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Advanced Surface Movement Guidance and Control System (A-SMGCS); Part 6: Harmonised Standard for access to radio spectrum for deployed surface movement radar sensors; Sub-part 1: X-band sensors using pulsed signals and transmitting power up to 100 kW

Reference
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ETSI

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

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

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Contents

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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 standards EN Approval Procedure.

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.6] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

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

The present document is part 6, sub-part 1 of a multi-part deliverable covering Advanced Surface Movement Guidance and Control System (A-SMGCS), as identified below:

Part 1: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for A-SMGCS surveillance service";

Part 2: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for A-SMGCS Level 2 including external interfaces";

Part 3: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for a deployed cooperative sensor including its interfaces";

Part 4: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for a deployed non-cooperative sensor including its interfaces";

Part 5: "Harmonised Standard for access to the radio spectrum for Multilateration (MLAT) equipment";

Part 6: "Harmonised Standard for access to radio spectrum for deployed surface movement radar sensors";

Sub-part 1: "X-band sensors using pulsed signals and transmitting power up to 100 kW".

Part 7: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for A-SMGCS routing service";

Part 8: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for A-SMGCS guidance service";

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).

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

1 Scope

The present document specifies technical characteristics and methods of measurements for monostatic X-band radar sensors intended for the surveillance of airport surface movement traffic with the following characteristics:

- Operating in one or both of the following frequency ranges:
  - 9 000 MHz to 9 200 MHz and 9 300 MHz to 9 500 MHz utilizing modulated or unmodulated pulses.
- Transmitter Peak Envelope Power up to 100 kW.
- The transceiver-antenna connection is using a hollow metallic rectangular waveguide.
- The antenna is rotating, waveguide-based and passive.
- At the transceiver output an RF-circulator is used.

NOTE 1: Since transceiver and antenna are hollow metallic rectangular waveguide based the frequency range for measurements that needs to be addressed covers 6,56 GHz to 26 GHz. The lower limit of this frequency range is obtained as cut-off frequency of the combination of WR112/R84 taper section and a WR90/R100 Waveguide IEC 60153-2 [i.3]. The upper limit corresponds to the upper limit stated in table 1 of ERC Recommendation 74-01 [2].

NOTE 2: Since at the transceiver output an RF circulator is used, it is assumed that the transceiver characteristics remain independent from the antenna.

NOTE 3: Aeronautical Surface Movement Radars covered by the present document are expected to use the bands 9 000 MHz to 9 200 MHz and/or 9 300 MHz to 9 500 MHz. According article 5 of the ITU Radio Regulations [3] the band 9 000 MHz to 9 200 MHz is allocated to the Aeronautical Radionavigation Service on a primary basis and the band 9 300 MHz to 9 500 MHz is allocated to the Radionavigation Service on a primary basis.

NOTE 4: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU [i.1] is given in annex A.

2 References

2.1 Normative references

References are specific, identified by date of publication and/or edition number or version number. Only the cited version applies.

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

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

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

[1] ECC Recommendation (02)05 (2012): "Unwanted emissions".

[2] ERC Recommendation 74-01 (2011): "Unwanted emissions in the spurious domain".

[3] ITU Radio Regulations (2016).

2.2 Informative references

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

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

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

[i.2] Merrill I. Skolnik: "Radar Handbook", 2nd Edition, McGraw Hill publications.

[i.3] IEC 60153-2 (Edition 2.0, 1974): "Hollow metallic waveguides. Part 2: Relevant specifications for ordinary rectangular waveguides".

[i.4] Void.

[i.5] Recommendation ITU-R SM.1541-6 (08/2015): "Unwanted emissions in the out-of-band domain".

[i.6] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

active state: which produces the authorized emission

allocated band: frequency span that regionally or nationally is allocated to one or more radio services on a primary or secondary basis

NOTE: A table of national frequency allocations are normally available from the radio authority for each national state. Also a generic frequency allocation table is available in the ITU Radio Regulations [3].

declared band: band or bands within which the product under test is declared to operate in the applicable operating modes

NOTE: The declared band for a given region or country is always contained within the allocated band.

idle/standby 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: This definition is taken from ITU Radio Regulations [3].

Minimum Detectable Signal (MDS): measure of the lowest detectable signal amplitude for a given signal type for a given radar

NOTE: For solid state radars a processing gain can be associated with a received signal. This processing gain has the effect of lowering the MDS level in comparison to a MDS which is based only on noise temperature.

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 β/2 of the total mean power of a given emission

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

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

operating mode: predefined configuration for a given service accessible to the operator of the radar system

NOTE 1: Several operating modes may be available.

NOTE 2: Changing operating mode might affect the radio characteristics of the radar system.

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 [3].

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

pulse duration: 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)

simple pulse radar: radar using pulsed emissions but not using frequency, phase or power modulation

3.2 Symbols

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

B_{-40}	-40 dB bandwidth
B_C	Chirp bandwidth
B_N	Necessary bandwidth
B_{res}	3 dB resolution bandwidth of transceiver
dB/dec	dB per decade
dBpp	dB with respect to peak power
$D_{no\ spur}$	Detectability Factor (function of PD & Pfa)
k	Boltzmann's constant
MDS	Minimum Detectable Signal
NF_{sys}	Noise Factor of the system
P_D	Probability of detection
P_{FA}	Probability of false alarm
P_t	Pulse power of transmission
t	Time
t_p	Pulse duration
t_r	Pulse rise time
T_0	Temperature in Kelvin
T_C	Pulse length (of individual chirp) in seconds
λ	Wavelength

3.3 Abbreviations

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

AC	Alternating Current
A-SMGCS	Advanced - Surface Movement Guidance and Control System
EN	European Standard
FM	Frequency Modulation
LNA	Low Noise Amplifier
MDS	Minimum Detectable Signal
OoB	Out-of-Band
PEP	Peak Envelope Power
RF	Radio Frequency
SMR	Surface Movement Radar
WG	WaveGuide

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 declared by the manufacturer, 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 which are identified as applicable in annex A at all times when operating within the boundary limits of the declared operational environmental profile.

4.2 Conformance requirements

4.2.1 Transmitter requirements

4.2.1.1 Frequency Tolerance

4.2.1.1.1 Definition

The transmitter of a pulsed radar produces microwave pulses, which cause a broad frequency spectrum, depending on the pulse duration.

The frequency tolerance is the maximum permissible departure by the centre frequency of the frequency band occupied by an emission from the assigned frequency or, by the characteristic frequency of an emission from the reference frequency.

4.2.1.1.2 Limits

The frequency tolerance for SMR applying unmodulated pulses shall not exceed 1 250 ppm as per appendix 2 of the Radio Regulations [3].

4.2.1.1.3 Conformance

The conformance tests are specified in clause 5.3.1.1.

4.2.1.2 Transmitter power

4.2.1.2.1 Definition

In the present document the transmitter power of a pulse radar is considered to be the peak value of the transmitter pulse power during the transmission pulse (PEP).

If the transmitter power varies over the azimuth, the highest PEP over at least one rotation period has to be used.

