ETSI EN 302 248 V2.1.1 (2016-11)

~~Harmonized~~HARMONISED EUROPEAN

~~Electromagnetic compatibility~~
~~and Radio spectrum Matters (ERM);~~
Navigation radar for use on non-SOLAS vessels;
~~Harmonized EN~~Harmonised Standard
covering the essential requirements
of article 3.2 of the ~~R&TTE~~ Directive 2014/53/EU

Reference

REN/ERM-TG26-144

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Contents

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Foreword

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

The present document has been ~~produced by ETSI in response to mandate M/284 issued from the European Commission~~prepared under ~~Directive 98/34/EC~~the Commission's standardisation request C(2015) 5376 final [i.5~~i.2~~5~~] as amended by Directive 98/48/EC [~~] 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~~i.81~~].

~~The title and reference to~~Once the present document ~~are intended to be included in the publication~~is cited in the Official Journal of the European Union ~~of titles and references of Harmonized Standard~~ under ~~the Directive 1999/5/EC [i.1].~~

~~See article 5.~~that Directive, compliance with the normative clauses of the present document given in table A.1 ~~of Directive 1999/5/EC [i.1] for information on~~ confers, within the limits of the scope of the present document, a presumption of conformity ~~and Harmonized Standards or parts thereof~~with the ~~references of which have been published in the Official Journal of the European Union.~~

~~The~~corresponding essential requirements ~~relevant to~~of that Directive~~ 1999/5/EC [i.1] are summarized in annex A~~, and associated EFTA regulations.

National transposition dates	
Date of adoption of this EN:	31 October 2016
Date of latest announcement of this EN (doa):	31 January 2017
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 July 2017
Date of withdrawal of any conflicting National Standard (dow):	31 July 2018

~~Introduction~~

~~The present document is part of a set of standards developed by ETSI and is designed to fit in a modular structure to cover all radio and telecommunications terminal equipment within the scope of the R&TTE Directive [i.1]. The modular structure is shown in EG 201 399 [i.7].~~

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 applies to non-SOLAS radar equipment.

The applicable frequencies of operation of this type of radio equipment are given in ~~table 1.~~table 1~~table 1~~. These frequencies are allocated to the radio navigation service, as defined in article 5 of the ITU Radio Regulations [~~i.6~~i.2~~i.2~~].

Table ~~1: Radionavigation~~1: Radio navigation service frequencies

	~~Radionavigation~~Radio navigation service frequencies
Transmit	2 900 MHz to 3 100 MHz
Receive	2 900 MHz to 3 100 MHz
Transmit	9 300 MHz to 9 500 MHz
Receive	9 300 MHz to 9 500 MHz

The present document ~~is intended~~contains requirements to ~~cover the provisions of Directive 1999/5/EC [i.1] (R&TTE Directive), article 3.2, which states~~demonstrate that ~~"...~~radio equipment ~~*shall be so constructed that it*~~both effectively uses ~~*the*~~ and supports the efficient use of radio spectrum ~~*allocated to terrestrial/space radio communications and orbital resources so as*~~in order 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~~of Directive 2014/53/EU [~~i.1~~i.1~~i.1~~] may apply to equipment within the scope of the present document.

~~NOTE: A list of such ENs is included on the web site http://www.newapproach.org.~~

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 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.

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

[1] ~~CENELEC EN 60945 (Edition 4 - 2002) +~~ IEC 62388:2013/COR1:2014: "Corrigendum 1 ~~(2010): "~~- Maritime navigation and radiocommunication equipment and systems - ~~General~~Shipborne radar - Performance requirements~~ - Methods~~, methods of testing and required test results".

[2] Recommendation ITU-R M.1177-4 (2011): "Techniques for measurement of unwanted emissions of radar systems".

[3] Recommendation ITU-R SM.1541-~~4 (2011~~6 (2015): "Unwanted emissions in the out-of-band domain".

[4] ETSI TS 103 052 (V1.1.1) (03-2011): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Radiated measurement methods and general arrangements for test sites up to 100 GHz".

[5] CISPR 16-1-1:2015: "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus".

[6] CISPR 16-1-4:2010+AMD1:2012: "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".

2.2 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 ~~1999/5/EC~~2014/53/EU of ~~The~~the European Parliament and of the Council of ~~9 March 1999~~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 ~~telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE~~repealing Directive~~).~~ 1999/5/EC.

[i.2~~] Directive 98/34/EC of the European Parliament and of the Council laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on information society services.~~

] ITU Radio Regulations (2016).

[i.3] ~~ANSI C63.5 (1988): "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electromagnetic Interference (EMI) Control".~~

~~[i.4]~~ ETSI TR 100 028-1 (V1.~~3~~4.1~~ - all parts): "ElectroMagnetic Compatibility~~): "Electromagnetic compatibility and Radio ~~Spectrum~~spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1".

[i.~~4~~5~~4~~] ~~ETSI TR 102 273 (V1.2.1 - all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".~~

~~[i.6] ITU Radio Regulations (2012).~~

~~[i.7] ETSI EG 201 399: "Electromagnetic compatibility and Radio spectrum Matters (ERM); A guide to the production of Harmonized Standards for application under the R&TTE Directive".~~

~~[i.8] Directive 98/48/EC of the European Parliament and of the Council of 20 July 1998 amending Directive 98/34/EC laying down a procedure for the provision of information in the field of technical standards and regulations.~~

[~~i.9~~] ETSI TR 100 028-2 (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".

[i.5] 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.6] Directive 2014/90/EU of the European Parliament and of the Council of 23 July 2014 on marine equipment and repealing Council Directive 96/98/EC.

3 ~~Symbols~~Definitions, symbols and abbreviations

3.1 Definitions

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

non SOLAS: equipment not proscribed under the SOLAS Convention and not subject to the Marine Equipment Directive 2014/90/EU [i.6~~i.6~~]

radar cross-section: cross-section determining the power density returned to the radar for a particular power density incident on a target

radar echo: signal reflected by a target to a radar antenna that appears in the radar video signal and radar image

3.2 Symbols

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

B_{-40}	-40 dB bandwidth
P_m	Transmission mean power
P_t	Transmission pulse power
t	Time
t_p	Transmission pulse duration
t_r	Pulse rise time

3.~~2~~3 Abbreviations

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

AC	Alternating Current
~~CSP~~	~~Channel Spacing~~
CISPR	Comité International Spécial des Perturbations Radioélectriques
CW	Carrier Wave
DC	Direct Current
EBL	Electronic Bearing Line
EFTA	European Free Trade Association
EN	European Norm
EUT	Equipment Under Test
FM	Frequency Modulation
FMCW	Frequency Modulated Carrier Wave
FTC	Fast Time Constant
~~HS~~	~~Harmonized Standard~~
IEC	International Electrotechnical Committee
ITU-R	International Telecommunications Union- - Radiocommunications
LNA	Low Noise Amplifier
~~OATS~~	~~Open Area Test Site~~
NM	Nautical Mile
OOB	Out Of Band
PEP	Peak Envelope Power
PRT	Pulse Repetition Time
RCS	Radar Cross-Section
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~~Testing for compliance with technical requirements

4.1 Environmental ~~profile~~conditions for testing

~~Tests defined in~~4.1.0 General

The technical requirements of the present document ~~shall be carried out at representative points within~~ apply under the ~~boundary limits of the declared operational~~ environmental profile ~~which,~~for operation of the equipment, which shall be declared by the manufacturer, but 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~~ The equipment shall ~~be carried out under a sufficient variety of environmental conditions as specified in~~ comply with all the technical requirements of the present document ~~to give confidence of compliance for the affected technical requirements (which shall also be~~at all times when operating 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 2.~~

~~Table 2: 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 156 MHz and 165 MHz to 2 GHz~~	~~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~~

~~Recommendation ITU-R SM.1541-4 [3] 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).~~

