ETSI EN 303 454 V1.1.1 (2018-01)

Short Range Devices (SRD);
Metal and object detection sensors
in the frequency range 1 kHz to 148,5 kHz;
Harmonised Standard covering the essential requirements
of article 3.2 of Directive 2014/53/EU

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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.6] 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.3].

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.

National transposition dates	
Date of adoption of this EN:	18 December 2017
Date of latest announcement of this EN (doa):	31 March 2018
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 September 2018
Date of withdrawal of any conflicting National Standard (dow):	30 September 2019

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).

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Introduction

The present document covers metal and object detection sensors in the frequency range 1 kHz to 148,5 kHz.

The present document is structured as follows:

- Clauses 1 through 3 provide a general description on the types of equipment covered by the present document and the definitions, symbols and abbreviations used.
- Clause 4 provides the technical requirements specifications, limits and conformance relative to transmitter and receiver.
- Clause 5 specifies the conditions for testing of the equipment and interpretation of the measurement results with the maximum measurement uncertainty values.
- Clause 6 specifies the required measurement methods.
- Annex A (informative) provides the relationship between the present document and the essential requirements of Directive 2014/53/EU [i.3].

1 Scope

The present document specifies technical characteristics and methods of measurements for metal and object detection sensors in the frequency range 1 kHz to 148,5 kHz.

The present document covers the essential requirements of article 3.2 of Directive 2014/53/EU [i.3] under the conditions identified in annex A.

The size for the inductive loops covered by the present document is limited to 3 m^2.

The present document does not cover other devices using the frequency range below 148,5 kHz, e.g. ETSI EN 303 348 [i.7] (Inductive loop for hearing impaired in 0 kHz to 20 kHz), ETSI EN 303 447 [i.8] (Inductive robotic mowers).

These radio equipment types are capable of operating in all or part of the frequency bands given in table 1.

Table 1: Permitted range of operation

Permitted range of operation	
Transmit	1 kHz to 148,5 kHz
Receive	1 kHz to 148,5 kHz

NOTE: It should be noted that the frequency range between 9 kHz and 148,5 kHz is EU wide harmonised for inductive Short Range Devices according to Decision 2017/1483 [i.2].

2 References

2.1 Normative references

References are specific, identified by date of publication and/or edition number or version number. Only the cited version 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] ETSI EN 300 330 (V2.1.1) (02-2017): "Short Range Devices (SRD); Radio equipment in the frequency range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

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.

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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] CEPT/ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)".

[i.2] Commission Implementing Decision (EU) 2017/1483 of 8 August 2017 amending Decision 2006/771/EC on harmonisation of the radio spectrum for use by short-range devices and repealing Decision 2006/804.

[i.3] 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.4] CEPT/ERC/REC 74-01: "Unwanted emissions in the spurious domain".

[i.5] ETSI EG 203 336: "Electromagnetic compatibility and Radio spectrum Matters (ERM); 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.6] 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.7] ETSI EN 303 348: "Induction loop systems intended to assist the hearing impaired in the frequency range 10 Hz to 9 kHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

[i.8] ETSI EN 303 447: "Short Range Devices (SRD); Inductive loop systems for robotic mowers in the frequency range 0 Hz to 148,5 kHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in ETSI EN 300 330 [1] and the following apply:

99 % OBW function: measurement function of a spectrum analyser

detection: means the indication of any type of objects as declared by the manufacturer

object detector: capacitive and inductive devices which detect the presence of an object within the nearfield

Occupied BandWidth (OBW): width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0,5 % of the total mean power of a given emission

NOTE: See figure 1.

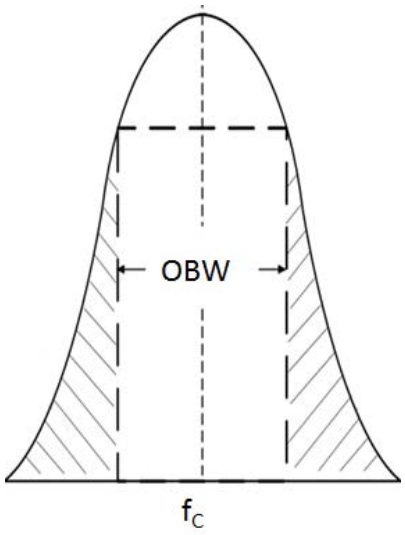

Figure 1: Occupied bandwidth (OBW)

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI EN 300 330 [1] and the following apply:

D	distance between EUT and the target during measurement
f_C	centre frequency of the OFR
f_H	highest frequency of the OFR
f_L	lowest frequency of the OFR
f_{sl}	frequency for the spurious emissions test (below f_C)
f_{sh}	frequency for the spurious emission test (above f_C)

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 300 330 [1] and the following apply:

OBW	Occupied Bandwidth
OFR	Operating Frequency Range
OOB	Out of Band
RBW	Resolution Bandwidth

4 Technical requirements specifications

4.1 Environmental conditions

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer. The equipment shall comply with all the technical requirements of the present document which are identified as applicable in annex A at all times when operating within the boundary limits of the declared operational environmental profile. The conditions shall be used as descripted in clause 5.3.

4.2 General

4.2.1 Wanted performance criteria

A metal and object detector is used to determine the presence of obscured objects made of conductive, magnetic, and/or dielectric materials such as non-ferrous metals, ferrous metals or wood. The objects are part of an environment, i.e. they are e.g. buried in the ground or embedded in building structures such as walls, floors, and ceilings.

The detection performance of the metal and object detector is measured in terms of the ability to detect objects from a specific set of objects in a specific set of environments up to a given maximum detection depth.

The manufacturer shall declare the specific set of objects, the specific set of environments, and the maximum detection depth for each of the relevant measurement modes.

The indications of objects by the EUT in the absence of objects are called false-positive indications.

For the purpose of the receiver performance tests, the EUT shall produce an appropriate output under normal conditions as indicated below:

- the objects in the specific set of objects, in the specific set of environments, up to the maximum detection depth/distance are indicated and no false-positive indications are observed; or
- a degradation of the detection performance is indicated by the EUT as described in the manual.

The possibilities for the indication of the degradation of the detection performance include in particular:

- indication by a dedicated means (e.g. specific light signal, specific tone signal, specific display content);
- indirect indication: the indicated detection result changes in short time intervals under otherwise stationary conditions.

4.2.2 Operational Modes

Metal and object detectors might have several operational modes:

- multiple measurement modes (one or several sensors switched on);
- non-measurement mode (sensors switched off).

The manufacturer shall declare the set of operational modes that are representative for the equipment.

