ETSI EN 300 718-1 V2.2.1 (2021-06)

Avalanche Beacons operating at 457 kHz;
Transmitter-receiver systems;
Part 1: Harmonised Standard for access to radio spectrum

Reference

REN/ERM-TG28-559

Keywords

harmonised standard, radio, testing

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - APE 7112B
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° w061004871

Contents

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The declarations pertaining to these essential IPRs, if any, are publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI Directives including the ETSI IPR Policy, no investigation regarding the essentiality of IPRs, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners. **oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners. **GSM**® and the GSM logo are trademarks registered and owned by the GSM Association.

Foreword

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

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.2] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

The present document is part 1 of a multi-part deliverable covering avalanche beacons operating at 457 kHz transmitter-receiver systems, as identified below:

Part 1: "Harmonised Standard for access to radio spectrum";

Part 2: "Harmonised Standard for features for emergency services";

Part 3: "Harmonized EN covering essential requirements of article 3.3e of the R&TTE Directive".

NOTE: This part 3 is obsolete and has been replaced with ETSI EN 300 718-2 [2].

National transposition dates	
Date of adoption of this EN:	24 May 2021
Date of latest announcement of this EN (doa):	31 August 2021
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	28 February 2022
Date of withdrawal of any conflicting National Standard (dow):	28 February 2023

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document specifies technical characteristics and methods of measurements for avalanche beacon transmitter-receiver systems operating from 456,9 kHz to 457,1 kHz. The frequency range 456,9 kHz to 457,1 kHz is EU wide harmonised for emergency detections of buried victims and valuable items devices according to Commission Implementing decision (EU) 2019/1345 [i.9].

An avalanche beacon comprises in one unit at least a transmitter/receiver including antenna and battery.

NOTE: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU [i.1] is given in annex A.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] CISPR 16-1-4 (2019): "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus - Antennas and test sites for radiated disturbance measurements".

[2] ETSI EN 300 718-2 (V2.1.1) (01-2018): "Avalanche Beacons operating at 457 kHz; Transmitter-receiver systems; Part 2: Harmonised Standard for features for emergency services".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.2] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

[i.3] ANSI C63.5: "American National Standard for Electromagnetic Compatibility-Radiated Emission Measurements in Electromagnetic Interference (EMI) Control-Calibration of Antennas (9 kHz to 40 GHz)".

[i.4] ETSI TR 100 028 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[i.5] ETSI TR 102 273-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 2: Anechoic chamber".

[i.6] ETSI TR 102 273-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 3: Anechoic chamber with a ground plane".

[i.7] ETSI TR 102 273-4: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties; Part 4: Open area test site".

[i.8] ECC Report 284 (September 2018): "Feasibility studies of Person detection and collision avoidance applications in the 442.2-457.1 kHz range".

[i.9] Commission Implementing decision (EU) 2019/1345 of 2 August 2019 amending Decision 2006/771/EC updating harmonised technical conditions in the area of radio spectrum use for short-range devices.

[i.10] ERC Recommendation 70-03 (June 2019): "Relating to the use of Short Range Devices (SRD)".

[i.11] ETSI EG 203 336 (V1.2.1): "Guide for the selection of technical parameters for the production of Harmonised Standards covering article 3.1(b) and article 3.2 of Directive 2014/53/EU".

[i.12] ETSI TS 103 361 (V1.1.1): "Short Range Devices (SRD) using Ultra Wide Band technology (UWB); Receiver technical requirements, parameters and measurement procedures to fulfil the requirements of the Directive 2014/53/EU".

[i.13] ETSI TS 103 567 (V1.1.1): "Requirements on signal interferer handling".

[i.14] Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services.

[i.15] Directive 2009/140/EC of the European Parliament and of the Council of 25 November 2009 amending Directives 2002/21/EC on a common regulatory framework for electronic communications networks and services, 2002/19/EC on access to, and interconnection of, electronic communications networks and associated facilities, and 2002/20/EC on the authorisation of electronic communications networks and services.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

avalanche beacons: portable radio systems used for locating avalanche victims, for the purpose of direct rescue (i.e. for rescue by comrades not buried by the avalanche)

NOTE: An avalanche beacon has two operating modes: transmit and receive.

E-field: electric component of the field measured as voltage per unit length

environmental profile: range of environmental conditions under which equipment within the scope of the present document is required to comply with the provisions of the present document

H-field: magnetic component of the field measured as current per unit length

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

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

measuring receiver: selective voltmeter or a spectrum analyser

NOTE: See clause 5.4.

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

receive mode: operating mode of the avalanche beacon where it receives, or is ready to receive, the signal(s) of other avalanche beacon(s) (also called: SEARCH mode)

transmit mode: operating mode of the avalanche beacon where it radiates a magnetic field with carrier frequency and on/off keying as defined in the present document (also called: SEND mode)

3.2 Symbols

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

E	Electrical field strength
Eo	Reference electrical field strength
f	Frequency
H	Magnetic field strength
Ho	Reference magnetic field strength
N	Newton
P	Power
R	Distance
Ro	Reference distance
t	Time
Z	Wave impedance
l	Wavelength

3.3 Abbreviations

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

CEPT	Conférence des administrations Européennes des Postes et Telecommunications
CISPR	Comité International Spécial des Perturbations Radioélectriques
DSP	Digital Signal Processor
EC	European Commission
ECC	Electronic Communications Committee
EFTA	European Free Trade Association
ERC	European Radio communications Committee
EU	European Union
EUT	Equipment Under Test
OATS	Open Area Test Site
RF	Radio Frequency
UWB	Ultra Wideband
VSWR	Voltage Standing Wave Ratio

4 Technical requirements specifications

4.1 Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be in accordance with its intended use, but as a minimum, shall be that specified in the test conditions contained in the present document (see clause 5.1). The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the operational environmental profile defined by its intended use.

4.2 Conformance requirements for transmitters

4.2.1 Modulation and carrier keying

4.2.1.1 Applicability

This requirement applies to all avalanche beacons.

4.2.1.2 Description

The modulation used for avalanche beacons is carrier keying. The carrier keying defines the on and off times for a non-continuous carrier.

4.2.1.3 Limits

The carrier keying shall be as shown in figure 1:

- on time: 70 ms minimum;
- off time: 400 ms minimum;
- period: 1 000 ms ± 300 ms (on time plus off time).

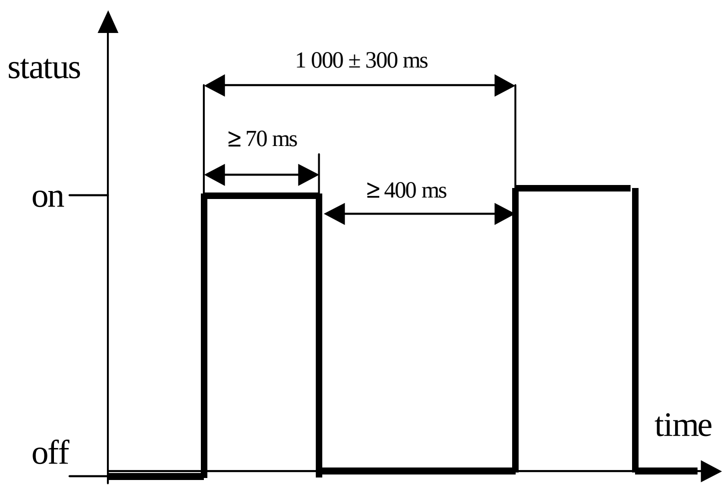

Figure 1

4.2.1.4 Conformance

The conformance tests for transmitter modulation and carrier keying shall be as defined in clause 5.3.1 of the present document.

Conformance shall be established under normal as well as under extreme test conditions according to clause 5.1.

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.2.

4.2.2 Frequency error

4.2.2.1 Applicability

This requirement applies to all avalanche beacons.

4.2.2.2 Description

The frequency error of the transmitter system is the difference between the measured carrier frequency and the nominal carrier frequency.

4.2.2.3 Limits

The frequency error shall not exceed ±80 Hz at 457 kHz.

4.2.2.4 Conformance

The conformance tests for transmitter frequency error shall be as defined in clause 5.3.2 of the present document.

Conformance shall be established under normal as well as under extreme test conditions according to clause 5.1.

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.2.

4.2.3 Output field strength (H-field)

4.2.3.1 Applicability

This requirement applies to all avalanche beacons.

