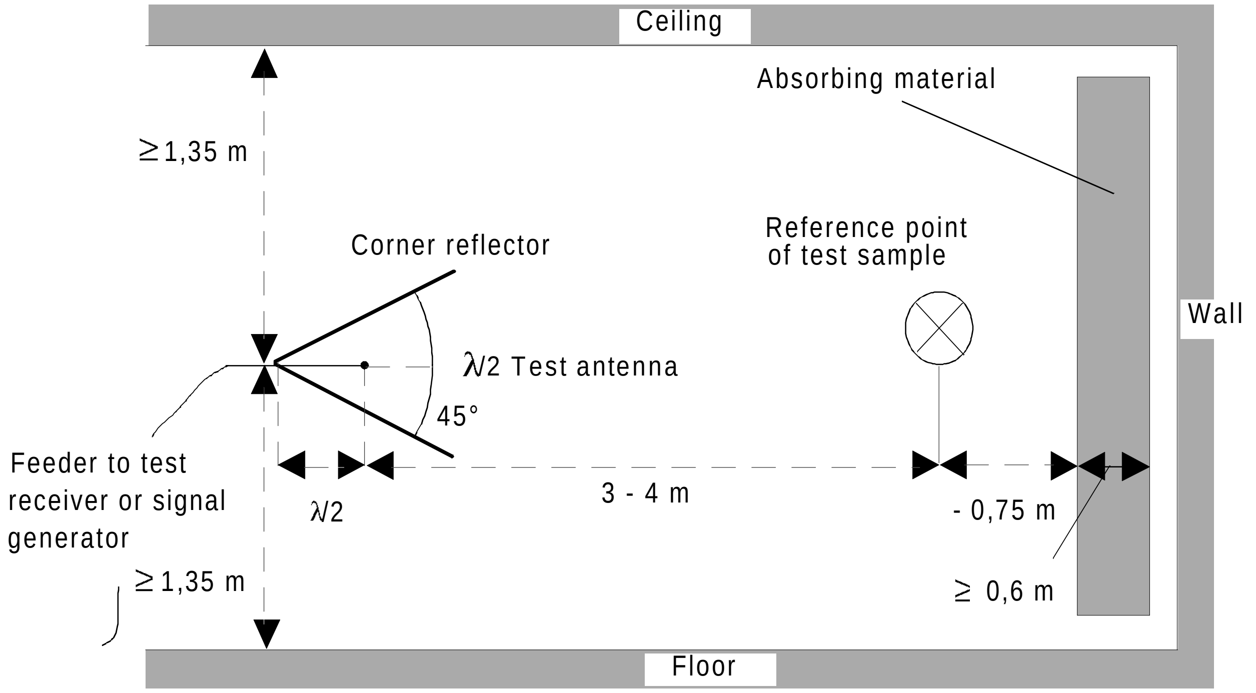

Figure A.2: Indoor site arrangement (shown for horizontal polarisation)

A.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 A.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 λ/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.

A.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 A.1. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

A.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.

A.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 maximum.

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

A.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.

A.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.

A.2.5 Auxiliary cables

The position of auxiliary cables (power supply and microphone cables etc.) which are not adequately de-coupled, 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).

A.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, Subclause A.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, capable of carrying test equipment and operators. The construction of the anechoic chamber is described in the following subclauses.

A.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 A.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 A.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 forming 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.

A.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 more readily shows the disturbances due to reflections and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in Subclause A.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.

A.3.3 Calibration of the shielded RF anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 1 Ghz.