The conformance measurements shall be performed in the representative set of operational modes.

Measurement modes might be specific but not limited to materials (e.g. metal, wooden studs), object properties (e.g. shape, diameter, depth), environments (e.g. concrete walls, dry walls), use case scenarios (e.g. finding, avoiding, tracing), sensitivities (e.g. high sensitivity, medium sensitivity, low sensitivity) or combinations thereof (e.g. universal mode).

The working principles of the sensors in the various modes might include continuous transmission (either stand-alone or in parallel) and intermittent transmission (either alternating or in parallel). The receivers of the sensors might be either switched on continuously or intermittent. In particular, receivers might at times be switched on while the respective transmitter is switched off (receiver only operation).

4.2.3 Presentation of equipment for testing purposes

Each EUT submitted for testing shall fulfil the requirements of the present document.

The manufacturer shall declare the range of operating conditions and power requirements as applicable, to establish the appropriate test conditions.

Additionally, technical documentation and operating manuals, sufficient to make the test, shall be supplied.

Measurements shall be performed for all operational modes from clause 4.2.2 on samples of equipment defined in clause 4.2.2 of ETSI EN 300 330 [1].

4.3 Transmitter conformance requirements

4.3.1 Operating Frequency Range (OFR)

4.3.1.1 Applicability

This requirement applies to all EUT.

4.3.1.2 Description

The operating frequency range is the frequency range over which the EUT is intentionally transmitting. The operating frequency range of the EUT is determined by the lowest (f_L) and highest frequency (f_H) as occupied by the power envelope.

The EUT could have more than one operating frequency range.

For single frequency systems the OFR is equal to the occupied bandwidth (OBW) of the EUT.

For multi-frequency systems, the OFR extends from the lowest edge of the OBW when operating on the lowest frequency to the highest edge of the OBW when operating on the highest frequency, for example as illustrated in figure 2.

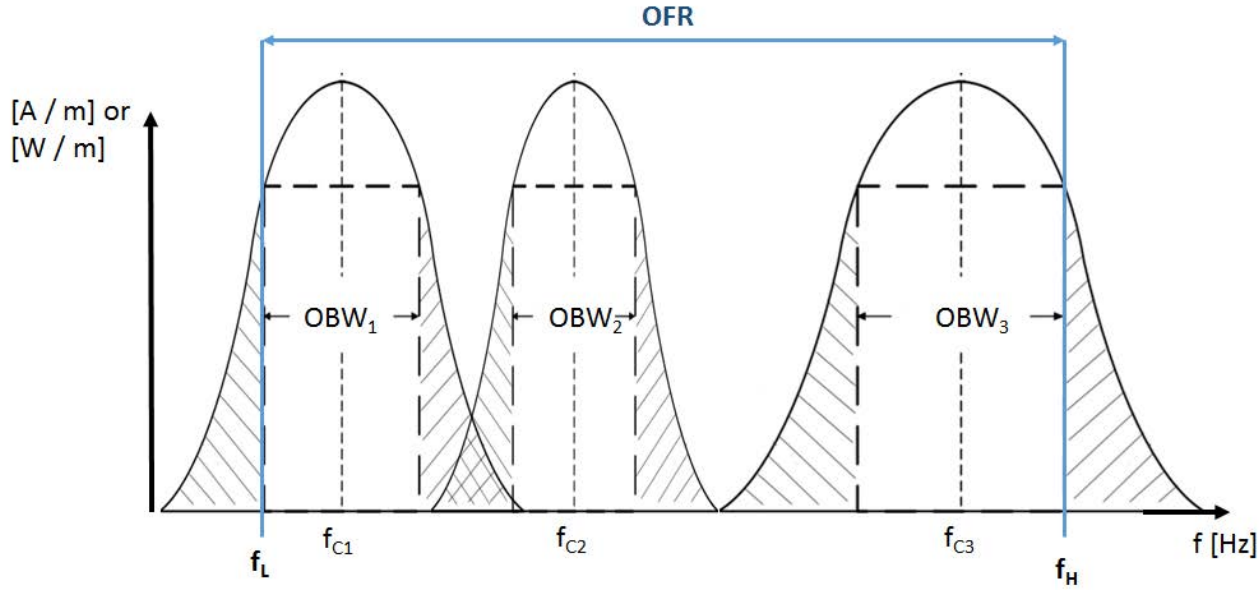

Figure 2: OFR of a multi - frequency system

4.3.1.3 Limits

The operating frequency range shall be within the following limits:

- Upper edge of the operating frequency range: $f_H \leq 148{,}5$ kHz.
- Lower edge of the operating frequency range: $f_L \geq 1$ kHz.

For the later unwanted emission measurement procedure in clause 4.3.3.3 the OFR shall be calculated as: $f_H - f_L$ and the centre frequency as: $f_C = \frac{f_H + f_L}{2}$.

4.3.1.4 Conformance

The conformance test suite for operational frequency range is provided in clause 6.1 and clause 6.2.1.

Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.

4.3.2 Transmitter H-field requirements

4.3.2.1 Applicability

This requirement applies to all EUT.

4.3.2.2 Description

The radiated H-field is defined in the direction of maximum field strength of the EUT.

4.3.2.3 Limits

The H-field limits for the frequencies < 9 kHz are provided in table 2 and for the frequency range 9 kHz to 148,5 kHz in table 3.

The H-field limits in table 3 are EU wide harmonised for the SRD category "inductive devices" according to Decision 2017/1483 [i.2]. Further information is available in CEPT/ERC/REC 70-03 [i.1].

For the frequency < 9 kHz no frequency usage conditions were known and available at the time of preparation of the present document. However, the H-field limits in table 2 are suggested to improve the intra- coexistence with other radio devices within this range.

Table 2: H-field limits below 9 kHz

Frequency range (kHz)	H-field strength limit (H_f) dBµA/m at 10 m
1 ≤ f < 9	72

Table 3: H-field limits between 9 kHz and 148,5 kHz according to Decision 2017/1483 [i.2]

Frequency range (MHz)	H-field strength limit (H_f) dBµA/m at 10 m
0,009 ≤ f < 0,090	72 descending 10 dB/dec above 0,03 MHz or according to note 1 (see note 2)
0,09 ≤ f < 0,119	42
0,119 ≤ f < 0,135	66 descending 10 dB/dec above 0,119 MHz or according to note 1 (see note 2)
0,135 ≤ f < 0,140	42
0,140 ≤ f < 0,1485	37,7
NOTE 1: For the frequency ranges 9 kHz to 135 kHz, the following additional restrictions apply to limits above 42 dBµA/m: - for loop coil antennas with an area between 0,05 m^2 and 0,16 m^2: the limit is: table value + 10 × log (area/0,16 m^2); - for loop coil antennas with an area < 0,05 m^2 the limit is 10 dB below the table value. NOTE 2: Limit is 42 dBµA/m for the following spot frequencies: 60 kHz ± 250 Hz, 66,6 kHz ± 750 Hz, 75 kHz ± 250 Hz, 77,5 kHz ± 250 Hz and 129,1 kHz ± 500 Hz. NOTE 3: Calculation rules for limits at other measurement distances, see annex I of ETSI EN 300 330 [1].	

