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Harmonized European Standard (Telecommunications series)

Electromagnetic compatibility and Radio spectum Matters (ERM); Navigation radar for use on non-SOLAS vessels: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive

Reference
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Contents

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Foreword

This Harmonized European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the Public Enquiry phase of the ETSI standards Two-step Approval Procedure.

The present document is a harmonized EN covering essential requirements under article 3.2 of the R&TTE directive for navigation radar for use on non-SOLAS vessels.

The present document has been produced by ETSI in response to a mandate from the European Commission issued under Council Directive 98/34/EC (as amended) laying down a procedure for the provision of information in the field of technical standards and regulations.

The present document is intended to become a Harmonized Standard, the reference of which will be published in the Official Journal of the European Communities referencing the Directive 1999/5/EC [1] of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity ("the R&TTE Directive").

Technical specifications relevant to Directive 1999/5/EC [1] are given in annex A.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	18 months after doa

1 Scope

The present document applies to radar equipment intended for the navigation of non-SOLAS vessels. The present document contains the minimum technical, operational and functional requirements, describes the tests and the conditions under which the tests take place in order to establish that the equipment meets these minimum requirements.

The present document is intended to cover the provisions of Directive 1999/5/EC [1] (R&TTE Directive) Article 3.2, which states that "… radio equipment shall be so constructed that it effectively uses the spectrum allocated to terrestrial/space radio communications and orbital resources so as to avoid harmful interference".

In addition to the present document, other ENs that specify technical requirements in respect of essential requirements under other parts of Article 3 of the R&TTE Directive [1] may apply to equipment within the scope of the present.

This radar equipment operates in the frequency range 2 900 MHz to 3 100 MHz or 9 300 MHz to 9 500 MHz allocated to the radio navigation service as defined in article 5 of the Radio Regulations [2].

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://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.

[1] Void.

[2] ITU Radio regulations 2004.

[3] CENELEC EN 60945 Edition 4 (2002): "Maritime navigation and radiocommunication equipment and systems-General requirements- Methods of testing and required test results".

[4] ITU-R Recommendation SM.329-10 (2003): "Unwanted emissions in the spurious domain".

[5] ITU-R Recommendation M.1177-3 (2003): "Techniques for measurement of unwanted emissions of radar systems".

[6] ITU-R Recommendation SM.1541-1(2002): "Unwanted emissions in the out-of-band domain".

[7] ANSI C63.5 (1988): "Electromagnetic Compatibility; Radiated Emission Measurements in Electromagnetic Interference (EMI) Control; Calibration of Antennas".

[8] ETSI TR 100 028-1 (V1.3.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1".

3 Abbreviations

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

EBL Electronic Bearing Line
EIA Electronics Industry Association

EMC	ElectroMagnetic Compatability
EUT	Equipment Under Test
FTC	Fast Time Constant
HS	Harmonized Standard
LNA	Low Noise Amplifier
OATS	Open Area Test Site
OoB	Out-Of-Band
PEP	Peak Envelope Power
PRT	Pulse Repetition Time
RF	Radio Frequency
RJ	Rotary Joint
SOLAS	Safety Of Life At Sea
STC	Sensitivity Time Control
VRM	Variable Range Marker
VSWR	Voltage Standing Wave Radio

4 Technical requirements

4.1 Environmental profile

Tests defined in the present document shall be carried out at representative points within the boundary limits of the declared operational environmental profile which, as a minimum, shall be that specified in the test conditions contained in the present document.

As 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 (which shall also be within the boundary limits of the declared operational environmental profile).

4.2 Conformance requirements

4.2.1 Radiated emissions

4.2.1.1 Definition

Radiated electromagnetic emissions are to be understood as any signals radiated by the completely assembled and operated radar equipment, other than the operating frequency, with its spectra, which can potentially disturb other equipment on the ship, such as radio receivers or rate of turn indicators.

4.2.1.2 Limits

In the frequency range 150 kHz to 2 GHz, the measured radio frequency field strength at a distance of 3 m caused by the EUT shall not exceed the limits shown in table 1.

Table 1: Radiated electromagnetic emission

Frequency range	Measuring Bandwidth	Limits
150 kHz to 300 kHz	9 kHz	10 mV/m to 316 µV/m (80 dBµV/m to 52 dBµV/m)
300 kHz to 30 MHz	9 kHz	316 µV/m to 50 µV/m (52 dBµV/m to 34 dBµV/m)
30 MHz to 2 GHz except for	120 kHz	500 µV/m (54 dBµV/m)
156 MHz to 165 MHz	9 kHz	16 µV/m (24 dBµV/m) quasi peak or 32 µV /m (30 dBµV/m) peak

4.2.1.3 Conformance

Conformance tests as defined in clause 5.3.1 shall be carried out.

4.2.2 Operating frequency

4.2.2.1 Definition

The transmitter produces short microwave pulses, which causes a broad frequency spectrum, depending on the pulse duration and the pulse repetition frequency. The operating frequency is to be understood as the frequency of the microwave during the transmitting pulse and is represented by the spectral line of highest amplitude.

4.2.2.2 Limits

In all switchable distance ranges and pulse durations the operation frequency of the radar equipment shall have values in the range of 2 900 MHz to 3 100 MHz or 9 300 MHz to 9 500 MHz.

4.2.2.3 Conformance

Conformance tests as defined in clause 5.3.2 shall be carried out.