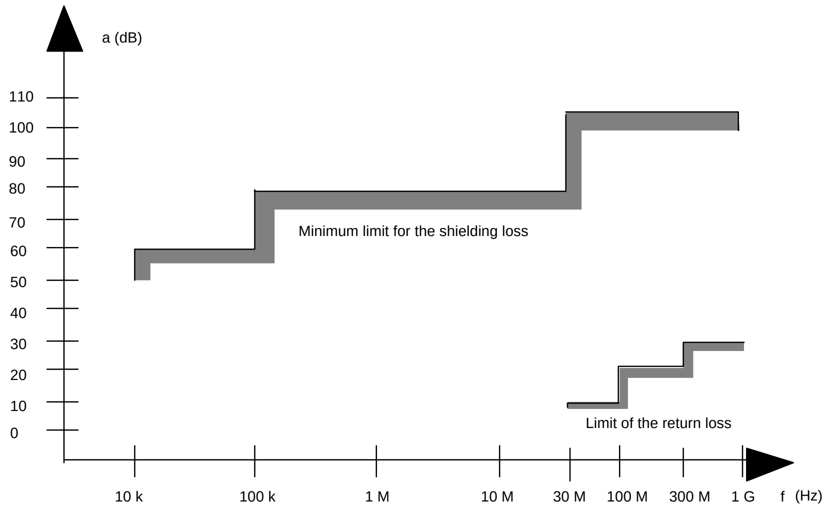

Figure A.3: Specification for shielding and reflections

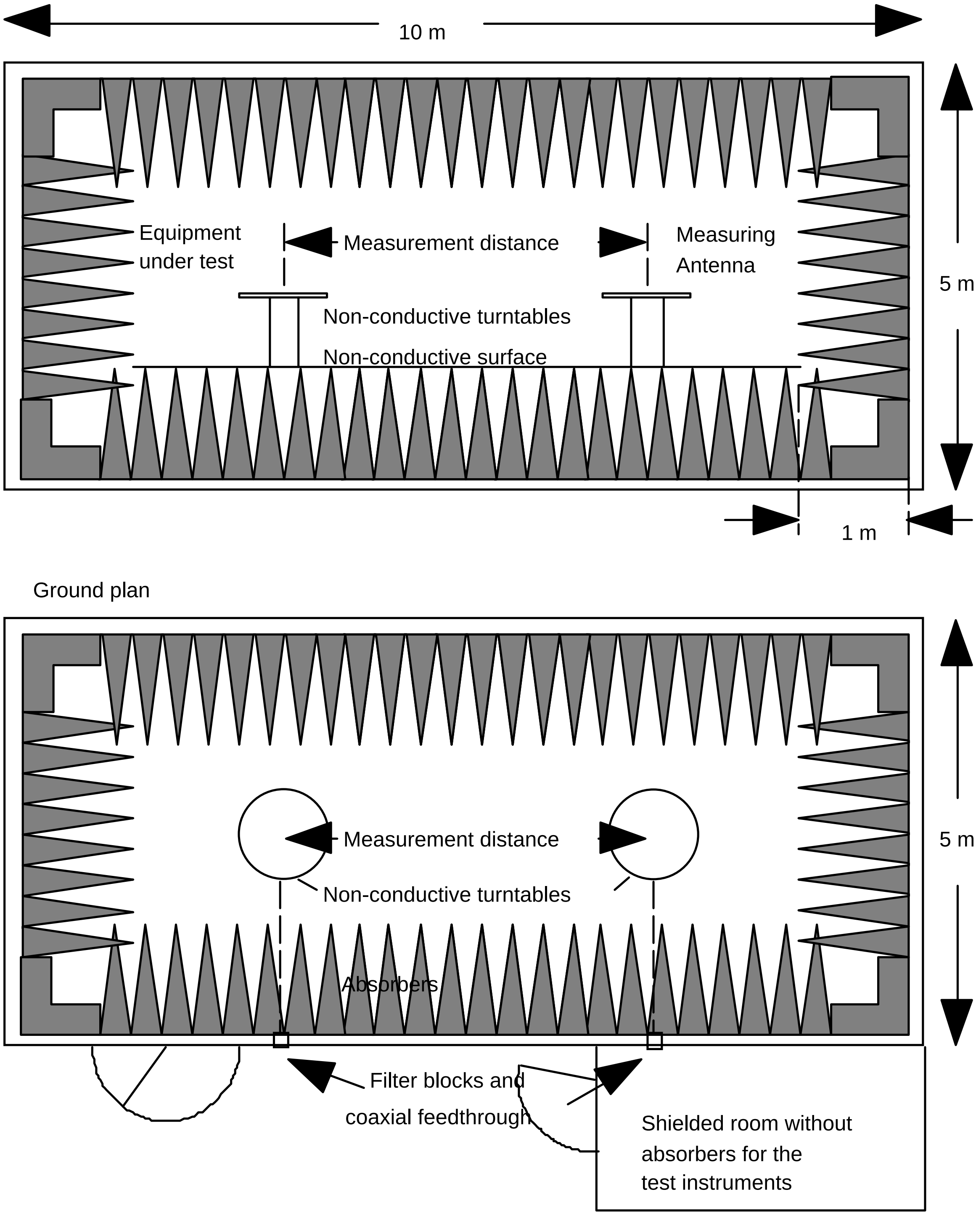

Figure A.4: Example of construction of an anechoic shielded chamber

Annex B (normative): Transmitter carrier limits, radiated H-Field @ 10 m distance