4.3.2.4 Conformance

The conformance test suite for transmitter H-field requirements is provided in clause 6.1 and clause 6.2.2.

Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.

4.3.3 Transmitter E-field requirements

4.3.3.1 Applicability

The transmitter radiated E-field applies to E-Field transmitters.

4.3.3.2 Description

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

For a detailed explanation of the relationship between E-field and H-field, see ETSI EN 300 330 [1], annex G.

4.3.3.3 Limits

In the frequency range 1 kHz to 148,5 kHz, the limits of H_{ef} follow the H-fields limits, H_f, as given in clause 4.3.2.3, tables 2 and 3 with an additional correction factor C. The correction factor C given below is specific for a 10 m measuring distance.

The limit $H_{ef} = H_f + C$;

where:

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

and where:

f_C is the carrier frequency in Hz.

4.3.3.4 Conformance

The conformance test suite for transmitter E-field requirements is provided in clause 6.1 and clause 6.2.4.

Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.

4.3.4 Transmitter spurious emissions

4.3.4.1 Applicability

This requirement applies to all EUT.

4.3.4.2 Description

The transmitter spurious emissions shall be considered in the frequency range 9 kHz to 1 000 MHz, excluding the frequencies within 250 % of the occupied bandwidth above and below the centre frequency of the transmitter. This is illustrated for single frequency systems in figure 3 and for multi-frequency systems in figure 4.

For multi-frequency systems the 250 % occupied bandwidth exclusion relates only to the individual frequencies, not the accumulated width of all frequencies (see figure 4).

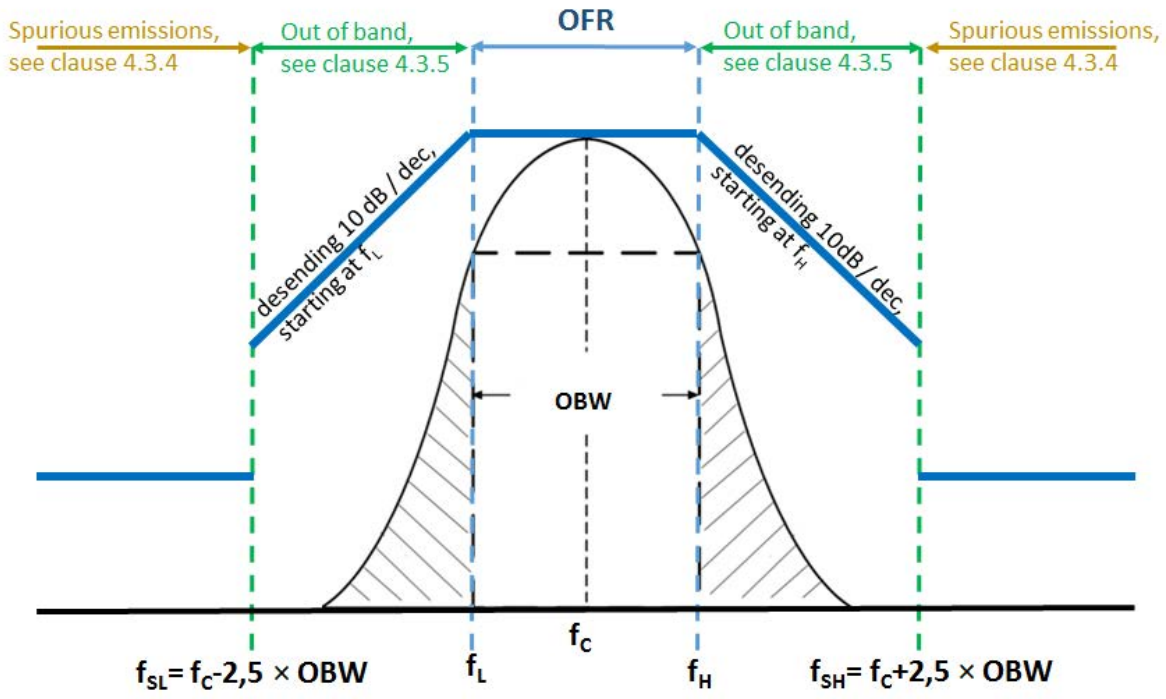

Figure 3: Out of band and spurious domain of a single frequency system

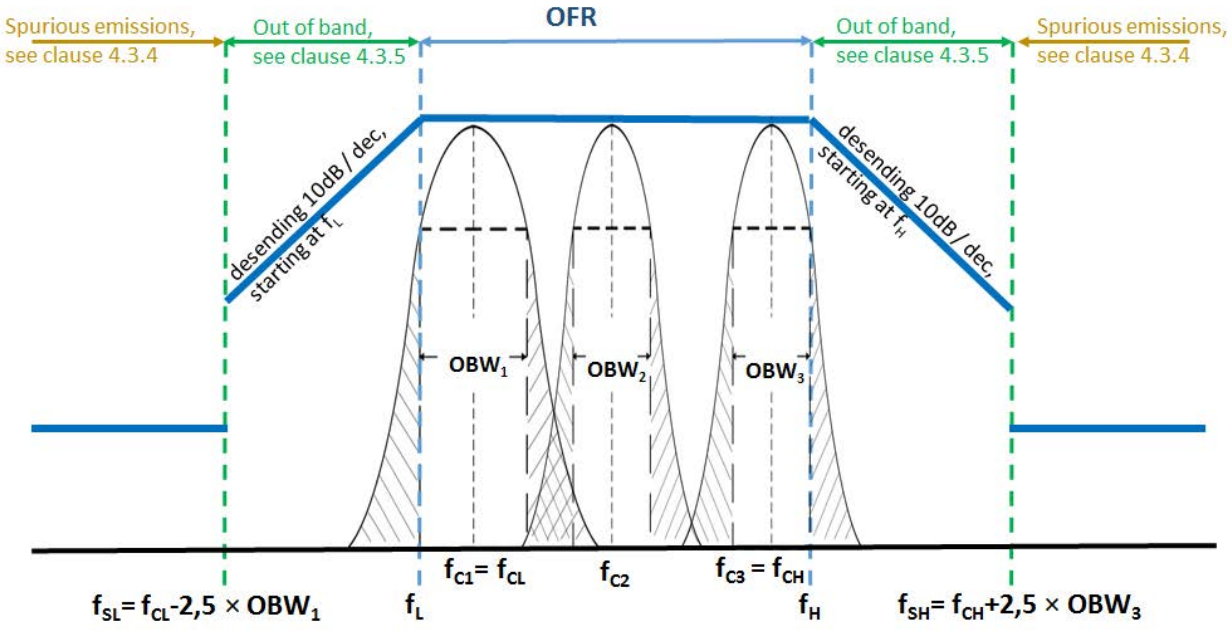

Figure 4: Out of band and spurious domain of a multi - frequency system

The following additional conditions applying for f_{SH} and f_{SL}:

1) For systems with $f_H \leq 9$ kHz: f_{SH} is set to 27 kHz in absence of selective measurement equipment below 9 kHz.

2) For systems with $f_H > 9$ kHz: f_{SH} whichever is the smallest of:

   - $f_C + 2,5 \times OFR$ (single frequency systems);
   - $f_{CH} + 2,5 \times OBW_3$ (multi frequency systems); or

- 148,5 kHz.

Bullet 2) ensures that the spurious limits of CEPT/ERC/REC 74-01 [i.4] apply above 148,5 kHz.

4.3.4.3 Limits

The unwanted emissions shall not exceed the limits given in tables 4 and 5.

Table 4: Magnetic field limits of CEPT/ERC/REC 74-01, table 2.1 [i.4] at 10 m distance

State	Frequency 9 kHz ≤ f < 4,78 MHz	Frequency 4,78 MHz ≤ f < 10 MHz	Frequency 10 MHz ≤ f < 30 MHz
Operating	27 dBµA/m at 9 kHz descending 10 dB/dec		-3,5 dBµA/m
Standby	5,5 dBµA/m at 9 kHz descending 10 dB/dec	-22 dBµA/m	
NOTE: There are no spurious emission limits < 9 kHz.			

Table 5: Unwanted emission limits of CEPT/ERC/REC 74-01 table 2.1 [i.4] between 30 MHz and 1 000 MHz

State	Between 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
Standby	2 nW	2 nW
NOTE: There are no spurious emission limits < 9 kHz.		

4.3.4.4 Conformance

The conformance test suite for transmitter spurious emissions is provided in clause 6.1 and clause 6.2.3.

Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.

4.3.5 Transmitter out of band (OOB) emissions

4.3.5.1 Applicability

This requirement applies to all EUT.

4.3.5.2 Description

The transmitter out-of-band (OOB) emissions shall be considered in the frequency ranges from the upper / lower edge of the OFR to 250 % of the occupied bandwidth above / below the centre frequency of the transmitter. This is illustrated for single frequency systems in figure 3 and for multi-frequency systems in figure 4.

4.3.5.3 Limits

The OOB limits are visualized in figure 3 and figure 4; the limits are descending from the intentional limits from tables 2 and 3 at f_H/f_L with 10 dB/decade.

4.3.5.4 Conformance

The conformance test suite for Transmitter out of band emissions is provided in clause 6.1 and clause 6.2.3.

Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.

4.4 Receiver Conformance requirements

4.4.1 Introduction

ETSI EG 203 336 [i.5] lists candidate technical parameters to be included in a Harmonised Standard aimed at providing a presumption of conformity of radio equipment with the essential requirements in articles 3.1(b) and 3.2 of the Radio Equipment Directive 2014/53/EU [i.3].

Essential requirements are high level objectives described in European Directives. The purpose of the present document is to translate those high level objectives into detailed technical specifications.

4.4.2 Receiver spurious emissions

4.4.2.1 Applicability

This requirement applies to all receivers.

Spurious emission levels from a receiver of co-located equipment are measured simultaneously and the test only needs to be conducted once for transmitter spurious emissions (see clause 4.3.4).

4.4.2.2 Description

Spurious radiation from the receiver are emissions at any frequency, radiated by the equipment and/or antenna. The receiver spurious emissions shall be considered in the frequency range 9 kHz to 1 000 MHz.

4.4.2.3 Limits

The spurious emissions below 30 MHz shall not exceed the limits given in table 6.

Table 6: Receiver spurious radiation limits below 30 MHz at 10 m distance

Frequency 9 kHz < f < 4,78 MHz	Frequency 4,78 MHz < f < 30 MHz
5,5 dBµA/m at 9 kHz descending 10 dB/dec	-22 dBµA/m

The spurious emissions above 30 MHz shall not exceed 2 nW.

4.4.2.4 Conformance

The conformance test suite for receiver spurious emissions is provided in clause 6.1 and clause 6.2.3.

Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.

4.4.3 Receiver blocking

4.4.3.1 Applicability

This requirement applies to all EUT.

4.4.3.2 Description

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 frequencies other than those of the receiver spurious responses.

The test shall be performed in the relevant operational modes (see clause 4.2.2).

In case of interference, the EUT shall react as intended and as declared by the manufacturer.

The wanted performance criteria from clause 4.2.1 shall be used as criterion for the receiver blocking tests.

4.4.3.3 Limits

The receiver blocking limits in table 8 at the test frequencies defined in table 7 shall be fulfilled.

In case that the OFR_{RX} of the receiver is equal to the OFR of the transmitter the test shall be performed with $f_{CRX} = f_C$ and OFR_{RX} = OFR as determined from the measurement of the OFR (see clause 4.2.1).

For sensor applications, the OFR_{RX} of the receiver is typically significantly broader than the OFR of the transmitter. In this case the manufacturer shall declare the values of f_{CRX} and OFR_{RX} reflecting the actual receiver performance of the EUT.

The receiver blocking limits are defined in table 8.

Table 7: Test frequencies related OFR for receiver blocking

Frequency range [kHz]	OOB signal	Remote-band signal
Testfrequency	$f = f_{CRX} \pm 2 \times OFR_{RX}$	$f = f_{CRX} \pm 10 \times OFR_{RX}$

Table 8: Receiver blocking limits

Frequency range [kHz]	H-field [dBµA/m] at EUT
$1 \le f < 9$	72
$9 \le f < 90$	72 descending 10 dB/dec above 30 kHz
$90 \le f < 119$	42
$119 \le f < 135$	66 descending 10 dB/dec above 119 kHz
$135 \le f < 140$	42
$140 \le f$	37,7

NOTE: Based on the technical implementation the object detectors are sensitive within the operating frequency range. Therefore, no "in-band" blocking test is required and the manufacturer should take other measures to inform the user about degradation of the detection performance.