~~4.2.4.1.1 Non-FM pulse radar~~

~~The -40 dB bandwidth (B_{-40}) for non-FM pulse radars shall 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 radio navigation service in the 2 900 MHz to 3 100 MHz and 9 300 MHz to 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.~~

~~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 3.~~

~~Table 3: Examples of -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~~

~~4.2.4.1.2 FM pulse radars~~

~~The -40 dB bandwidth (B_{-40}) for FM pulse radars shall be determined with the following formula:~~

$$\cancel{B_{-40} = 1.5 \times \left\{ B_c + \sqrt{\pi} \times \left[\ln(B_c \times \tau) \right]^{0.53} \times \left[Min(B_{rise}, B_{fall}, B_{rise+fall}) + Max(B_{rise}, B_{fall}, B_{rise+fall}) \right] \right\}}$$

~~Where:~~

$$\cancel{B_{rise} = \frac{1}{\sqrt{\tau \times t_r}}}$$

$$\cancel{B_{fall} = \frac{1}{\sqrt{\tau \times t_f}}}$$

$$\cancel{B_{rise+fall} = \frac{1}{\sqrt[3]{\tau \times t_r \times t_f}}}$$

~~B_c = bandwidth of the frequency deviation (total frequency shift during the pulse generation)~~

~~τ = pulse length including rise and fall times~~

~~And where:~~

~~t_r = pulse rise time~~

~~t_f = pulse fall time~~

~~4.2.4.1.3 Other modulation formats~~

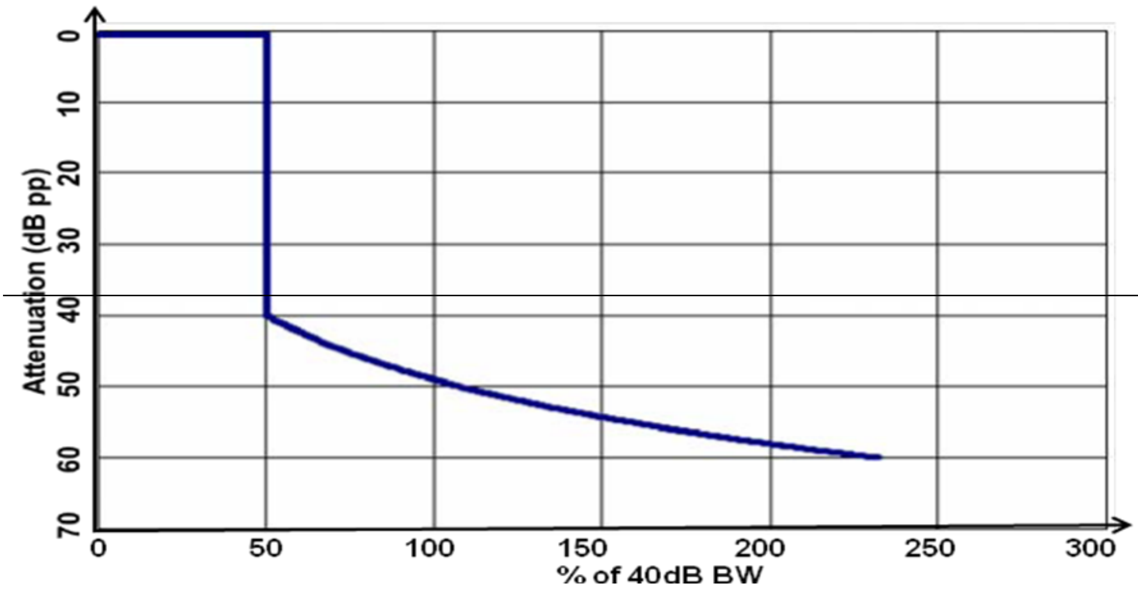
~~For all other modulation formats refer to Annex 8 of Recommendation ITU-R SM.1541-4 [3].~~

~~4.2.4.2 Limits~~

~~4.2.4.2.1 Out of band limits~~

~~For all radar types except those excluded in clause 4.2.4.2.2, the roll-off shall be 30dB/decade as shown in figure 1.~~

~~The maximum radiated Out Of Band-emission power level shall not exceed the limits given in figure 1.~~

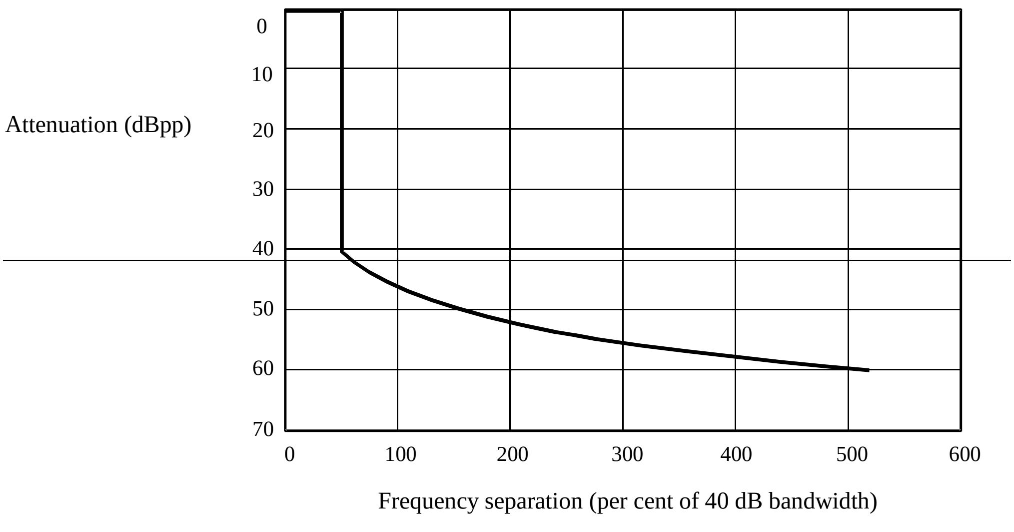


~~**Figure 1: OoB mask for all non-excluded radar waveforms in clause 4.2.4.2.2**~~

~~4.2.4.2.2 Out of band limits (excluded types)~~

~~Radars using CW, FMCW and phase coded waveforms are excluded from the requirements of clause 4.2.4.2.1 and for these radars the roll-off shall be 20 dB/decade as shown in figure 2.~~

~~The maximum radiated Out Of Band-emission power level shall not exceed the limits given in figure 2.~~



~~**Figure 2: OoB mask for radars using CW, FMCW and phase coded waveforms**~~

~~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 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 43+10 log PEP or 60 dB below the PEP level of the radiated operating frequency (see figure C.3) whichever is less stringent.~~

~~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 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~~4.1.1 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 (~~transmitting with antenna ~~turns);~~turning;
Antenna height:	~~7~~15 m;
~~RANGE~~Pulse Width:	shortest;
TUNE setting:	optimal;
GAIN setting:	optimal;
STC setting:	~~zero~~off;
FTC setting:	off;
Range rings:	visible;
VRM:	visible;
EBL:	visible;
Brilliance of all attributes:	optimal (well readable).

5~~.1.2~~ General conditions of measurement

5.1 Test conditions, power sources and ambient temperatures

5.1.1 Normal test conditions

5.1.~~2~~1.1 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~~1.2 Normal test power supply

5.1.1.2.~~2.1~~ ~~AC~~0 General

For the purpose of the present document, the test power supply shall be the primary input source that the equipment is designed for. If the equipment is designed for direct connection to DC power supplies then that shall take precedent over a combination using an AC adaptor.

5.1.1.2.1 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~~within ± 1 Hz of the manufacturers declared specification.

5.1.~~2~~1.2.2 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~~2 Extreme test conditions

5.1.~~3~~2.1 Extreme temperatures

5.1.~~3~~2.1.1 ~~Indoor~~Protected 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~~2.1.2 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~~2.2 Extreme power supply voltage test conditions

The extreme power supply test voltages applied to the equipment shall be according to ~~table 4.~~table 2~~table 2~~.

