



**Navigation radars used on inland waterways;
Harmonised Standard for access to radio spectrum;
Part 1: Magnetron Radars**

Reference

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Foreword

This draft Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI Standardisation Request deliverable Approval Procedure (SRdAP).

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.1] 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.2].

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

The present document is part 1 of a multi-part deliverable covering navigation radars used on inland waterways, as identified below:

Part 1: "Magnetron Radars";

Part 2: "Solid State Radars".

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

Modal verbs terminology

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

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1 Scope

The present document specifies technical characteristics and methods of measurements for magnetron-based inland waterways navigational radars having the following characteristics:

- Transmitter peak power not exceeding 10 kW.
- Operating on a pulse modulated single, non-tuneable carrier frequency in the range specified in Table 1.
- At the transmitter output, a 4 port RF-circulator or equivalent is used.
- The antenna is passive, rotating and waveguide based.
- The radar display is an integral part of the equipment.

Table 1: Radio navigation service frequencies

	Radio navigation service frequencies
Transmit	9 300 MHz to 9 500 MHz
Receive	9 300 MHz to 9 500 MHz

NOTE: The relationship between the present document and the essential requirements of article 3.2 of Directive 2014/53/EU [i.2] is given in Annex A.

2 References

2.1 Normative references

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

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The following referenced documents may be useful in implementing an ETSI deliverable or add to the reader's understanding, but are not required for conformance to the present document.

- [i.1] [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.2] [Directive 2014/53/EU](#) of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.
- [i.3] ITU Radio Regulations (2024).
- [i.4] Recommendation ITU-R M.1177-4 (04/2011): "Techniques for measurement of unwanted emissions of radar systems".
- [i.5] ETSI EG 203 336 (V1.2.1) (05-2020): "Guide for the selection of technical parameters for the production of Harmonised Standards covering article 3.1(b) and article 3.2 of Directive 2014/53/EU".
- [i.6] ETSI EN 303 676 (V1.1.1) (07-2021): "Navigation radar used on inland waterways; operational, functional and technical requirements".
- [i.7] Recommendation ITU-R SM.1541-7 (09/2024): "Unwanted emissions in the out-of-band domain".
- [i.8] ERC Recommendation 74-01 (05/2022): "Unwanted emissions in the spurious domain".
- [i.9] ECC Recommendation (02)05 (03/2012): "Unwanted emissions".
- [i.10] IEC 60945:2002/COR1:2008 including corrigendum 1 (04/2008): "Maritime navigation and radiocommunication equipment and systems - General requirements - Methods of testing and required test results".
- [i.11] IEC 60153-2: 2016: "Hollow metallic waveguides. Part 2: Relevant specifications for ordinary rectangular waveguides".
- [i.12] Recommendation ITU-R SM.332-4 (07/1978): "Selectivity of receivers".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

active state: state producing the authorized emission

idle/stand-by state: state where the transmitter is available for traffic but is not in the active state

necessary bandwidth: width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions for a given class of emission

NOTE 1: This definition is taken from ITU Radio Regulation [i.3].

NOTE 2: For the radars covered by the present document the necessary bandwidth B_N is considered to be B_{-20} (20 dB bandwidth) as defined in Recommendation ITU-R SM.1541-7 [i.7].

occupied bandwidth: width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean power of a given emission

NOTE 1: Unless otherwise specified in a Recommendation ITU-R for the appropriate class of emission, the value of $\beta/2$ should be taken as 0,5 %.

NOTE 2: This definition is taken from ITU Radio Regulations [i.3], chapter I, 1.153.

NOTE 3: For primary radars $\beta/2$ equals 0,5 %.

Peak Envelope Power (PEP): average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions

NOTE: This definition is taken from ITU Radio Regulations [i.3], chapter I, 1.157.

product configuration: hardware variant of the same typology of system under test (e.g. different power outputs, magnetrons)

pulse length: time between the 50 % amplitude (voltage) points

pulse rise time: time taken for the leading edge of the pulse to increase from 10 % to 90 % of the maximum amplitude (voltage)

radial resolution capability: shortest distance between two targets on the same bearing that can be discriminated

NOTE: This is defined in ETSI EN 303 676 [i.6], clause 5.2.2.5.

3.2 Symbols

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

B_{-20}	-20 dB bandwidth (in MHz)
B_{-40}	-40 dB bandwidth (in MHz)
B_{IF}	Intermediate frequency bandwidth
B_m	Measurement bandwidth
B_{ref}	Reference bandwidth
dB	decibel
dBm	Power ratio expressed in decibels (dB) with reference to one milli watt
$dBpp$	Power ratio expressed in decibels (dB) with reference to peak power
f_{image}	Image frequency
f_{rx}	Nominal frequency of the receiver
f_o	Operating frequency (in MHz) of the magnetron
G_s	Gain of the measurement system (dB)
k	Boltzmann's constant ($1,38 \times 10^{-23}$ J/K)
P_t	Pulse power of transmission
t	Time
t_p	Pulse length
t_r	Pulse rise time

3.3 Abbreviations

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

ANSI	American National Standardization Institute
CW	Carrier Wave
dBi	Antenna gain in deciBels relative to an isotropic antenna
DC	Direct Current
ECC	Electronic Communication Committee
EFTA	European Free Trade Association
EN	European Norm
ENR	Excessive Noise Ratio
ERC	Electronic Radiocommunication Committee
EUT	Equipment Under Test
FM	Frequency Modulation
FTC	Fast Time Constant
GHz	GigaHertz
Hz	Hertz
IEC	International Electrotechnical Committee
IMD	Intermodulation Distortion
ITU-R	International Telecommunications Union - Radiocommunications
kHz	kiloHertz
kW	kiloWatt
LO	Local Oscillator
MBR	Measurement Bandwidth Ratio
MHz	MegaHertz
NA	not applicable

OoB	Out of Band
PEP	Peak Envelope Power
RBW	Resolution BandWidth
RF	Radio Frequency
RML	Receiver Maximal input Level
RWB	Referenced Bandwidth
STC	Sensitive Time Control
SWT	SWEEP Time
VBW	Video BandWidth
VRM	Variable Range Marker
VSWR	Voltage Standing Wave Ratio

4 Technical requirements specifications

4.1 Environmental profile

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

4.2 Conformance requirements

4.2.1 Transmitter Requirements

4.2.1.1 Occupied Bandwidth

4.2.1.1.1 Definition

Occupied bandwidth is the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage $\beta/2$ of the total mean power of a given emission as defined in ITU Radio Regulations [i.3], chapter I, 1.153.

4.2.1.1.2 Limits

The occupied bandwidth with $\beta/2 = 0,5 \%$ shall be maintained wholly within the frequency range specified in Table 1.

NOTE: The value of $\beta/2 = 0,5 \%$ is taken from ITU Radio Regulations [i.3], chapter I, 1.153.

4.2.1.1.3 Conformance

The conformance tests are specified in clause 5.5.1.1.

4.2.1.2 Transmitter Peak Power

4.2.1.2.1 Definition

The transmitter peak power of a pulse radar is the peak value of the transmitter pulse power during the transmission pulse.

4.2.1.2.2 Limits

The transmitter peak power shall not exceed 10 kW.

4.2.1.2.3 Conformance

The conformance tests are specified in clause 5.5.1.2.

4.2.1.3 Measured Bandwidth (B_{-20})

4.2.1.3.1 Definition

The measured -20 dB bandwidth (B_{-20}) is the measured bandwidth of the emission 20 dB below the measured peak power.

4.2.1.3.2 Limits

The measured -20 dB bandwidth (B_{-20}) of the signal shall be contained completely within the frequency range specified in Table 1.

4.2.1.3.3 Conformance

The conformance tests are specified in clause 5.5.1.3.

4.2.1.4 Out-of-band Emissions

4.2.1.4.1 Definition

Out of Band (OoB) emissions refer to emissions in the region between calculated -40 dB bandwidth (B_{-40}) and the spurious region (see definition of spurious region in clause 4.2.1.5.1).

NOTE 1: The calculated B_{-40} is defined in Annex I.

NOTE 2: More information can be found in Recommendation ITU-R SM.1541-7 [i.7], Annex 8 (OoB domain emission limits for primary radar systems), clause 3.

4.2.1.4.2 Limits

Out-of-Band (OoB) emissions shall not exceed the limits specified in Table 2 below.

NOTE: These limits are specified in table 1 of Annex 2 of ECC Recommendation (02)05 [i.9].

The Out-of-Band mask rolls off at 30 dB/decade from the calculated B_{-40} to the level specified for spurious emissions (see Figure 1 below).

Table 2: Limits for unwanted emissions in the OoB domain

Offset Frequency x B_{-40}	Limit dB_{pp}	Slope dB/decade
0 to 0,5	0	0
0,5	-40	$-\infty$
0,5 to 2,3	-40 to -60	-30

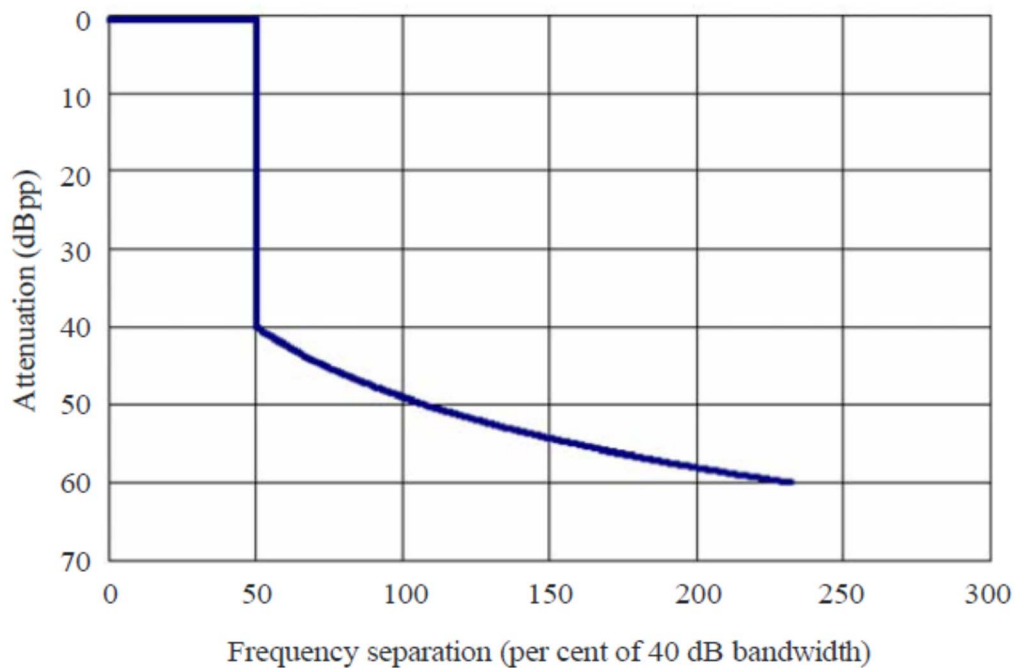


Figure 1: Out-of-Band emission limit masks [i.7]

4.2.1.4.3 Conformance

The conformance tests are specified in clause 5.5.1.4.