The transmitter power shall be referenced with respect to the output port of the radar transmitter.

4.2.1.2.2 Limits

The transmitter power shall be as specified by the manufacturer and shall not exceed 100 kW (50 dBW).

4.2.1.2.3 Conformance

The conformance tests are specified in clause 5.3.1.2.

4.2.1.3 Measured Bandwidth

4.2.1.3.1 Definition

The measured -40 dB bandwidth (B_{-40}) is the measured bandwidth of the emission 40 dB below the measured PEP.

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

4.2.1.3.2 Limits

For radar types using a modulated pulse the measured -40 dB bandwidth of the signal shall be contained completely within the declared band in all operating modes.

In case of multiple carrier-frequencies, all measured -40 dB emissions shall be contained within the declared band.

NOTE 1: The declared band is always contained in the 9 000 MHz - 9 200 MHz and/or 9 300 MHz - 9 500 MHz frequency range.

For magnetron radars the measured -20 dB bandwidth of the signal shall be contained completely within the band. In case of multiple carrier-frequencies magnetron radars, all measured -20 dB emissions shall be contained within the declared band.

NOTE 2: Magnetron radars will not be able to fit the -40 dB bandwidth within the band due to the physical properties of this technology and the requirements for the minimal operational performance.

4.2.1.3.3 Conformance

The conformance tests are specified in clause 5.3.1.3.

4.2.1.4 Out-of-band emissions

4.2.1.4.1 Definition

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

The Out-of-Band emission limits and the spurious emission limits are defined based on the effective -40 dB bandwidth. Annex C contains the applicable formulae for calculating the -40 dB bandwidth.

For radars with multiple carrier frequencies, the overall emission mask is obtained by superimposing the emission masks of each individual carrier frequency. An example can be seen in figure 1.

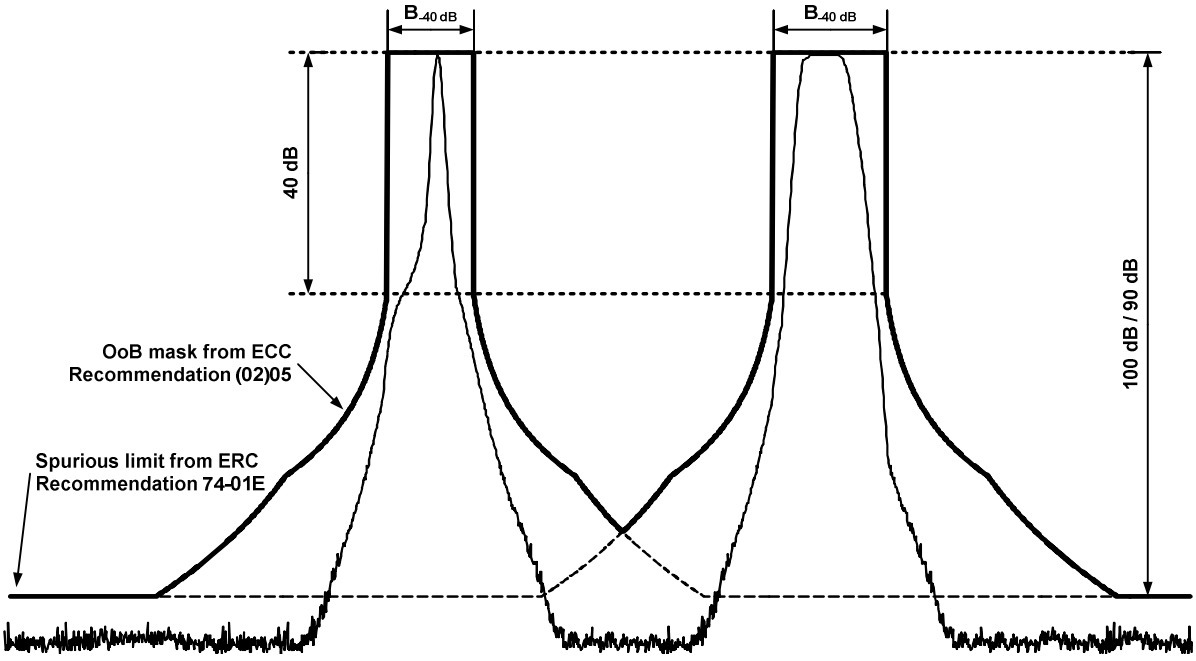

Figure 1: Example of superimposed (combined) mask from two carrier frequencies

4.2.1.4.2 Limits

The limits for the OoB spectrum mask shall be as specified in Annex 2 of ECC Recommendation (02)05 [1].

The Out-of-Band emission limits are defined based on the -40 dB bandwidth (B_{-40}). The Out of Band mask rolls off at 30 dB per decade, from the B_{-40} bandwidth to the level specified for spurious emissions.

For multi-frequency/frequency diversity and active array radars spurious emission limits shall be 43+ 10log (PEP) or 60 dB_{pp} (whichever is less stringent) as specified in table 5.1 of ECC Recommendation 74-01 [2] and in table 1 below.

Table 1: Limits for unwanted emissions for multiple frequency and active arrays

Frequency offset relative to B_{-40}	Limit dBpp	Slope dB/decade
0,5 to 2,3	-40 to -43 - 10*log(PEP) / -60 (see note)	-30
NOTE: From -40 to -43 - 10*log(PEP) or -60 dBpp whichever is less stringent.		

For all other radar systems spurious emission limits shall be -30 dBm or 100 dB_{pp} (whichever is less stringent) as specified in table 5.1 of ECC Recommendation 74-01 [2] and in table 2 below.

Table 2: Limits for unwanted emissions for all other radar systems

Frequency offset relative to B_{-40}	Limit dBpp	Slope dB/decade
0,5 to 5	-40 to -70	-30
5 to 15,8	-70 to -100 / -30 dBm (see note)	-60
NOTE: From -70 to -100 or -30 dBm whichever is less stringent		

Example of the unwanted emission mask per table 2 is shown in figure 2.