4.2.3.2 Description

The H-field is measured in the direction of maximum field strength under specified conditions of measurement.

4.2.3.3 Limits

The minimum transmitted field strength at 457 kHz shall not be lower than -6 dBμA/m (0,5 μA/m) at a distance of 10 m.

The maximum transmitted field strength at 457 kHz shall not exceed 7 dBμA/m (2,23 μA/m) at a distance of 10 m.

4.2.3.4 Conformance

The conformance tests for Transmitter output field strength (H-field) shall be as defined in clause 5.3.3 of the present document.

Conformance shall be established under normal as well as under extreme test conditions according to clause 5.1.

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.2.

4.2.4 Transmitter spurious emissions

4.2.4.1 Applicability

This requirement applies to all avalanche beacons.

4.2.4.2 Description

Spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with its modulation. The level of spurious emissions shall be measured at normal conditions as their effective radiated power or field strength radiated by the cabinet and the integral antenna.

4.2.4.3 Limits

Radiated emissions below 30 MHz shall not exceed the generated H-field at 10 m given in table 1.

Table 1

State	Frequency 9 kHz ≤ f < 10 MHz Except 457 kHz ± 0,1 kHz	Frequency 10 MHz ≤ f < 30 MHz
Transmit	27 dBµA/m descending 3 dB/oct	-3,5 dBµA/m

A graphical representation is shown in annex C, figure C.1.

The power of any radiated emission shall not exceed the values given in table 2.

Table 2

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 MHz to 1 000 MHz
Operating	4 nW	250 nW

4.2.4.4 Conformance

The conformance tests for Transmitter spurious emissions shall be as defined in clause 5.3.4 of the present document.

Conformance shall be established under normal test conditions according to clause 5.1.

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.2.

4.3 Conformance requirements for receiver parameters

4.3.1 Receiver sensitivity

4.3.1.1 Applicability

This requirement applies to all avalanche beacons.

4.3.1.2 Description

The maximum usable sensitivity of the receiver is the minimum level of the wanted signal (H-field strength which, when applied to the receiver input, produces an optical and/or acoustic indication of a received beacon).

4.3.1.3 Limits

The receiver sensitivity limit is 80 nA/m (-22 dBµA/m) at a frequency of 457 kHz.

4.3.1.4 Conformance

The conformance tests for Receiver sensitivity shall be as defined in clause 5.3.5 of the present document.

Conformance shall be established under normal as well as under extreme test conditions according to clause 5.1.

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.2.

4.3.2 Receiver blocking

4.3.2.1 Applicability

This requirement applies to all avalanche beacons.

4.3.2.2 Description

Receiver blocking is a measure of the ability of the equipment to receive a wanted signal on its operating frequency without exceeding a given degradation in the presence of an unwanted signal (blocking signal) on frequencies other than the operating frequency.

4.3.2.3 Limits

The interference field strength at the EUT shall be 25 dBµA/m at 450 kHz.

The maximum level of the wanted signal (H-field strength) which, when applied to the receiver input, produces an optical and/or acoustic indication of a received beacon, shall be 113 nA/m (-19 dBµA/m which is 3 dB above the test level for receiver sensitivity).

NOTE: Testing frequency and level were derived from the requirements specified in ECC Report 284 [i.8].

4.3.2.4 Conformance

The conformance tests for Receiver blocking shall be as defined in clause 5.3.6 of the present document.

Conformance shall be established under normal test conditions according to clause 5.1.

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.2.

4.3.3 Receiver spurious emissions

4.3.3.1 Applicability

This requirement applies to all avalanche beacons.

4.3.3.2 Description

The level of spurious emissions shall be measured at normal conditions as their effective radiated power or field strength radiated by the cabinet and the integral antenna.

4.3.3.3 Limits

Radiated emissions below 30 MHz shall not exceed the generated H-field at 10 m given in table 3.

Table 3

State	Frequency 9 kHz ≤ f < 10 MHz	Frequency 10 MHz ≤ f < 30 MHz
Receive	6 dBµA/m descending 3 dB/oct	-24,5 dBµA/m

A graphical representation is shown in annex C, figure C.1.

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

Table 4

State	30 MHz to 1 000 MHz
Operating	2 nW

4.3.3.4 Conformance

The conformance tests for Receiver sensitivity shall be as defined in clause 5.3.7 of the present document.

Conformance shall be established under normal test conditions according to clause 5.1.

The interpretation of the results for the measurements uncertainty shall be as given in clause 5.2.

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

5.1.1 General

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use, which, as a minimum, shall be that specified in the test conditions contained in the present document (see below).

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions as specified in the present document to give confidence of compliance for the affected technical requirements.

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 clauses 5.1.2 to 5.1.4.

5.1.2 External test power source

During the 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 clauses 5.1.3.2 and 5.1.4.2. 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.

The non-grounded terminal of the batteries shall be disconnected, but batteries shall be left in place. The external test power source shall be suitably de-coupled and applied as close to the equipment battery terminals as practicable. The power leads shall be as short as practicable and properly dressed. For radiated measurements fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the manufacturer.

During tests the external test power source voltages shall be within a tolerance ±1 % relative to the voltage at the beginning of each test.

5.1.3 Normal test conditions

5.1.3.1 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.

5.1.3.2 Normal test voltage

The normal test voltage shall be the nominal voltage of the device. The value shall be stated in the test report.

NOTE: The nominal voltage of the device depends on type and number of batteries, as specified in the user manual.

5.1.3.3 Normal test modulation

The normal test modulation shall be carrier-keying with 100 ms on-time and 900 ms off-time.

5.1.4 Extreme test conditions

5.1.4.1 Extreme temperatures

The equipment shall be able to operate correctly in the temperature range from -20 °C to +45 °C and shall be stored without damage in the temperature range from -25 °C to +70 °C.

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 stabilization circuits designed to operate continuously, the temperature stabilization 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 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.

5.1.4.2 Extreme test voltages

The extreme test voltages shall be as defined by the intended use of the EUT. The values shall be stated in the test report.

NOTE: The extreme test voltages of the device depend on type and number of batteries (as specified in the user manual) and the degree of battery discharge, which is allowed to maintain proper function of the device.

5.2 Interpretation of test results

Guidance on the interpretation of test results is given in annex F.

5.3 Compliance test procedures

5.3.1 Modulation and carrier keying

The carrier keying shall be measured by means of an oscilloscope connected to an H-field test antenna, or alternatively by means of a spectrum analyser, set to 457 kHz in zero span mode with resolution bandwidth ≥ 1 kHz.

NOTE: The attenuation of the magnetic field at 457 kHz of a temperature test chamber is considered to be low, therefor the magnetic field emitted by an avalanche beacon inside the test chamber can be measured outside the test chamber by an H-field test antenna.

The H-field test antenna shall be placed in best coupling position to the EUT in a distance smaller than 1 m.

5.3.2 Frequency error

The carrier frequency shall be measured by means of a frequency counter, connected to an H-field test antenna.

The frequency counter shall be capable to measure the transmit frequency of the EUT within the on-time of the on/off-keyed carrier, that is within ≥ 70 ms.

5.3.3 Output field strength (H-field)

Step 1: Absolute measurement at normal test conditions

The H-field produced by the equipment shall be measured in best coupling position at distances of 10 m on an open area test site (see clause B.1.3). The test antenna shall be a calibrated shielded magnetic field antenna.

The measurement shall be done by means of a measuring receiver, tuned to 457 kHz, with resolution bandwidth ≥ 1 kHz.

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

Step 2: Relative measurement at extreme test conditions

The equipment shall be placed in a temperature test chamber. The H-field test antenna shall be placed in best coupling position to the EUT in a distance smaller than 1 m. A first measurement shall be made at the same temperature as in step 1. Subsequent measurements shall be made at extreme temperatures. The difference of the H-field level relative to the first measurement shall be noted and added to the value from step 1.

NOTE: The attenuation of the magnetic field at 457 kHz of a temperature test chamber is considered to be low, therefor the magnetic field emitted by an avalanche beacon inside the test chamber can be measured outside the test chamber by an H-field test antenna.

5.3.4 Transmitter spurious emissions

5.3.4.1 Method of measurement Radiated H-field (< 30 MHz)

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 open area 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 B, clause B.1.3.