4.2.1.5 Spurious Emissions

4.2.1.5.1 Definition

Spurious emissions are unwanted emissions in the spurious domain. For active transmitters, the spurious domain is all frequencies outside the OoB domain.

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.

4.2.1.5.2 Limits

The spurious emissions shall not exceed the limits specified in Table 3 for the frequency range defined in Table 3.

Table 3: Limits for spurious emissions

Lower band measurement	Upper band measurement	Limits spurious emissions
$30 \text{ MHz} \leq f < f_0 - 2,3 \times B_{-40}$ (see note 1)	$f_0 + 2,3 \times B_{-40} < f \leq 26 \text{ GHz}$ (see notes 1 and 3)	$-43 - 10 \times \log(\text{PEP}) \text{ dB}$ or -60 dB (see notes 2 and 3)
NOTE 1: The OoB boundaries are taken from ECC Recommendation (02)05 [i.9], Annex 2. NOTE 2: Whichever is less stringent (attenuation (dB) below the power (PEP) supplied to the antenna port). NOTE 3: These limits are specified in ERC Recommendation 74-01 [i.8], Annex 5 (" <i>all other types of radar for radiodetermination</i> ").		

4.2.1.5.3 Conformance

The conformance tests are specified in clause 5.5.1.5.

4.2.1.6 Stand-by Mode Emissions

4.2.1.6.1 Definition

The idle/stand-by state is defined as the state where the transmitter is available for operation but is not in the active state.

4.2.1.6.2 Limits

The stand-by mode emissions shall not exceed the limits specified in Table 4.

Table 4: Limits for stand-by mode emissions

Frequency Range	Limits
$30 \text{ MHz} \leq f \leq 1 \text{ GHz}$	-57 dBm
$1 \text{ GHz} < f \leq 26 \text{ GHz}$	-47 dBm
NOTE: The frequency range of measurements and the limits are specified in ERC Recommendation 74-01 [i.8], Table 1 and Table 15 respectively.	

4.2.1.6.3 Conformance

The conformance tests are specified in clause 5.5.1.6.

4.2.2 Receiver Requirements

4.2.2.1 Receiver Sensitivity

4.2.2.1.1 Definition

Receiver sensitivity is the ability to receive a specified wanted signal level while providing a pre-determined level of performance.

NOTE: The definition of selectivity is taken from Recommendation ITU-R SM.332-4 [i.12].

4.2.2.1.2 Limits

The equipment shall be capable to receive a wanted radar signal with a level of -80 dBm, resulting in an echo on the radar display.

4.2.2.1.3 Conformance

The conformance tests are specified in clause 5.5.2.1.

4.2.2.2 Receiver Selectivity

4.2.2.2.1 Definition

The radar receiver selectivity is a measure of its ability to discriminate between a wanted signal to which the receiver is tuned and unwanted signals.

NOTE 1: The definition of selectivity is taken from Recommendation ITU-R SM.332-4 [i.12].

NOTE 2: Radar receiver selectivity refers to effects measured within the linear range of the receiver to transpose at its output the radar desired signal and to reject unwanted signals located outside the B₄₀ bandwidth.

NOTE 3: Unwanted signals inside the B_{-40} bandwidth are not considered for the receiver selectivity since they fall into the desired frequency range for the reception of wanted signals.

4.2.2.2.2 Limits

With a wanted signal with a power level of -77 dBm and an unwanted signal as in Table 5 and illustrated in Figure 2, the equipment's display shall not show a radar signal for the applied disturbing signal.

Table 5: Receiver selectivity mask

Frequency offset relative to f_0 by multiple of the B_{-40} bandwidth	Test signal output level in dBm	Slope dB/decade
0 to 0,5	-80	-
0,5	-40	$-\infty$
0,5 to 2,3	-40 to -20	-30
2,3 to ∞	-20	0

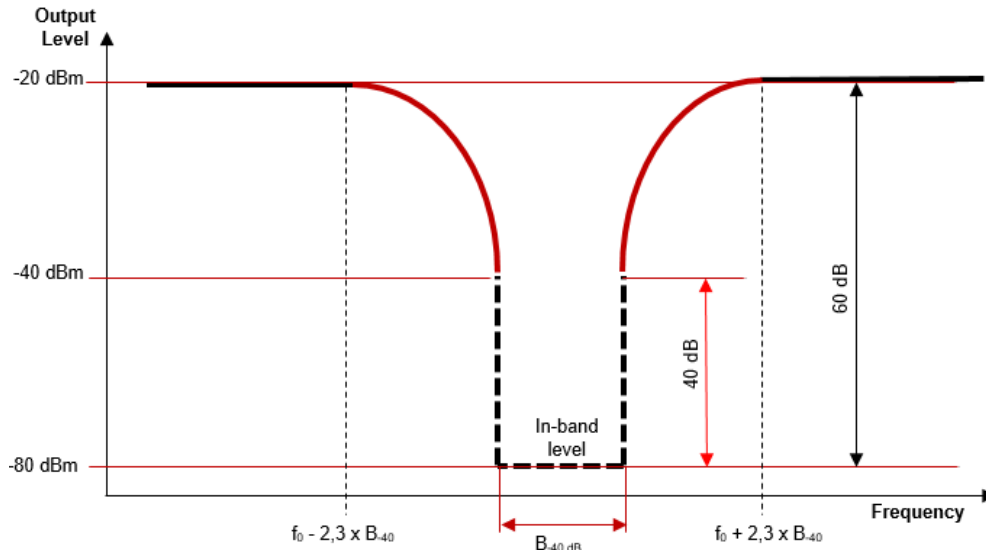


Figure 2: Receiver selectivity mask (not to scale)

The selectivity of a receiver tuned at an operating frequency f_0 shall be verified in the following frequency ranges:

$$f_0 - 2,3 \times B_{-40} - 800 \text{ MHz} \leq f \leq f_0 - B_{-40} / 2$$

$$f_0 + B_{-40} / 2 \leq f \leq f_0 + 2,3 \times B_{-40} + 800 \text{ MHz}$$

If the image frequencies, as calculated in formula (1) below, are not covered by the frequency ranges defined above, the selectivity measurement shall also be done on the following frequency range:

$$f_{\text{image}} - B_{-40} / 2 \leq f \leq f_{\text{image}} + B_{-40} / 2$$

to cover the image frequencies susceptibility.

$$f_{\text{Image}} = \begin{cases} f_0 + 2 \times f_{IF}, & \text{if } f_{LO} > f_0 \\ f_0 - 2 \times f_{IF}, & \text{if } f_{LO} < f_0 \end{cases} \quad (1)$$

4.2.2.2.3 Conformance

The conformance tests are specified in clause 5.5.2.2.

4.2.2.3 Receiver Maximum input Level

4.2.2.3.1 Definition

The Receiver Maximum Input Level is the input level of two input radar signals, resulting in two radar echoes on the same bearing in a defined distance in accordance with the radial resolution capability of the EUT, such that the radar echoes can be discriminated.

4.2.2.3.2 Limits

The Receiver Maximum Input Level with a radial resolution capability of 15 m shall be at least -35 dBm.

$$\text{RML} \geq -35 \text{ dBm} \quad (2)$$

NOTE: The value for the radial resolution 3capability is taken from clause 5.2.2.5 of ETSI EN 303 676 [i.6].

4.2.2.3.3 Conformance

The conformance tests are specified in clause 5.5.2.3.

4.2.2.4 Receiver non-linearity

4.2.2.4.1 Definition

Receiver non-linearity is a measure of the capability of the radar to suppress the 3rd order Intermodulation Distortion (IMD) product due to two unwanted signals with the specified levels.

NOTE 1: The unwanted signals at frequencies f_1 and f_2 are selected as follows:

$$f_{rx} = 2 \times f_1 - f_2 \quad (3)$$

Equation 3 corresponds to the 3rd order IMD.

NOTE 2: For the radars within the scope of the present document, only the third order IMD products are of primary interest.

NOTE 3: Superheterodyne receivers as used by radars in the scope of the present document use mixers to convert RF signals to an Intermediate Frequency (IF). Due to imperfection of a real-world mixer, it comes always with a non-linear response, i.e. additional unwanted signals occur at the output of a mixer.

4.2.2.4.2 Limits

With the equipment's receiver tuned at a frequency $f_{rx} = 9\,400$ MHz and its display set up to suppress a wanted radar signal with a level of -35 dBm, two unwanted signals at frequencies $f_1 = 9\,500$ MHz and $f_2 = 9\,600$ MHz with a power level of -35 dBm shall not cause any radar echo on the equipment's display.

4.2.2.4.3 Conformance

The conformance tests are specified in clause 5.5.2.4.

5 Testing for compliance with technical requirements

5.1 General Requirements

All tests shall be performed under normal test conditions specified in clause 5.3 unless stated otherwise.

5.2 Environmental conditions for testing

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

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

5.3 Normal Test Conditions

5.3.1 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 °C to +35 °C;
- b) relative humidity: not exceeding 75 %.

The relative humidity shall be recorded in the test report.

NOTE: These values are defined in clause 5.2.1 of IEC 60945 [i.10].

5.3.2 Normal test power supply

5.3.2.1 DC test power supply

The normal test voltage shall be the nominal voltage as stated in the user documentation.

For the purpose of testing, the power source voltage shall be measured at the input terminals of the equipment.

During testing, the power source voltage deviation relative to the voltage level at the beginning of each test shall not exceed 3 %.

NOTE: This voltage deviation is defined in clause 5.2.1 of IEC 60945 [i.10].

5.4 Extreme test conditions

5.4.1 Extreme temperature and humidity

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

- a) temperature: -25 °C to +55 °C;
- b) relative humidity: not exceeding 93 %.

Measurements shall be made at least at the lowest and highest temperatures. The relative humidity shall be recorded in the test report.

NOTE: These values are defined in clause 8.1, table 3 of IEC 60945 [i.10].

5.4.2 Extreme test power supply

Extreme power voltage and frequency variations shall be as specified in Table 6.

Table 6: Extreme power supply voltage variations

Power supply	Voltage variation %
DC	+30 -10

NOTE: These values are defined in clause 5.2.2, Table 1 of IEC 60945 [i.10].

5.5 Radio test suites

5.5.1 Transmitter test specification

5.5.1.1 Occupied Bandwidth

The measurement setup shall be as described in Annex D and with the settings defined in Annex J.