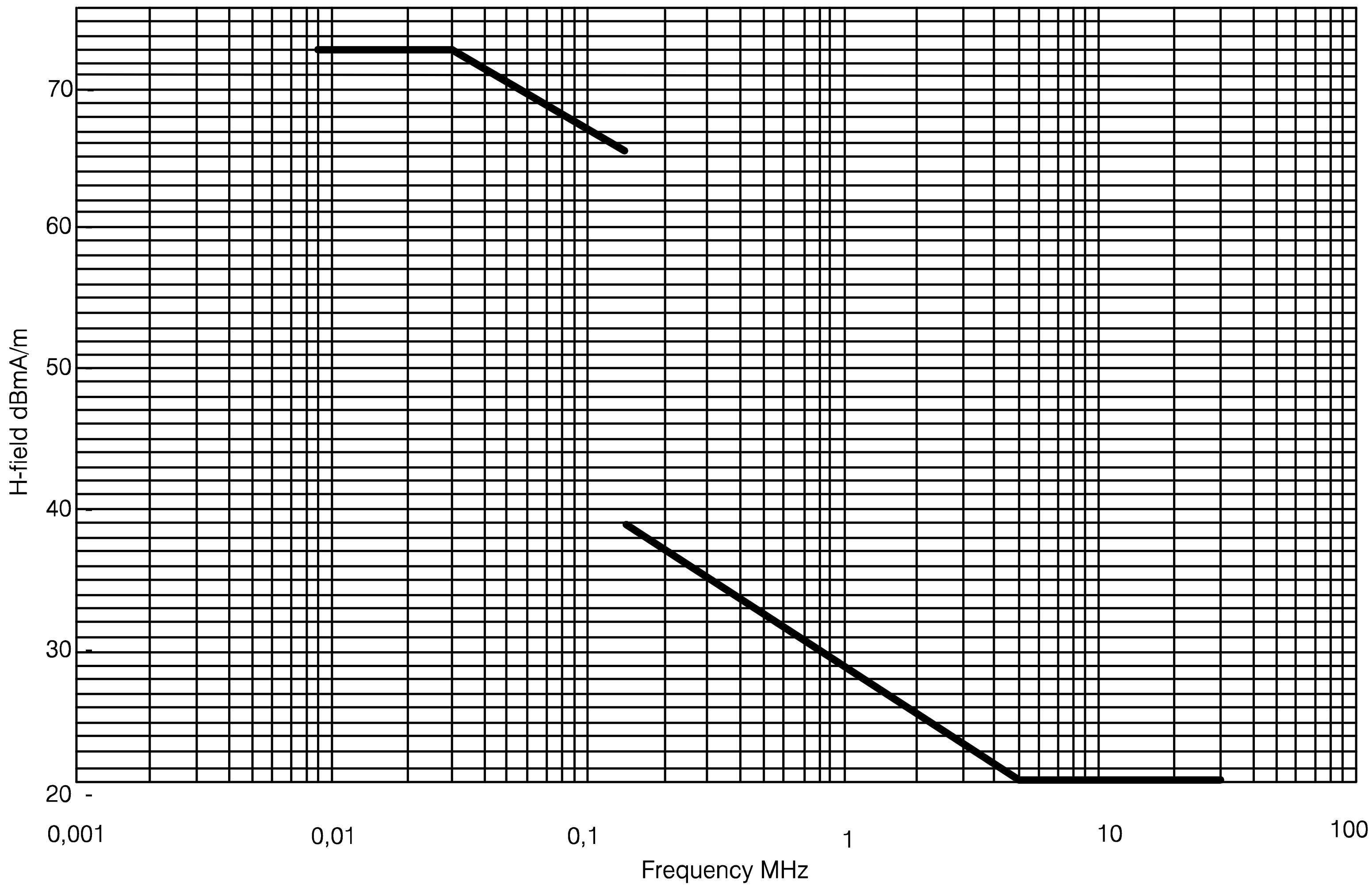

Figure B.1

Annex C (normative): Transmitter RF carrier current limit for large size loop

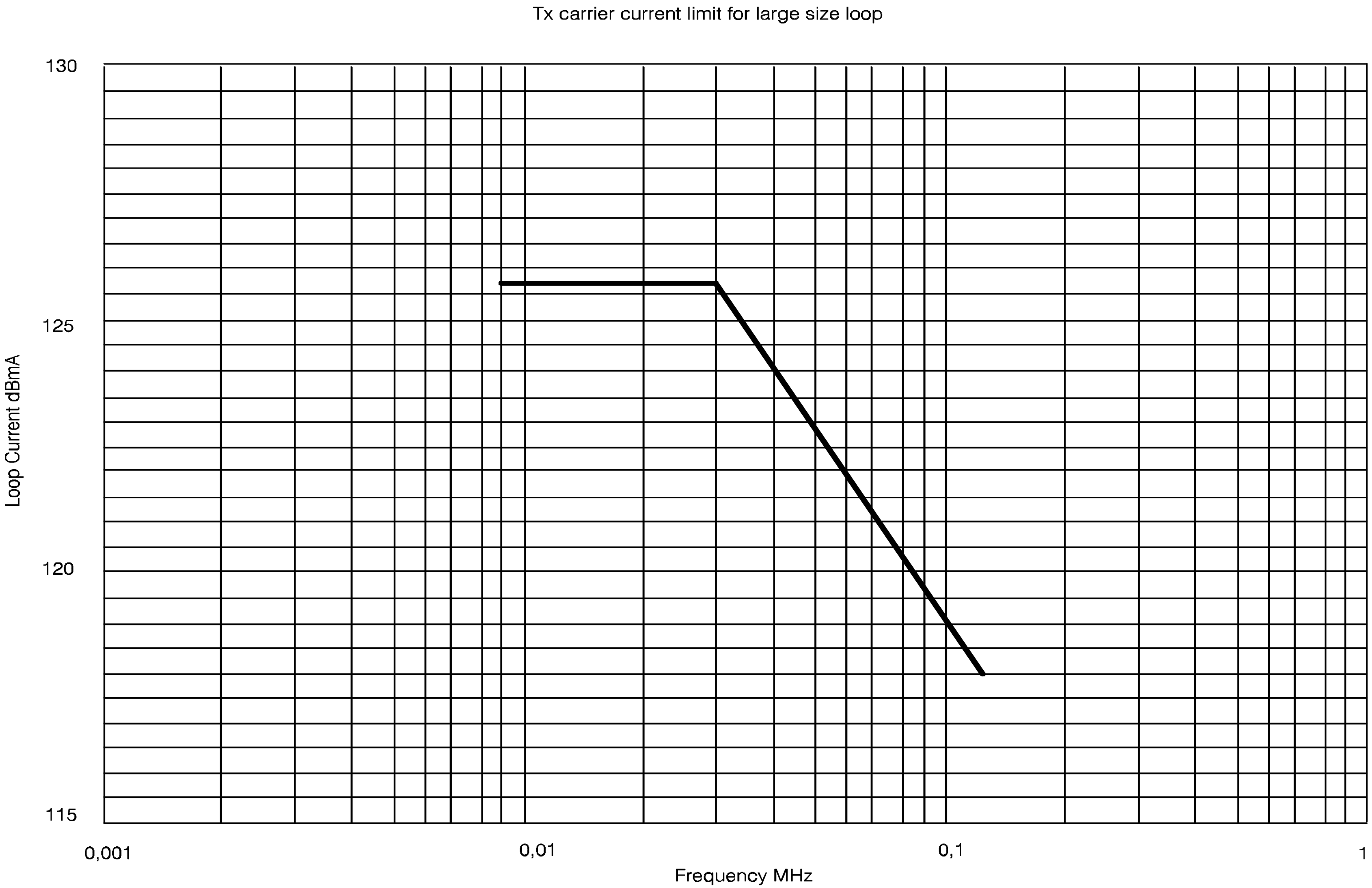

Figure C.1

Annex D (normative): H-field limit