The EUT shall achieve the wanted performance criterion, see clause 4.2.1, in the presence of the blocking signal.

4.4.3.4 Conformance

The conformance test suite for receiver blocking is provided in clause 6.1, clause 6.3.2 and annex B.

Conformance shall be established under test conditions to be declared by the manufacturer according to clause 4.1.

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

Tests defined in the present document shall be carried out at representative points within the boundary limits of the declared operational environmental profile.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the declared operational environmental profile) to give confidence of compliance for the affected technical requirements.

5.2 General conditions for testing

5.2.1 Product information

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

5.3 Normal and extreme test conditions

The provisions of ETSI EN 300 330 [1], clause 5.3 shall apply.

5.4 Test sites and general arrangements for radiated measurements

The required test setups and procedures are provided in clause 6.1.

5.5 Measuring receiver

The term "measuring receiver" refers to a selective voltmeter, oscilloscope or a spectrum analyser. The bandwidth and detector type of the measuring receiver are given in table 9.

If a different detector type shall be used for the conformance test this shall be specified in the related clause 6.

Table 9: Overview measuring receiver requirements

Frequency: (f)	Detector type	Measurement receiver bandwidth	Spectrum analyser bandwidth
1 kHz ≤ f < 9 kHz	Quasi Peak	200 Hz	300 Hz
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. The measurement bandwidth and any related calculations shall be stated in the test report.

5.6 Measurement uncertainty

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;
- the value of the measurement uncertainty 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 provisions of ETSI EN 300 330 [1], clause 5.13.

5.7 Interpretation of the measurement results

The provisions of ETSI EN 300 330 [1], clause 5.14 shall apply.

6 Conformance methods of measurement for transmitters and receivers

6.1 General

For the conformance test of the essential requirements see clause 4 of the present document. The measuring receiver may be a spectrum analyser, oscilloscope, selective power meter or any measuring receiver which is appropriate to perform the intended measurement of the EUT.

A principle test set-up is shown in figure 5.

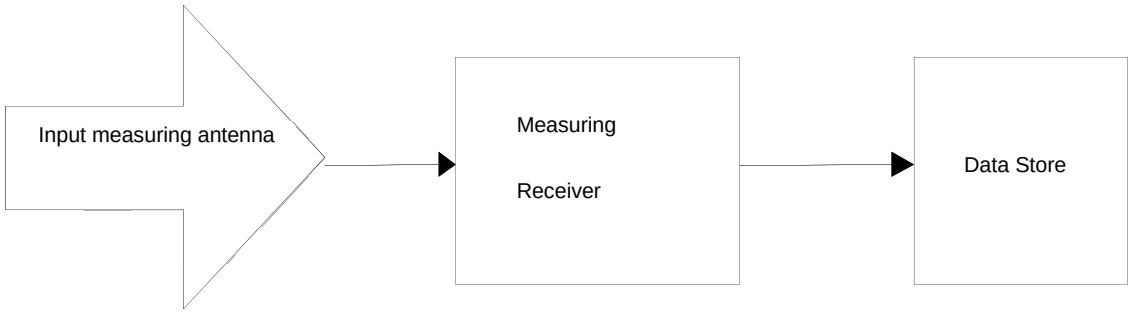

Figure 5: Test set-up for measurement of the operating frequencies

The measurements of the transmitter requirements shall be made on an open field test site as specified in ETSI EN 300 330 [1], clause C.1.3 or within an anechoic chamber as specified in ETSI EN 300 330 [1], clause C.1.1 and clause C.1.2. Any measured values shall be at least 6 dB above the ambient noise level.

The emissions of the equipment shall be measured at standard distance of 10 m. Where this is not practical, e.g. due to physical size of the equipment including the antenna or with use of special field cancelling antenna, then other distances may be used. When another distance is used, the distance used and the field strength value measured shall be stated in the test report. In this case, the measured value at actual test distance shall be extrapolated to 10 m according to annex H in ETSI EN 300 330 [1] and these calculations shall be stated in the test report. For frequencies below 10 kHz, figures H.1 and H.2 of ETSI EN 300 330 [1] does not provide values the conversion factors C30 of -28,6 dB and C3 of 31,3 dB shall be used.

The emissions shall be measured with a shielded loop antenna connected to a measurement receiver. The measuring bandwidth and detector type of the measurement receiver shall be in accordance with the definition in clause 5.5. The detailed conformance test procedures are provided below:

- OFR, see clause 6.2.1.
- H-Field, see clause 6.2.2.
- Transmitter unwanted emissions (including spurious and out of band emissions), see clause 6.2.3.
- E-Field transmitter, see clause 6.2.4.
- Receiver spurious emissions, see clause 6.3.1.
- Receiver Blocking, see clause 6.3.2 and annex B.

The equipment under test shall operate where possible, in the operational modes, specified in clause 4.2.2. Where this is not possible, it shall be stated in the test report.

6.2 Transmitter conformance methods

6.2.1 OFR

A representative test signal from the EUT shall be measured with a spectrum analyser. The EUT shall be modulated with standard test modulation (see clause 5.2).

The transmission shall be measured using a spectrum analyser with the following settings:

- Start frequency: 1 kHz or f_C - 2,5 × OBW (whichever is lower).
- Stop frequency: higher than 148,5 kHz.
- Resolution Bandwidth: 200 Hz.
- Video Bandwidth: ≥ 300 Hz.
- Detector mode: peak.
- Display mode: Maxhold over > 10 s.
- Sweep time, averaging time: ≥ 1 ms per sweep point.

The following values shall be recorded:

- f_H as the frequency of the upper marker resulting from the "OBW"-function of a spectrum analyser, using 99 % of the power (see figure 2). Alternatively the frequency above the centre frequency f_C shall be recorded where the level is 23 dB lower as the maximum;
- f_L as the frequency of the upper marker resulting from the "OBW"-function of a spectrum analyser, using 99 % of the power (see figure 2). Alternatively the frequency below the centre frequency shall be recorded where the level is 23 dB lower as the maximum;
- f_C is the centre frequency. $f_C = \frac{f_H + f_L}{2}$;
- OFR= f_H - f_L.

The results shall be compared with the limits in clause 4.3.1.3.

NOTE: If the OFR of the signal is smaller than the resolution bandwidth of the measuring receiver (e.g. CW TX-Signals) than the OFR is measured as equal to the RBW (see clause 5.5, table 9).