The equipment under test shall be switched on in transmit mode. The measuring receiver shall be tuned over the frequency range 9 kHz to 30 MHz, except for the frequency band ±100 Hz from the frequency 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.

The limits are quoted in dBμA/m, so it is necessary to reduce the reading as explained in annex D for measuring equipment calibrated in dBμV/m.

5.3.4.2 Method of measurement Effective radiated power (≥ 30 MHz)

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.

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

The equipment shall be switched on in transmit mode, and the measuring receiver shall be tuned over the frequency range 30 MHz 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 equipment 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 polarization 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.

If a ground plane is used (clauses B.1.2 and B.1.3) then the test antenna shall be raised and lowered through the range of heights (see clauses B.1.2 and B.1.3) to ensure that the maximum signal is received.

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 polarization.

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.

5.3.5 Receiver sensitivity

Step 1: Measurement at normal test conditions

A test signal at a carrier frequency of 457 kHz, modulated by the normal test modulation (see clause 5.1.3.3) shall be applied in the best coupling position.

The test shall be carried out inside a test chamber according to clause B.1.1 or clause B.1.2.

The field strength at the position of the EUT shall be 80 nA/m. Under these conditions the EUT shall indicate an optical and/or acoustic indication of a received beacon.

Step 2: Measurement at extreme test conditions

The equipment shall be placed in a temperature test chamber. After the temperature stabilizing period the equipment shall be placed in a non-metallic thermal insulating box and moved to the measuring position as in step 1. The measuring procedure of step 1 shall be repeated.

5.3.6 Receiver blocking

Two signal generators A and B shall be connected via a combining network to the test antenna. The receiver should be positioned in the best coupling position.

The test shall be carried out inside a test chamber according to clause B.1.1 or clause B.1.2.

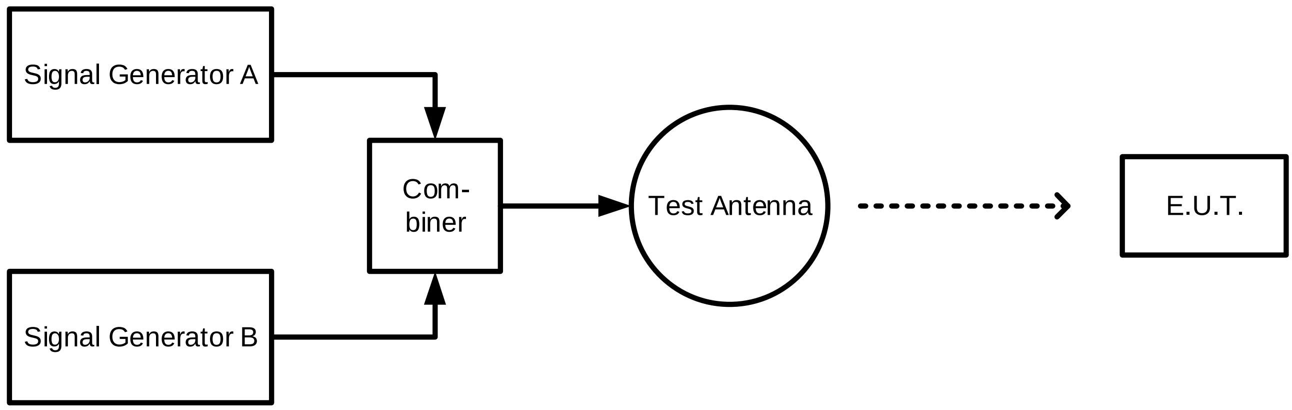

Figure 2: Measuring arrangement for Receiver Blocking

Signal generator A shall be at a frequency of 457 kHz with normal test modulation (see clause 5.1.3.3). Its level shall be adjusted to a field strength of -19 dBμA/m measured at the position of the receiver.

Signal generator B shall be unmodulated and shall be adjusted to a test frequency of 450 kHz. Its level shall be adjusted to a field strength of +25 dBμA/m measured at the position of the receiver.

Under these conditions the EUT shall indicate an optical and/or acoustic indication of a received beacon.

5.3.7 Receiver spurious emissions

5.3.7.1 Method of measurement Radiated H-Field (< 30 MHz)

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 open area 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 B, clause B.1.3.

The equipment under test shall be switched on in receive mode. The measuring receiver shall be tuned over the frequency range 9 kHz to 30 MHz.

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.

The limits are quoted in dBμA/m, so it is necessary to reduce the reading as explained in annex D for measuring equipment calibrated in dBμV/m.

5.3.7.2 Method of measurement Effective radiated power (≥ 30 MHz)

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 described in the user manual.

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

The equipment shall be switched on in receive mode, and the measuring receiver shall be tuned over the frequency range 30 MHz to 1 000 MHz.

If a ground plane is used (clauses B.1.2 and B.1.3) then at each frequency at which a spurious component is detected, the test antenna shall be raised and lowered through the range of heights (see clauses B.1.2 and B.1.3) until a maximum signal level is detected on the measuring receiver.

The equipment 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 polarization 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.

If a ground plane is used (clauses B.1.2 and B.1.3) then the test antenna shall be raised and lowered through the range of heights (see clauses B.1.2 and B.1.3) to ensure that the maximum signal is received.

The input signal to the substitution antenna shall be adjusted until an equal or a known related level to that detected from the receiver 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 polarization.

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.

5.4 Measuring receiver

The term "measuring receiver" refers to a selective voltmeter or a spectrum analyser. The bandwidth and detector type of the measuring receiver are given in table 5.

Table 5

Frequency: (f)	Detector type	Measurement receiver bandwidth	Spectrum analyser bandwidth
9 kHz ≤ f < 150 kHz	Quasi Peak	200 Hz	300 Hz
150 kHz ≤ f < 30 MHz	Quasi Peak	9 kHz	10 kHz
30 MHz ≤ f ≤ 1 000 MHz	Quasi Peak	120 kHz	100 kHz

Different bandwidth may be used if agreed with the test laboratory, for further guidance see annex G. The measurement bandwidth and any related calculations shall be stated in the test report.

Annex A (informative): Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.2] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive and associated EFTA regulations.

Table A.1: Relationship between the present document and the essential requirements of Directive 2014/53/EU

Harmonised Standard ETSI EN 300 718-1					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Modulation and carrier keying	3.2	4.2.1	U	
2	Frequency error	3.2	4.2.2	U	
3	Output field strength (H-field)	3.2	4.2.3	U	
4	Transmitter spurious emissions	3.2	4.2.4	U	
5	Receiver sensitivity	3.2	4.3.1	U	
6	Receiver blocking	3.2	4.3.2	U	
7	Receiver spurious emissions	3.2	4.3.3	U	

Key to columns:

Requirement:

No A unique identifier for one row of the table which may be used to identify a requirement.

Description A textual reference to the requirement.

Essential requirements of Directive

Identification of article(s) defining the requirement in the Directive.

Clause(s) of the present document

Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

U/C Indicates whether the requirement is unconditionally applicable (U) or is conditional upon the manufacturer's claimed functionality of the equipment (C).

Condition Explains the conditions when the requirement is or is not applicable for a requirement which is classified "conditional".

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (normative): Radiated measurement

B.0 General

This annex is applicable to the assessment of data or equipment providing a specific response.

It covers test sites and methods to be used with integral antenna equipment or equipment having an antenna connector.

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

B.1.0 Test sites

This annex introduces three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in ETSI TR 102 273-2 [i.5], ETSI TR 102 273-3 [i.6] and ETSI TR 102 273-4 [i.7].

NOTE: To ensure reproducibility and tractability of radiated measurements only these test sites should be used in measurements in accordance with the present document.

B.1.1 Anechoic chamber

An anechoic chamber is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The chamber usually contains an antenna support at one end and a turntable at the other. A typical anechoic chamber is shown in figure B.1.