The test shall be performed under both normal and extreme test conditions as defined in clause 5.3 and clause 5.4 respectively.

The measurement steps shall be as follows:

- Set the EUT to a range of 1 200 m.
- Adjust the signal attenuation to ensure that the signal power envelope is above the noise floor of the spectrum analyser to avoid the noise signals on either side of the power envelope being included in the measurement.
- Set the sweep time SWT to 10 s.
- Measure the total power in a frequency range from 100 MHz below to 100 MHz above the peak value by adding up each measurement. The lower boundary of the occupied bandwidth is found by adding up each measurement, starting 100 MHz below the peak value upwards, as long as the sum remains below 0,5 % of the total power. The upper boundary is found by adding each measurement, starting from 100 MHz above the peak value downwards, as long as the sum remains below 0,5 % of the total power.

The insertion losses of all components in the test setup shall be taken into account.

The results obtained shall not exceed the limits specified in clause 4.2.1.1.2 in order to prove compliance with the requirement.

5.5.1.2 Transmitter Peak Power

The measurement setup shall be as described in Annex C.

The test shall be executed under normal and extreme test conditions defined in clause 5.3 and clause 5.4 respectively.

The measurement steps shall be as follows:

- Set the EUT to a range of 1 200 m.
- Measure the transmitter power by reading the value of the peak power meter.
- Reference the indicated transmitter power to the transmitter output flange by taking the coupling factor into account. If the peak power meter does not allow for the compensation of the coupling loss, the coupling loss is added to the reading.

The insertion losses of all components in the test setup shall be taken into account.

The results obtained shall not exceed the limits specified in clause 4.2.1.2.2 in order to prove compliance with the requirement.

5.5.1.3 Measured Bandwidth (B_{-20})

The measurement setup shall be as described in Annex D and with the settings defined in Annex J.

The test shall be performed under both normal and extreme test conditions as defined in clause 5.3 and clause 5.4 respectively.

The measurement steps shall be as follows:

- a) Set the EUT to a range of 1 200 m.
- b) Record the used RBW in the test report.
- c) Measure the bandwidth of the emissions 20 dB below peak power.

The insertion losses of all components in the test setup shall be taken into account.

No corrections to the measurement are required since both the peak of the spectrum and the data points are measured using the same measurement bandwidth B_m in accordance with Section 3.1 of Annex 1 of Recommendation ITU-R 1177-4 [i.4].

The results obtained shall not exceed the limits specified in clause 4.2.1.3.2 in order to prove compliance with the requirement.

5.5.1.4 Out-of-band Emissions

The measurement setup shall be as described in Annex E.

The test shall be executed under normal and extreme test conditions defined in clause 5.3 and clause 5.4 respectively.

The measurement steps shall be as follows:

- a) Set the EUT to a range of 1 200 m.
- b) Record the used RBW as well as the antenna arrays intended to be used in the test report.
- c) Calculate B_{-40} by the formula in Annex I.
- d) For each type of antenna array intended to be used, measure the OoB power emission according to the measurement procedure as described in Annex K, in the frequency bands given in Table 7.

Table 7: Out-of-Band emissions boundaries

Lower OoB boundary	Upper OoB boundary
Carrier frequency - $2,3 \times B_{-40}$	Carrier frequency + $2,3 \times B_{-40}$
NOTE: The OoB boundaries are taken from ECC Recommendation (02)05, Annex 2 [i.9]	

No correction to the measurement is required since both the peak of the spectrum and the data points are measured using the same measurement bandwidth B_m in accordance with Section 3.1 of Annex 1 of Recommendation ITU-R1177-4 [i.4].

The insertion losses of all components in the test setup shall be taken into account.

The results obtained shall not exceed the limits specified in clause 4.2.1.4.2 in order to prove compliance with the requirement.

5.5.1.5 Spurious Emissions

The measurement setup shall be as described in Annex E. The measurement procedure shall be as described in Annex K.

The test shall be executed under normal and extreme test conditions defined in clause 5.3 and clause 5.4 respectively.

The measurement steps shall be as follows:

- a) Set the EUT to a range of 1 200 m.
- b) Record the used RBW as well as the antenna arrays intended to be used in the test report.
- c) For each type of antenna array intended to be used, measure the spurious emissions according to the measurement procedure as described in Annex K, in the frequency bands defined in Table 3.
- d) Apply the correction of the measurement data to the Peak Envelope Power (PEP) according to the following formula:

$$PEP = P_{meas} + 20 \times \log\left(\frac{B_{pep}}{B_m}\right) \quad (4)$$

where:

- PEP: peak envelope power;
 P_{meas} : spectrum peak power;
 B_{pep} : one divided by the radar pulse length.

NOTE 1: This formula is defined in Recommendation ITU-R 1177-4 [i.4], Annex 1, Section 3.2.2.

In case the spectrum analyser does not exactly support the RBW as given in Annex J, then the measured spectrum shall be corrected according to the following formula:

$$Spurious\ level, B_{ref} = Spurious\ level\ (measured\ in\ B_m) + 10 \times \log\left(\frac{B_{ref}}{B_m}\right) \quad (5)$$

NOTE 2: This formula is defined in Recommendation ITU-R 1177-4 [i.4], Annex 1, Section 3.2.1.

The insertion losses of all components in the test setup shall be taken into account.

The results obtained shall not exceed the limits specified in clause 4.2.1.5.2 in order to prove compliance with the requirement.

5.5.1.6 Stand-by Mode Emissions

The measurement setup shall be as described in Annex E.

The test shall be executed under normal and extreme test conditions defined in clause 5.3 and clause 5.4 respectively.

The measurement steps shall be as follows:

- a) Place the EUT in stand-by mode but still powered on.
- b) Record the used RBW as well as the antenna arrays intended to be used in the test report.
- c) For each type of antenna array intended to be used, measure the stand-by mode emissions according to the measurement procedure as described in Annex K, in the frequency bands defined in Table 4.

If the spectrum analyser does not exactly support the RBW as given in Annex J, the correction defined in clause 5.5.1.5, equation (5) shall be applied.

The insertion losses of all components in the test setup shall be taken into account.

The results obtained shall not exceed the limits specified in clause 4.2.1.6.2 in order to prove compliance with the requirement.

5.5.1.7 Pulse Length

The measurement setup shall be as described in Annex F.

The pulse length t is measured at the -6 dB points (50 % voltage points) of a radar pulse according to Figure 3.

The measurement is performed with combined vertical and horizontal marker lines of the oscilloscope.

The measurement steps shall be as follows:

- a) Set the EUT to a range of 1 200 m.
- b) Set the input port of the oscilloscope to DC coupling and 50 Ohm input impedance.
- c) Measure the peak voltage of the pulse by setting a horizontal line to the 100 % amplitude as shown in Figure 3.
- d) Move the position of this line to 50 % of this peak voltage.
- e) Set a vertical line 1 to the interception point of the horizontal line with the rising edge.
- f) Set another vertical line 2 to the interception point of the horizontal line with the falling edge of the pulse.
- g) Note the difference of the reading of the time value of vertical line 2 and 1 as the pulse length

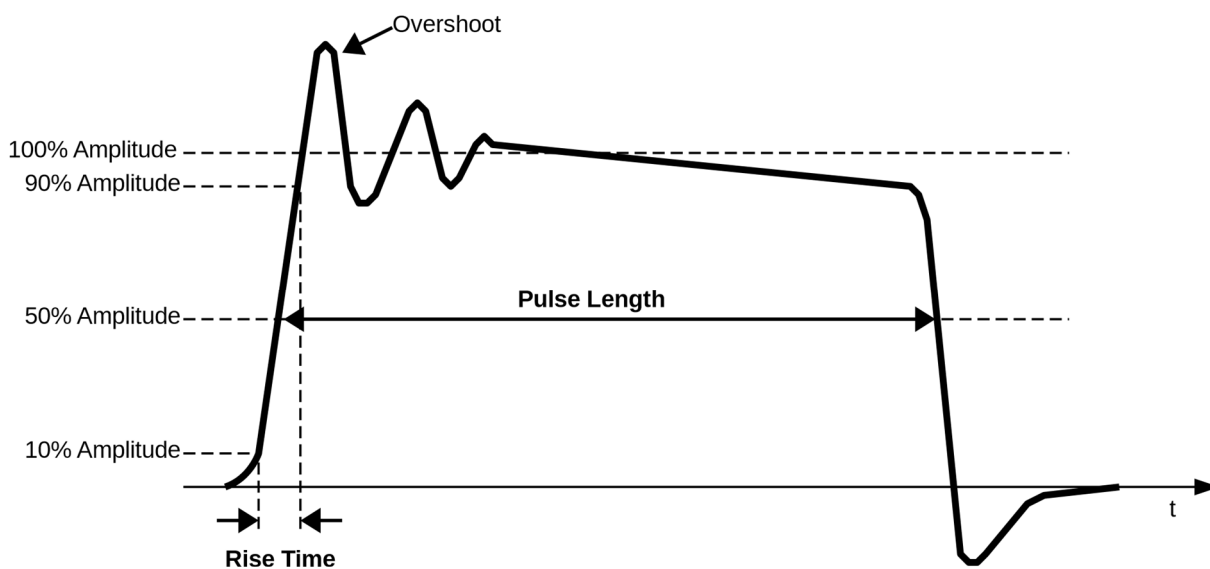


Figure 3: Definition of pulse parameter

NOTE: The definition of pulse length is taken from Appendix 3 to Annex 1 of Recommendation ITU-R M.1177-4 [i.4].

The result obtained shall be recorded in the test report.

5.5.1.8 Pulse Rise Time

The measurement setup shall be as described in Annex F.

The rise time t_r shall be measured between the -20 dB and -0,9 dB (10 % to 90 % voltage points) on the leading edge of the pulse according to Figure 3.

The measurement shall be performed with combined vertical and horizontal lines.

The measurement steps shall be as follows:

- a) Set the EUT to a range of 1 200 m.
- b) Set the input port of the oscilloscope to DC coupling and 50 Ohm input impedance.
- c) Measure the peak voltage of the pulse by setting a horizontal line to the 100 % amplitude as shown in Figure 3.
- d) Move the position of this horizontal line 1 to 90 % of this peak voltage.

- e) Set another horizontal line 2 to 10 % of this peak voltage.
- f) Set a vertical line 1 to the interception point of the horizontal line 1 with the rising edge.
- g) Set another vertical line 2 to the interception point of the horizontal line 2 with the rising edge of the pulse.
- h) Note the difference of the reading of the time value of vertical line 2 and 1 as the pulse rise time.

NOTE: The definition of pulse rise time is taken from Appendix 3 to Annex 1 of Recommendation ITU-R M.1177-4 [i.4].