6.2.2 H-field

A representative test signal from the EUT shall be measured with a spectrum analyser. The EUT shall be modulated with standard test modulation (see clause 5.2).

The transmission shall be measured using a spectrum analyser with the following settings:

- Start frequency: 1 kHz or f_C - 2,5 × OBW (whichever is lower).
- Stop frequency: higher than f_H (requirement see clause 4.2.1, test procedure see clause 6.2.1).
- Resolution Bandwidth: according to clause 5.5.
- Video Bandwidth: ≥ RBW.
- Detector mode: according to clause 5.5.
- Display mode: Maxhold over > 10 s.
- Sweep time, Averaging time: ≥ 1 ms per sweep point.

The maximum H-Field results shall be compared with the limits in clause 4.3.2.3.

6.2.3 Transmitter unwanted emissions

A representative test signal from the EUT shall be measured with a spectrum analyser (see clause 5.2).

The transmitter unwanted emissions shall be measured using a spectrum analyser from 9 kHz to 1 GHz with the following settings:

- Resolution Bandwidth: according to clause 5.5.
- Video Bandwidth: ≥ RBW.
- Detector mode: quasi peak.
- Display mode: Maxhold over > 10 s.
- Sweep time, Averaging time: ≥ 1 ms per sweep point.

The maximum measured spurious emission results shall be compared with the limits in clause 4.3.4.3 and the out of band emission results with the limits in clause 4.3.5.3.

6.2.4 Transmitter radiated E-field

The transmitter radiated E-field is calculated from the equivalent H-field, measured at 10 m.

The H-field is measured with a shielded loop antenna connected to a measurement receiver. The measuring bandwidth and detector type of the measurement receiver shall be in accordance with clause 5.6.

For a detailed explanation of the relationship between E-field and H-field, see annex G in ETSI EN 300 330 [1].

6.3 Receiver conformance methods

6.3.1 Receiver spurious emissions

The methods of measurement shall be in accordance with clause 6.2.3.

6.3.2 Receiver blocking

- Guidance on the measurement method may be found in annex B.
- The fulfilment of the EUT performance criterion in all possible operational modes (see clause 4.2.2) shall be tested in presence of the inference signals according to table 6.
- The manufacturer shall declare in which device orientation(s) (worst case) the test shall be performed, see figure B.2.
- The EUT shall initially operate without interference according to its specified sensitivity (detecting an specific object in the maximum depth as declared by the manufacturer (see clause 4.2.1 on wanted performance criteria)).
- The test setup is visualized in the following figures 6, 7 and B.2.
- The EUT shall be operated as intended (e.g. some EUTs might require to be moved across the object, whilst others can be used stationary).
- The test shall be carried out inside a test chamber according to clauses C.1.1 and C.1.2 in ETSI EN 300 330 [1].
- A test loop with a radius R shall be used to create the magnetic field.

- The test loop shall be positioned at a minimum distance to metallic objects (e.g. ground plane) shall be 0,75 m.
- The test loop shall be sufficiently large so that the test loop itself does not influence the EUT; The radius R of the test-loop shall be in minimum $\Delta R = 0{,}5$ m larger than the maximum dimension r of the EUT. (See figure 7: $R \geq r + \Delta R$).
- The EUT shall be placed in the centre of the test-loop (e.g. see figures 6 and 7 and annex B for further information).
- The maximum H-Field can be calculated from the loop current I (into the test-loop) with the following formula:

$$H = \frac{I}{2R}$$

- The required output current to achieve the required magnetic field from table 8 at the EUT shall be generated with a signal generator (unmodulated signal) at the test frequencies from table 7.
- The test shall be started at the H-Field requested test limit according table 8.
- If the EUT shows a degradation of the detection performance (see clause 4.2.1) at the H-Field according table 8 than the level shall be decreased by 5dBµA/m (for each test step) until the EUT detection performance is as intended.
- For each test frequency and H-Field limit the "reaction" of the device shall be recorded and checked against the performance criterion from clause 4.2.1.

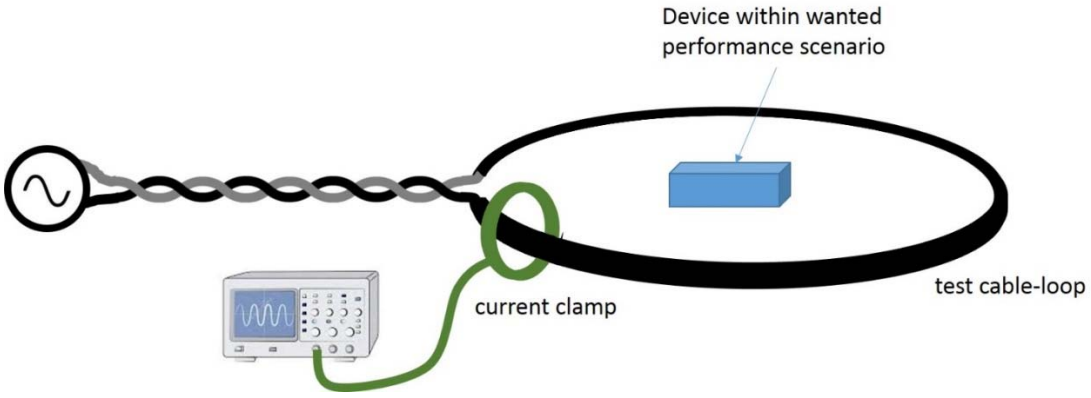

Figure 6: Schematic test set-up for the RX-blocking test

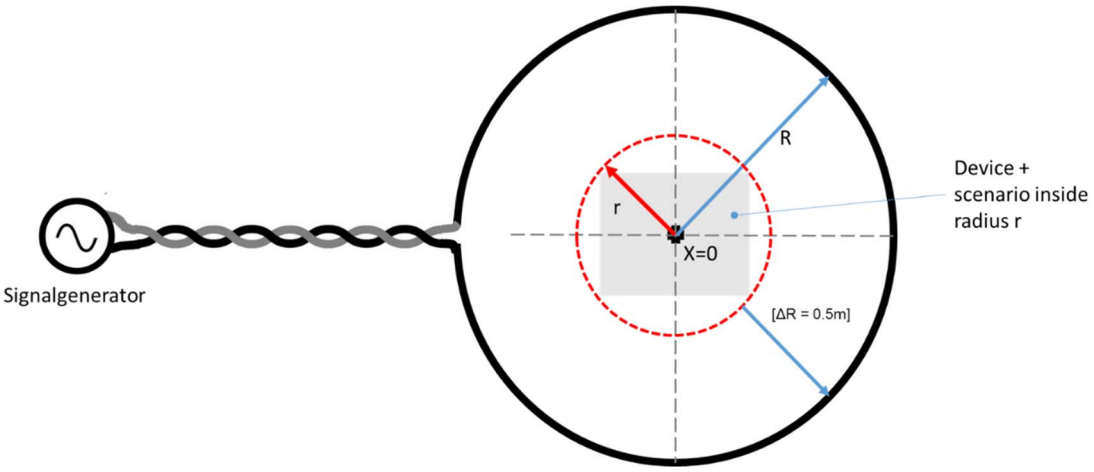

Figure 7: Schematic test set-up for the RX-blocking test

If the EUT meets the wanted performance criterion at all times, then the test shall be considered as passed. Otherwise, the test is considered as failed.