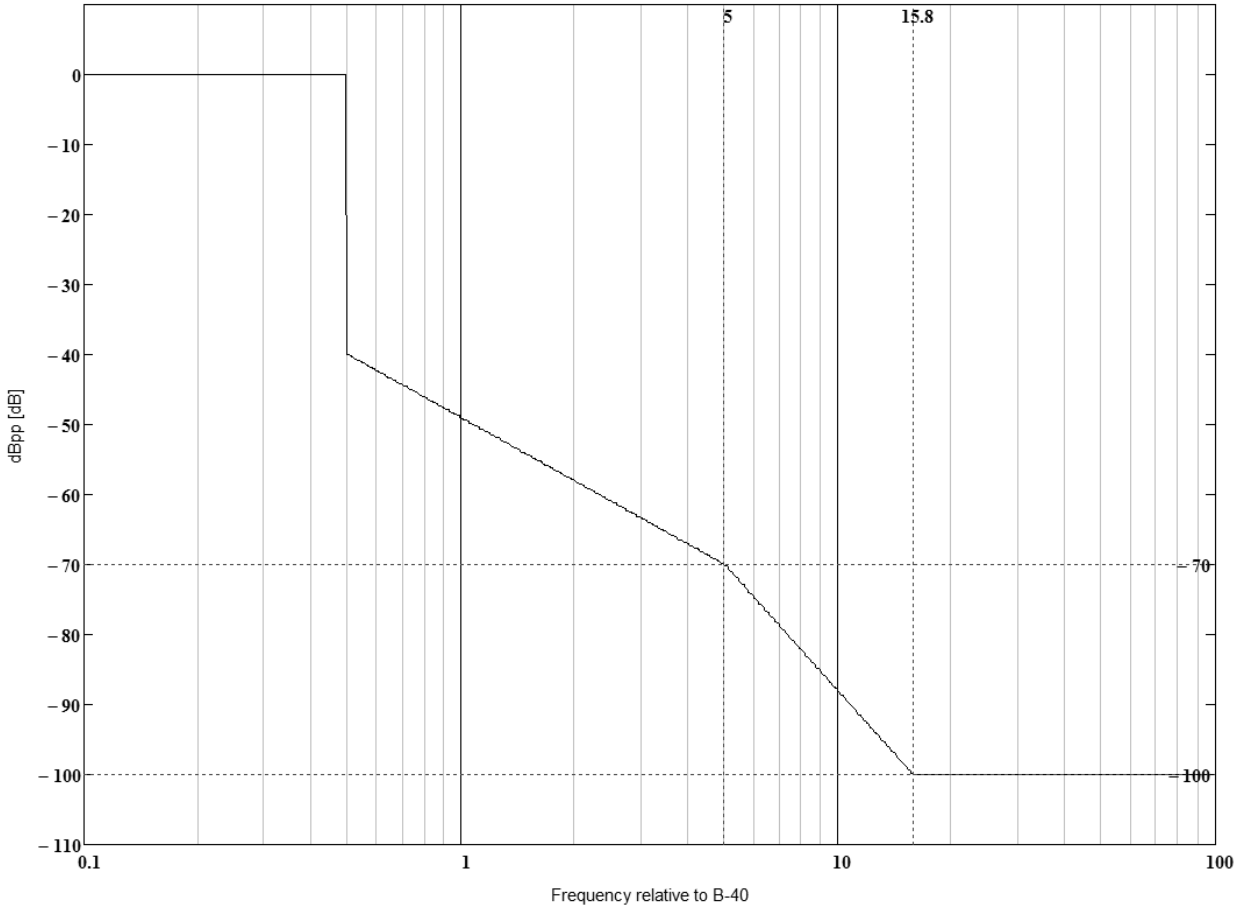

Figure 2: Out-of-Band emission limit masks

4.2.1.4.3 Conformance

The conformance tests are specified in clause 5.3.1.4.

4.2.1.5 Spurious emissions

4.2.1.5.1 Definition

Spurious emissions are defined as the entity of all emissions in the frequency range of the cut-off frequency 6,56 GHz of the waveguide section to 26 GHz, but outside the OoB-boundaries.

NOTE: The lower limit of this frequency range of 6,56 GHz is obtained as cut-off frequency of the combination of WR112/R84 taper section and a WR90/R100 Waveguide as defined in IEC 60153-2 [i.3]. The upper limit corresponds to the upper limit stated in table 1 of ERC Recommendation 74-01 [2].

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.

The boundaries between OoB domain and the spurious domain are where the OoB limit mask specified in ECC Recommendation (02)05 [1], annex 2 specifies a spurious emission limit of -100 dBpp according to ERC Recommendation 74-01 [2], annex 5. This is illustrated in figure 3.

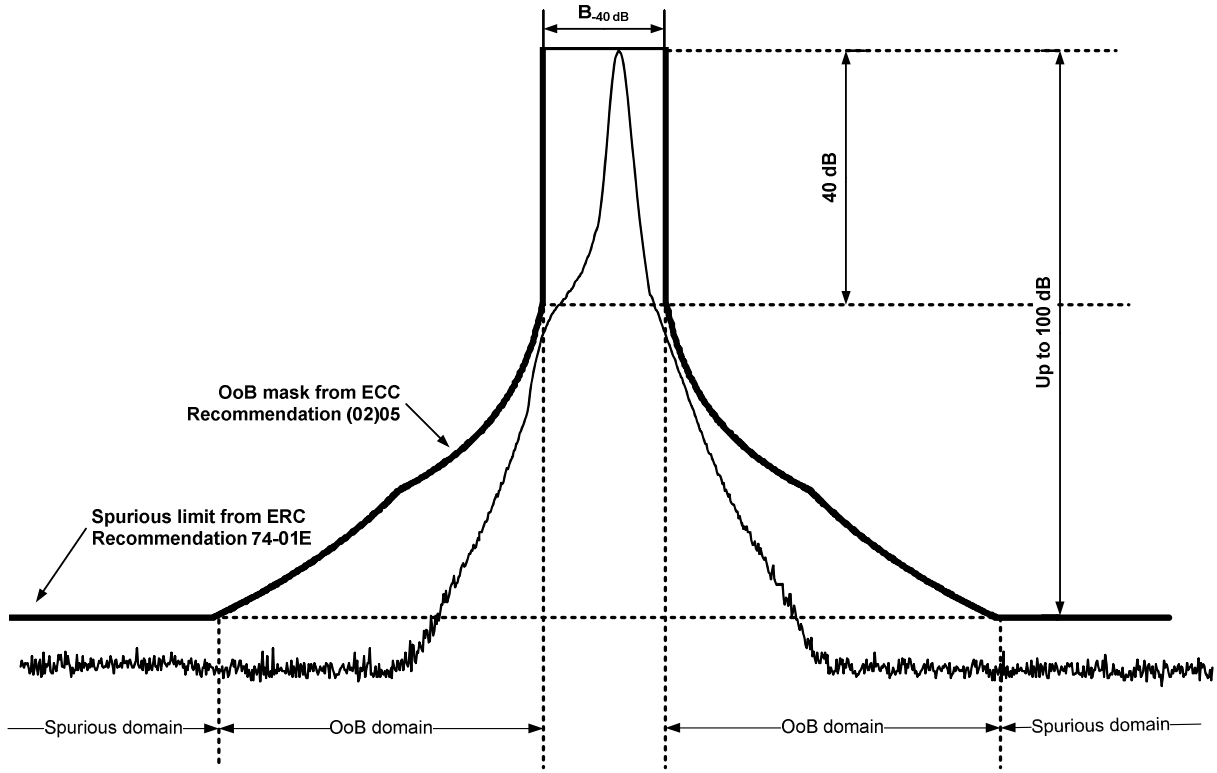

Figure 3: Definition of OoB and spurious emission domains (not to scale)

4.2.1.5.2 Limits

For primary surveillance radar systems, the spurious emissions limits are related to the PEP and shall be as specified in ERC Recommendation 74-01 [2], annex 5 and also shown in table 3 below.