The result obtained shall be recorded in the test report.

5.5.2 Receiver test specifications

5.5.2.1 Receiver Sensitivity

The measurement setup shall be as described in Annex G.

The test shall be completed under normal and extreme test conditions defined in clause 5.3 and clause 5.4 respectively.

The measurement steps shall be as follows:

- a) Switch the EUT transmitter off.
- b) Set STC and FTC of the EUT to their minimum values.
- c) Set the EUT to a range of 1 200 m.
- d) Configure the RF signal generator such that it is triggered by the tx-trigger of the EUT.
- e) Apply a pulsed radar signal with a frequency of $f = f_0$, a pulse length as measured in clause 5.5.1.7 and a level of -60 dBm at the antenna port of the EUT, taking into account the insertion losses of all the components in the test setup.
- f) Observe a radar echo in the shape of a circle on the EUT display.
- g) Adjust the video gain of the EUT such that a radar echo without any clutter is visible.
- h) Reduce the level of the signal generator until the radar echo disappears.
- i) Note the level at the input of the EUT, taking into account the insertion losses of all the components in the test setup.

The results obtained shall not exceed the limits specified in clause 4.2.2.1.2 in order to prove compliance with the requirement.

5.5.2.2 Receiver Selectivity

The measurement setup shall be as described in Annex H.

A selectivity curve shall be measured incrementally using a disturbing test signal which steps through the entire frequency ranges described in clause 4.2.2.2.2.

The measurement steps shall be as follows:

- a) Switch the EUT transmitter off.
- b) Set STC and FTC of the EUT to their minimum values.
- c) Set the EUT to a range of 1 200 m.
- d) Disconnect the delayed-trigger cable from RF signal generator 2 to enable RF signal generator 2 free running.
- e) Disable the output of RF signal generator 2.

- f) Configure the RF signal generator 1 such that it outputs a pulsed radar signal 1 (wanted signal) with a frequency of $f = f_0$, a pulse length as measured in clause 5.5.1.7 and a level of -80 dBm at the antenna port of the EUT.
- g) Ensure that a radar echo in the shape of a circle around the centre point of the EUT display is observed.
- h) Adjust the video gain of the EUT until the resulting radar echo on the display disappears.
- i) Increase the level of RF signal generator 1 by 3 dB.
- j) Ensure that the radar echo in the shape of a circle reappears on the EUT display (reference signal) is observed.
- k) Configure the RF signal generator 2 such that it outputs a pulsed radar signal 2 with a pulse length of 500 ns.
- l) Enable the output of RF signal generator 2.
- m) Inject the disturbing pulsed test signal (test signal 2) with a level as given in Table 5 over the frequency range specified in clause 4.2.2.2.2 with a discrete frequency step of 10 MHz.
- n) Continuously inspect the EUT's display for any occurrence of a radar echoes of the disturbing signal 2.

The frequencies f_{LO} , f_{IF} and f_{image} shall be noted in the test report.

The equipment's display shall not show a radar signal for the applied disturbing signal as specified in clause 4.2.2.2.2 in order to prove compliance with the requirement.

5.5.2.3 Receiver Maximum input Level

The measurement setup shall be as described in Annex H.

The measurement steps shall be as follows:

- a) Switch the EUT transmitter off.
- b) Set STC and FTC of the EUT to their minimum values.
- c) Set the EUT to a range of 1 200 m.
- d) Connect the delayed-trigger cable to RF signal generator 1 and to RF signal generator 2.
- e) Configure the RF signal generator 1 such that it is triggered by the tx-trigger of the EUT.
- f) Disable the output of RF signal generator 2.
- g) Configure RF signal generator 1 such that it outputs a pulsed radar signal with a frequency of $f_1 = f_0$, a pulse length as measured in clause 5.5.1.7 and a level of -50 dBm at the antenna port of the EUT, taking into account the insertion losses of all the components in the test setup.
- h) Observe a radar echo in the shape of a circle on the EUT display.
- i) Adjust the video gain of the EUT such that a radar echo without any clutter is visible (circle 1).
- j) Configure RF signal generator 2 such that it output a pulsed radar signal 2 with a frequency of $f_2 = f_0$, a pulse length as measured in clause 5.5.1.7, a level of -50 dBm and with a delay of 100 ns to signal 1 at the antenna port of the EUT, taking into account the insertion losses of all the components in the test setup.
- k) Enable the output of RF signal generator 2.
- l) Observe a second concentric radar echo circle, clearly separated from circle 1.
- m) Measure the distance of the leading edges of both circles with the VRM.
- n) Confirm, that the leading edges have a distance of 15 m.
- o) Increase the input level of both input signals.
- p) Adjust the video gain as required.

- q) Repeat steps n and o until discrimination of the two radar echo circles is not possible anymore (i.e. there are no separation pixels between both circles).
- r) Note the level of the signals at the antenna port of the EUT, taking into account the insertion losses of all the components in the test setup. The value shall be noted as Receiver Maximal input Level (RML) of the EUT.

The RML shall be compared with the limits specified in clause 4.2.2.3.2 in order to prove compliance with the requirement.

5.5.2.4 Receiver non-linearity

The measurement setup shall be as described in Annex H.

The measurement steps shall be as follows:

- a) Switch the EUT transmitter off.
- b) Set STC and FTC of the EUT to their minimum values.
- c) Disable the output of RF signal generator 2.
- d) Configure the RF signal generator 1 such that it is triggered by the tx-tigger of the EUT.
- e) Set the EUT to a range of 1 200 m.
- f) Configure RF signal generator 1 such that it outputs a pulsed radar signal with a frequency of f_{rx} , a pulse length as measured in clause 5.5.1.7 and a level of -35 dBm at the antenna port of the EUT, taking into account the insertion losses of all the components in the test setup (see Table 8).
- g) Tune the receiver to f_{rx} .
- h) Observe a radar echo in the shape of a circle on the EUT display.
- i) Adjust the video gain of the EUT such that the resulting radar echo on the display just disappears completely.
- j) Disconnect the tx-trigger cable from RF signal generator 1 to enable RF signal generator 1 and RF signal generator 2 free running, leaving the connection between both signal generators connected.
- k) Configure RF signal generator 1 such that it outputs a pulsed signal with a frequency of f_1 (see Table 8), a pulse length of 500 ns and a power level of -35 dBm at the antenna port of the EUT, taking into account the insertion losses of all the components in the test setup.
- l) Configure RF signal generator 2 such that it outputs a pulsed signal with a frequency of f_2 (see Table 8), a pulse length of 500 ns and a power level of -35 dBm at the antenna port, taking into account the insertion losses of all the components in the test setup.
- m) Set the delayed trigger for signal generator 2 to zero (both signal generators shall be triggered simultaneously).
- n) Enable the output of RF signal generator 2.

Table 8: Receiver non-linearity test signals

Test signal	Frequency	Power level
f_{rx}	9 400 MHz	-35 dBm
f_1	9 500 MHz	-35 dBm
f_2	9 600 MHz	-35 dBm

As described in clause 4.2.2.4.2, no radar echo shall be visible on the display to prove compliance with the requirement.

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

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.1] 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.2].

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 302 194-1					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Occupied Bandwidth	3.2	4.2.1.1	U	
2	Transmitter Pulse Power	3.2	4.2.1.2	U	
3	Measured Bandwidth	3.2	4.2.1.3	U	
4	Out-of-Band Emissions	3.2	4.2.1.4	U	
5	Spurious Emissions	3.2	4.2.1.5	U	
6	Stand-by Mode Emissions	3.2	4.2.1.6	U	
7	Receiver Sensitivity	3.2	4.2.2.1	U	
8	Receiver Selectivity	3.2	4.2.2.2	U	
9	Receiver Maximum input Level	3.2	4.2.2.3	U	
10	Receiver non-linearity	3.2	4.2.2.4	U	

Key to columns:

Requirement:

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

Description A textual reference to the requirement.

Essential requirements of Directive

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

Clause(s) of the present document

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

Requirement Conditionality:

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

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

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

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

Annex B (informative): Maximum measurement uncertainty

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

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

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

Table B.1: Maximum measurement uncertainty

Parameter	Uncertainty
Environment measurements	
Temperature	$\pm 1\text{ }^{\circ}\text{C}$
Relative Humidity	$\pm 5\text{ }\%$
Transmitter measurements	
Transmitter Power	$\pm 1,5\text{ dB}$
Out-of-Band Emissions	$\pm 4\text{ dB}$
Spurious Emissions	$\pm 4\text{ dB}$
Stand-by Mode Emissions	$\pm 4\text{ dB}$
Mains Supply Voltage	$\pm 0,1\text{ }\%$
Receiver measurements	
System Noise Figure	$\pm 1,5\text{ dB}$
Receiver Selectivity	$\pm 1,5\text{ dB}$
Receiver Compression Level	$\pm 1,5\text{ dB}$
Receiver non-linearity	$\pm 1,5\text{ dB}$

Annex C (normative): Transmitter Pulse Power measurement set up

General setup description

The setup for the measurement of the transmitter pulse power is shown in Figure C.1.

A *coupler* shall replace the antenna. If the radar does not provide a possibility to interrupt the antenna rotation by stopping the antenna motor while maintaining full functionality, this coupler shall be a rotary coupler. The port of the coupler shall be connected to a *waveguide*. This waveguide, in turn, shall be connected to a *directional coupler*. The main port ("transmitted port") of the directional coupler shall be terminated by a matching *dummy load*. The other output ("coupled port") of the directional coupler shall be connected to a *peak power meter*, i.e. a power sensor connected to an RF peak power analyser, by a *coax cable*. An *adapter* shall be used to connect the waveguide port of the directional coupler to the coax cable. If the overall attenuation provided by the used piece of waveguide, the directional coupler as well as the coaxial adapter and the coax cable is not sufficient, an additional *attenuator* shall be used.

Measurement components specifications

The input port of the *coupler* shall be identical to the input port of the radar antenna. The output waveguide port shall be the same as used in the EUT.

The *waveguide* used for this test shall be the same as used in the EUT.

NOTE: The equipment covered by the present document typically uses an R100/WR90 waveguide (see IEC 60153-2 [i.11]).

The *directional coupler* shall have a flat attenuation (within 2 dB) within the whole frequency band 8 900 MHz to 9 900 MHz (at least 400 MHz outside the edges of the frequency range as specified in Table 1. It shall have a coupling factor of at least 30 dB.

The *dummy load* shall match the impedance of the used waveguide and shall be rated to have a power dissipation of at least 10 W average power and 10 kW peak power for 100 ns.

The input port of the waveguide-to-coax *adapter* shall be identical to the input port of the coupled port of the directional coupler. The output port of the adapter shall match the connector of the coax-cable in type and impedance, i.e. 50 Ohm.