The results are to be compared with the limits in clause 4.4.3.3.

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.6] 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.3].

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 [i.3]

Harmonised Standard ETSI EN 303 454				
Requirement			Requirement Conditionality	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**
1	Operating frequency range	4.3.1	U	
2	Transmitter H-field requirements	4.3.2	U	
3	Transmitter E-field requirements	4.3.3	C	Only for E-Field Transmitter
4	Transmitter spurious emissions	4.3.4	U	
5	Transmitter out of band (OOB) emissions	4.3.5	U	
6	Receiver spurious emissions	4.4.2	U	
7	Receiver blocking	4.4.3	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.

Clause Number 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 (informative): Guidance for testing receiver blocking

B.1 Introduction

The following guidance may be used, by test laboratories and manufacturers, when evaluating the compliance of object detectors with the receiver blocking requirements. This annex does not constitute additional requirements and does not modify the technical requirements of the present document.

The blocking test is reliant upon having a defined field at the receiver under test, however certain EUT may require movement in order to work as intended. Due account should be taken of the effect of any operator intervention on the test field, e.g. distortion of the field by the presence of the operator or excessive movement of the EUT.

B.2 H-field pattern

As stated in clause 6.3.2 the field strength, H_{max}, at the centre of a loop (with radius R in meters) can be calculated from the equation:

$$H_{max} = \frac{I}{2 \times R} \quad \text{(B.1)}$$

The field strength will reduce with distance away from the centre. On the central axis, the field strength may be calculated from the equation:

$$H = \frac{I \times R^2}{2(z^2 + R^2)^{\frac{3}{2}}} \quad \text{(B.2)}$$

where z is the distance, in metres, along the axis.

EXAMPLE:

- 2 m radius test-loop with loop current of 63 mA.
- with (B.1): maximum H-field at centre, H_{max} = 0,016 A/m = 42 dBµA/m.
- with (B.2): H at 0,5 m offset along the z axis = 0,0145 A/m = 41,6 dBµA/m.

For any point in space off the central axis, the field strength calculations are much more complex. The magnetic field lines are shaped as shown in figure B.1. The field strength along the straight line down the middle is defined by the above equations. The remaining lines are elliptical in shape, with those closest to the loop almost circular similar to the lines generated around a long straight wire.

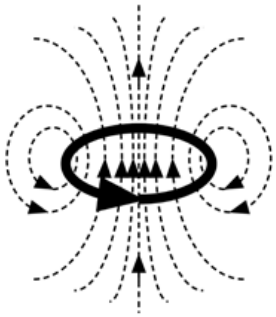

Figure B.1: Magnetic field lines from current carrying loop

For purposes of testing:

The EUT could be maintained (including possible necessary movement) within a reasonably uniform field if:

$$(H_{max} - 3\ dB) < H \leq H_{max} \quad \text{(B.3)}$$

It can be seen from the above equations that the extent of the 3 dB uniformity along the central axis is a large proportion of the loop radius.

EXAMPLE:

- 2 m loop, 63 mA loop current. Hmax = 0,016 A/m = 42 dBμA/m.
- Distance along axis for H = 39 dBμA/m is 1,53 m.

The field density in the axial direction will fall as distance from the axis increases. Even so, in the above example a sphere of 1,2 m radius will fit within the 3 dB uniform area.

B.3 EUT and target positioning

Figure B.2 illustrates a typical test set-up. The EUT is initially positioned at the centre of the loop with the test target positioned at the maximum specified depth/distance (D) for detection. This could be in any direction from the EUT as the EUT is operated in its most susceptible orientation. The exact orientation of the EUT may need to be found by experiment. The manufacturer's operating instructions could give guidance for the tests and these instructions can be used, however movement is restricted to within the boundary conditions of clause 6.3.2. I.e. the EUT should not be moved closer than 0,5 m to the test-loop. It is permissible to move the target instead, if the EUT can function in this manner.