correction factor for generated E-fields

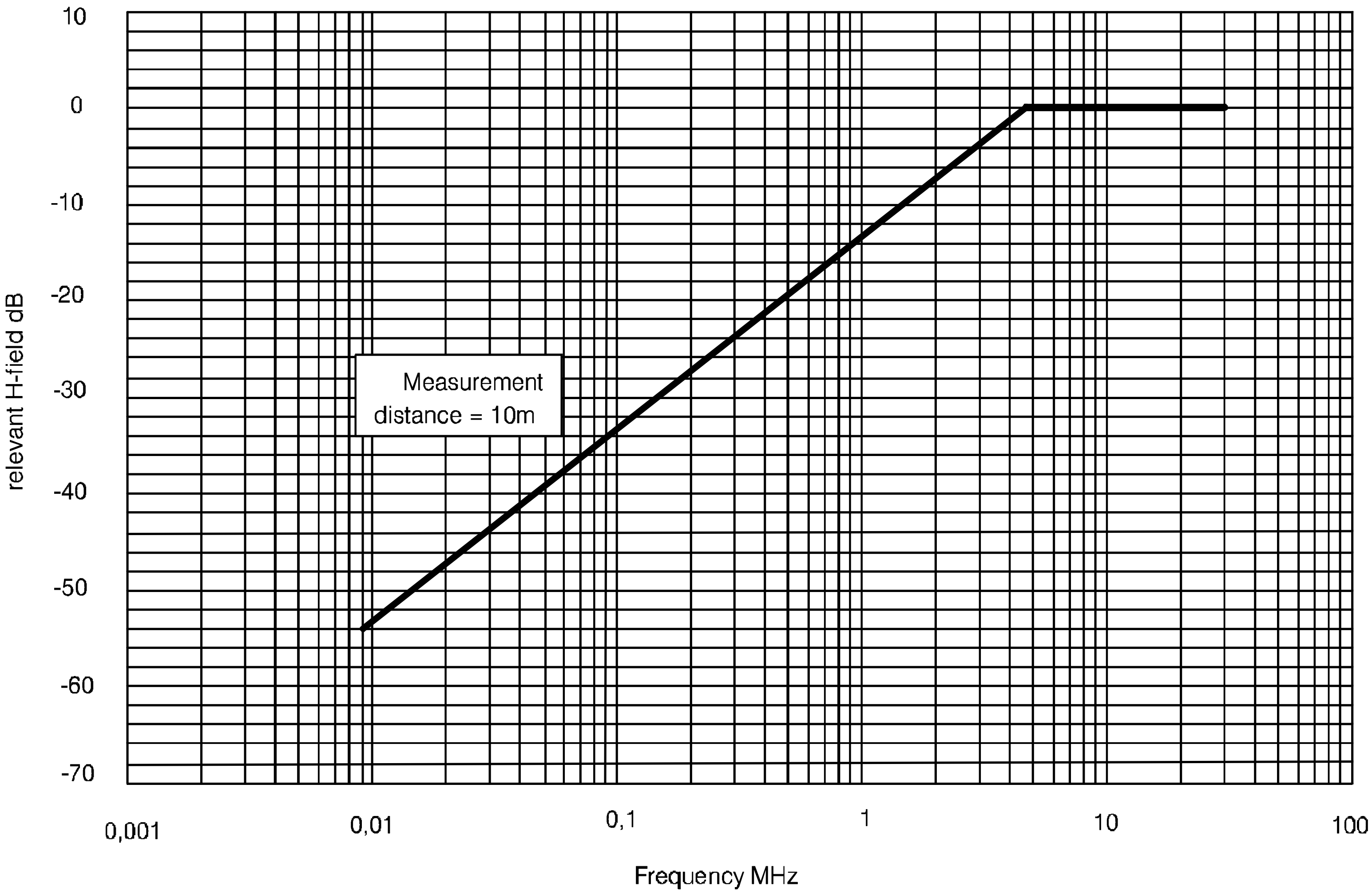

Figure D.1

Annex E (normative): Spurious limits, radiated H-field at 10 m distances

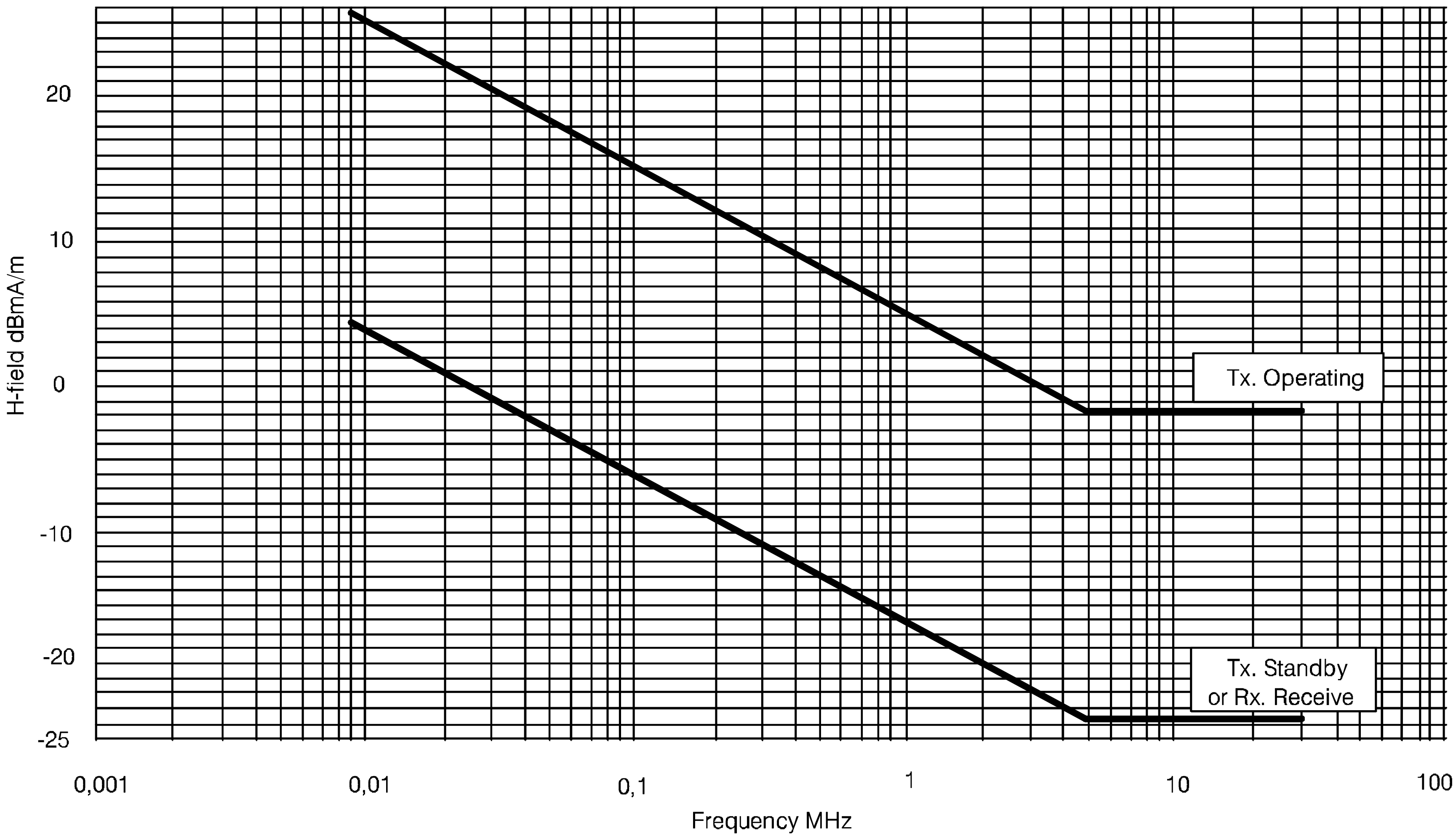

Figure E.1

Annex F (normative): Test fixture for measuring carrier and harmonic currents by use of an artificial antenna

The artificial antenna is used for equipment with an antenna connector and submitted for type testing without an antenna. The measurement is to determine the RF carrier current and spurious currents in the artificial antenna as the radiated fields for the carrier and spurious which are proportional to the carrier and spurious currents.