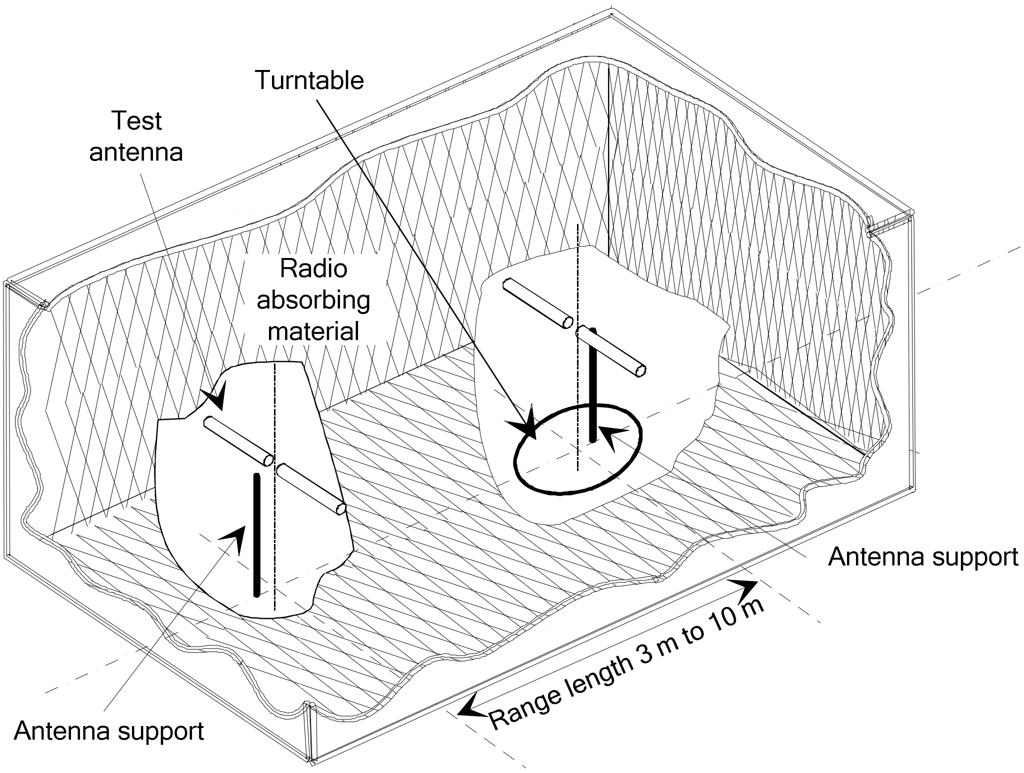

Figure B.1: A typical anechoic chamber

The chamber shielding and radio absorbing material work together to provide a controlled environment for testing purposes. This type of test chamber attempts to simulate free space conditions.

The shielding provides a test space, with reduced levels of interference from ambient signals and other outside effects, whilst the radio absorbing material minimizes unwanted reflections from the walls and ceiling which can influence the measurements. In practice it is relatively easy for shielding to provide high levels (80 dB to 140 dB) of ambient interference rejection, normally making ambient interference negligible.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at the same height as the test antenna representing typical use of the EUT. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2 (d_1 + d_2)^2/\lambda$ (m), whichever is greater (see clause B.2.4). The distance used in actual measurements shall be recorded with the test results.

The anechoic chamber generally has several advantages over other test facilities. There is minimal ambient interference, minimal floor, ceiling and wall reflections and it is independent of the weather. It does however have some disadvantages which include limited measuring distance and limited lower frequency usage due to the size of the pyramidal absorbers. To improve low frequency performance, a combination structure of ferrite tiles and urethane foam absorbers is commonly used.

All types of emission, sensitivity and immunity testing can be carried out within an anechoic chamber without limitation.

B.1.2 Anechoic chamber with a conductive ground plane

An anechoic chamber with a conductive ground plane is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The floor, which is metallic, is not covered and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other. A typical anechoic chamber with a conductive ground plane is shown in figure B.2.

This type of test chamber attempts to simulate an ideal Open Area Test Site whose primary characteristic is a perfectly conducting ground plane of infinite extent.

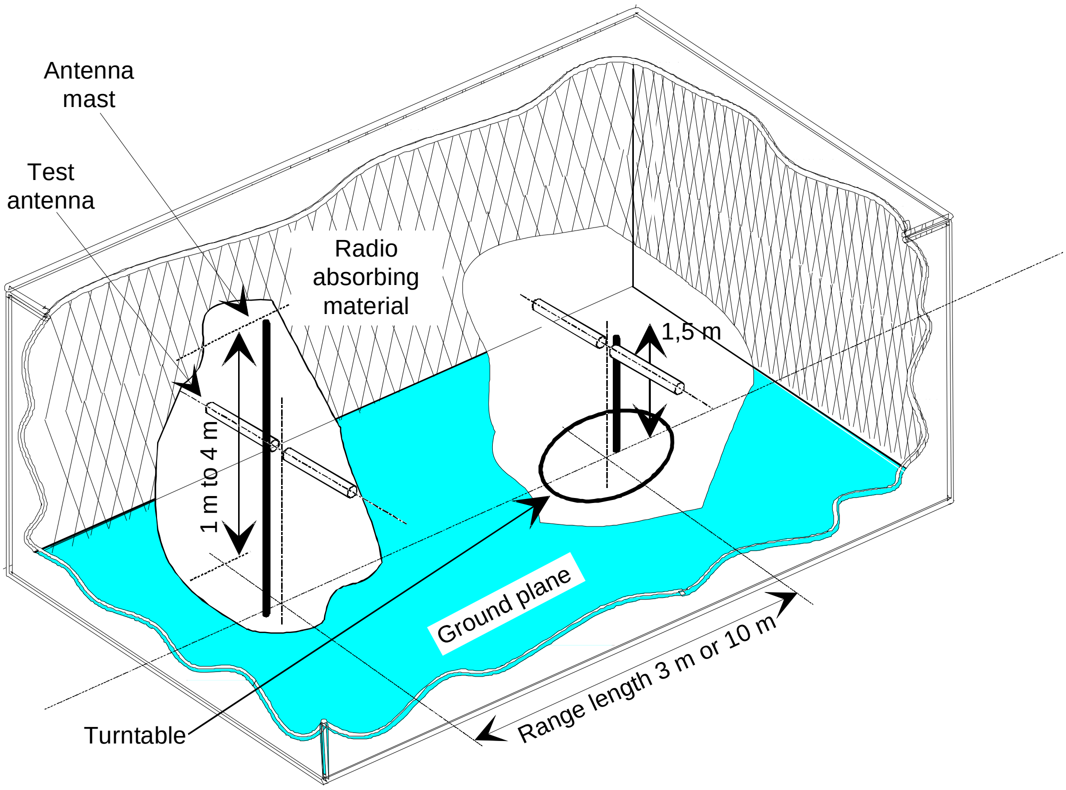

Figure B.2: A typical Anechoic Chamber with a conductive ground plane

In this facility the ground plane creates the wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals from both the direct and reflected transmission paths. This creates a unique received signal level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

The antenna mast provides a variable height facility (from 1 m to 4 m) so that the position of the test antenna can be optimized for maximum coupled signal between antennas or between an EUT and the test antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a height above the ground plane (representing typical use of the EUT but at least at 1 m). The chamber shall be large enough to allow the measuring distance of at least 3 m or $2 (d_1 + d_2)^2/\lambda$ (m), whichever is greater (see clause B.2.4). The distance used in actual measurements shall be recorded with the test results.

Emission testing involves first "peaking" the field strength from the EUT by raising and lowering the receiving antenna on the mast (to obtain the maximum constructive interference of the direct and reflected signals from the EUT) and then rotating the turntable for a "peak" in the azimuth plane. At this height of the test antenna on the mast, the amplitude of the received signal is noted. Secondly the EUT is replaced by a substitution antenna (positioned at the EUT's phase or volume centre) which is connected to a signal generator. The signal is again "peaked" and the signal generator output adjusted until the level, noted in stage one, is again measured on the receiving device.

Receiver sensitivity tests over a ground plane also involve "peaking" the field strength by raising and lowering the test antenna on the mast to obtain the maximum constructive interference of the direct and reflected signals, this time using a measuring antenna which has been positioned where the phase or volume centre of the EUT will be during testing. A transform factor is derived. The test antenna remains at the same height for stage two, during which the measuring antenna is replaced by the EUT. The amplitude of the transmitted signal is reduced to determine the field strength level at which a specified response is obtained from the EUT.

B.1.3 Open Area Test Site (OATS)

B.1.3.0 General for OATS

The OATS can be used for measurements in the range of 9 kHz to 1 000 MHz.

Measurements below 30 MHz shall be made according to clause B.1.3.1 and measurements above 30 MHz shall be made according to clause B.1.3.2.

An Open Area Test Site comprises a turntable at one end and an antenna mast of variable height at the other end. A typical OATS is shown in figure B.3.