Table 4~~:~~2: 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 shall 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 4.~~

~~For the test methods, according to the present document, the measurement uncertainty figures shall be calculated 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)). Principles for the calculation of measurement uncertainty are contained in TR 100 028 [i.4], in particular in annex D of the TR 100 028-2 [i.9].~~

~~Table 5 is based on such expansion factors.~~

~~Table 5: Absolute measurement uncertainties: maximum values~~

~~Parameter~~	~~Maximum uncertainty~~
~~RF frequency~~	~~1×10^{-7}~~
~~RF pulse power~~	~~1,5 dB~~
~~Radiated emission of transmitter~~	~~6 dB~~

~~5.3 Essential radio test suites~~

~~5.3~~6 Radio tests

6.1 Radiated emissions

6.1.1 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.

6.1.2 Method of measurement

6.1.2.1 General

On a test site selected from ~~annex B,~~clause 5 of ETSI TS 103 052 [4], the EUT shall be placed on a non-conductive support with a height of 1,5 m.

The quasi-peak measuring receivers specified in CISPR 16-1-1 [5] shall be used. The receiver bandwidth in the frequency ranges 150 kHz to 30 MHz shall be 9 kHz and in the frequency ranges 30 MHz to 2 GHz shall be 120 kHz.

For frequencies from 150 kHz to 30 MHz measurements shall be made of the magnetic H field. The measuring antenna shall be an electrically screened loop antenna of dimension so that the antenna can be completely enclosed by a square having sides of 60 cm in length, or an appropriate ferrite rod as described in CISPR 16-1-4 [6]. The correction factor for the antenna shall include the factor +51,5 dB to convert the magnetic field strength to equivalent electric field strength.

For frequencies above 30 MHz measurements shall be made of the electric E field. The measuring antenna shall be a balanced dipole of resonant length, or alternate shortened dipole or higher gain antenna as described in CISPR 16-1-4 [6]. The dimension of the measuring antenna in the direction of the EUT shall not exceed 20 % of its distance from the EUT. At frequencies above 80 MHz it shall be possible to vary the height of the centre of the measuring antenna above the ground over a range of 1 m to 4 m.

The EUT shall be fully assembled, complete with its associated interconnecting cables and mounted in its normal plane of operation, where possible the antenna may be replaced by a suitable dummy load.

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~~protected- and the outdoor -units, at a height of 1,5 m above the ground plane.

The test antenna shall be placed at a distance of 3 m from the EUT. The centre of the antenna shall be at least 1,5 m above the ground plane. The E-field antenna only shall be adjusted in height and rotated to give horizontal and vertical polarization, one being parallel to the ground, in order to determine the maximum emission level. Finally the antenna shall either be moved around the EUT, again in order to determine the maximum emission level, or alternatively, the EUT may be placed on a plane orthogonal to the test antenna at its mid-point and rotated to achieve the same effect.

In the frequency band 156 MHz to 165 MHz testing shall be performed according to either clause 6.1.2.2 or 6.1.2.3.

6.1.2.2 Frequency band 156 MHz to 165 MHz method 1

In addition, for the frequency band 156 MHz to 165 MHz, the measurement shall be repeated with a receiver bandwidth of 9 kHz, all other conditions of clause 6.2.1.1 remaining unchanged.

6.1.2.3 Frequency band 156 MHz to 165 MHz method 2

Alternatively, for the frequency band 156 MHz to165 MHz, a peak receiver or a frequency analyser may be used, in accordance with the agreement between the manufacturer and the test house.

6.1.3 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 3.

Table 3: Radiated electromagnetic emission

Frequency range	Reference 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 156 MHz and 165 MHz to 2 GHz	120 kHz	500 μV/m (54 dBμV/m)

~~The test method shall be according to EN 60945 [1].~~

~~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~~156 MHz to 165 MHz	9 kHz	16 μV/m (24 dBμV/m) quasi peak or 32 μV/m (30 dBμV/m) peak

6.2 Operating frequency

6.2.1 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.

6.2.2 Method of measurement

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 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~~6.2.~~2.2~~3 in order to prove compliance with the requirement.

~~5~~6.2.3 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.

6.3 Transmitter pulse power

6.3.1 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.

6.3.2 Method of measurement

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 t_p and the pulse repetition time PRT have 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:

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

6.3.3 Limits

The ~~results obtained~~transmitter pulse power P_t shall be ~~compared~~as specified by the manufacturer +0 dB to ~~the limits in clause 4.2.3.2 in order to prove compliance with the requirement~~-3 dB.

~~5.3~~6.4 Out of band emissions

6.4.1 Definition

6.4.1.0 General

Recommendation ITU-R SM.1541-6 [3] 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).

6.4.1.1 Non-FM pulse radar

The -40 dB bandwidth (B_{-40}) for non-FM pulse radars shall 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 radio navigation service in the 2 900 MHz to 3 100 MHz and 9 300 MHz to 9 500 MHz band. The latter expression applies if the rise time t_r is less than about 0,0094*t* when *K* is 6,2 or about 0,014*t* when *K* is 7,6.

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 4.

Table 4: Examples of -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

6.4.1.2 FM pulse radars

The -40 dB bandwidth (B_{-40}) for FM pulse radars shall be determined with the following formula:

$$B_{-40} = 1.5 \times \left\{ B_c + \sqrt{\pi} \times \left[\ln(B_c \times \tau) \right]^{0.53} \times \left[Min(B_{rise}, B_{fall}, B_{rise+fall}) + Max(B_{rise}, B_{fall}, B_{rise+fall}) \right] \right\}$$

Where:

$$B_{rise} = \frac{1}{\sqrt{\tau \times t_r}}$$

$$B_{fall} = \frac{1}{\sqrt{\tau \times t_f}}$$

$$B_{rise+fall} = \frac{1}{\sqrt[3]{\tau \times t_r \times t_f}}$$

B_c = bandwidth of the frequency deviation (total frequency shift during the pulse generation)

τ = pulse length including rise and fall times

And where:

t_r = pulse rise time

t_f = pulse fall time

6.4.1.3 Other modulation formats

For all other modulation formats the -40 dB bandwidth shall be calculated according to annex 8 of Recommendation ITU-R SM.1541-6 [3].

6.4.2 Method of measurement

To perform the measurement, the radar and the measuring equipment shall be installed as described in the Recommendation ITU-R M.1177-4 [2]. Then the radar equipment shall be set to the shortest range (shortest pulse duration).

Measures described in the Recommendation ITU-R M.1177-4 [2] shall be taken to ensure that interferences caused by multiple reflections do not occur.

The radiated out of band power emission shall be measured in the frequency bands given in ~~table 6~~table 5 with the antenna rotating using the selected method from those described in the Recommendation ITU-R M.1177-4 [~~2~~2].

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

Table ~~6~~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~~6.4.3 Limits

6.4.3.1 Out of band limits

For all radar types except those excluded in clause 6.4.3.2, the roll-off shall be 30 dB/decade as shown in figure 1~~figure 1~~.

The maximum radiated Out Of Band-emission power level shall not exceed the limits given in figure 1~~figure 1~~.

NOTE: See also figure B.2.