4.2.3 Transmitter pulse power

4.2.3.1 Definition

Transmitter pulse power P_t is to be understood as the mean value of the microwave power during the transmission pulse at the antenna side of the Rotary Joint (RJ). For the arithmetic mean value of the transmitting power, integrated over the PRT, the abbreviation P_m will be used.

4.2.3.2 Limits

The transmitter pulse power P_t shall be as specified by the manufacturer +0 dB to -3 dB.

4.2.3.3 Conformance

Conformance tests as defined in clause 5.3.3 shall be carried out.

4.2.4 Out of band emissions

4.2.4.1 Definition

ITU-R Recommendation SM.1541-1 [6] gives guidance to calculate the -40 dB bandwidth and to specify the OoB mask for primary radars in per cent of the -40 dB bandwidth (see figure 1).

The -40 dB bandwidth (B_{-40}) for primary radars will be determined with the following established formula by using the lesser of:

$$B_{-40} = \frac{K}{\sqrt{t \times t_r}} \text{ or } \frac{64}{t}$$

where the coefficient K is 6,2 for radars with output power greater than 100 kW and 7,6 for lower-power radars and radars operating in the radionavigation service in the 2 900 MHz - 3 100 MHz and 9 300 MHz-9 500 MHz band. The latter expression applies if the rise time t_r is less than about 0,0094t when K is 6,2 or about 0,014t when K is 7,6.

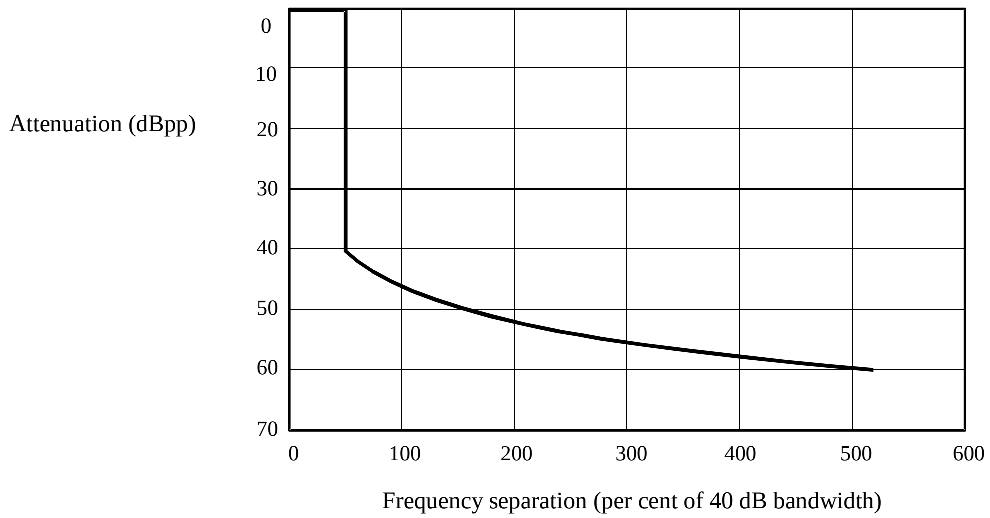

Figure 1: OoB mask for primary radards

For ideal rectangular pulses, the spectrum falls off at 20 dB per decade leading to a B_{-40} of 6,4/t and a 40 dB bandwidth ten times as large, i.e. 64/t. To discourage the use of pulses with abrupt rise and fall times, no margin is allowed. The spectra of trapezoidal pulses fall off firstly at 20 dB per decade and then ultimately at 40 dB per decade. If the radio or rise time to pulse duration exceeds 0,008 the 40 dB points will fall on the 40 dB per decade slope, in which case the bandwidth B_{-40} would be:

$$B_{-40} = \frac{5{,}7}{\sqrt{t \times t_r}}$$

e.g. a radar with a fixed 10 ns rise time would result in bandwidth values as shown in table 2.

Table 2: -40 dB bandwidth of a primary radar at different pulse durations (rise time = 10 ns)

Pulse duration	**- 40 dB bandwidth B_{-40}**
Short pulse (t = 50 ns)	B_{-40} = 255 MHz
Medium Pulse (t = 200 ns)	B_{-40} = 127 MHz
Long Pulse (t = 500 ns)	B_{-40} = 81 MHz

4.2.4.2 Limits

The maximum radiated out-of-band-emission power level shall not exceed the limits given in figure C.3.

4.2.4.3 Conformance

Conformance tests as defined in clause 5.3.4 shall be carried out.

4.2.5 Radiated spurious emissions

4.2.5.1 Definition

Spurious emissions as described in ITU-R Recommendation SM. 329-10 [4] are defined as the entity of all emissions in the frequency range of 70 % of the cut-off frequency of the waveguide to 26 GHz, but outside the OoB-boundaries.

They include:

- harmonic emissions (whole multiples of the operating frequency);
- parasitic emissions (independent, accidentally);

- intermodulation (between oscillator- and operation frequency or between oscillator and harmonics);
- emissions caused by frequency conversions.

4.2.5.2 Limits

All radiated spurious emission levels shall be 60 dB below the PEP level of the radiated operating frequency (see figure C.3).

4.2.5.3 Conformance

Conformance tests as defined in clause 5.3.5 shall be carried out.