In figure B.3, for measurements below 30 MHz the dipole antennas shall be replaced by loop antennas and as explained in clause B.1.3.1.

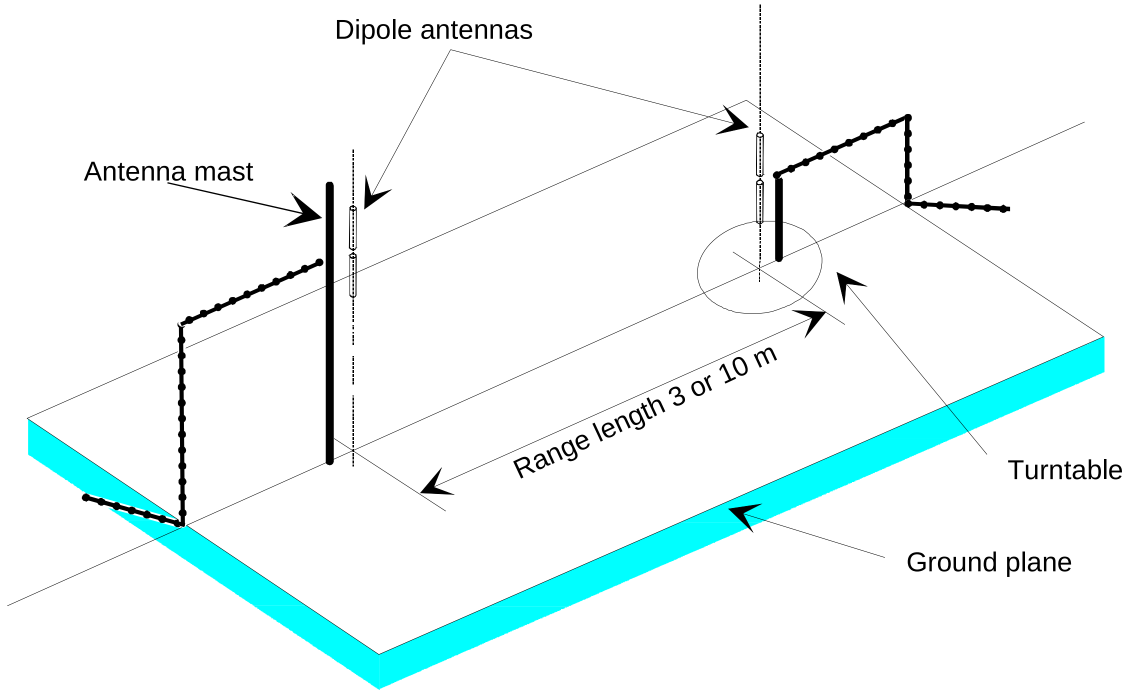

Figure B.3: A typical Open Area Test Site

B.1.3.1 Measurements below 30 MHz

For measurements below 30 MHz tests may be made according to CISPR 16-1-4 [1]. The measurements are made with an inductive shielded loop test antenna, which reads the magnetic field (H-field) only. These measurements are valid for both the far-field and the near-field situations. In this case the OATS shall not have a ground plane with an electrical or magnetic conductive material.

Radiated emission test sites (OATS) below 30 MHz shall be free from metal objects, buried pipes, and any objects that can affect radiated measurements. An alternative test site that can demonstrate equivalence to a test site as described in the preceding paragraph shall be accepted for the purposes of the present document.

B.1.3.2 Measurements above 30 MHz

An Open Area Test Site comprises a turntable at one end and an antenna mast of variable height at the other end above a ground plane, which in the ideal case, is perfectly conducting and of infinite extent. In practice, whilst good conductivity can be achieved, the ground plane size has to be limited. A typical OATS is shown in figure B.3.

The ground plane creates a wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals received from the direct and reflected transmission paths. The phasing of these two signals creates a unique received level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

Site qualification concerning antenna positions, turntable, measurement distance and other arrangements are same as for anechoic chamber with a ground plane. In radiated measurements an OATS is also used by the same way as anechoic chamber with a ground plane.

Typical measuring arrangement common for ground plane test sites for spurious emission testing is presented in figure B.4.

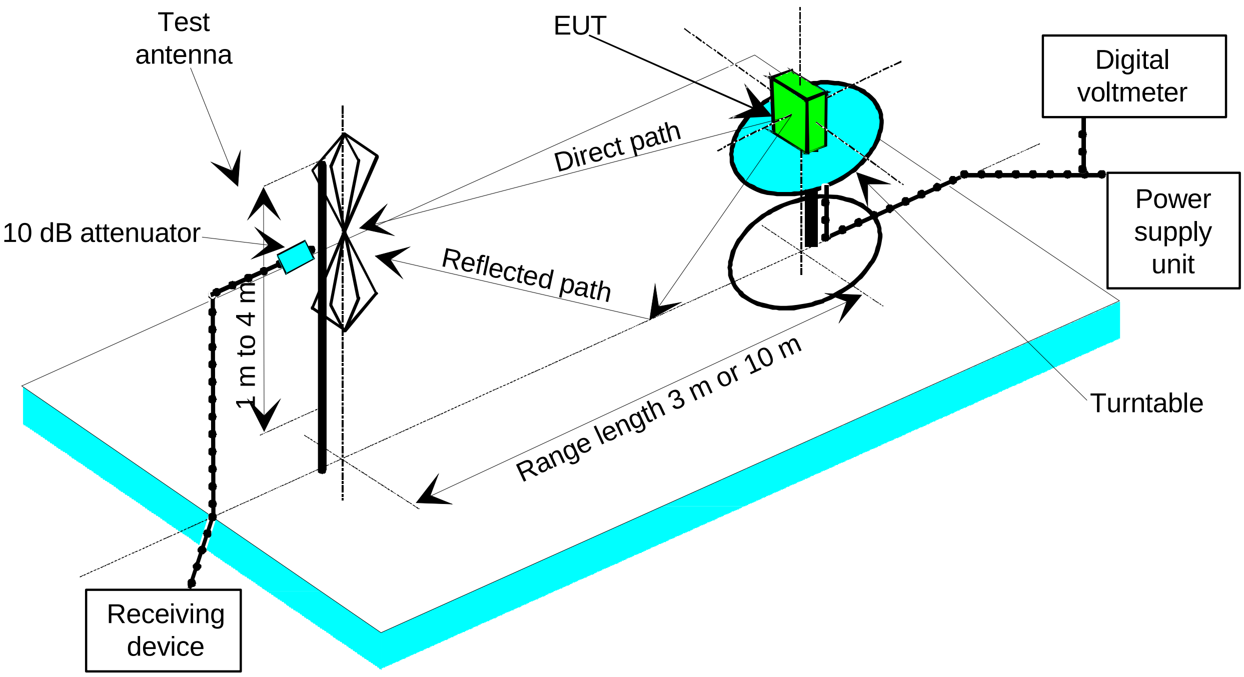

Figure B.4: Measuring arrangement on ground plane test site (OATS set-up for spurious emission testing)

B.1.4 Test antenna

A test antenna is always used in radiated test methods. In emission tests (i.e. frequency error, effective radiated power, spurious emissions and adjacent sub-band power) the test antenna is used to detect the field from the EUT in one stage of the measurement and from the substitution antenna in the other stage. When the test site is used for the measurement of receiver characteristics (i.e. sensitivity and various immunity parameters) the antenna is used as the transmitting device.

The test antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization which, on ground plane sites (i.e. anechoic chambers with ground planes and Open Area Test Sites), should additionally allow the height of its centre above the ground to be varied over the specified range (usually 1 m to 4 m).

In the frequency range 9 kHz to 30 MHz, inductive shielded loop antennas according to CISPR 16-1-4 [1] are generally recommended. This test antenna method supports measurements in both the far-field and near-field.

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [i.3]) are generally recommended. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For spurious emission testing, however, a combination of bicones and log periodic dipole array antennas (commonly termed "log periodics") could be used to cover the entire 30 MHz to 1 000 MHz band. Above 1 000 MHz, waveguide horns are recommended although, again, log periodic could be used.

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

B.1.5 Substitution antenna

The substitution antenna is used to replace the EUT for tests in which a transmitting parameter (i.e. frequency error, effective radiated power, spurious emissions and adjacent sub-band power) is being measured. For measurements in the frequency band 30 MHz to 1 000 MHz, the substitution antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [i.3]). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For measurements above 1 000 MHz, a waveguide horn is recommended. The centre of this antenna should coincide with either the phase centre or volume centre.