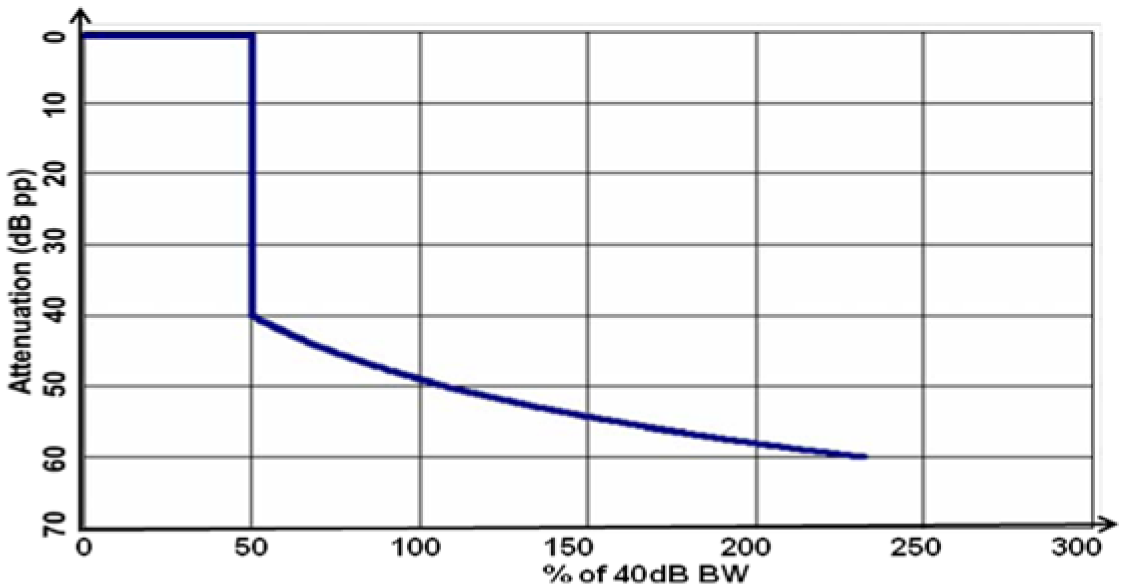


Figure 1: OoB mask for all non-excluded radar waveforms in clause 6.4.3.2

6.4.3.2 Out of band limits (excluded types)

Radars using CW, FMCW and phase coded waveforms are excluded from the requirements of clause 6.4.3.1 and for these radars the roll-off shall be 20 dB/decade as shown in figure 2.

The maximum radiated Out Of Band-emission power level shall not exceed the limits given in figure 2.

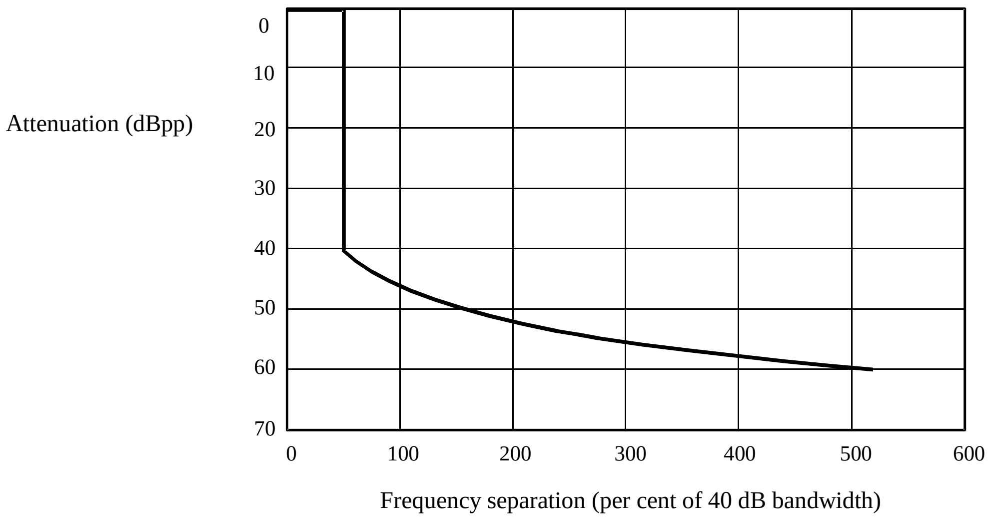


Figure 2: OoB mask for radars using CW, FMCW and phase coded waveforms

6.5 Radiated spurious emissions

6.5.1 Definition

Spurious emissions are defined as the entity of all emissions in the frequency range of 30 MHz to 26 GHz, but outside the OOB-boundaries. In the case where waveguide is used, the lower frequency limit may be set at 70 % of the cut-off frequency of the waveguide.

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.

6.5.2 Method of measurement

To perform the measurement, the radar and the measuring equipment shall be installed as described in the Recommendation ITU-R M.1177-4 [2]. Then the radar equipment shall be set to the shortest range (shortest pulse duration).

Measures described in the Recommendation ITU-R M.1177-4 [2] shall be taken to ensure that interferences caused by multiple reflections do not occur.

The radiated spurious power emission shall be measured in several overlapping frequency sweep steps in the frequency bands given in ~~table 7.~~table 6.

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

The results obtained shall be compared to the limits in clause ~~4.2~~6.5.~~2~~3 in order to prove compliance with the requirement.

Table ~~7~~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

6.5.3 Limits

All radiated spurious emission levels shall be 43 + 10 log PEP or 60 dB below the PEP level of the radiated operating frequency (see figure B.3 in annex B) whichever is less stringent.

6.6 Minimum range

6.6.1 Definition

The minimum range is the shortest distance at which a stationary target is presented separately from the position and image representing the antenna position.

6.6.2 Method of measurement

Before measurements are made the range index compensation shall be set correctly as described in clause 6.7.2 of IEC 62388 [1].

For this measurement, a test target (equivalent to the navigational buoy with corner reflector) having a known RCS of 10 m^2 at X-band (having a known RCS of 1 m^2 at S-band) and mounted at a height of 3,5 m shall be used.

For this measurement, only the range scale selector may be changed. The sea and gain controls may be adjusted before commencing this test. After adjustment, the test target shall be visible at the minimum range and at 1 NM with the same setting of the sea and gain control. An off-centred presentation is permitted for this measurement. The methods of test and the required results are as follows:

a) confirm by observation and document inspection that if a down-mast transceiver is an option for the radar under test, the test is conducted using a down-mast transceiver, or otherwise the test shall be conducted with an up-mast unit. If the implementation of up-mast and down-mast systems is different, both types of systems shall be tested;

b) confirm by observation that a reference test target is available having the same properties as the mobile test target. The reference test target shall be stationary and positioned at 1 NM range. Adjust the radar system so that the reference test target at approximately 1 NM is clearly visible;

c) confirm by measurement that with the radar antenna mounted at the specified height, the separation of a mobile test target (representative of a navigational buoy) and the antenna position can be decreased to the closest point at which the target can be identified within 75 m of the antenna position. Record the result. After adjustment, the mobile test target at the minimum range and the reference target at 1 NM shall be visible with the same setting of the gain and clutter controls;

d) alternatively a mobile target with an RCS of 10 m^2 at X-band may be used and moved from the closest point at which the target is visible up to 1 NM with the same settings of the gain and clutter controls.

6.6.3 Limits

The distance of the test target from the radar under test shall be not greater than 75 m.

6.7 Range discrimination

6.7.1 Definition

The ability of a radar to display two point targets on the same bearing, separated by a short distance in range.

6.7.2 Method of measurement

The radar shall be set to a range scale of 0,75 NM. Two test targets having a known RCS of 10 m^2 at X-band (having a known RCS of 1 m^2 at S-band) shall be placed on the same bearing with respect to the radar antenna, at a distance of between 0,375 NM and 0,75 NM, and separated from each other by a distance of not more than 75 m. The rain control and the effective pulse length of the radar shall be set to their minimum values. The sea and gain controls shall be adjusted to show separation of the two targets on the display.

6.7.3 Limits

When the two targets are visibly separated for at least 8 scans out of 10, the linear distance between the two targets shall not be greater than 75 m.

6.8 Bearing discrimination

6.8.1 Definition

The ability of a radar to display two point targets at the same range, separated by a narrow angle.

6.8.2 Method of measurement

The radar shall be set to the range scale of 1,5 NM or less and the test targets positioned at between 60 % and 100 % of the range scale selected. Two test targets of equal radar cross-section having a known RCS of 10 m^2 at X-band (having a known RCS of 1 m^2 at S-band) shall be placed at the same distance and shall be separated in bearing with respect to the radar antenna. The measurement may be made at any convenient bearing from the antenna location. The angular separation between the two targets shall be decreased until they cease to be displayed separately.