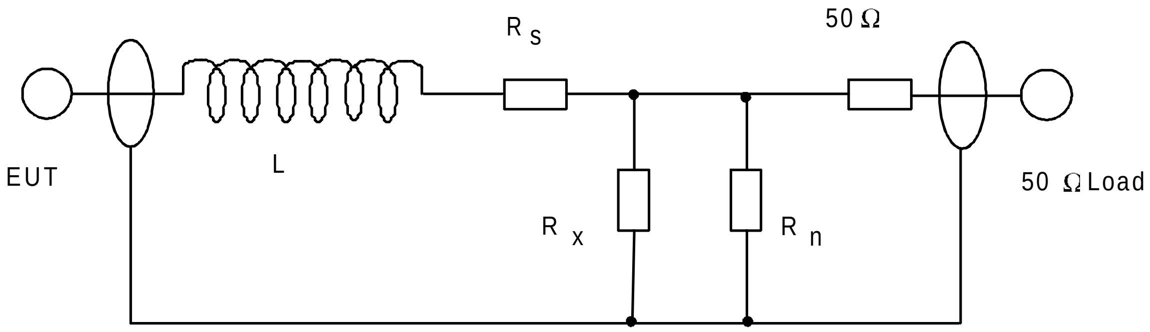

Figure F.1

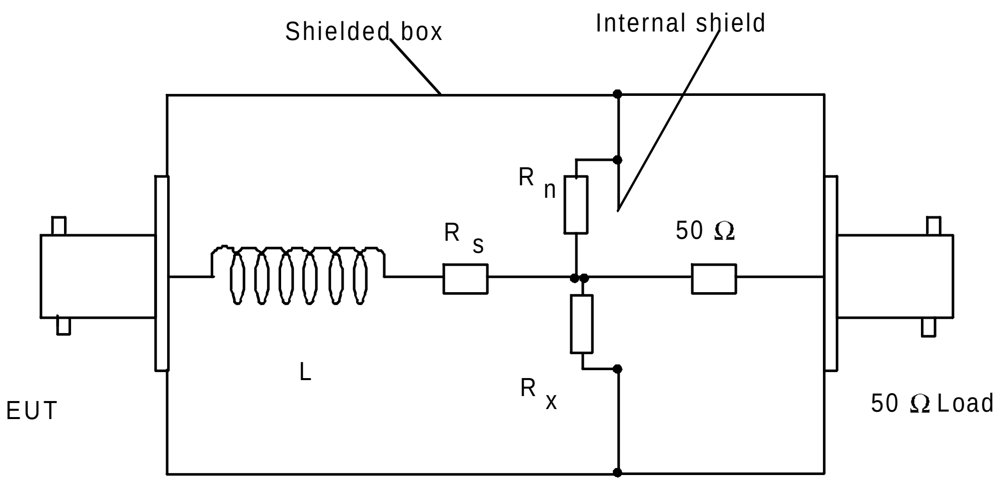

Figure F.2

The mechanical layout and equivalent circuit of the components are given in figures F.1 and F2.

L is the equivalent antenna inductance.

r_x and r_n are low value resistors in parallel to provide a low value inductance free resistor r_z.

r_s insure in combination with r_z identical Q for the artificial antenna and the actual antenna.

If the manufacturer uses several values of antenna inductance two artificial antennas having maximum and minimum inductance L must be supplied.

Annex G (informative): E-fields in the near field at low frequencies

E-field at low frequencies is often in the near field and it is in reality only possible to measure with the shielded loop antenna; in this case there is also a relation between the E-field and the H-field by the wave impedance Z. In the near field the wave impedance is highly dependent on the type of radiating antenna (loop or open end wire) and the wavelength. If the power density at a certain distance is the same for a H-field and an E-field generated signal, the following calculation can be made:

In the direction of maximum power in the near field, the power density S is:

$$S = \frac{E^2}{Z_e} = H_e^2 Z_e = H_m^2 Z_m \qquad (1)$$

where:

S = power density;
E = electrical field generated by an E-field antenna at distance d;
H_e = magnetic field generated by an E-field antenna at distance d;
H_m = magnetic field generated by a H-field antenna at distance d;
Z_e = wave impedance of a field generated by an E-field antenna at distance d;
Z_m = wave impedance of a field generated by an H-field antenna at distance d.

$$Z_m = Z_o 2\pi \frac{d}{\lambda} \quad if \quad d < \frac{\lambda}{2\pi} \ (\text{near field}) \qquad (2)$$

$$Z_e = Z_0 \frac{\lambda}{2\pi d} \quad \text{if} \quad \text{d} < \frac{\lambda}{2\pi} \ (\text{near field}) \qquad (3)$$

Equation (1) gives:

$$H_e = H_m \sqrt{\frac{Z_m}{Z_e}} \ (A/m) \qquad (4)$$

Equation (2) and (3) into (4) gives:

$$H_e = H_m \frac{2\pi d}{\lambda} = H_m \frac{2\pi d\, f_c}{300} \qquad (5)$$

where fc is the carrier frequency in MHz.

For $2\pi d/\lambda = 1$, d = 10 and f_c=4,78 MHz, and using equation (5), this gives:

$$H_e = H_m \frac{f_c}{4{,}78} \ (f \text{ in MHz}) \qquad (6)$$

For $2\pi d/\lambda < 1$ if $f_c < 4{,}78$ MHz then equation (5) is valid, (i.e. near field).

For $2\pi d/\lambda \geq 1$ if $f_c > 4{,}78$ MHz then $H_e = H_m$, (i.e. far field).

The method allows an electric generated E-field to be measured as a magnetic generated H-field by adding a correction factor derived from (6).

For a graphical representation of the correction factor, see annex D.

Annex H (informative): Category 2 - customised loop antennas

H.1 Carrier currents

The radiated magnetic field from a loop coil antenna in the near field is given by:

$$H = \frac{NIA}{2\pi d^3} \quad (\mathrm{A / m}) \qquad (1)$$

where:

N is the number of turns of the loop coil antenna;
I is the current in the loop coil antenna;
A is the area of the loop coil antenna;
d is the distance from the transmitter.

The formula is valid at low frequencies under the following conditions:

- Length of the coil wire: $l < \lambda / 2\pi$
- Distance from coil: $d < \lambda / 2\pi$

The product of NIA is the magnetic moment of the coil.

Equation (1) gives:

$$M = NIA = H 2\pi d^3 \quad (\mathrm{Am}^2) \qquad (2)$$

In this I-ETS the reference measuring distance d is 10m.

If inserted into (2):

$$M = H\, 6283 \quad (\mathrm{Am}^2) \qquad (3)$$

$$NA = 6283 \frac{H}{I} \quad (\mathrm{turns\ m}^2) \qquad (4)$$

where:

H is the H-field limit @ 10m (see subclause 7.1.1);

I is the current limit of the type testing Class.