Below 30 MHz substitution measurements are not used as the radiated H-field is measured with a shielded loop antenna according to CISPR 16-1-4 [1].

B.1.6 Measuring antenna

The measuring antenna is used in tests on an EUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric filed strength in the vicinity of the EUT.

For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [i.3]). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT.

For measurements on inductive loop systems operating below 30 MHz, the measurement antenna is a calibrated loop antenna.

B.2 Guidance on the use of radiation test sites

B.2.0 General

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated tests are undertaken. These schemes are common to all types of test sites described in clause B.1.

B.2.1 Verification of the test site

No test should be carried out on a test site which does not possess a valid certificate of verification. The verification procedures for the different types of test sites described in clause B.1 (i.e. anechoic chamber, anechoic chamber with a ground plane and Open Area Test Site) are given in ETSI TR 102 273-2 [i.5], ETSI TR 102 273-3 [i.6] and ETSI TR 102 273-4 [i.7], respectively.

B.2.2 Preparation of the EUT

The manufacturer should supply information about the EUT covering the operating frequency, polarization, supply voltage(s) and the reference face. Additional information, specific to the type of EUT should include, where relevant, carrier power, sub-band separation, whether different operating modes are available (e.g. high and low power modes) and if operation is continuous or is subject to a maximum test duty cycle (e.g. 1 min on, 4 min off).

Where necessary, a mounting bracket of minimal size should be available for mounting the EUT on the turntable. This bracket should be made from low conductivity, low relative dielectric constant (i.e. less than 1,5) material(s) such as expanded polystyrene, balsa wood, etc.

B.2.3 Power supplies to the EUT

All tests should be performed using power supplies wherever possible, including tests on EUT designed for battery-only use. In all cases, power leads should be connected to the EUT's supply terminals (and monitored with a digital voltmeter) but the battery should remain present, electrically isolated from the rest of the equipment, possibly by putting tape over its contacts.

The presence of these power cables can, however, affect the measured performance of the EUT. For this reason, they should be made to be "transparent" as far as the testing is concerned. This can be achieved by routing them away from the EUT and down to the either the screen, ground plane or facility wall by the shortest possible paths. Precautions should be taken to minimize pick-up on these leads (e.g. the leads could be twisted together, loaded with ferrite beads at 0,15 m spacing or otherwise loaded).

B.2.4 Range length

B.2.4.1 Far-field length above 30 MHz

The range length for all these types of test facility should be adequate to allow for testing in the far-field of the EUT i.e. it should be equal to or exceed:

$$\frac{2(d_1 + d_2)^2}{\lambda} \qquad \text{(B.1)}$$

where:

d_1 is the largest dimension of the EUT/dipole after substitution (m);

d_2 is the largest dimension of the test antenna (m);

λ is the test frequency wavelength (m).

It should be noted that in the substitution part of this measurement, where both test and substitution antennas are half wavelength dipoles, this minimum range length for far-field testing would be:

$$2\lambda$$

It should be noted in the test report when either of these conditions is not met so that the additional measurement uncertainty can be incorporated into the results.

NOTE 1: For the fully anechoic chamber, no part of the volume of the EUT should, at any angle of rotation of the turntable, fall outside the "quiet zone" of the chamber at the nominal frequency of the test.

NOTE 2: The "quiet zone" is a volume within the anechoic chamber (without a ground plane) in which a specified performance has either been proven by test, or is guaranteed by the designer/manufacture. The specified performance is usually the reflectivity of the absorbing panels or a directly related parameter (e.g. signal uniformity in amplitude and phase). It should be noted however that the defining levels of the quiet zone tend to vary.

NOTE 3: For the anechoic chamber with a ground plane, a full height scanning capability, i.e. 1 m to 4 m, should be available for which no part of the test antenna should come within 1 m of the absorbing panels. For both types of Anechoic Chamber, the reflectivity of the absorbing panels should not be worse than -5 dB.

NOTE 4: For both the anechoic chamber with a ground plane and the Open Area Test Site, no part of any antenna should come within 0,25 m of the ground plane at any time throughout the tests. Where any of these conditions cannot be met, measurements should not be carried out.

B.2.4.2 Near-field and Far-field length below 30 MHz

Inductive systems below 30 MHz can be measured both in the near-field and far-field regions at an open test site by means of a shielded loop antenna according to CISPR 16-1-4 [1].

The minimum measurement distance, d is determined by:

$$d \geq 3D \quad \text{(B.2)}$$

where D is the maximum dimension in metre of the inductive loop.

B.2.5 Site preparation

The cables for both ends of the test site should be routed horizontally away from the testing area for a minimum of 2 m (unless, in the case both types of anechoic chamber, a back wall is reached) and then allowed to drop vertically and out through either the ground plane or screen to the test equipment. Precautions should be taken to minimize pick up on these leads (e.g. dressing with ferrite beads, or other loading). The cables, their routing and dressing should be identical to the verification set-up.

NOTE: For ground reflection test sites (i.e. anechoic chambers with ground planes and Open Area Test Sites) which incorporate a cable drum with the antenna mast, the 2 m requirement may be impossible to comply with. In this case the cable routing should be described in the test report.

Calibration data for all items of test equipment should be available and valid. For test, substitution and measuring antennas, the data should include gain relative to an isotropic radiator (or antenna factor) for the frequency of test. Also, the VSWR of the substitution and measuring antennas should be known.

The calibration data on all cables and attenuators should include insertion loss and VSWR throughout the entire frequency range of the tests. All VSWR and insertion loss figures should be recorded in the log book results sheet for the specific test.

Where correction factors/tables are required, these should be immediately available.

For all items of test equipment, the maximum errors they exhibit should be known. The provisions of clause 5.2 shall apply.

At the start of measurements, system checks should be made on the items of test equipment used on the test site.

B.3 Coupling of signals

B.3.1 General

The presence of leads in the radiated field may cause a disturbance of that field and lead to additional measurement uncertainty. These disturbances can be minimized by using coupling methods offering signal isolation and minimum field disturbance.

B.3.2 Data signals

Isolation can be provided by the use of optical, ultrasonic or infrared means. Field disturbance can be minimized by using a fibre optic connection. Ultrasonic or infrared radiated connections require measures for the minimization of ambient noise.

B.4 Standard test position

The standard position in all test sites shall be on a non-conducting support, capable of rotating about a vertical axis through the equipment. The standard position of the equipment shall be placed in the position closest to normal use.