6.8.3 Limits

When the two targets are visibly separated for at least 8 scans out of 10 the linear distance between the two targets shall be not be greater than 8,0 degrees.

6.9 Range of first detection in minimal clutter

6.9.1 Definition

Range at which the radar system will detect a range of different targets at various distances and in the absence of significant sea clutter, precipitation and evaporation duct, and with an antenna height of 15 m.

6.9.2 Method of measurement

If the radar is capable of being supplied with a range of antennas, the lowest gain antenna shall be used for this test.

Adjust the system for best target visibility with a light and even background noise speckle to provide good detection sensitivity. The sea conditions shall be calm for assessing the range of first detection (maximum sea state 1, see table 6 of IEC 62388 [1] for guidance on sea states). The test may be conducted from a land site overlooking the sea or from a stable platform at sea. All observations shall be conducted in clear conditions.

Additional information can be found in IEC 62388 [1], section 9.2.

6.9.3 Limits

Limits for range of first detection in minimal clutter are defined in table 7.

Table 7: Range of first detection in clutter-free conditions

Target description	Radar cross-section	Target feature height above sea level	Detection Range
Navigation Buoy with corner reflector	10 sq m	3,5 m	1,4 NM
Small vessel of length 10 m with no radar reflector	2,5 sq m	2,0 m	1,0 NM

7 Testing for compliance with technical requirements

7.1 Environmental conditions for testing

These shall be as described in clause 5.

7.2 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 8.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated 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)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028-1 [i.3~~i.3~~] and ETSI TR 100 028-2 [i.4~~i.4~~], in particular in annex D of the ETSI TR 100 028-2 [i.4~~i.4~~].

Table 8 is based on such expansion factors.

Table 8: Maximum measurement uncertainty

Parameter	Uncertainty
RF frequency	1 x 10^{-7}
RF pulse power	1,5 dB
Radiated emission of transmitter	6 dB
Angular measurement	0,5°
Linear distance	1 %

~~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 technical 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(s);~~
- ~~it provides a statement of all the test procedures corresponding to those technical 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 technical requirement to be either:~~
  - ~~Unconditional: meaning that technical the requirement applies in all circumstances; or~~
  - ~~Conditional: meaning that the technical requirement is dependent on the manufacturer having chosen to support optional functionality defined within the schedule.~~
- ~~in the case of Conditional technical requirements, it associates the technical 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 technical 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 technical requirement are permitted.~~

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

~~**Harmonized Standard EN 302 248**~~ ~~The following technical requirements and test specifications are relevant to the presumption of conformity under the article 3.2 of the R&TTE Directive [i.1]~~						
~~Technical Requirement Reference~~			**~~Technical 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~~

Annex A (normative): 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.5~~i.5~~] 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~~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 302 248 The following requirements are relevant to the presumption of conformity under the article 3.2 of Directive 2014/53/EU [i.1~~i.1~~]				
Requirement			**Requirement Conditionality**	
No	**Description**	**Reference: Clause No**	**U/C**	**Condition**
1	Radiated emissions	6.1	U	
2	Operating frequency	6.2	U	
3	Transmitter pulse power	6.3	U	
4	Out of band emissions	6.4	U	
5	Radiated spurious emissions	6.5	U	
6	Minimum range	6.6	U	
7	Range discrimination	6.7	U	
8	Bearing discrimination	6.8	U	
9	Range of first detection in minimal clutter	6.9	U	

Key to columns:

~~Technical~~ Requirement:

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

Description A textual reference to the ~~technical~~ requirement.

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

~~Technical~~ Requirement Conditionality:

U/C Indicates whether the ~~technical~~ requirement ~~is to~~shall be unconditionally applicable (U) or is conditional upon the ~~manufacturers~~ manufacturer's claimed functionality of the equipment (C).

Condition Explains the conditions when the ~~technical~~ 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 technical 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 technical requirement. The completion of all tests classified "E" as specified with satisfactory outcomes is a necessary condition for a presumption of conformity. Compliance with technical requirements associated with tests classified "O" or "X" is a necessary condition for presumption of conformity, although conformance with the technical 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.~~

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~~

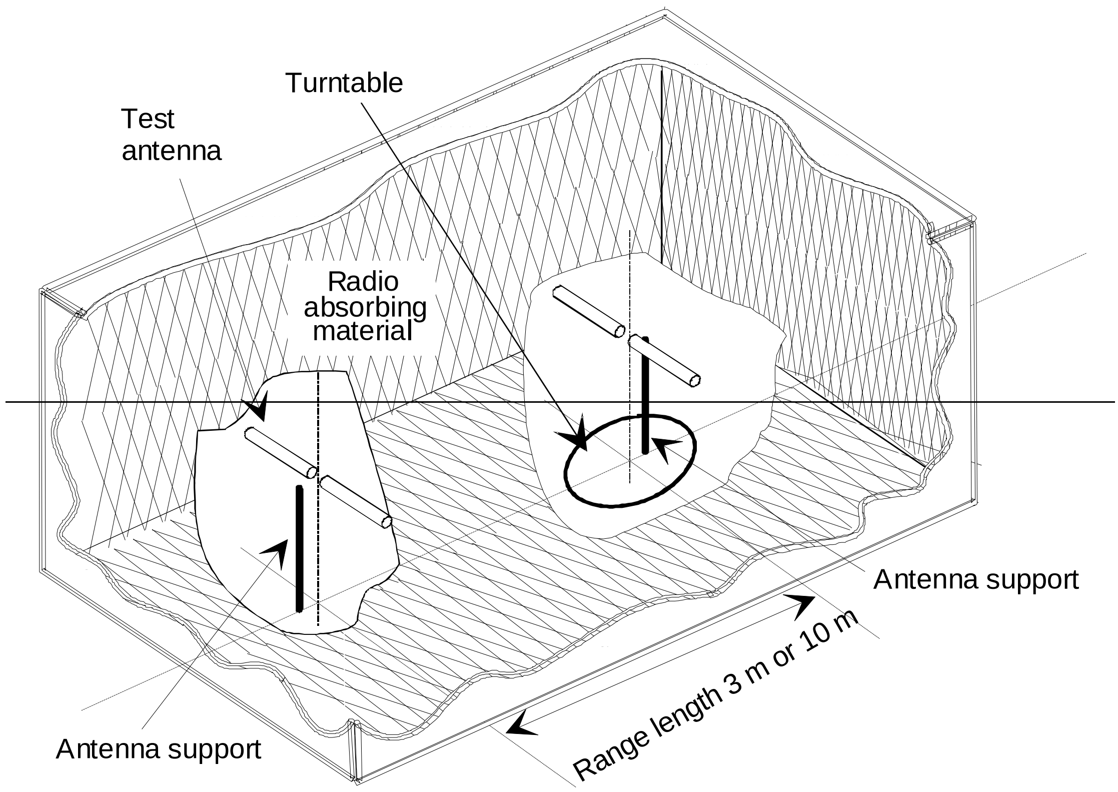
~~B.1 Test sites and general arrangements for measurements involving the use of radiated fields~~

~~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 [i.5] 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.~~