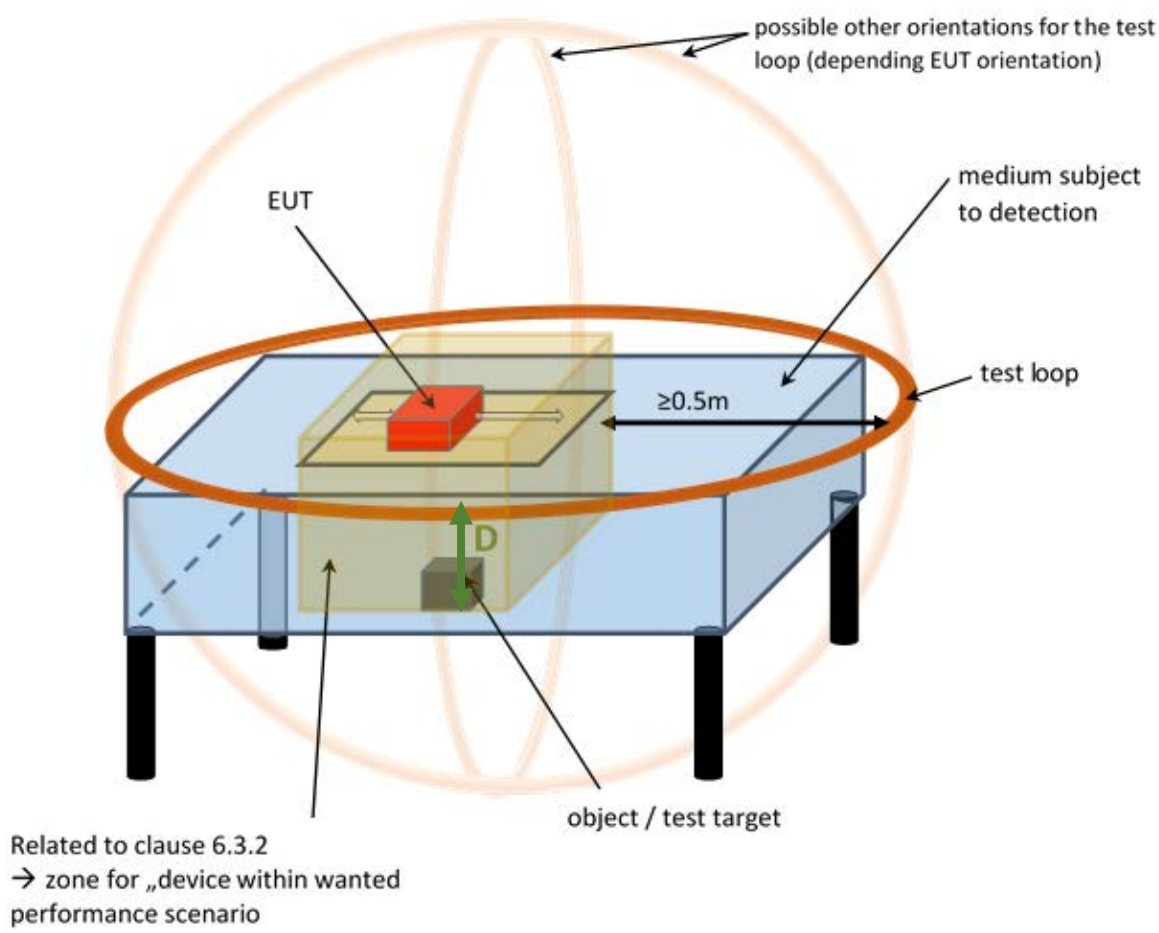

Figure B.2: Typical test set-up

B.4 Chamber considerations

In order to isolate the test environment from external noise, a shielded enclosure according to clauses C.1.1 or C.1.2 of ETSI EN 300 330 [1] is used. Most anechoic / semi-anechoic rooms are built for testing from 30 MHz to 1 GHz or higher frequencies and therefore the materials chosen are not ideal for H-field testing. For the test there is a need be taken into account that measurements are made at sufficient distance from the walls, floor and ceiling of the chamber to avoid undue influence on the test.

Given that the magnetic flux pattern is strongest perpendicular to the loop, any metal parallel to the loop (e.g. floors and ceiling) will have more influence than metal which is perpendicular to the loop (e.g. walls). On the other hand, ferrite tiles, which can be magnetized, tend to be mounted on the walls.

The EUT and target should be kept at a sufficient distance from the enclosure to avoid any adverse effects such as reflections, imaging and de-tuning.

B.5 Supporting structures

To enable correct placement of the test-loop, the EUT and target, supporting structures will be required. Movement of the EUT or target may also be achieved by means of artificial arms. To avoid undue influence on the test, contact with the test-loop, EUT and target should be kept to a minimum and the materials used should be non-conductive and non-ferrous (i.e. a relative permeability of approximately 1).

For the test it needs to take into account that the human body does not disrupt a magnetic field in the same way as E-field. Therefore, the main concern of using operators within the shielded room is with unnecessary equipment they may use or have on their person.

B.6 Field verification

Verification of the magnetic field generated by large or non-standard test-loops can be performed with a small magnetic field sensor. The set-up is similar to the blocking test and is illustrated in figure B.3.

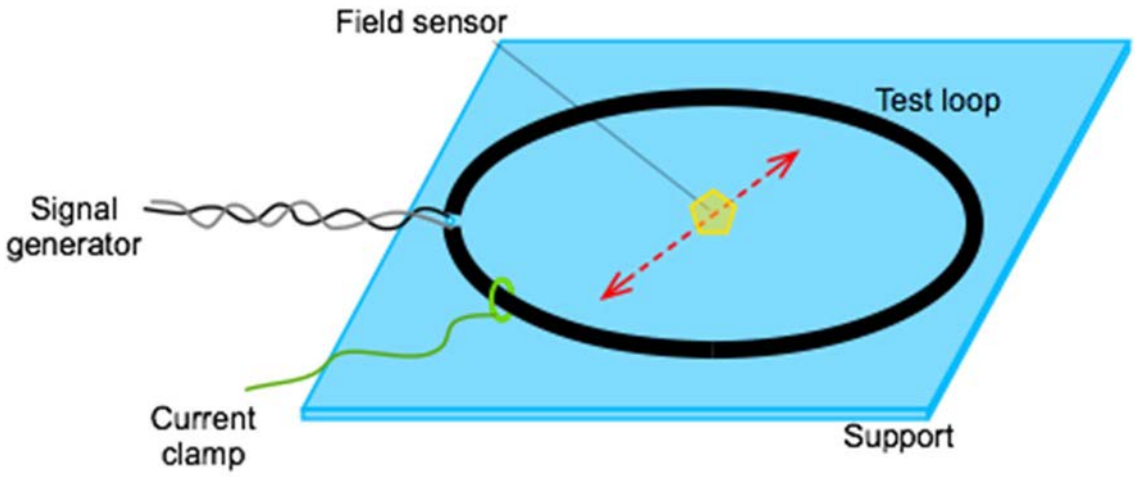

Figure B.3: Test-loop magnetic field verification

- Position the inductive loop at 0,75 m minimum distance from the walls, ceiling and floor of the chamber (see clauses C.1.1 and C.1.2 in ETSI EN 300 330 [1]) and any magnetic material by using insulating supports.
- Connect the loop to the signal generator. The connections between the generator and the loop should be as short as possible, no more than 2 m, and twisted together.
- Monitor the loop current by means of a current clamp and adjust for the maximum H-field requirement.

- Place the field sensor at the centre of the loop and orientate for maximum field strength reading, H_{max}.
- Move the field sensor in a straight line towards the loop, whilst maintaining its orientation and observe the drop in field strength (in the axial direction). Note the position where the field strength falls to:
  - $H = H_{max} – 3$ dB.

Annex C (informative): Change history

Version	Information about changes
1.1.1	First version of the present document to cover the essential requirements for metal and object detection sensors in the frequency range 1 kHz to 148,5 kHz on article 3.2 of Directive 2014/53/EU.

History

Document history			
V1.1.0	March 2017	EN Approval Procedure	AP 20170606: 2017-03-08 to 2017-06-06
V1.1.1	October 2017	Vote	V 20171216: 2017-10-17 to 2017-12-18
V1.1.1	January 2018	Publication	