The maximal operating frequency of the *coax cable* shall be at least 10 GHz and the attenuation shall not exceed 2 dB/m at a frequency of 10 GHz. It shall have an impedance of 50 Ohm. The maximum length of the coax cable shall not exceed 1,5 m. The length of the used coax cable shall be recorded in the test report.

The *peak power meter* shall have a video and single shot bandwidth equal or greater than 25 MHz. The input impedance shall be 50 Ohm.

The input and the output port of the additional *attenuator* shall match the connector of the coax-cable in size and impedance, i.e. 50 Ohm. The attenuation shall be high enough to protect the power sensor from overload. The power rating shall be at least 1 W average power and 10 W peak power.

All components shall be calibrated and shall have a VSWR of 1,5 or better.

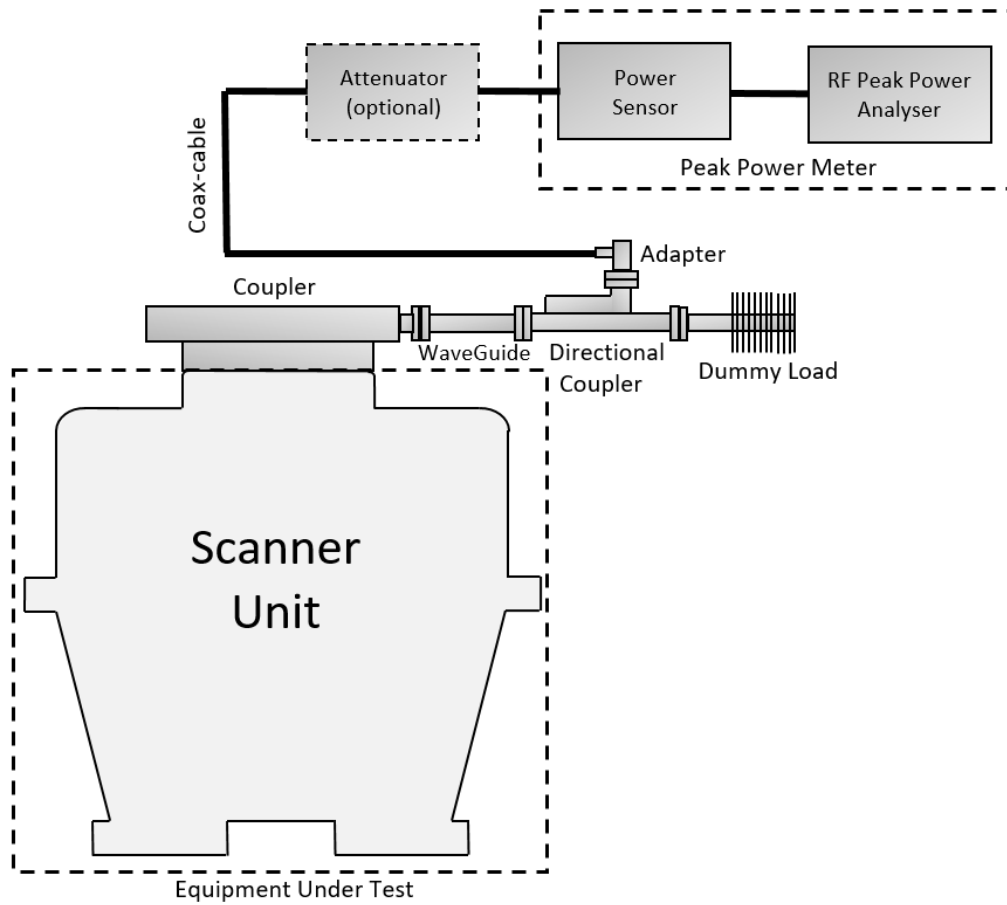


Figure C.1: Set up for the measurement of Transmitter Pulse Power

Annex D (normative): Occupied Bandwidth and Measured Bandwidth (B_{-20}) measurement set up

General setup description

The setup for the measurement of the occupied bandwidth and the measured bandwidth (B_{-20}) is shown in Figure D.1.

A *coupler* shall replace the antenna. If the radar does not provide a possibility to interrupt the antenna rotation by stopping the antenna motor while maintaining full functionality, this coupler shall be a rotary coupler. The port of the coupler shall be connected to a *waveguide*. This waveguide, in turn, shall be connected to a *directional coupler*. The main port ("transmitted port") of the directional coupler shall be terminated by a matching *dummy load*. The other output ("coupled port") of the directional coupler shall be connected to a *spectrum analyser* by a *coax cable*. An *adapter* shall be used to connect the waveguide port of the directional coupler to the coax cable. If the overall attenuation provided by the used piece of waveguide, the directional coupler as well as the coaxial adapter and the coax cable is not sufficient to protect the spectrum analyser from overload, an additional *attenuator* shall be used.

Measurement components specifications

The input port of the *coupler* shall be identical to the input port of the radar antenna. The output waveguide port shall be the same as used in the EUT.

The *waveguide* used for this test shall be the same as used in the EUT.

NOTE: The equipment covered by the present document typically use an R100/WR90 waveguide (see IEC 60153-2 [i.11]).

The *directional coupler* shall have a flat attenuation (within 2 dB) within the whole frequency band 8 900 MHz to 9 900 MHz (at least 400 MHz outside the edges of the frequency range as specified in Table 1). It shall have a coupling factor of at least 30 dB.

The *dummy load* shall match the impedance of the used waveguide and shall be rated to have a power dissipation of at least 10 W average power and 10 kW peak power for 100 ns.

The input port of the waveguide-to-coax *adapter* shall be identical to the input port of the coupled port of the directional coupler. The output port of the adapter shall match the connector of the coax-cable in type and impedance, i.e. 50 Ohm.

The maximal operating frequency of the *coax cable* shall be at least 10 GHz and the attenuation shall not exceed 2 dB/m at a frequency of 10 GHz. It shall have an impedance of 50 Ohm. The maximum length of the coax cable shall not exceed 1,5 m. The length of the used coax cable shall be recorded in the test report.

The *spectrum analyser* shall have a frequency range of at least up to 12 GHz and a Resolution Bandwidth (RBW) of at least 1 MHz.

The input and the output port of the additional *attenuator* shall match the connector of the coax-cable in size and impedance, i.e. 50 Ohm. The attenuation shall be high enough to protect the spectrum analyser from overload.

All components shall be calibrated and shall have a VSWR of 1,5 or better.

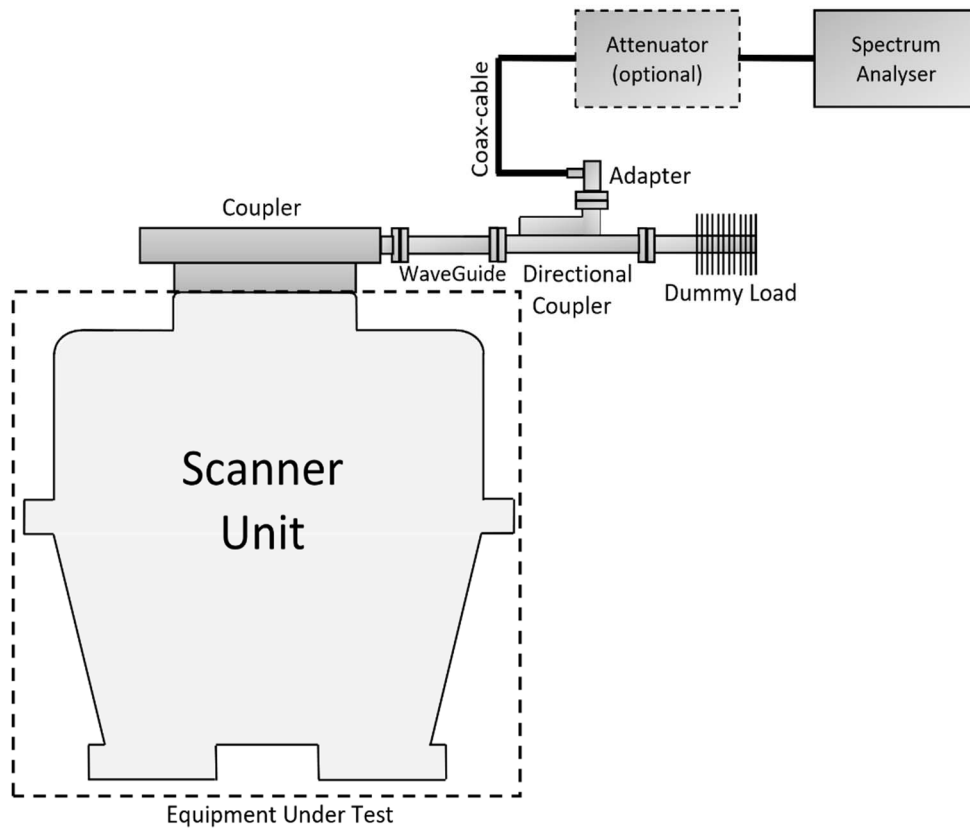


Figure D.1: Set up for the measurement of the Occupied Bandwidth and the Measured Bandwidth (B_{20})

Annex E (normative): Out-of-band Emissions, Spurious Emissions and Stand-by Mode Emissions measurement set up

General setup description

The setup for the measurement of OoB, spurious and stand-by mode emissions is shown in Figure E.1.

NOTE: In Recommendation ITU-R M.1177-4 [i.4], Annex 1 the direct method to measure unwanted emissions (OoB and spurious) is recommended for all radars. Annex 1 of Recommendation ITU-R M.1177-4 [i.4] allows to carry out the direct method in an anechoic chamber. Regarding the measurement distance, due to limited space available in an anechoic chamber, near field measurements can be performed.

The EUT shall be set on a *post*. The height *H* shall be determined considering the vertical beam width of the radar and measurement antennas and the distance *D* between both antennas. For out-of-band and spurious emissions measurements, the *measurement antenna* shall be connected to a *spectrum analyser* with a low-loss RF *coax cable*. For the stand-by mode emission measurement, the *measurement antenna* shall be connected directly to a *spectrum analyser* with a low-loss RF *coax cable*.

No reflective objects shall be between the radar and the measurement antenna. RF absorbers shall be laid out on the floor to avoid multipath reflections.

Measurement components specifications

The *post* shall be made of non-conductive material, e.g. wood. The construction shall not have any metal screws or clamps.

The *measurement antenna* shall have a horizontal polarization. If the frequency range to be measured cannot be covered with a single antenna, different antennas shall be used; each of these antennas shall be specified for the corresponding sub-frequency range.