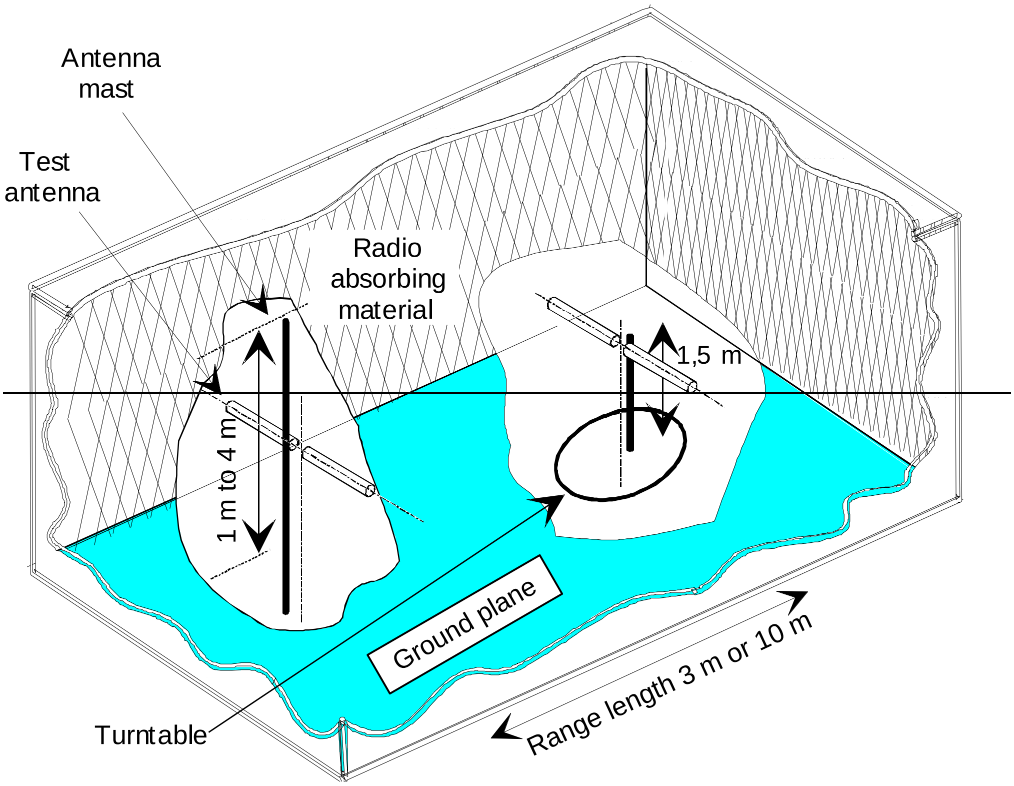
~~The anechoic chamber generally has several advantages over other test facilities. There is minimal ambient interference, minimal floor, ceiling and wall reflections and it is independent of the weather. It does however have some disadvantages which include limited measuring distance and limited lower 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 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.~~

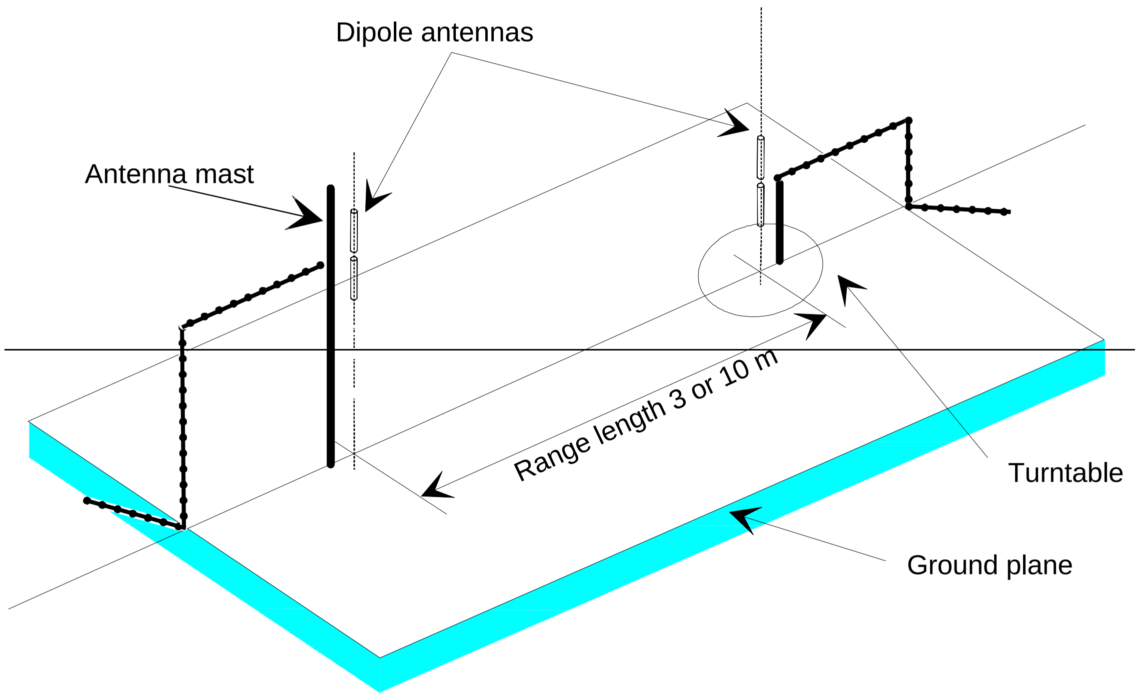
~~A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2/\lambda$ (m), whichever 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.~~

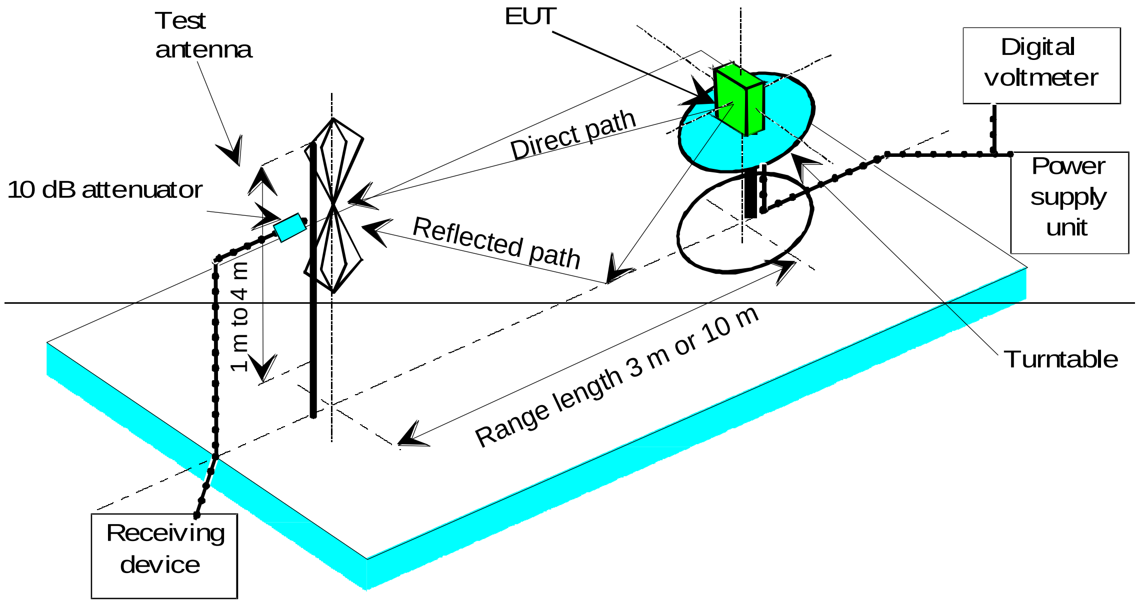


~~Figure B.3: A typical OATS~~

~~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 [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 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 [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 (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 [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.~~

~~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. Examples of 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 [i.5] 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.~~