5 Testing for compliance with technical requirements

5.1 Test conditions, power supply and ambient temperatures

5.1.1 Standard operating mode of the radar equipment

Unless otherwise stated the radar equipment shall be set to the standard operating mode which is understood to be as follows:

Operation state:	on (antenna turns);
Antenna height:	7 m;
RANGE:	Shortest;
TUNE setting:	optimal;
GAIN setting:	optimal;
STC setting:	zero;
FTC setting:	off;
Range rings:	visible;
VRM:	visible;
EBL:	visible;
Brilliance of all attributes:	optimal (well readable).

5.1.2 Normal test conditions

5.1.2.1 Normal temperature and humidity

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

a) temperature: +15 ºC to +35 ºC; or within the manufacturers stated operating range and stated in the report;

b) relative humidity: 20 % to 75 %.

When the relative humidity is lower than 20 %, it shall be stated in the test report.

5.1.2.2 Normal test power supply

5.1.2.2.1 AC test power supply

The test voltage for equipment to be connected to an AC supply shall be the nominal mains voltage declared by the manufacturer -10 % to +10 %. For the purpose of the present document, the nominal voltage shall be the declared voltage or any of the declared voltages for which the equipment is indicated as having been designed. The frequency of the test voltage shall be 50 Hz ±1 Hz.

5.1.2.2.2 DC test power supply

Where the equipment is designed to operate from a DC source, the normal test voltage shall be the nominal voltage as declared by the manufacturer -10 % to +20 %.

The internal impedance of the test power source shall be low enough for its effect on the test results to be negligible. For the purpose of testing the power source voltage shall be measured at the input terminals of the equipment.

During testing, the power source voltages shall be maintained within a tolerance of ±3 % relative to the voltage level at the beginning of each test.

5.1.3 Extreme test conditions

5.1.3.1 Extreme temperatures

5.1.3.1.1 Indoor unit

The temperature and humidity conditions for extreme tests shall be a combination of nominal temperature and humidity within the following ranges:

a) temperature: 0 ºC to +40 ºC;

b) relative humidity: 20 % to 75 %.

When the relative humidity is lower than 20 %, it shall be stated in the test report.

5.1.3.1.2 Outdoor unit

The temperature and humidity conditions for extreme tests shall be a combination of nominal temperature and humidity within the following ranges:

a) temperature: -20 ºC to +55 ºC;

b) relative humidity: 20 % to 93 %.

When the relative humidity is lower than 20 %, it shall be stated in the test report.

5.1.3.2 Extreme power supply voltage test conditions

Table 3: Extreme power supply voltage and frequency tolerances

Power supply	Voltage variation %	Frequency variation %
AC	±10	±5
DC	+20 -10	Not applicable

5.2 Interpretation of the measurement results

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 figures in table 2.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with TR 100 028 [8] and shall 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)).

Table 4 is based on such expansion factors.

Table 4: Absolute measurement uncertainties: maximum values

Parameter	Maximum uncertainty
RF frequency	$\pm 1 \times 10^{-7}$
RF pulse power	±1,5 dB
Radiated emission of transmitter	±6 dB

5.3 Essential radio test suites

5.3.1 Radiated emissions

On a test site selected from annex B, the EUT shall be placed on a non-conductive support with a height of 1,5 m.

When the EUT consists of more than one unit the interconnecting cables shall have the maximum length and type as indicated by the manufacturer or 20 m whichever is shorter. Available input and output ports of the ancillary equipment under test shall be connected to the maximum length of cable as indicated by the manufacturer or 20 m whichever is shorter.and terminated to simulate the impedance of the relevant ports of the radio equipment. These cables shall be bundled at the approximate centre of the cable with the bundles of 30 cm to 40 cm in length running in the horizontal plane from the port to which it is connected. If it is impractical to do so because of cable bulk or stiffness, the disposition of the excess cable shall be precisely noted in the test report.

The test antenna shall be placed at a radial distance of 3 m from the edge of the minimum dimension circle, the smallest dimension circle in the horizontal plane that encloses all elements of the indoor- and the outdoor -units, at a height of 1,5 m above the ground plane.

The test method shall be according to EN 60945 [3].

The radiated emission of the EUT shall be measured in the frequency range 150 kHz to 2 GHz.

The results obtained shall be compared to the limits in clause 4.2.1.2 in order to prove compliance with the requirement.

5.3.2 Operating frequency

The antenna shall be replaced by a suitable adapter to adapt the rotary joint to a waveguide with a plane flange. This adapter shall be provided by the radar manufacturer. On that flange a high-power directional coupler will be mounted with its main port terminated by a matching high-power dummy load. The coupled port shall have an adequate attenuation within the whole frequency band 2 800 MHz to 3 200 MHz or 8 900 MHz to 9 900 MHz to protect the measurement equipment.

To measure and display the the transmitted signal a suitable spectrum analyser will be used. The spectral line of highest amplitude will be considered to be the operating frequency.

Alternatively the operating frequency can be measured as well with a direct reading frequency meter.

The results obtained shall be compared to the limits in clause 4.2.2.2 in order to prove compliance with the requirement.

5.3.3 Transmitter pulse power

The antenna shall be replaced by a suitable adapter to adapt the rotary joint to a waveguide with a plane flange. This adapter shall be provided by the radar manufacturer. On that flange a high-power directional coupler will be mounted with its main port terminated by a matching high-power dummy load. The coupled port shall have a known attenuation of about 40 dB within the whole frequency band 2 800 MHz to 3 200 MHz or 8 900 MHz to 9 900 MHz.