Table 3: Limits for spurious emissions

Radar type	Spurious emission limits
Multi-frequency and active array	-43 - 10*log(PEP) or -60 dB (see notes 1 and 2)
Other types of fixed stations	-100 dB or -30 dBm (see note 1)
NOTE 1: Whichever is less stringent. NOTE 2: PEP is measured in Watts in the reference bandwidth of 1 MHz.	

NOTE: A reference bandwidth of 1 MHz is recommended for frequencies above 1 GHz as in ERC Recommendation 74-01 [2].

4.2.1.5.3 Conformance

The conformance tests are specified in clause 5.3.1.5.

4.2.1.6 Stand-by Mode Emissions

4.2.1.6.1 Definition

Stand-by Mode emissions refer to emissions radiated during periods of non-transmission (e.g. between pulses).

The stand-by mode output power is defined as the power output at the antenna flange in the spurious region.

For the stand-by mode the limits between OoB and spurious regions are considered the same as calculated for the active state.

4.2.1.6.2 Limits

The maximum allowed power level shall be -47dBm when measured with a measurement bandwidth of 1 MHz as specified in table 5.1 of ERC Recommendation 74-01 [2].

4.2.1.6.3 Conformance

The conformance tests are specified in clause 5.3.1.6.

4.2.2 Receiver requirements

4.2.2.1 System Noise Figure

4.2.2.1.1 Definition

The system noise figure measures the degradation of the signal-to-noise ratio, caused by components in the radio-frequency signal chain.

4.2.2.1.2 Limits

The maximum system Noise Figure shall be 6 dB.

4.2.2.1.3 Conformance

The conformance tests are specified in clause 5.3.2.1.

4.2.2.2 Receiver Selectivity

4.2.2.2.1 Definition

The receiver selectivity is the ability of a receiver to reject interfering signals outside the B_{-40} bandwidth.

NOTE: Signals inside the B_{-40} bandwidth are not considered as interfering signals because they fall into the desired frequency range for the reception of wanted signals.

4.2.2.2.2 Limit

The input selectivity characteristic of the radar receiver shall correspond to the requirements for the spectrum of the emitted signal as specified in clause 4.2.1.4. The derivation of the receiver Out-of-Band selectivity curve is described in clause 5.3.2.2.

4.2.2.2.3 Conformance

The conformance tests are specified in clause 5.3.2.2.

4.2.2.3 Receiver Compression Level

4.2.2.3.1 Definition

The compression level is defined as when one of the receiver stages becomes non-linear thereby causing distortion and other non-linear effects that prevent proper operation of the receiver.

The receiver input compression level is defined as when the receiver output is 1 dB into compression.

4.2.2.3.2 Limit

The input of the radar shall be able to handle signal levels up to at least -35 dBm (measured at the waveguide flange) without being in compression. The measurement of compression signal level shall be done at the output of the A/D driver amplifier (analog) or by data analysis at the output of the A/D converter (digital).

NOTE: A high compression level corresponds to high immunity against blocking.

4.2.2.3.3 Conformance

The conformance tests are specified in clause 5.3.2.3.

5 Testing for compliance with technical requirements

5.0 General requirements

The manufacturer shall ensure that all operating modes and product configurations are in compliance with the technical requirements in the present document.

5.1 Environmental conditions for testing

5.1.1 Test Conditions

Unless otherwise stated, all tests shall take place under the following normal test conditions.

The standard operating parameters depend very much on the type of the radar. If a particular operating mode is used for measurement this shall be noted by the manufacturer.

5.1.2 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;

b) relative humidity: not exceeding 75 %.

5.1.3 Normal 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 each of the declared voltages for which the equipment is indicated as having been designed. The frequency of the test voltage shall be 50 Hz ± 1 Hz.

5.2 Interpretation of the measurements 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.

Recommended values for the maximum measurements uncertainty figures can be found in annex D.

5.3 Radio test suites

5.3.1 Transmitter test specification

5.3.1.1 Frequency Tolerance

In order to measure the frequency tolerance for unmodulated pulse radars the measurement is done on the antenna interface. The antenna shall be replaced by a suitable adapter to adapt the rotary joint to a waveguide with a plane flange. 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 8 600 MHz to 9 900 MHz (400 MHz outside edges of the declared bands) to protect the measurement equipment.

When measuring the frequency tolerance for radars with a phase or frequency modulated pulse the tolerance shall be measured on the frequency reference(s) used for generating the radar output signal.

The results obtained shall be compared to the limits in clause 4.2.1.1.2 in order to prove compliance with the requirement.

5.3.1.2 Transmitter power

The antenna shall be replaced by a suitable adapter to adapt the rotary joint to a waveguide with a plane flange. On that flange a high-power directional coupler will be mounted with its main port terminated by a matching high-power dummy load (see figure B.1). The coupled port shall have a sufficient attenuation within the whole frequency band 8 600 MHz to 9 900 MHz to avoid saturation of the measurement equipment.

Measurement setup shall be as described in annex B.

To determine the Peak Envelope Power (PEP) of the pulse a suitable pulse power meter with direct reading of the transmitter pulse power shall be used.

To reference the indicated transmitter power to the transmitter output flange the coupling factor has to be taken into account.

NOTE: Either the power meter allows already for compensation of the coupling loss, or the coupling loss has to be added to the meter reading.

The results obtained shall be compared to the limits in clause 4.2.1.2.2 in order to prove compliance with the requirement.

5.3.1.3 Measured Bandwidth

The measurements of the bandwidth (B_{-40} or, for magnetron radars, B_{-20}) shall be performed with the same settings as in clause 5.3.1.4.

The bandwidth of the emissions 40 dB below PEP (or 20 dB below PEP for magnetron radars) shall be measured. Measurement setup shall be as described in annex B.

The results obtained shall be compared to the limit in clause 4.2.1.3.2 in order to prove compliance with the requirement.

5.3.1.4 Out-of-Band-emissions

The so-called indirect method shall be applied for the measurement of unwanted emissions of radar systems. At first the transmitter output spectrum is measured with removed antenna at the output port of the transmitter as illustrated in figure B.1.

NOTE 1: To obtain a sufficient dynamic range the radar signal may need to be suppressed by e.g. additional notch-filter.

For multi-frequency and active array radars the Out-of-Band power emission shall be measured in the frequency bands given in table 4.

For all other radar systems the Out-of-Band power emission shall be measured in the frequency bands given in table 5.

B_{-40} is calculated from the formulae in annex C.

Measurement setup shall be as described in annex B.

The results obtained shall be compared to the limits in clause 4.2.1.4.2 and depicted in figure 1 and 2 in order to prove compliance with the requirement.

NOTE 2: These OoB-boundaries are taken from ECC Recommendation (02)05 [1], annex A.

Table 4: Out-of-Band emissions boundaries for multiple frequency and active arrays

Lower OoB boundary	Upper OoB boundary
Centre frequency -2,3 B_{-40}	Centre frequency + 2,3 B_{-40}
NOTE 1: The values are taken from ECC Recommendation (02)05 [1]. NOTE 2: Measurements below the waveguide cut-off frequency are not necessary.	