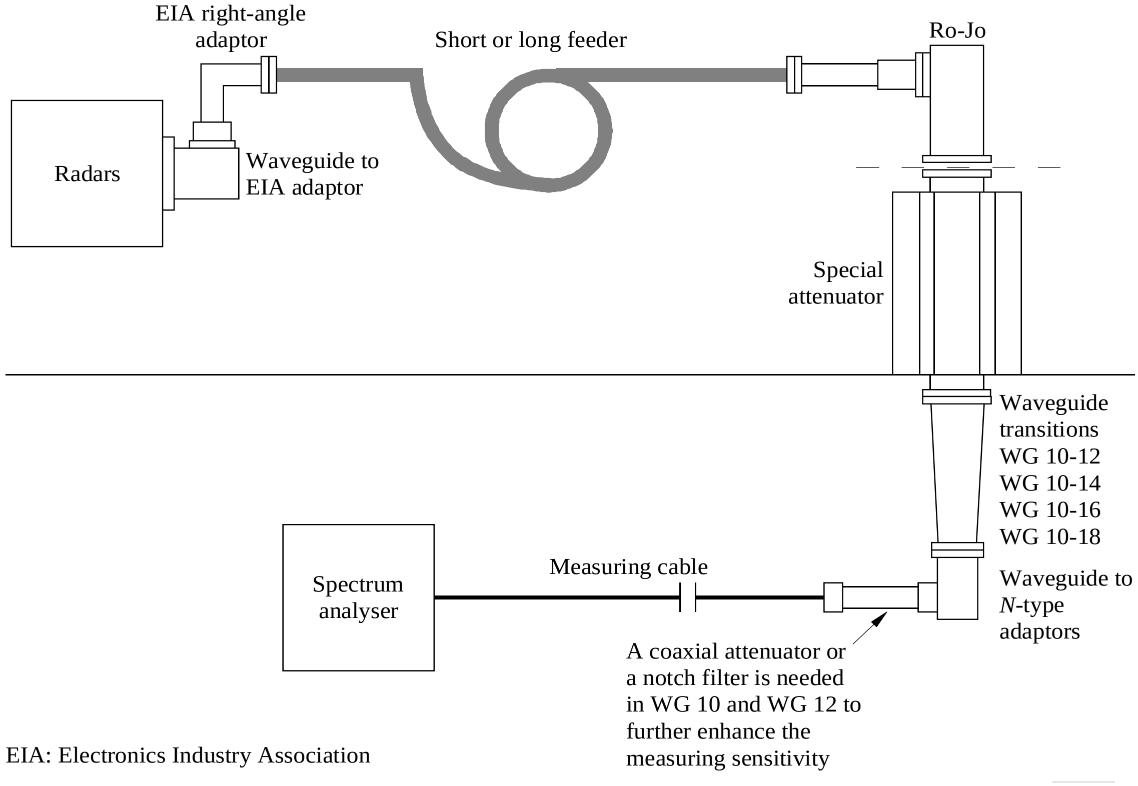
~~For all items of test equipment, the maximum errors they exhibit should be known along with the distribution of the error e.g.:~~

- ~~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~~B.1 Indirect connection via the rotating joint



Test set up shall be as illustrated in figure B.1.

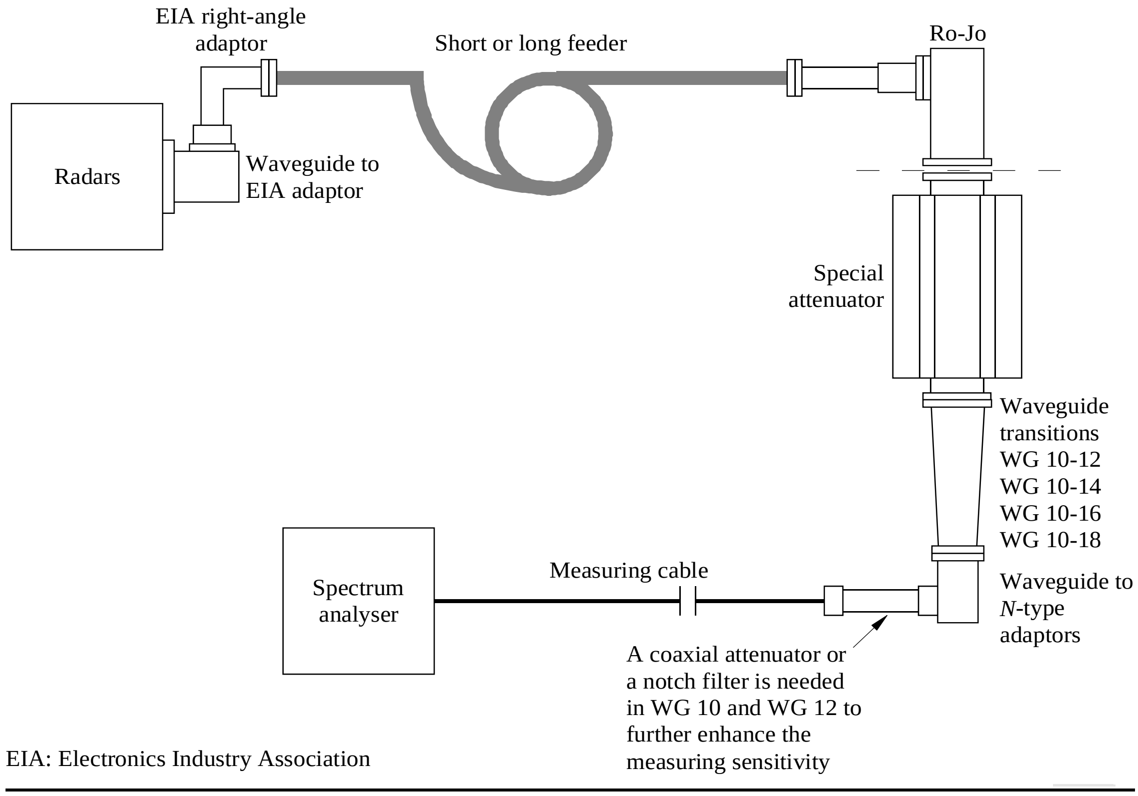
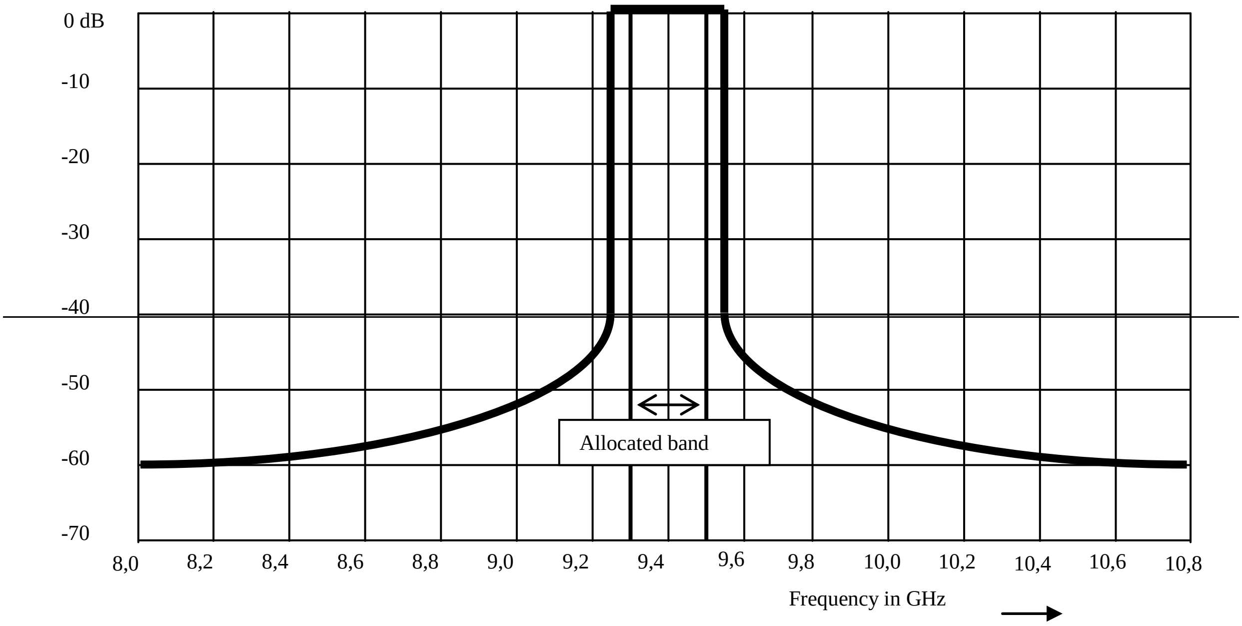