To determine the pulse power, the use of both, a mean power meter or a suitable pulse power meter with direct reading of the transmitter pulse power is permitted. In case of measurement with a mean power meter the transmission pulse duration tp and the pulse repetition time PRT has to be determined in a preceding step i.e. by use of a detector and an oscilloscope. Then the transmitter pulse power P_t is calculated as follows:

$$P_t = P_m \times PRT/t_p$$

The results obtained shall be compared to the limits in clause 4.2.3.2 in order to prove compliance with the requirement.

5.3.4 Out of band emissions

To perform the measurement the radar and the measuring equipment shall be installed as displayed in figure C.2. Then the radar equipment shall be set to the standard operating mode as defined in clause 5.1 and to the shortest range (shortest pulse duration).Suitable measures as described in the ITU-R Recommendation M.1177-3 [5] should be taken to ensure that interferences caused by multiple reflections do not occur.

The radiated out of band power emission will be measured in the frequency bands given in Table 5 with the antenna rotating using the direct method as recommended in the ITU-R Recommendation M.1177-3 [5].

The results obtained shall be compared to the limits in clause 4.2.4.2 in order to prove compliance with the requirement.

Table 5: Out of band emissions measurement bands

Operating frequency	Lower measurement band	Upper measurement band
9,3 GHz to 9,5 GHz	8,0 GHz to 9,3 GHz	9,5 GHz to 10,8 GHz
2,9 GHz to 3,1 GHz	2,7 GHz to 2,9 GHz	3,1 GHz to 3,3 Ghz

5.3.5 Radiated spurious emissions

To perform the measurement the radar and the measuring equipment shall be installed as displayed in figure C.2. Then the radar equipment shall be set to the standard operating mode as defined in clause 5.1.

Because of possible not reproducible effects of the interrelation between the transceiver output and the antenna the direct method as recommended in the ITU-R Recommendation M.1177 -3 [5] shall be used.

Suitable measures as described in the ITU-R Recommendation M.1177-3 [5] should be taken to ensure that interferences caused by multiple reflections do not occur.

The radiated spurious power emission will be measured in several overlapping freququency sweep steps in the frequency bands given in Table 6 from 4,5 GHz to 8,0 GHz and from 10,8 GHz to 26 GHz with the antenna rotating.

If required to reach a dynamic amplitude measuring range of 70 dB minimum a Low Noise Amplifier (LNA), and to prevent the influence of the main carrier a notch filter for the operating frequency should be used.

The results obtained shall be compared to the limits in clause 4.2.5.2 in order to prove compliance with the requirement.

Table 6: Spurious emissions measurement bands

Operating frequency	Lower measurement band	Upper measurement band
9,3 GHz to 9,5 GHz	4,5 GHz to 8,0 GHz	10,8 GHz to 26 GHz
2,9 GHz to 3,1 GHz	2,0 GHz to 2,7 GHz	3,3 GHz to 26 Ghz

5.4 Other test specifications

There are no tests under this clause.

Annex A (normative): HS Requirements and conformance Test specifications Table (HS-RTT)

The HS Requirements and conformance Test specifications Table (HS-RTT) in table A.1 serves a number of purposes, as follows:

- it provides a statement of all the essential requirements in words and by cross reference to (a) specific clause(s) in the present document or to (a) specific clause(s) in a specific referenced document;
- it provides a statement of all the test procedures corresponding to those essential requirements by cross reference to (a) specific clause(s) in the present document or to (a) specific clause(s) in (a) specific referenced document(s);
- it qualifies each requirement to be either:
  - Unconditional: meaning that the requirement applies in all circumstances; or
  - Conditional: meaning that the requirement is dependant on the manufacturer having chosen to support optional functionality defined within the schedule.
- in the case of Conditional requirements, it associates the requirement with the particular optional service or functionality;
- it qualifies each test procedure to be either:
  - Essential: meaning that it is included with the Essential Radio Test Suite and therefore the requirement shall be demonstrated to be met in accordance with the referenced procedures;
  - Other: meaning that the test procedure is illustrative but other means of demonstrating compliance with the requirement are permitted.

Table A.1: HS Requirements and conformance Test specifications Table (HS-RTT)

Harmonized Standard EN 302 248 The following essential requirements and test specifications are relevant to the presumption of conformity under Article 3.2 of the R&TTE Directive						
Technical Requirement			**Requirement Conditionality**		**Test Specification**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**	**E/O**	**Reference: Clause No**
1	Radiated emissions	4.2.1	U		E	5.3.1
2	Operating frequency	4.2.2	U		E	5.3.2
3	Transmitter pulse power	4.2.3	U		E	5.3.3
4	Out of band emissions	4.2.4	U		E	5.3.4
5	Radiated spurious emissions	4.2.5	U		E	5.3.5

Key to columns:

Essential Requirement:

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

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 to be *unconditionally* applicable (U) or is *conditional* upon the manufacturers claimed functionality of the equipment (C).

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

Test Specification:

E/O Indicates whether the test specification forms part of the Essential Radio Test Suite (E) or whether it is one of the Other Test Suite (O).