Table 5: Out-of-Band emissions boundaries for all other radar systems

Lower OoB boundary	Upper OoB boundary
Carrier frequency -15,8 B_{-40}	Carrier frequency + 15,8 B_{-40}
NOTE 1: The values are taken from ECC Recommendation (02)05 [1]. NOTE 2: Measurements below the waveguide cut-off frequency are not necessary.	

All measurements of Out-of-Band emissions shall be made with a reference bandwidth of 1 MHz.

Figures 4 and 5 depict the calculated emission masks for the aforementioned parameters of a typical SMR applying the mask specification in clause 4.2.1.4 which is corresponding to the standard mask in figure A2.1c of ECC Recommendation (02)05 [1].

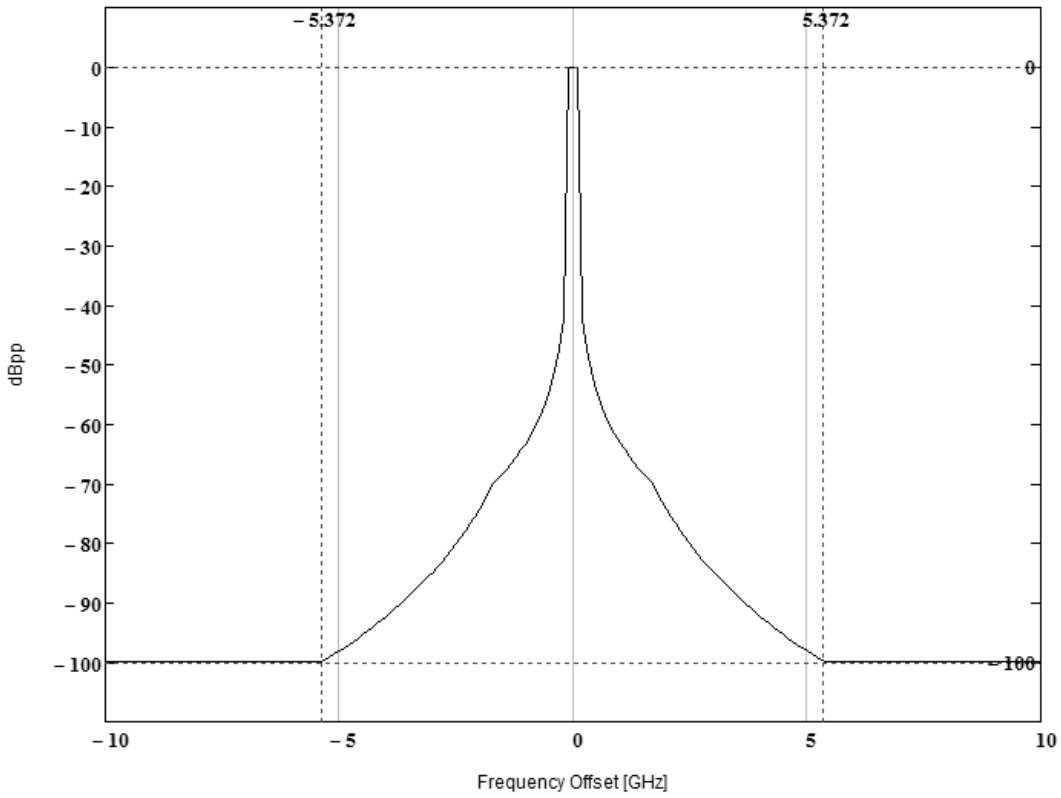

Figure 4: Calculated emission mask for typical pulse duration of t = 50 ns and rise time of t_r = 10 ns

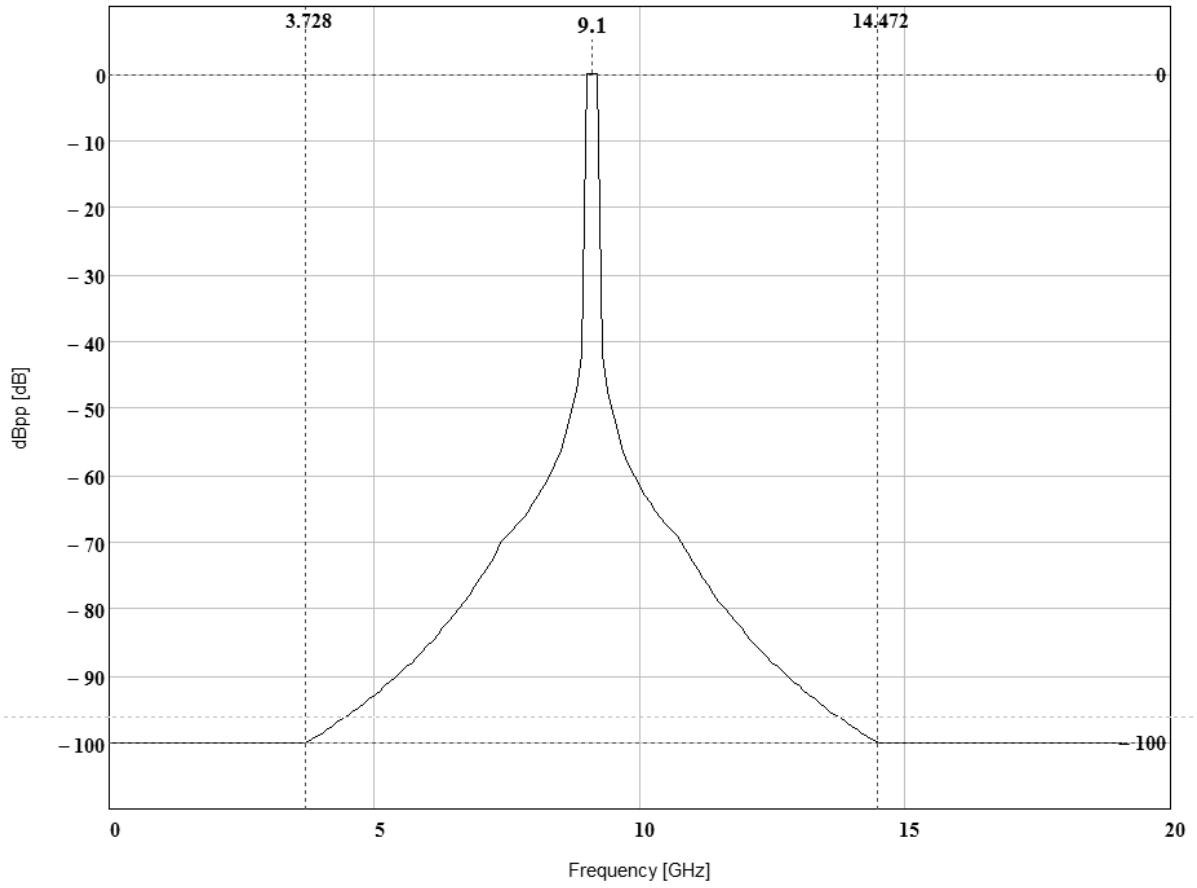

Figure 5: Calculated emissions mask for pulse duration of t = 50 ns and rise time of t_r = 10 ns at centre frequency of 9,1 GHz

5.3.1.5 Spurious emissions

For the spurious emission measurements the aforementioned indirect method shall be used. To perform the measurement the radar and the measuring equipment shall be installed as displayed in figure B.1. The spurious power emission shall be measured in frequency ranges outside the Out-of-Band emissions boundaries (see table 6).