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

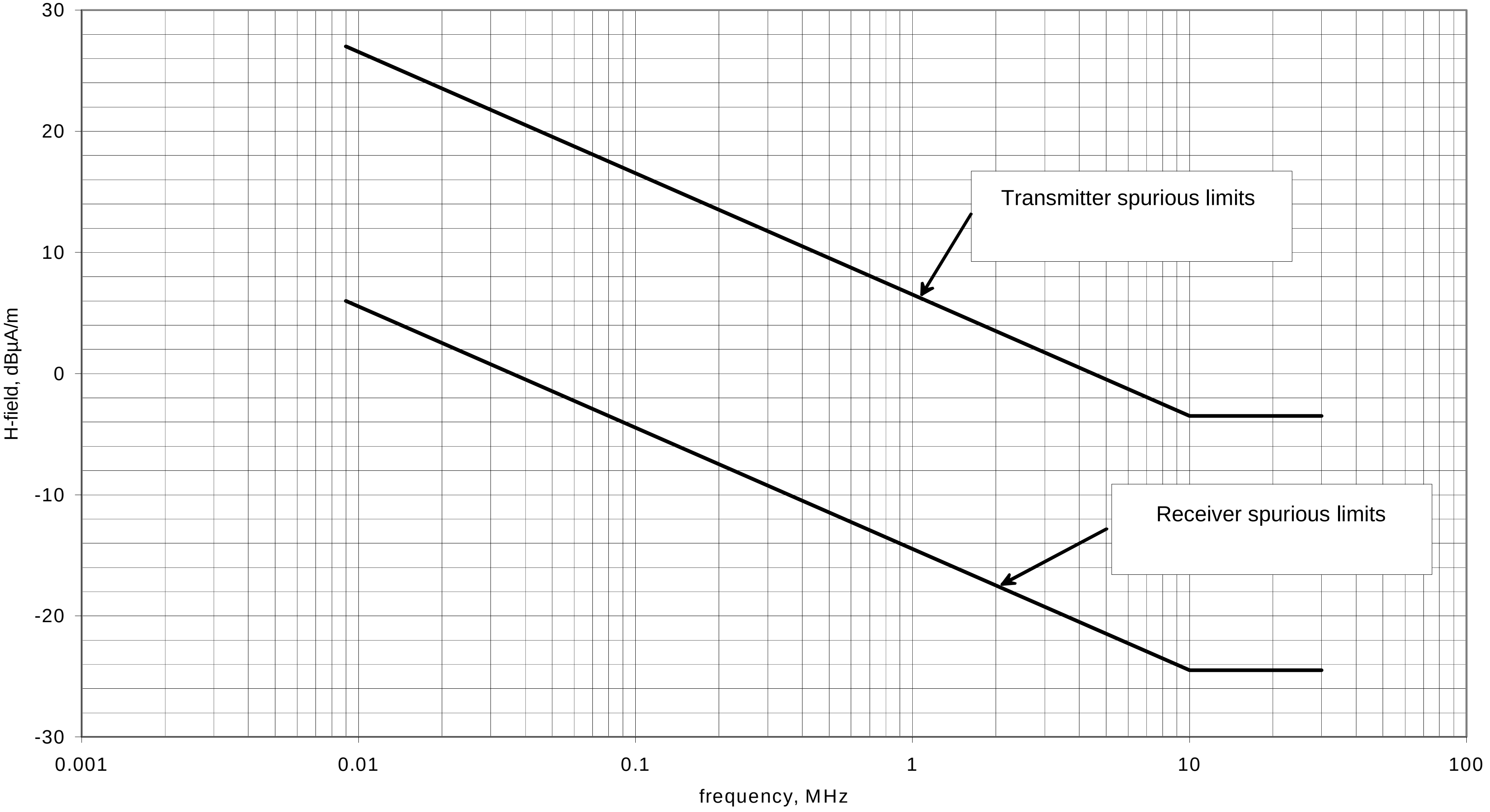

Figure C.1

Annex D (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:

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

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.

$$Z_m = Z_0 2\pi \frac{d}{\lambda} \text{ if } d < \frac{\lambda}{2\pi} \text{ (near field)} \qquad \text{(D.2)}$$

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

Equation (D.1) gives:

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

Equations (D.2) and (D.3) into (D.4) give:

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

where f_c is the carrier frequency in MHz.

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

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

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

For 2 $\pi d/\lambda > 1$ 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 (D.6).

For a graphical representation of the correction factor, see figure D.1.

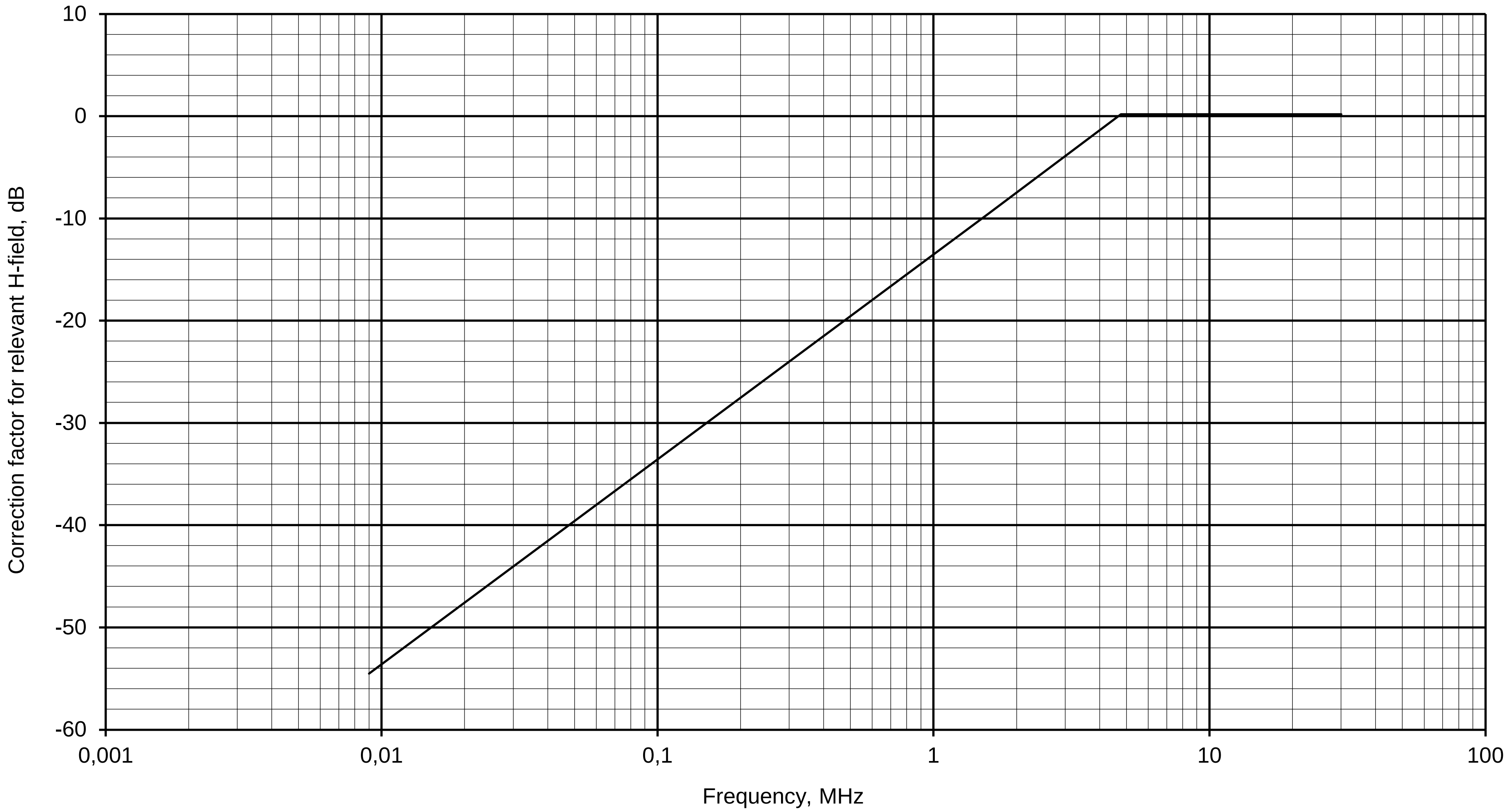
10
0
-10
-20
-30
-40
-50
-60
Correction factor for relevant H-field, dB
0,001
0,01
0,1
1
10
100
Frequency, MHz

Figure D.1

Annex E (informative): Justification of receiver requirements

E.1 Introduction

Article 3.2 of the RED [i.1] states that *"Radio equipment shall be so constructed that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference"*. The RED further defines *'harmful interference'* by referring to point (r) of article 2 of Directive 2002/21/EC [i.14] (with the amendments from Directive 2009/140/EC [i.15]) where it is written that *"'harmful interference' means interference which endangers the functioning of a radio navigation service or of other safety services or which otherwise seriously degrades, obstructs or repeatedly interrupts a radio communications service operating in accordance with the applicable international, Community or national regulations"*.

According to this definition, interference into SRDs cannot be considered *'harmful interference'* as SRDs are not a 'radio service' according to the radio regulations. This is also recognized in ERC Recommendation 70-03 [i.10] which regulates SRDs within the CEPT countries. Therefore one can argue whether the RED really mandates implementing (additional) receiver requirements in SRDs to protect them against interference.

However, some receiver requirements are offered in the present document. A justification for the chosen- and not-chosen receiver parameter from ETSI EG 203 336 [i.11] is given in the following clause.

E.2 Justification of receiver requirements chosen in the present document

Knowledge of incumbent radio users is a precondition for the assessment of receiver requirements. ECC Report 284 [i.8] was used in this regard as guidance document. ECC Report 284 [i.8] has recently considered the coexistence situation of Person detection and collision avoidance application in the range 442,2 kHz to 450 kHz with existing radio users and it has also considered avalanche beacons as potential victim systems.

Table E.1 provides an assessment of each of the receiver parameter from ETSI EG 203 336 [i.11].