NOTE: All tests whether "E" or "O" are relevant to the requirements. Rows designated "E" collectively make up the Essential Radio Test Suite; those designated "O" make up the Other Test Suite; for those designated "X" there is no test specified corresponding to the requirement. The completion of all tests classified "E" as specified with satisfactory outcomes is a necessary condition for a presumption of conformity. Compliance with requirements associated with tests classified "O" or "X" is a necessary condition for presumption of conformity, although conformance with the requirement may be claimed by an equivalent test or by manufacturer's assertion supported by appropriate entries in the technical construction file.

Clause Number Identification of clause(s) defining the test specification in the present document unless another document is referenced explicitly. Where no test is specified (that is, where the previous field is "X") this field remains blank.

Annex B (normative): Radiated measurement

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

This normative 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 TR 102 273 relevant parts 2, 3 and 4.

NOTE: To ensure reproducibility and traceability of radiated measurements only these test sites should be used in test measurements.

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.

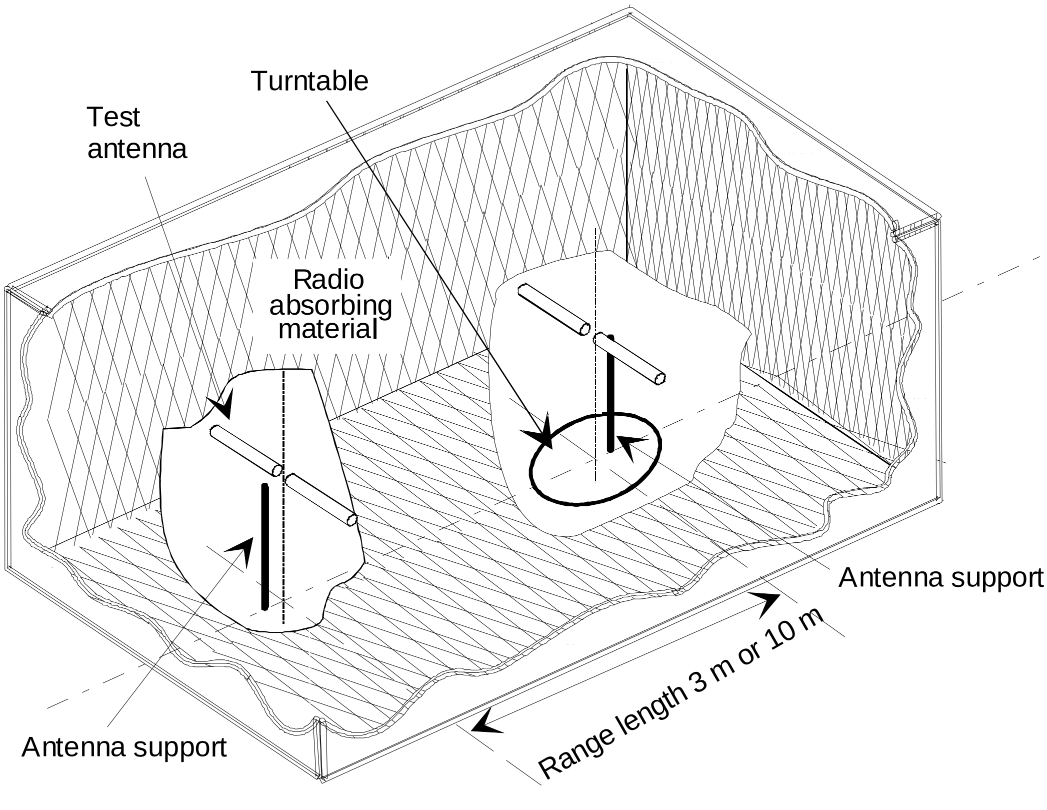

Figure B.1: A typical anechoic chamber

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 a suitable height (e.g. 1 m) above the ground plane. 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.2.5). 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 ground plane

An anechoic chamber with a 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 ground plane is shown in figure B.2.