If required to reach a dynamic amplitude measuring range of 110 dB minimum, a Low Noise Amplifier (LNA), and a notch filter for the operating frequency should be used.

Measurement setup shall be as described in annex B.

The results obtained shall be compared to the limits in clause 4.2.1.5.2 in order to prove compliance with the requirement.

All measurements of spurious emissions shall be made with a reference bandwidth of 1 MHz.

Table 6: Spurious emissions measurement bands

Lower measurement band	Upper measurement band
From 6,56 GHz to the lower OoB boundary	From the upper OoB boundary to 26 GHz

5.3.1.6 Stand-by Mode Emissions

For the spurious emission measurements the aforementioned indirect method shall be used. To perform the measurement the radar and the measuring equipment shall be installed as displayed in figure B.1 and be placed in stand-by mode but still powered on.

The spurious power emission shall be measured in frequency ranges outside the Out-of-Band emissions boundaries (see tables 4 and 5).

The results obtained shall be compared to the limit in clause 4.2.1.6.2 in order to prove compliance with the requirement.

All measurements of spurious emissions shall be made with a reference bandwidth of 1 MHz.

5.3.2 Receiver test specification

5.3.2.1 System Noise Figure

5.3.2.1.0 General

The system noise figure is measured along the complete receiving signal chain (as close as possible, including quantization noise, but excluding antenna & installation waveguide, and noise processing). It shall be measured using a noise source over the operating band.

The required measurement method for the System Noise Figure is the Y-factor method. A noise source is connected in lieu of the antenna to the radar receiver input port. The System Noise Figure is then determined from the ratio between the noise power values at output of the intermediate frequency stage (or its digitized equivalent) with noise source on and noise source off.

5.3.2.2 Receiver Selectivity

5.3.2.2.0 General

For modern solid state digital radars the emitted signals may be very complicated and include both phase-modulation, frequency-hopping and -sweeping and pulse width modulation. This makes a single definition of MDS and interfering signal difficult. The following is a generalized approach based upon a calculated MDS value:

$$MDS = kT_0 B_{res} NF_{sys} D_{nospur} \frac{1}{T_C B_C} M \quad (1)$$

Where:

MDS	Minimum Detectable Signal
k	Boltzmann constant
T_0	Temperature in Kelvin
B_{res}	3 dB resolution bandwidth of transceiver
Nf_{sys}	Noise Factor of the system
$D_{no\ spur}$	Detectability Factor (function of P_D & P_{fa}) = 0,03 (-15 dB)

NOTE: The detectability factor is the signal to noise ratio between the disturbance and a real target. The value of 0,03 (-15dB) for $D_{no\ spur}$ is taken from figure 2.3 of "Radar Handbook" [i.2].

P_D	Probability of detection = 10^{-3} (selected value)
P_{FA}	Probability of false detection = 10^{-3} (selected value)
T_C	Pulse length (of individual chirp) in seconds
B_C	Effective bandwidth of receiver
M	Test margin = 0,1 (Without this margin the receiver should give a detectable signal)

The factor $1/(T_C\ B_C) = 1$ is applicable for a simple pulse radar.

5.3.2.2.1 Receiver Out-of-Band selectivity

In order to determine if the receiver selectivity follows the required mask, a disturbance test signal level at MDS level plus the required attenuation shall be applied at the antenna flange.

Disturbing Test Signal

The disturbance signal shall be a sinusoidal pulsed signal with pulse duration of 100 ns and a pulse repetition frequency of 1 kHz. The rise/fall time of the disturbance signal shall be maximum 10 ns.

Maximum Level of Disturbing Signal

The maximum level of the disturbing signal shall be selected such that the receiver will not be saturated. The selected test signal level shall be 6 dB below compression level for the given receiver design.

Roll off of Disturbing Test Signal

From each edge of B_{-40} the signal strength shall increase from MDS level by 30 dB per decade to 70 dB above MDS level. This is illustrated in figure 6 below.

Test Pass Criteria

The requirement is that the disturbing test signal shall not result in detection of false targets with a higher probability than 10^{-3}.

Measurement Points

The selected disturbance test signal shall be swept over a frequency span of the Out of Band domain. Manufacturer shall ensure that the swept frequency span encompasses all image frequencies present in the OoB domain/region. The spurious domain is not checked since it is unlikely that the receiver is sensitive that far from the used band.

The interspacing between measurement points shall be selected to be less than half the system resolution bandwidth (3 dB bandwidth of the processed radar output). This should ensure that all possible disturbance frequencies are covered.

The Case of Multi-Frequency and/or Chirping Radars

In case a radar makes use of multiple frequencies and/or chirps the effective B_{-40} where full sensitivity is allowed may be taken as the joined envelope of all frequencies used; provided the frequencies are adjacent.

If frequencies are not adjacent, there will be a separate B_{-40} for each frequency where full sensitivity is allowed.

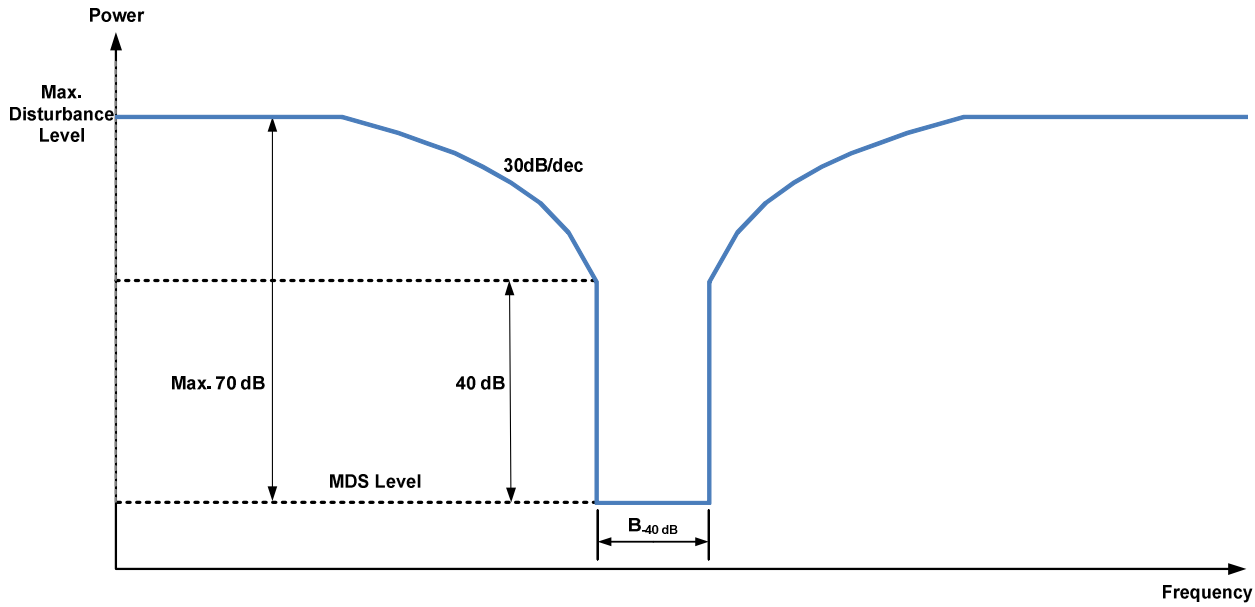

Figure 6: Resulting receiver selectivity mask (not to scale) - The max. disturbance level is -30 dBm