Since the deviation of the gain of the measurement antenna from constant effective aperture (i.e. from the decreasing $20 \log(f)$ curve) shall be applied to measurements results (see Annex K), the following needs to be considered for the choice of the measurement antenna(s):

- a) No corrections for variable antenna gain are required, if the measurement antenna has a constant effective aperture.
- b) Antenna gain levels are usually specified relative to that of a theoretically perfect isotropic antenna (dBi).
- c) The effective aperture of an isotropic antenna decreases as $20 \log(f)$, where *f* is the frequency being measured.
- d) For antennas with a constant effective aperture, the isotropic gain increases as $20 \log(f)$.
- e) Theoretically a perfect parabolic reflector antenna has a constant effective aperture.

The maximal operating frequency of the *coax cable* shall be at least 26 GHz. The attenuation shall not exceed 2 dB/m at a frequency of 26 GHz. It shall have an impedance of 50 Ohm. The maximum length of the coax cable shall not exceed 1,5 m. The length of the used coax cable shall be recorded in the test report. The cables shall be equipped with connectors, specified for a frequency up to minimal 26 GHz.

The *spectrum analyser* shall have a frequency range of at least up to 26 GHz and a Resolution Bandwidth (RBW) of at least 1 MHz.

All components shall be calibrated and shall have a VSWR of 1,5 or better.

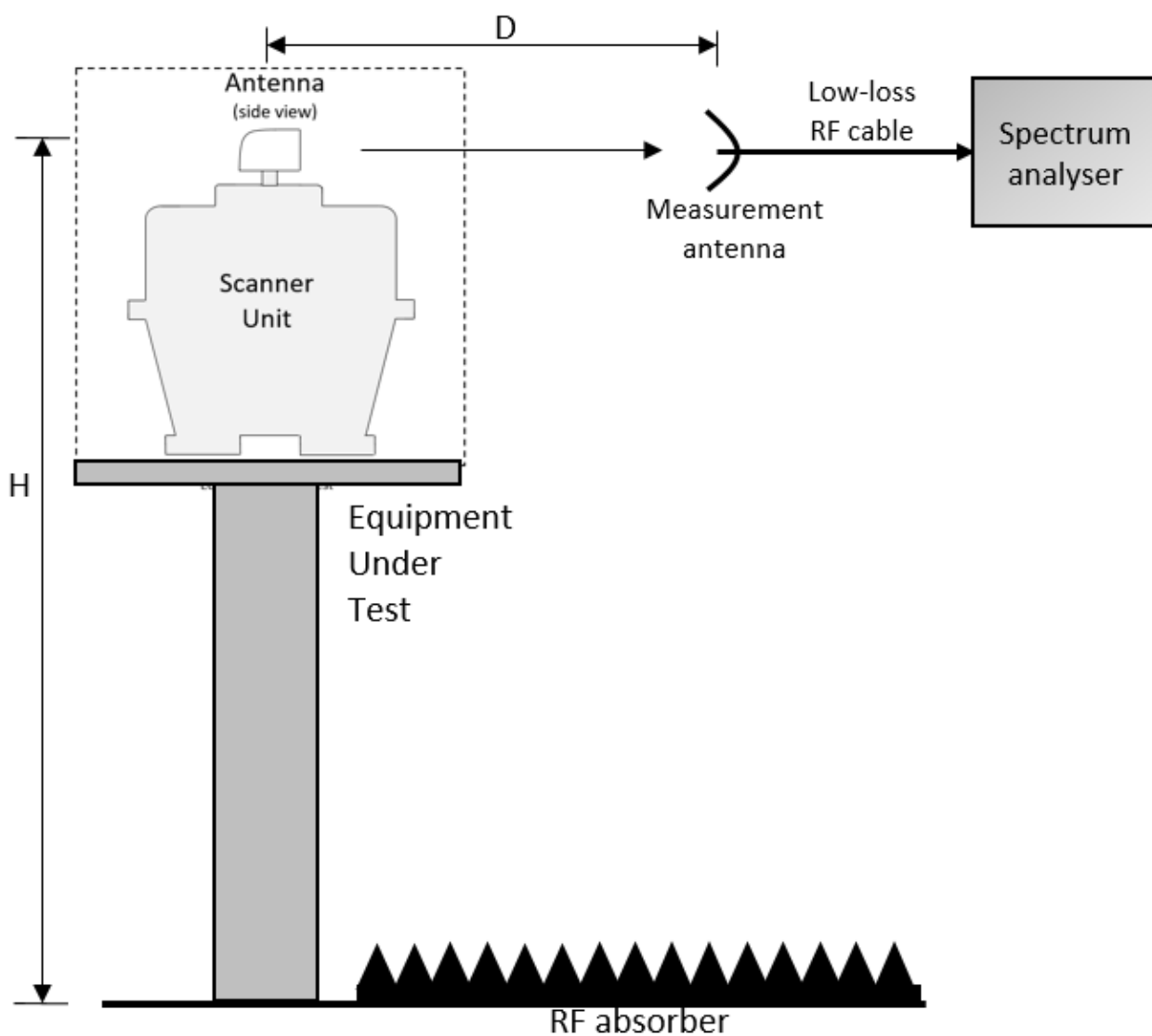


Figure E.1: Set up for the measurement of OoB emissions, spurious emissions and stand-by mode emissions

Annex F (normative): Pulse Length and Pulse Rise Time measurement set up

General setup description

The setup for the measurement of the pulse length and the pulse rise time is shown in Figure F.1.

A *coupler* shall replace the antenna. If the radar does not provide a possibility to interrupt the antenna rotation by stopping the antenna motor while maintaining full functionality, this coupler shall be a rotary coupler. The port of the coupler shall be connected to a *waveguide*. This waveguide, in turn, shall be connected to a *directional coupler*. The main port ("transmitted port") of the directional coupler shall be terminated by a matching *dummy load*. The other output ("coupled port") of the directional coupler shall be connected to a wideband *crystal detector* by a *coax cable*. An *adapter* shall be used to connect the waveguide port of the directional coupler to the coax cable. The output of the crystal detector shall be connected to an *oscilloscope*. If the overall attenuation provided by the used piece of waveguide, the directional coupler as well as the coaxial adapter and the coax cable is not sufficient, an additional *attenuator* shall be used to protect the crystal detector from overload.

Measurement components specifications

The input port of the *coupler* shall be identical to the input port of the radar antenna. The output waveguide port shall be the same as used in the EUT.

The *waveguide* used for this test shall be the same as used in the EUT.

NOTE: The equipment covered by the present document typically uses an R100/WR90 waveguide (see IEC 60153-2 [i.11]).

The *directional coupler* shall have a flat attenuation (within 2 dB) within the whole frequency band 8 900 MHz to 9 900 MHz (at least 400 MHz outside the edges of the frequency range as specified in Table 1). It shall have a coupling factor of at least 30 dB.

The *dummy load* shall match the impedance of the used waveguide and shall be rated to have a power dissipation of at least 10 W average power and 10 kW peak power for 100 ns.

The input port of the waveguide-to-coax *adapter* shall be identical to the input port of the coupled port of the directional coupler. The output port of the adapter shall match the connector of the coax-cable in type and impedance, i.e. 50 Ohm.

The maximal operating frequency of the *coax cable* shall be at least 10 GHz and the attenuation shall not exceed 2 dB/m at a frequency of 10 GHz. It shall have an impedance of 50 Ohm. The maximum length of the coax cable shall not exceed 1,5 m. The length of the used coax cable shall be recorded in the test report.

The bandwidth of the wideband *crystal detector* shall exceed 100 MHz.

The bandwidth of the *oscilloscope* shall be at least 500 MHz. The bandwidth shall be available in a single-shot (not repetitively sampled) mode, as the measurements are made on single radar pulses.

The input and the output port of the additional *attenuator* shall match the connector of the coax-cable in size and impedance, i.e. 50 Ohm. The attenuation shall be high enough to protect the power sensor from overload, at least it shall be 10 dB. The power rating shall be at least 1 W average power and 10 W peak power.

All components shall be calibrated and shall have a VSWR of 1,5 or better.

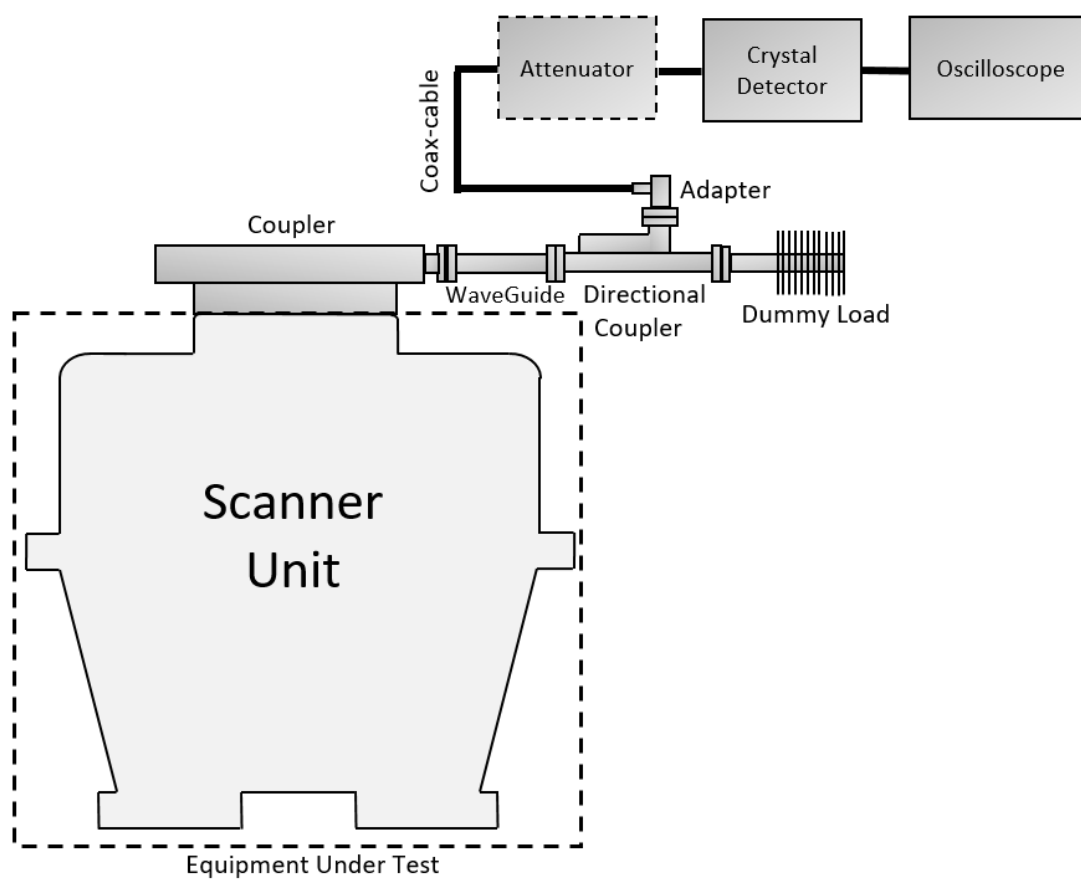


Figure F.1: Set up for the measurement of the pulse length and pulse rise time

Annex G (normative): Receiver Sensitivity measurement setup

General setup description

The setup for the measurement of the receiver sensitivity is shown in Figure G.1.