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

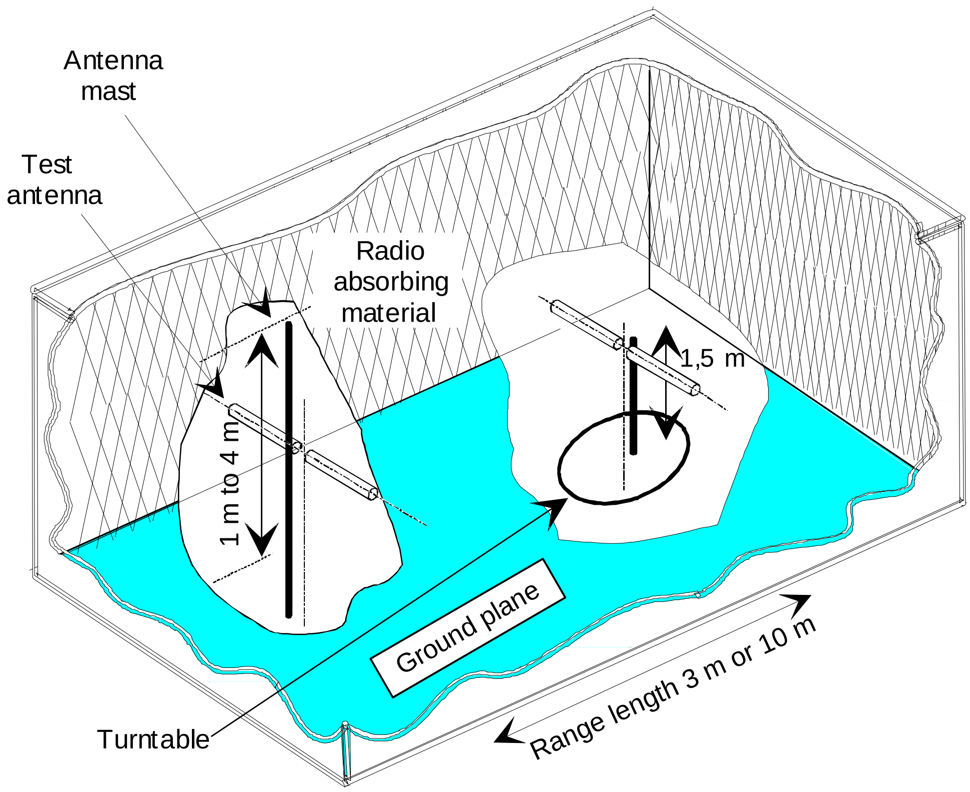

Figure B.2: A typical anechoic chamber with a ground plane

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 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 specified height, usually 1,5 m. above the ground plane. 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.2.5). The distance used in actual measurements shall be recorded with the test results.

Emission testing involves firstly "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 OATS

An OATS 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.

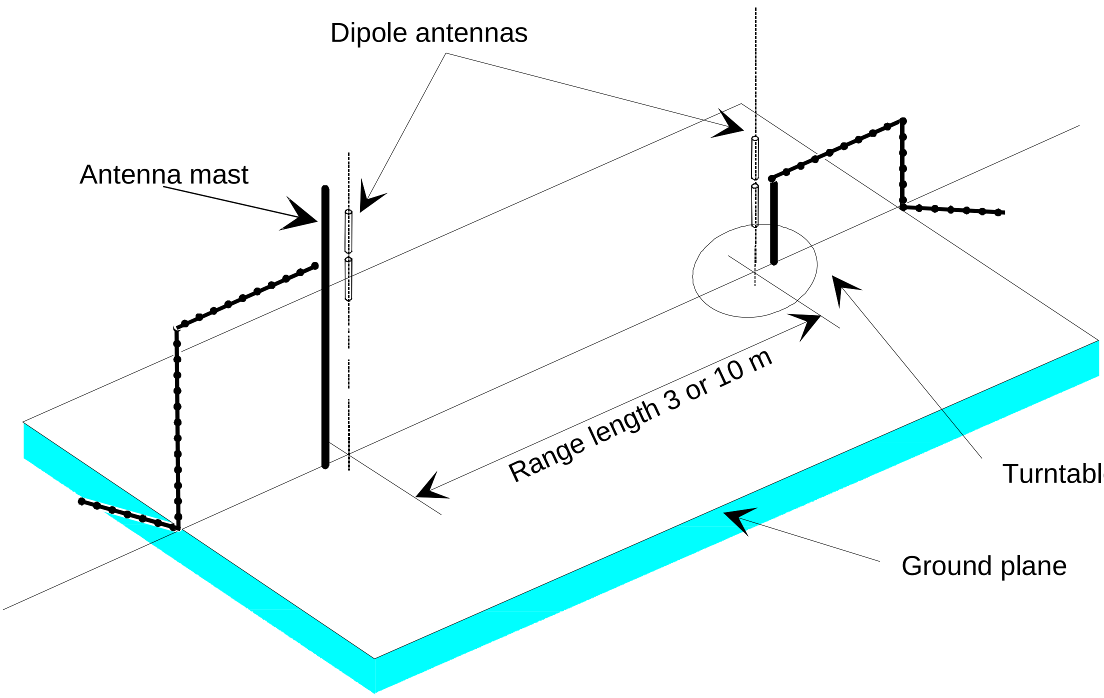

Figure B.3: A typical OATS

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 is presented in figure B.4.

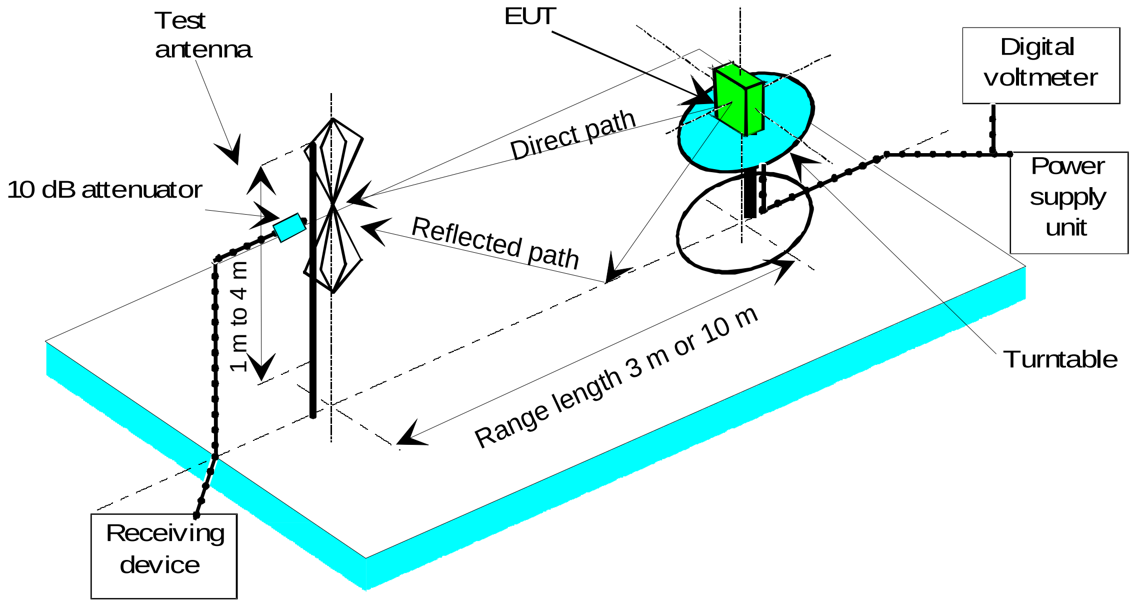

Figure B.4: Measuring arrangement on ground plane test site (OATS set-up for spurious emission testing)