Table E.1: Justification of receiver requirements

Rx Parameter	Comment
Receiver sensitivity	See clause 4.3.1.
Receiver blocking	Receiver blocking is a measure of the capability of the receiver to receive a wanted signal without exceeding a given degradation due to the presence of an unwanted input signal at any frequency other than those of the spurious responses or of the adjacent channels. See clause 4.3.2; the limit of 25 dBµA/m at 450 kHz was chosen to simulate a Person detection and collision avoidance application in the range 442,2 kHz to 450 kHz according to band 85 of Commission Implementing decision (EU) 2019/1345 [i.9] and according to ECC Report 284 [i.8]. A distance of 5 m between the avalanche beacon and the person detection application has been assumed.
Receiver spurious emissions	See clause 4.3.3.
Co-Channel Rejection	The co-channel rejection is seen as the ratio between the wanted signal level C and the maximum acceptable interfering signal I (C/I ratio); it depends on the modulation of the wanted and interfering signal; for a noise like interfering signal and an analogue wanted modulation it is typically about 6 dB; for digital modulation is typically lower, for some analogue modulation in can be higher; it is not possible to specify one value only. Receiver co-channel rejection is an essential parameter in channelized spectrum to determine the spatial reuse of the same channel. Such determination is important for national authorities to do proper spectrum planning, for e.g. fixed links, mobile networks, etc. operating in licensed channelized spectrum.

Rx Parameter	Comment
	Any specific requirement for Receiver co-channel rejection has to take into account the parameters of the wanted signal, notably its bandwidth and modulation as well as the sources of potential interference. In the case of license exempt spectrum, as it is from 456,9 kHz to 457,1 kHz, there is no need for nor the possibility to apply network planning. There exist no studies that provide evidence that the implementation of Receiver co-channel rejection would further improve spectrum utilization and/or spectrum efficiency.
Adjacent Channel/Signal Selectivity	Receiver adjacent channel selectivity is a measure of the capability of the receiver to receive a wanted signal, without exceeding a given degradation, due to the presence of an unwanted signal, in the adjacent channel. Receiver adjacent band selectivity is a measure of the capability of the receiver to receive a wanted signal, without exceeding a given degradation, due to the presence of an unwanted signal, near the band edges of the operating band but within the adjacent band. The 457 kHz band is a non-channelized band. Neither the ERC Recommendation 70-03 [i.10] nor the EC Decision for SRDs [i.9] mandates channelization or the use of a channel plan for avalanche beacons. In addition, an active radio use in close proximity to an avalanche beacon directly below and above the band edges (e.g. at 456,8 kHz and 457,2 kHz) is not expected to be a realistic case. The information on radio users in ECC Report 284 [i.8] do not point in that direction. Rather the collision with a Person detection and collision avoidance application in the range 442,2 kHz to 450 kHz according to ECC Report 284 [i.8] would be expected; but this effect is covered in the blocking clause (see above).
Spurious response rejection	A receiver spurious response is caused by an interfering signal at a specific discrete frequency offset from the victim wanted channel. Occurrence of spurious responses depend on receiver architecture, local oscillator frequencies and DSP design. Finding spurious responses would require the measurement of the complete selectivity mask of the receiver, which would be very time consuming. Probability for spurious response is very low, since: • There is no system known which uses the same or a similar modulation scheme • The detection range is very short (< 100 m) • The antenna bandwidth is very narrow (typically < 10 kHz) There exist no studies or evidence that a separate Receiver Spurious Response Rejection requirement in addition to the Receiver Blocking requirement would further improve spectrum utilization and/or spectrum efficiency.
Intermodulation	Receiver inter-modulation response rejection is a measure of the capability of the receiver to receive a wanted modulated signal, without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship to the wanted signal frequency. This parameter is used in the planning of channelized systems operating in licensed bands and using a single technology which is often the case for cellular networks. As stated above, the 457 kHz band is a non-channelized band. Intermodulation performance is not specified as it is not considered a major failure mechanism. The risk of failure due to second or third order intermodulation products is considered low because the blocking specification leads to the ability to handle strong out of band signals, and because of the very narrow antenna bandwidth (typically < 10 kHz). There exist no studies providing evidence that the implementation of Receiver Inter-modulation Response Rejection for SRDs at 457 kHz operating in non-channelized spectrum in addition to Receiver Blocking would further improve spectrum utilization and/or spectrum efficiency.
Dynamic Range	Receiver dynamic range is defined as the range of the wanted input signal level over which a receiver functions at a specified performance level. The lower end of this range is normally the sensitivity of the receiver (which is specified above). The upper end of a receiver's dynamic range determines how strong a received signal can be before producing degradation due to overloading. Limiting the upper edge will not support the aim of the RED to "improve spectrum efficiency in order to avoid harmful interference", it is more a quality parameter. However, this is tested indirectly tested with clause 4.4.2 "Changes in the received signal" of ETSI EN 300 718-2 [2]. There exist no studies providing evidence that the implementation of Dynamic range for SRDs at 457 kHz would improve spectrum utilization and/or spectrum efficiency.

Rx Parameter	Comment
Desensitization	Is covered by the blocking requirement.
Reciprocal mixing	Is covered by the blocking requirement.
Signal interferer handling	This receiver requirement provides an alternative to the above "classical" receiver requirements; it is based on ETSI TS 103 361 [i.12] and ETSI TS 103 567 [i.13] and it applies typically to UWB applications having a large bandwidth of more than 50 MHz. It does not apply to the present document.

Annex F (informative): Maximum Measurement uncertainty

The measurements described in the present document are based on the following assumptions:

- the measured value related to the corresponding limit is used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty for the measurement of each parameter is included in the test report.

Table F.1 shows the recommended values for the maximum measurement uncertainty figures.

Table F.1: Maximum measurement uncertainty

Parameter	Uncertainty
RF frequency	$\pm 1 \times 10^{-6}$
Radiated emission of transmitter, valid up to 1 GHz (Substitution method)	±2 dB
Radiated emission of transmitter, valid up to 1 GHz (direct measurement, using calibrated antennas)	±6 dB
Temperature	±1 °C
Humidity	±5 %
Transmitted H field at a distance of 10 m	±0,1 µA/m
Carrier keying times	±3 ms
NOTE: For the test methods according to the present document the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in the ETSI TR 100 028 [i.4].	

For the test methods, according to the present document, the measurement uncertainty figures should be calculated and should correspond to an expansion factor (coverage factor) k = 1,96 or k = 2 (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028-2 [i.4], annex D.

Table F.1 is based on such expansion factors.

Annex G (informative): Determination and use of the measurement bandwidth

CISPR 16-1-4 [1] specifies a reference bandwidth for the measurement of unwanted emissions by measurement receivers and spectrum analysers.

The reference bandwidth ($BW_{REFERENCE}$) cannot always be used as the measurement bandwidth ($BW_{MEASUREMENT}$). This is particularly the case if the measurement is to be made for example on the slope of a spectrum mask or a receiver selectivity curve. In such situations the measurement should be made with a sufficiently low bandwidth in order not to distort the reading.

The actual measured value, A, should be referred back to the reference bandwidth by:

either:

a) Correcting the measured value, A, for any signal having a flat level spectrum with formula (G.1):

$$B = A + 10\log\frac{BW_{REFERENCE}}{BW_{MEASURED}} \quad \text{(G.1)}$$

where:

- B is the measured level, A, transferred to the reference bandwidth.

or:

b) Use the measured value, A, directly if the measured spectrum is a discrete spectral line.

A discrete spectrum line is defined as a narrow peak with a level of at least 6 dB above the average level inside the measurement bandwidth.

Annex H (informative): Change history

Version	Information about changes
2.1.1	Receiver sensitivity was added
2.2.1	Receiver Blocking Test was added Updated annex B Annex E "Justification for Receiver Requirements" was added Annex G was added "Measurement uncertainty" shifted to annex F (informative) Several minor corrections and clarifications Measurement procedures moved to clause 5

History

Document history		
Edition 1	March 1997	Publication as ETSI ETS 300 718
V1.1.1	January 1999	Publication as ETSI TS 100 718 (Historical)
V1.2.1	May 2001	Publication
V2.1.1	January 2018	Publication
V2.2.0	February 2021	EN Approval Procedure AP 20210523: 2021-02-22 to 2021-05-24
V2.2.1	June 2021	Publication