Figure ~~C~~B.1: Measurement at the Ro-Jo port

~~C~~B.2 Maximum permitted out of band emissions power levels



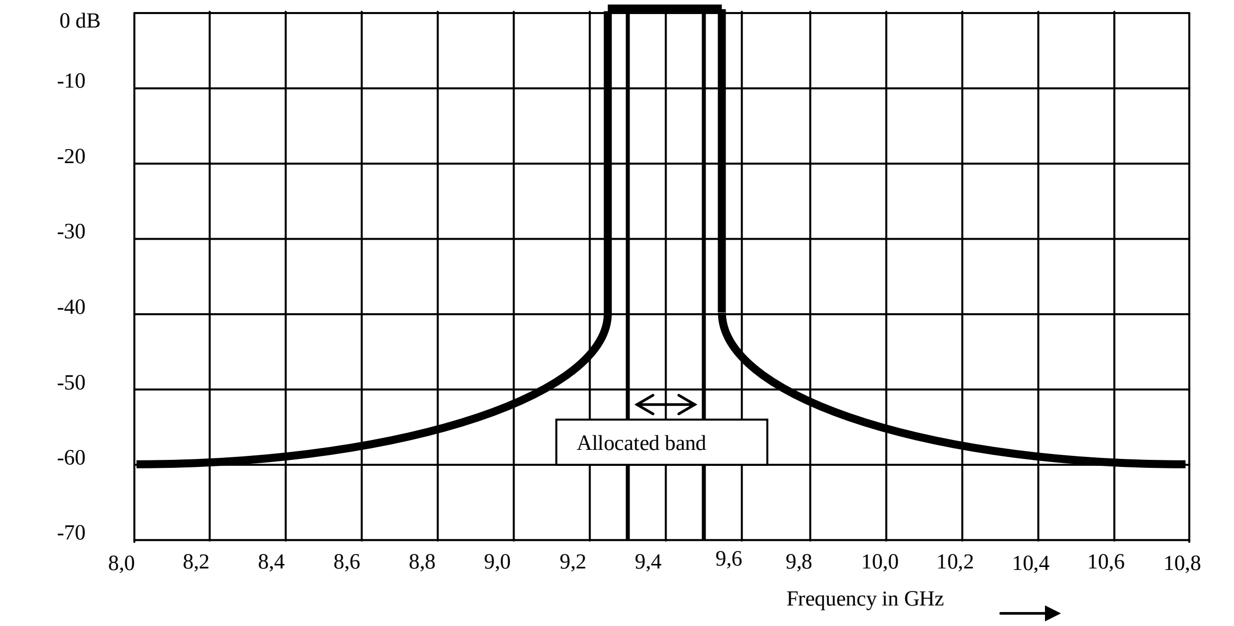
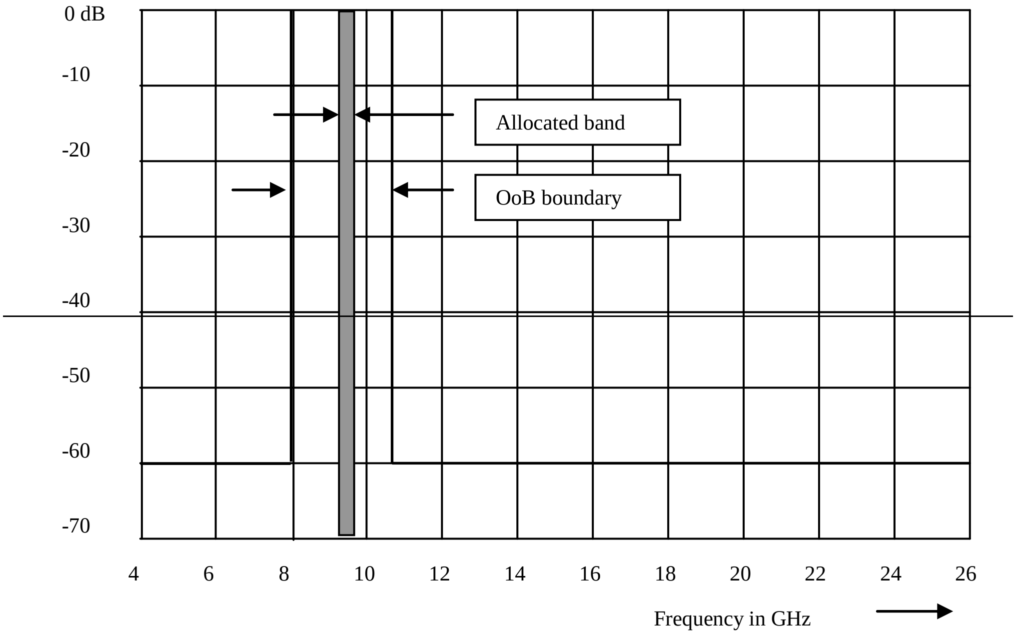


Figure ~~C~~B.2: Maximum permitted Out Of Band-emissions power level

The 0 dB level means the radiated power level at the operation frequency~~.~~ (see figure B.2). All power levels shall be determined by the same method and the same measuring parameters.

~~C~~B.3 Maximum permitted spurious emissions power levels



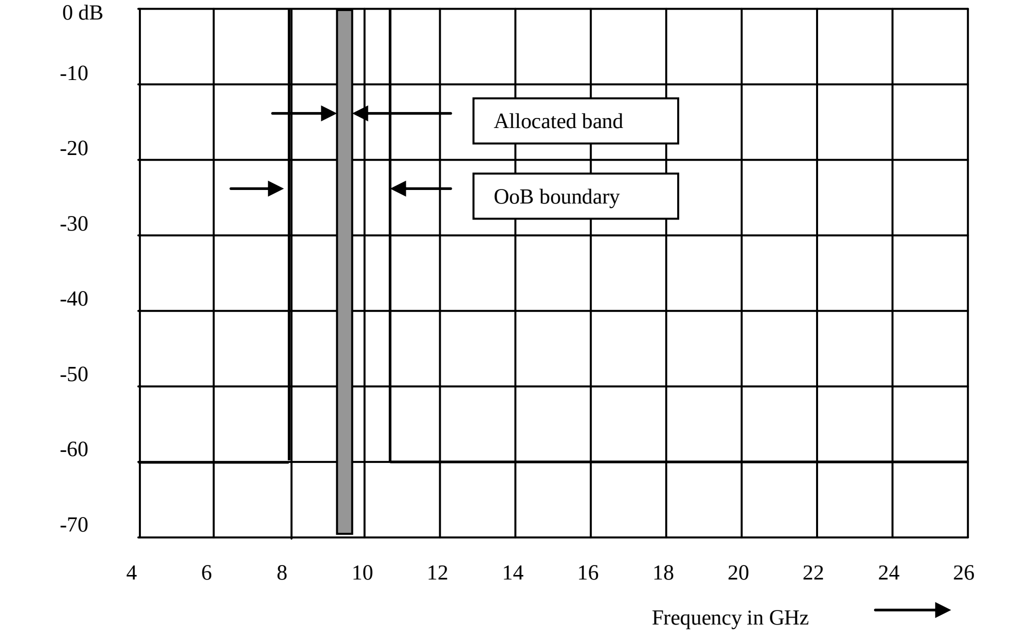


Figure ~~C~~B.3: Maximum permitted spurious emissions power level

The 0 dB level means the radiated power level at the operation frequency~~.~~ (see figure B.3). All power levels shall be determined by the same method and the same measuring parameters.

History

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V2.1.1	November 2016	Publication