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 channel 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 OATS), 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 band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [7]) 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 periodics 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 channel 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 [7]). 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 (as specified in the test method) of the EUT it has replaced.

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 [7]. 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.

B.2 Guidance on the use of radiation test sites

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

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 this annex (i.e. anechoic chamber, anechoic chamber with a ground plane and OATS) are given in TR 102 273 parts 2, 3 and 4, 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, CSP, 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 m on, 4 m 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, balsawood, 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 (as appropriate) 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).

Details shall be included in the test report.

B.2.4 Volume control setting for analogue speech tests

Unless otherwise stated, in all receiver measurements for analogue speech the receiver volume control where possible, should be adjusted to give at least 50 % of the rated audio output power. In the case of stepped volume controls, to volume control should be set to the first step that provides an output power of at least 50 % of the rated audio output power. This control should not be readjusted between normal and extreme test conditions in tests.

B.2.5 Range length

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:

$$\frac{2(d_1+d_2)^2}{\lambda}$$

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 OATS**, 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.2.6 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 (as appropriate) 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 OATS**) which incorporate a cable drum with the antenna mast, the 2 m requirement may be impossible to comply with.

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 along with the distribution of the error e.g.:

- cable loss: ±0,5 dB with a rectangular distribution;
- measuring receiver: 1,0 dB (standard deviation) signal level accuracy with a Gaussian error distribution.

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

Annex C (normative): Transmission power and unwanted emissions of radar systems; measuring methods