For method of measurement for loop current into an artificial antenna, see annex F.

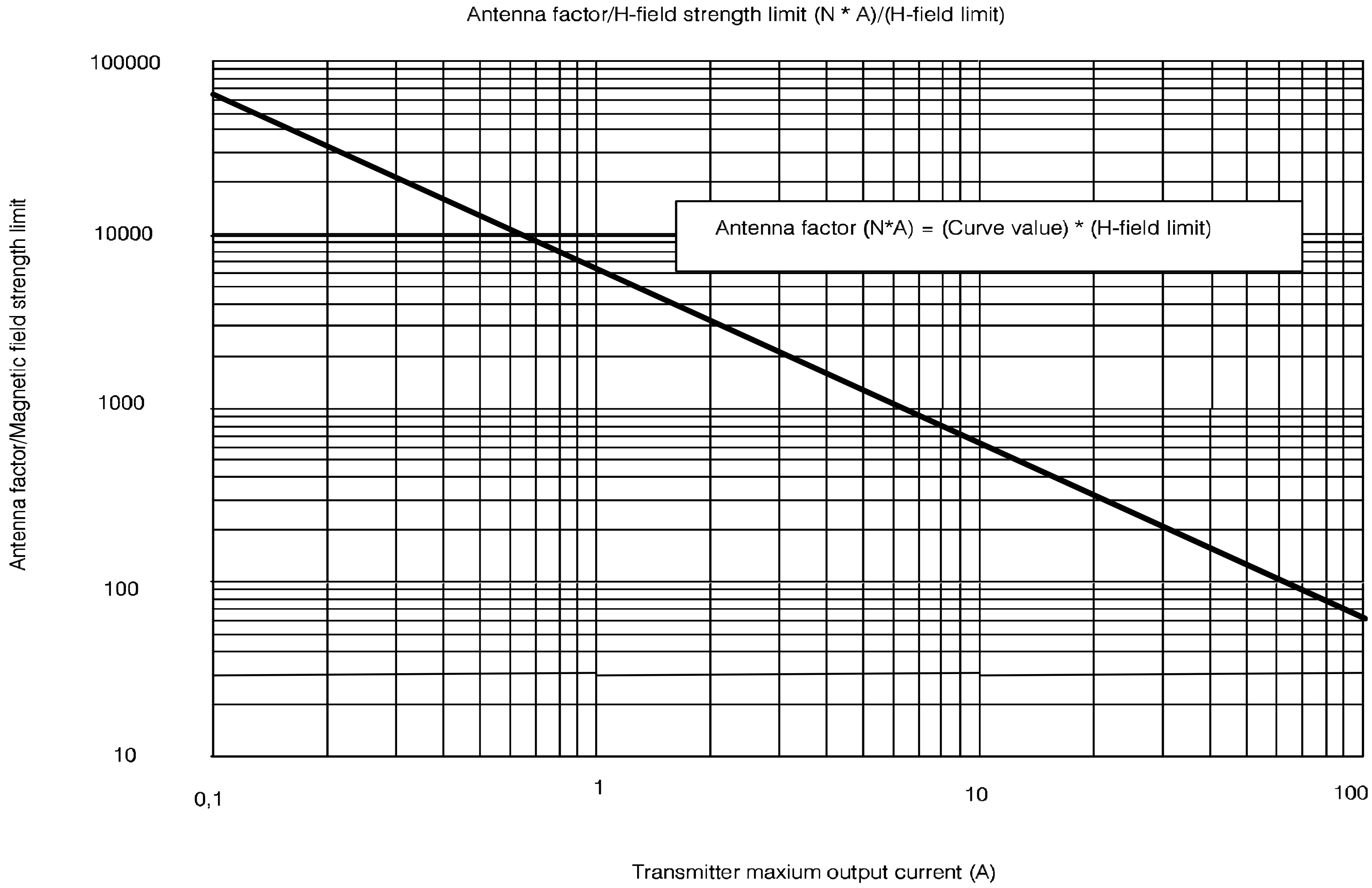
Antenna factor/H-field strength limit (N * A)/(H-field limit)
Antenna factor (N*A) = (Curve value) * (H-field limit)
Antenna factor/Magnetic field strength limit
100000
10000
1000
100
10
0,1
1
10
100
Transmitter maxium output current (A)

Figure H.1

For type testing of Class 2 equipment, the maximum RF carrier current is stated by the applicant and the minimum NA is determined from figure H.1. This minimum value should never be exceeded by the manufacturer when designing customised antenna.

History

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