5.3.2.3 Receiver Compression Level

5.3.2.3.0 General

While the receiver compression level is defined as the 1 dB compression point of the receiver chain it is not possible without knowing the design of the receiver circuits of a radar to define a general measurement circuit. The best way to measure the compression level is to increase the power of a sine wave signal injected at the LNA input and check linearity by reading digital values at the A/D converter output.

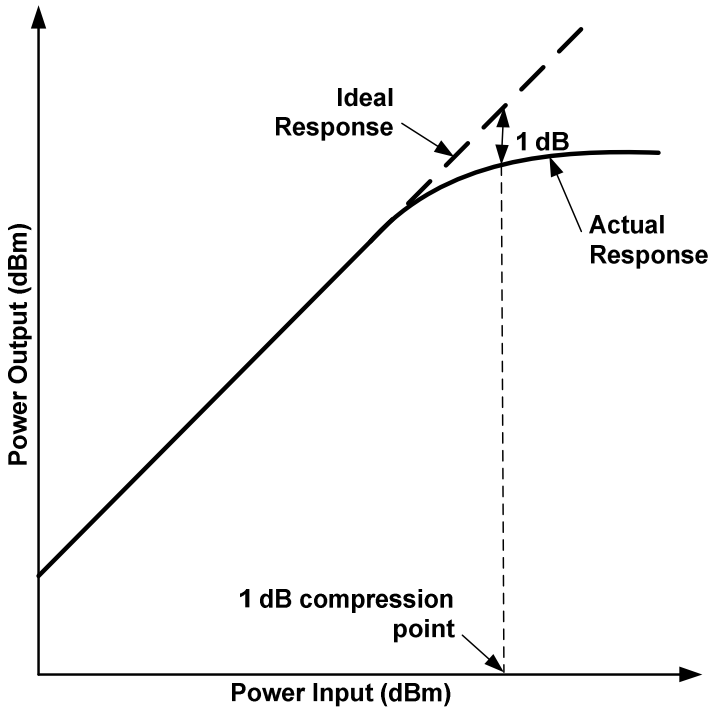

Figure 7: Illustration of finding the LNA input 1 dB compression point

5.3.2.3.1 Receiver Compression Level

Depending on receiver design a CW or pulsed test signal is injected into the antenna WG flange (it has to be a signal that passes through the receiver). The gain response curve of the receiver input amplifier (LNA) shall be measured and the 1 dB compression point shall be noted. This value shall be higher than or equal to a signal level of -35 dBm.

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

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.6] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.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 303 213-6-1					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Frequency Tolerance	3.2	4.2.1.1	U	
2	Transmitter 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	System Noise Figure	3.2	4.2.2.1	U	
8	Receiver Selectivity	3.2	4.2.2.2	U	
9	Receiver Compression Level	3.2	4.2.2.3	U	

Key to columns:

Requirement:

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

Description A textual reference to the requirement.

Essential requirements of Directive

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

Clause(s) of the present document

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

Requirement Conditionality:

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

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

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

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

Annex B (normative): Transmission power and unwanted emissions of radar systems with indirect methods

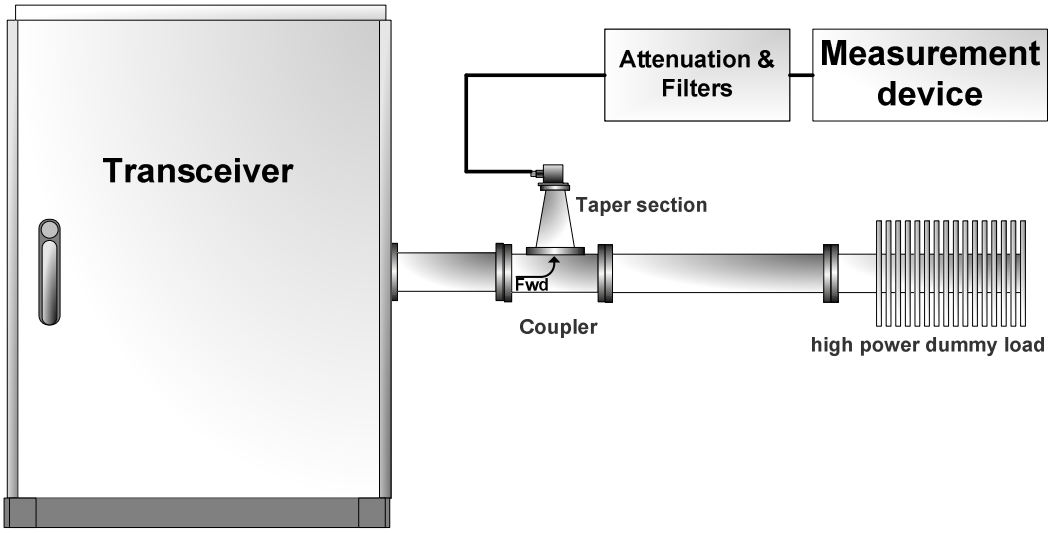

Figure B.1: Indirect method for radio frequency measurements with dismounted antenna

The method for measurement of the operation frequency, transmit power as well as out-of-band and spurious emission shown in figure B.1 shall be applied.

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

Annex 8 of Recommendation ITU-R SM.1541-6 [i.5] specifies the -40 dB bandwidth for various types of waveforms (e.g. pulsed radar signals). With the following assumptions which apply to most airport surface movement radars these specifications can be further simplified:

- the radar is operating in the bands 9 000 MHz to 9 200 MHz or 9 300 MHz to 9 500 MHz;
- the pulse power is below 100 kW (at the transmitter output);
- the pulse rise time t_r is greater than 0,0094·t, where t is the pulse duration.