A *coupler* shall replace the antenna. If the radar does not provide a possibility to interrupt the antenna rotation by stopping the antenna motor while maintaining full functionality, this coupler shall be a rotary coupler. The port of the coupler shall be connected to a *waveguide*. This waveguide, in turn, is connected to the *rf signal generator* via a waveguide/coaxial transition (the *adapter* in Figure G.1) and a *coax cable*. The EUT's tx-trigger signal shall be connected to the trigger input port of the *rf signal generator*.

Measurement components specifications

The input port of the *coupler* shall be identical to the input port of the radar antenna. The output waveguide port shall be the same as used in the EUT.

The *waveguide* used for this test shall be the same as used in the EUT.

NOTE: The equipment covered by the present document typically use an R100/WR90 waveguide (see IEC 60153-2 [i.11]).

The input port of the waveguide-to-coax *adapter* shall be identical to the input port of the coupled port of the directional coupler. The output port of the adapter shall match the connector of the coax-cable in type and impedance, i.e. 50 Ohm.

The maximal operating frequency of the *coax cable* shall be at least 10 GHz and the attenuation shall not exceed 2 dB/m at a frequency of 10 GHz. It shall have an impedance of 50 Ohm. The maximum length of the coax cable shall not exceed 1,5 m. The length of the used coax cable shall be recorded in the test report.

The *RF signal generator* shall have a frequency range of at least 12 GHz. It shall be capable of generating pulses with a length of 50 ns and a rise-time of 10 ns in the frequency range up to 10 GHz. The output of these pulses shall be triggerable by an external signal.

All components shall be calibrated and shall have a VSWR of 1,5 or better.

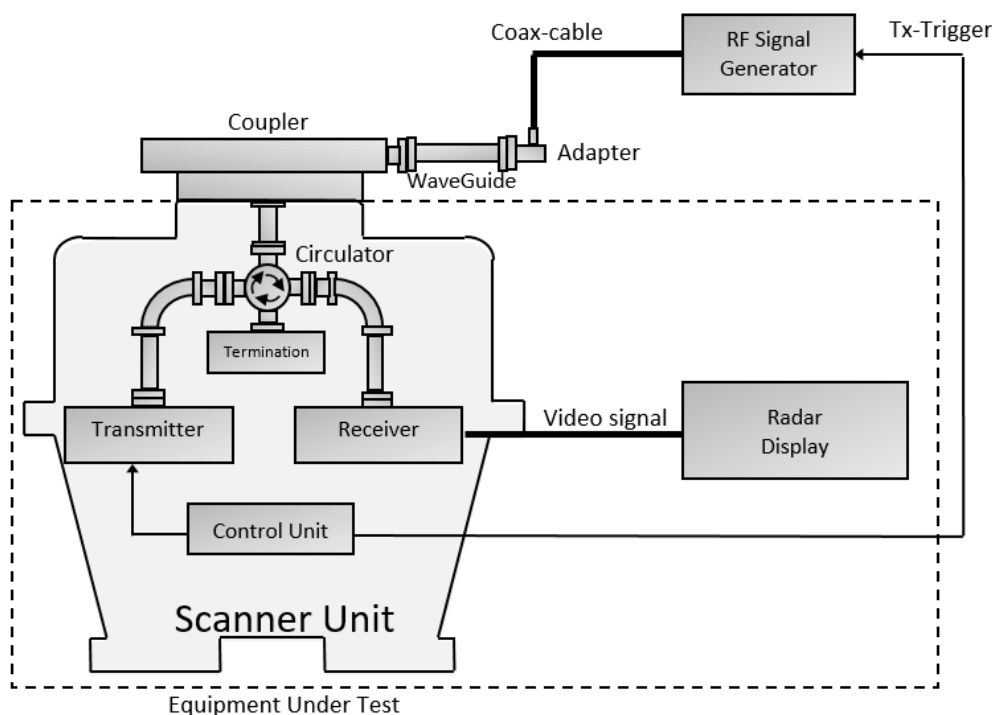


Figure G.1: Set up for the measurement of receiver sensitivity

Annex H (normative): Receiver Selectivity, Receiver Maximum input Level and Receiver non-linearity measurement setup

General setup description

The setup for the measurement of the receiver selectivity, receiver maximum input level and the receiver non-linearity is shown in Figure H.1.

A *coupler* shall replace the antenna. If the radar does not provide a possibility to interrupt the antenna rotation by stopping the antenna motor while maintaining full functionality, this coupler shall be a rotary coupler. The port of the coupler shall be connected to a *waveguide*. This waveguide, in turn, is connected to a RF power combiner via a waveguide/coaxial transition (the *adapter* in Figure G.1) and a *coax cable*. The RF output of the *rf signal generator 1* and the *rf signal generator 2* are connected to the *rf power combiner* via a *coax cable*. The EUT's tx-trigger signal shall be connected to the trigger input port of the *rf signal generator 1* and the rf signal generator 2's trigger input signal shall be connected to the (delayed) trigger output port of *rf signal generator 2*.

Measurement components specifications

The input port of the *coupler* shall be identical to the input port of the radar antenna. The output waveguide port shall be the same as used in the EUT.

The *waveguide* used for this test shall be the same as used in the EUT.

NOTE: The equipment covered by the present document typically use an R100/WR90 waveguide (see IEC 60153-2 [i.11]).

The input port of the waveguide-to-coax *adapter* shall be identical to the input port of the coupled port of the directional coupler. The output port of the adapter shall match the connector of the coax-cable in type and impedance, i.e. 50 Ohm.

The maximal operating frequency of the *coax cable* shall be at least 10 GHz and the attenuation shall not exceed 2 dB/m at a frequency of 10 GHz. It shall have an impedance of 50 Ohm. The maximum length of the coax cable shall not exceed 1,5 m. The length of the used coax cable shall be recorded in the test report.

The *RF power combiner* shall have an insertion loss less than 1,5 dB in the frequency range from 9 GHz to 10 GHz. The two input-to-output paths shall have an amplitude unbalance less than 0,5 dB. Additional ports, if any, shall be terminated with a matched load.

The *RF signal generator 1* shall have a frequency range of at least 12 GHz. It shall be capable of generating pulses with a length of 50 ns and a rise-time of 10 ns in the frequency range up to 10 GHz. The output of these pulses shall be triggerable by an external signal. In addition, it shall have an output port to provide a delayed trigger signal.

The *RF signal generator 2* shall have a frequency range of at least 12 GHz. It shall be capable of generating pulses with a length of 50 ns and a rise-time of 10 ns in the frequency range up to 10 GHz. The output of these pulses shall be triggerable by an external signal.

All components shall be calibrated and shall have a VSWR of 1,5 or better.

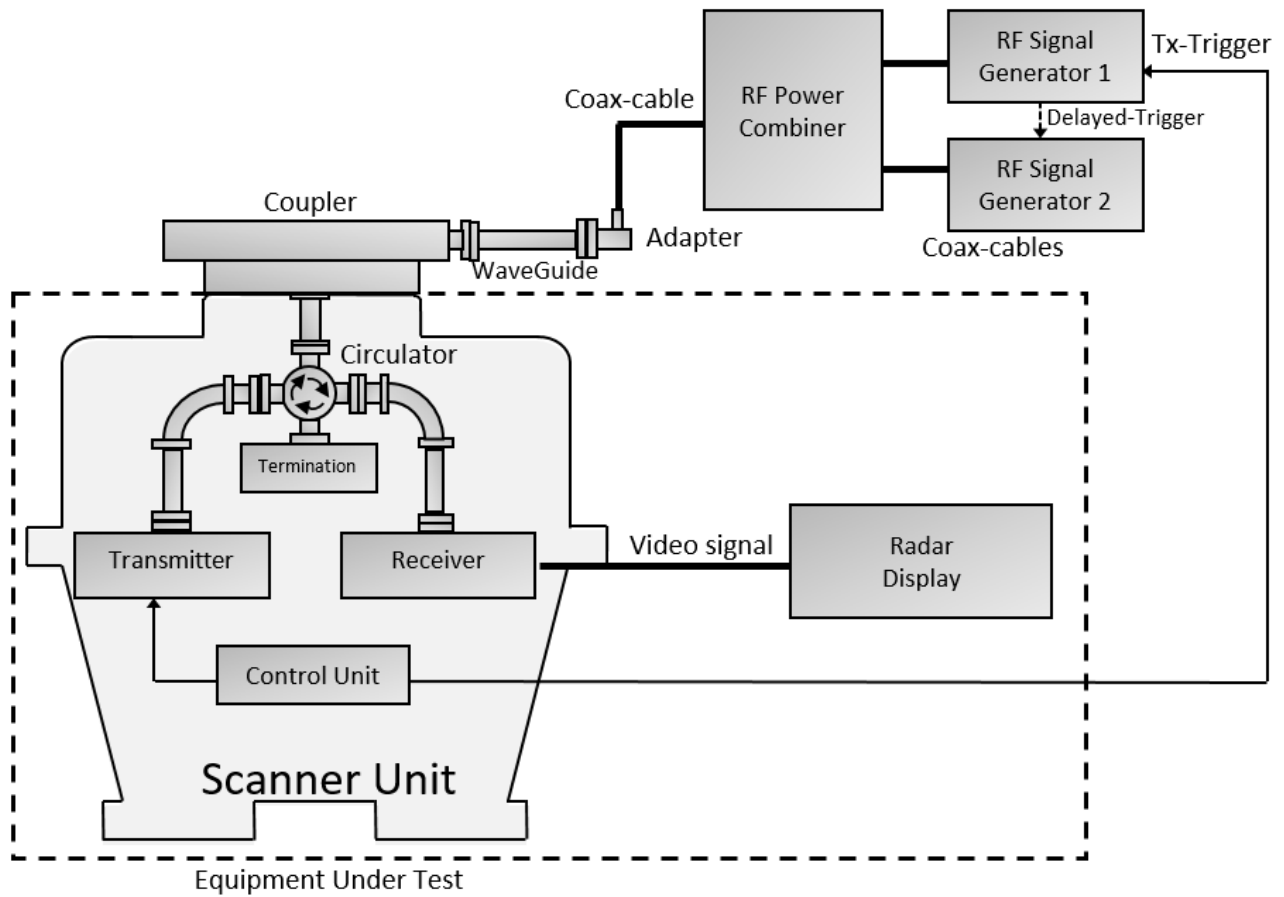


Figure H.1: Set up for the measurement of receiver selectivity, receiver maximum input level and receiver non-linearity

Annex I (normative): Calculation of the -40 dB Bandwidth

Annex 8 of Recommendation ITU-R SM.1541-6 [i.7] specifies the -40 dB bandwidth for various types of waveforms (e.g. pulsed radar signals). The -40 dB bandwidth (B_{-40}) for primary non-FM pulse radars shall be determined as follows:

$$B_{-40} = \frac{7,6}{\sqrt{t \times t_r}} \quad (\text{I.1})$$

Where:

t is the pulse length.

t_r is the rise time in the case of a trapezoidal pulse.