C.1 Indirect connection via the rotating joint

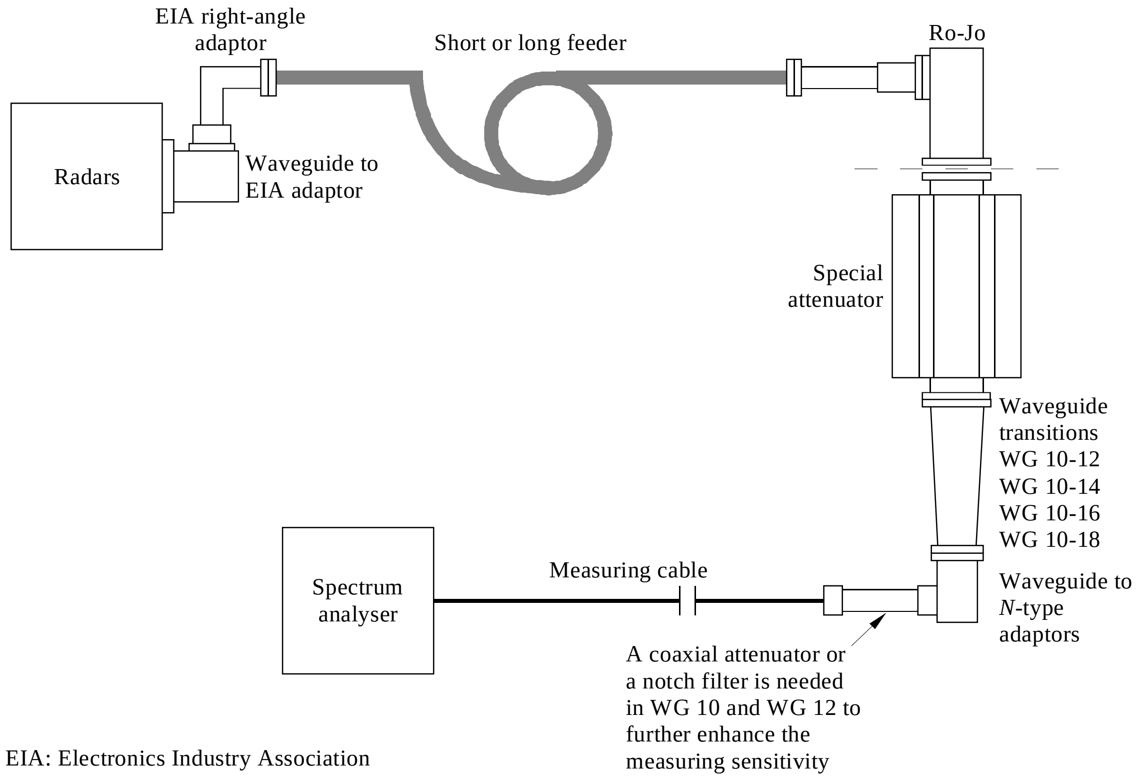

Figure C.1: Measurement at the Ro-Jo port

C.2 Maximum permitted out of band emissions power levels

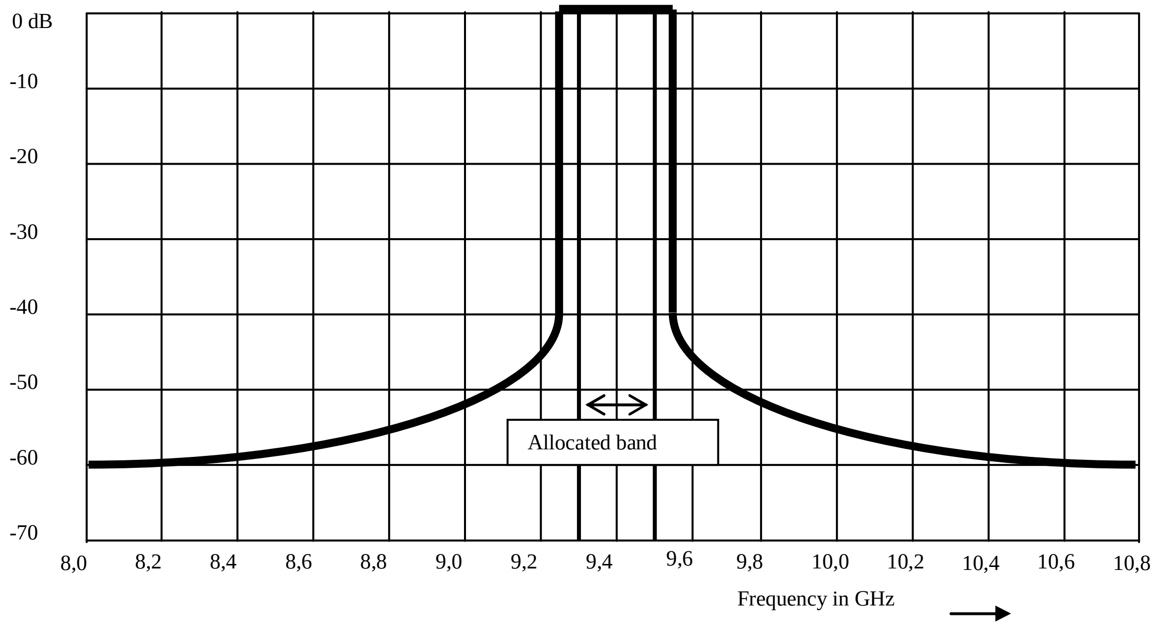

Figure C.2: Maximum permitted out-of-band-emissions power level

The 0 dB level means the radiated power level at the operation frequency. All power levels shall be determined by the same method and the same measuring parameters.

C.3 Maximum permitted spurious emissions power levels

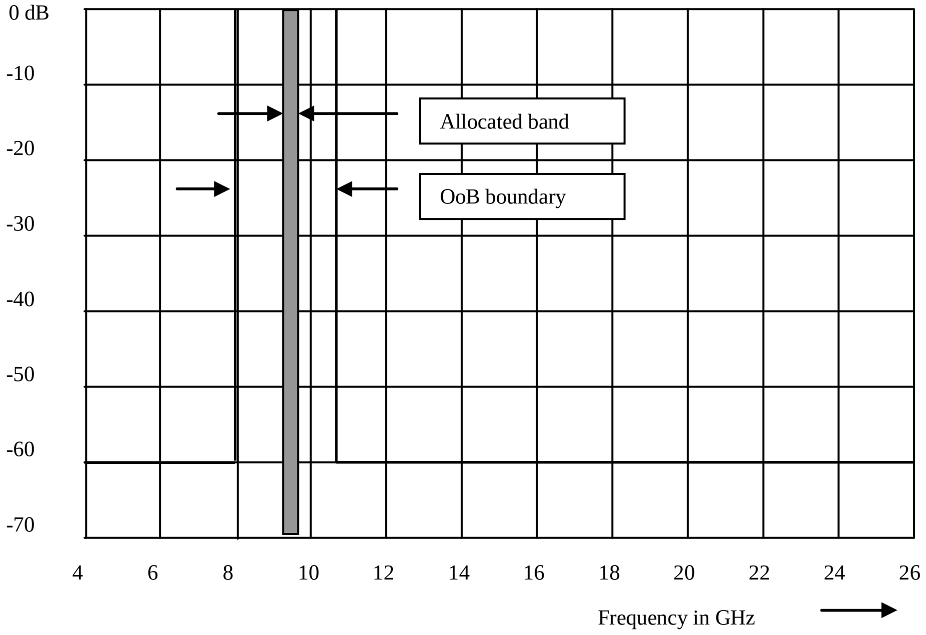

Figure C.3: Maximum permitted spurious emissions power level

The 0 dB level means the radiated power level at the operation frequency. All power levels shall be determined by the same method and the same measuring parameters.

Annex D (informative): The EN title in the official languages

Language	EN title
Bulgarian	
Czech	
Danish	
Dutch	
English	Electromagnetic compatibility and Radio spectrum Matters (ERM); Navigation radar for use on non-SOLAS vessels: Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive
Estonian	
Finnish	
French	
German	
Greek	
Hungarian	
Icelandic	
Italian	
Latvian	
Lithuanian	
Maltese	
Norwegian	
Polish	
Portuguese	
Romanian	
Slovak	
Slovenian	
Spanish	
Swedish	

Annex E (informative): Bibliography

ETSI TR 102 273 (2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

Directive 1999/5/EC of The European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

History

Document history			
V1.1.2	July 2007	Public Enquiry	PE 20071116: 2007-07-18 to 2007-11-16