NOTE: Formula (I.1) is applicable when:

- the radar is operating in the band 9 300 MHz to 9 500 MHz;
- the pulse power is below 100 kW (at the transmitter output).

These conditions are met by the radars in the scope of the present document.

The pulse length shall be measured as described in clause 5.5.1.7. The rise time shall be measured as described in clause 5.5.1.8.

Annex J (normative): Setting of B_{ref} , B_{m} , RBW and VBW for Occupied Bandwidth, Measured Bandwidth (B_{-20}), Out-of-Band Emissions, Spurious Emissions and Stand-by Emissions

The setting of the reference bandwidth (B_{ref}), the measurement bandwidth (B_{m}), the Resolution Bandwidth (RBW) and the Video Bandwidth (VBW) shall be done as follows:

- $B_{\text{ref}} = 1 \text{ MHz}$ (see note 2).
- $B_{\text{m}} < 1 \text{ MHz}$ (see note 3).
- The RBW shall be set close to but less than 667 kHz (see note 4).
- $\text{VBW} = 1 \text{ MHz}$ (see note 5).

NOTE 1: In Recommendation ITU-R 1177-4 [i.4], the ITU Radiocommunication Assembly recommends that measurement techniques described in Annex 1 of that document should be used to provide guidance in quantifying radiated unwanted emission levels from radar stations operating above 400 MHz.

NOTE 2: Recommendation ITU-R 1177-4 [i.4], Annex 1 recommends calculating the reference bandwidth B_{ref} for fixed-frequency, non-pulse-coded radar as subject to the present document with the following formulae: one divided by the radar pulse length. Since the shortest pulse length is in all cases far below $1 \mu\text{s}$ (typically 50 ns) to meet the requirements of the performance standard for navigational radar used on inland waterways defined in ETSI EN 303 676 [i.6], this formulae gives a result greater than 1 MHz. Recommendation ITU-R 1177-4 recommends for all cases, where the bandwidth is greater than 1 MHz to use a B_{ref} of 1 MHz.

NOTE 3: Recommendation ITU-R 1177-4 [i.4], Annex 1 recommends setting the measurement bandwidth B_{m} for fixed-frequency, non-pulse-coded radar as subject to the present document to less than or equal to one divided by the radar pulse length. As explained in note 2, this gives a result less than or equal to 1 MHz. Recommendation ITU-R 1177-4 [i.4] recommends using a RBW of the spectrum analyser leading to a B_{m} less than B_{ref} .

NOTE 4: Recommendation ITU-R 1177-4 [i.4], Section 3 of Annex 1 recommends using a B_{IF} (RBW) of the spectrum analyser leading to a B_{m} equal to $\text{RBW} \times \text{MBR}$. MBR is the Measurement Bandwidth Ratio. MBR is approximately 3/2 for a -3 dB IF bandwidth Gaussian filter as typically used in many commercial spectrum receivers.

NOTE 5: Recommendation ITU-R 1177-4 [i.4], Annex 1 recommends setting the video bandwidth greater or equal to measurement system bandwidth.

NOTE 6: Whilst the recommendations in Recommendation ITU-R 1177-4 [i.4] apply to unwanted emissions only, the same settings are applied to the measurement of the occupied bandwidth and B_{-20} since these measurements are relative power measurements as well.

Annex K (normative): Out-of-band Emissions, Spurious Emissions and Stand-by Mode Emissions measurement procedure

K.1 Measurement antenna position

The measurement setup shall be as described in Annex E.

The measurement steps shall be as follows:

- a) Place the antenna to a point of maximum peak received signal.
- b) Use absorber such that a movement of the antenna by $\lambda D/2H$ in horizontally or vertically direction away from this point does not cause a reduction of the peak received signal by more than 3 dB (H: height of the transmitting point, D: measurement distance, λ : transmitting wave length), see Annex E, Figure E.1.

NOTE: See Annex 1 of Recommendation ITU-R 1177-4 [i.4] for additional information.

K.2 Correction for variable measurement antenna gain

If the measurement antenna has a constant effective aperture, no corrections for variable antenna gain are required. Otherwise, the measurement steps shall be as follows:

- a) Apply the deviation of the gain of the measurement antenna from constant effective aperture (i.e. from the decreasing $20 \log(f)$ curve) to measurements results.
- b) Record the corrections in the test report.

NOTE: See Annex 1, Section 6.2 of Recommendation ITU-R 1177-4 [i.4] for additional information.

K.3 Measurement system calibration

All the measuring components shall be calibrated individually.

K.4 Measurement procedure

The measurement steps shall be as follows:

- a) Set the spectrum analyser to the values given in Annex J.
- b) Set trace mode to "Max Hold".
- c) Set the sweep time to automatic.
- d) Sweep across the spectrum in fixed increments, determined by the span set in the spectrum analyser.
- e) Adjust the attenuator to keep the signal peak power within the dynamic range of the measurement system.
- f) Perform the measurement.
- g) Record the signal a least for three complete antenna rotations.

Annex L (informative): Checklist

This annex provides a traceability of the technical parameters for article 3.2 of Directive 2014/53/EU [i.1] defined in ETSI EG 203 336 [i.5] with the technical requirements for conformance defined in clause 4 of the present document. If a technical parameter for article 3.2 of Directive 2014/53/EU [i.2] defined in ETSI EG 203 336 [i.5] has not been included in the present document, an explanation is provided. An explanation is also provided whenever a technical parameter defined in ETSI EG 203 336 [i.5] is covered by an alternative technical requirement.

Some technical parameters defined in ETSI EG 203 336 [i.5] are applicable only to communication systems and not to non-cooperative radar systems such as coastal surveillance radar systems. Non-cooperative radar systems are different from radiocommunication systems since they do not communicate with a known target with known properties. They continually scan for unknown targets of any nature and do not adjust receiver or transmitter parameters according to what they detect.

Table L.1: Checklist

Technical Parameters defined in ETSI EG 203 336 [i.5]	Clauses of the present document	Comments
Transmitter Parameters		
Transmit power (and possible accuracy)	4.2.1.2	
Spectrum mask	4.2.1.4 4.2.1.5	
Transmitter frequency stability	4.2.1.1	As specified in appendix 2 of the ITU Radio Regulations [i.3], footnote 33: "Where specific frequencies are not assigned to radar stations, the bandwidth occupied by the emissions of such stations shall be maintained wholly within the band allocated to the service and the indicated tolerance does not apply". This technical requirement is therefore addressed by the occupied bandwidth specified in clause 4.2.1.1.
Transmitter intermodulation attenuation	NA	Radars in the scope of the present document have a magnetron driven transmitter. A magnetron generates the power RF signal directly without a mixer stage. Therefore, no intermodulation in the transmitter is possible. In addition, the radars within the scope of the present document are using a 4-port circulator or equivalent.
Unwanted emissions (OoB and spurious domains)	4.2.1.4 4.2.1.5 4.2.1.6	
Transmitter time domain characteristics (e.g. the duty cycle, turn-on and turn-off, frequency hopping cycle, dynamic changes of modulation scheme and others)	NA	The time domain characteristics for the radars are ruled by physical restrictions and design properties. For example, it is not possible to set a requirement for the duty cycle since this depends on the radar range and is linked to the performance of the radar which is not coordinated with other radars. Radars in the scope of the present document are designed for sharing the same nominal frequency without any coordination using techniques like low duty cycle and transmitter timing (staggered transmission scheme). Coexistence between radars is managed in a different way from communication systems. This is possible due to rotating high directivity antennas, staggered transmission schemes, gating of receiver and digital processing. Due to their mobility a geographic coordination is also not possible. The conclusion is that this requirement is not applicable.
Transmitter transients	4.2.1.4 4.2.1.5	This requirement is covered by the spectrum mask.

Receiver Parameters		
Receiver sensitivity	4.2.2.1	
Receiver co-channel rejection	NA	The concept of spatial reuse of the same frequency as stated in ETSI EG 203 336 [i.5] does not apply for mobile radars. Radars in scope of the present document are designed for sharing the exact same frequencies without any coordination between the systems. This is possible due to rotating high directivity antennas, pulsed and staggered transmission schemes, gating of receiver, digital processing, not-co-siting etc. An interference from another service (i.e. from other radar) would be filtered out by the Interference Rejection function that is available in all products on the market.
Adjacent band/channel selectivity	4.2.2.2	
Spurious response rejection	4.2..2.2	The selectivity requirement covers also image and intermediate frequencies.
Receiver blocking	4.2.2.3	Receiver Blocking is addressed by receiver maximum input level. Too strong disturbing input signals are leading to insufficient radial resolution capability of the radar. The receiver maximum input level test is defined in clause 5.5.2.3. In a radar design this has to be weighed against the performance requirement of detecting very low signals, and the possible dynamic range.
Receiver radio-frequency intermodulation	4.2.2.4	Receiver radio-frequency intermodulation is addressed by the receiver non-linearity test.
Receiver dynamic range	4.2.2.1 4.2.2.3	The lower end of the receiver dynamic range is addressed by the sensitivity. The upper end is addressed by the receiver maximum input level.
Reciprocal mixing	4.2.2.2	Reciprocal mixing is addressed by the receiver selectivity test.
Receiver unwanted emissions in the spurious domain	4.2.1.6	

Annex M (informative): Bibliography

Recommendation ITU-R SM.328-11: "Spectra and bandwidth of emissions".

Recommendation ITU-R SM.329-12: "Unwanted emissions in the spurious domain".

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".

ANSI C63.5 (2006): "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electro Magnetic Interference".

Annex N (informative): Change history

Version	Information about changes
V2.1.1.1.2 (2017-02)	First version of the Harmonised Standard
V2.2.1 (2025)	Emissions are aligned with ERC 74-01 and ECC (02)05 The following requirements have been added: • Occupied Bandwidth • Measured Bandwidth • Stand-by Mode Emissions • Receiver requirements (Sensitivity, Selectivity, Maximum input Level and non-Linearity).

History

Document history		
V2.0.0	November 2025	SRdAP process EV 20260215: 2025-11-17 to 2026-02-16