With the aforementioned assumptions the -40 dB bandwidth (B_{-40}) for primary non-FM pulse radars can be determined as follows:

$$B_{-40} = \frac{7.6}{\sqrt{t \times t_r}} \quad \text{(C.1)}$$

Where:

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

For frequency modulated pulse radar systems the -40 dB bandwidth is:

$$B_{-40} = 1{,}5\left\{B_C + \sqrt{\pi} \cdot [\ln(B_C \cdot \tau)]^{0{,}53} \cdot \left[Min\left(B_{rise}, B_{fall}, B_{rise\&fall}\right) + Max\left(B_{rise}, B_{fall}, B_{rise\&fall}\right)\right]\right\} \quad \text{(C.2)}$$

Where:

- B_C is the bandwidth of the frequency deviation (total frequency shift during the pulse generation).
- τ is the pulse length including rise and fall times.
- $B_{rise} = \frac{1}{\sqrt{\tau \cdot t_r}}$ to account for the rise time.
- $B_{fall} = \frac{1}{\sqrt{\tau \cdot t_f}}$ to account for the fall time.
- $B_{rise\&fall} = \frac{1}{\sqrt[3]{\tau \cdot t_r \cdot t_f}}$ to account for both the rise and fall times combination.
- t_r is the rise time.
- t_f is the fall time.

The equation 2 above is only valid when the following conditions are met:

1) The product B_C • Minimum (t_r, t_f) is greater than or equal to 0,10 and
2) that the product of B_C • τ or compression ratio is greater than 10.

In all other cases, the following equations shall be used:

$$B_{-40} = \frac{K}{\sqrt{t \cdot t_r}} + 2\left(B_C + \frac{A}{t_r}\right) \quad \text{(C.3)}$$

Where:

- A is 0,105 when K = 6,2 and 0,065 when K 7,6.

NOTE: The term A/t_r adjusts the value of B_{-40} to account for the influence of the rise time, which is substantial when the time-bandwidth product $B_c \bullet t$, is small or moderate and the rise time is short.

For radars with an asymmetrical spectrum (e.g. magnetron based radars), the B_{-40} dB bandwidth can be offset from the frequency of maximum emission level, but the necessary bandwidth, B_N and preferably the overall occupied bandwidth should be contained completely within the declared band as stipulated in section 4 of annex 8 of Recommendation ITU-R SM.1541-6 [i.5].

The application of this rule is illustrated in figure C.1.

For radars with multiple pulse waveforms, the B_{-40} bandwidth shall be calculated for each individual pulse and the largest B_{-40} bandwidth shall be used.

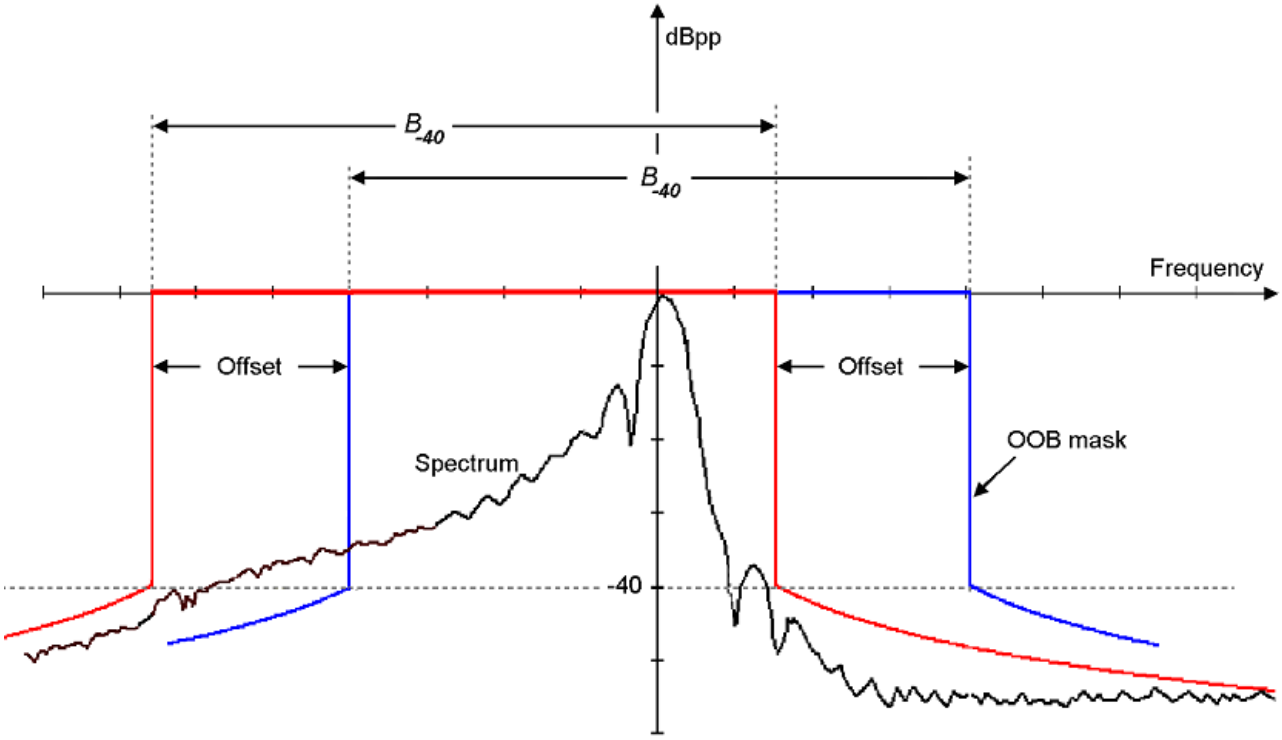

Figure C.1: Application of the offset-rule for the Out-of-Band emission limit mask

Annex D (informative): Maximum Measurement Uncertainty

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

Table D.1: Maximum measurement uncertainty

Parameter	Uncertainty
Environment measurements	
Temperature	1 °C
Relative Humidity	5 %
Transmitter measurements	
Operating frequency	±1 ppm
Transmitter power	±1,5 dB
Out-of-Band emissions	±4 dB (see note 1)
Spurious emissions	±4 dB (see note 1)
Mains Supply Voltage	0,1%
Receiver measurements	
System Noise Figure	±1 dB
Receiver Selectivity	±4 dB (see note 2)
NOTE 1: Between 0 and -30 dBc for CW signals. These radar systems use very complicated waveforms using pulse length modulation, frequency hopping, unlinear frequency chirping or phase coding. A frequency analyser is specified to sinusoid signals and for high dynamic ranges is only specified for accuracy in the top most 30 dB of its dynamic range. Therefore the actual accuracy that can be achieved during such measurements up to 100 dB below PEP at 26 GHz power is no better than ±4 dB.	
NOTE 2: Between 0 and -20 dBm. As for note 1 it is limited by what is possible to measure for the given signals and frequencies.	

Annex E (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 F (informative): Change history

Version	Information about changes
2.1.1	First version of the Harmonised Standard under the Radio Equipment Directive.
3.1.1	Implemented changes: • The measured -40 dB emissions have to be contained within the declared band (not applicable for magnetron radars) (New requirement) • The OoB emission limit mask is defined for multiple non-adjecent carrier frequencies (New requirement) • Unwanted emission limits are defined specifically for multi-frequency radars (New requirement) • Stand-by Mode Emissions must be max. -47 dBm (New requirement) • A System Noise Figure must be max. 6 dB (New requirement) • A Receiver 1 dB Compression level must be at least -35 dBm (New requirement) • The Receiver Selectivity mask is defined with a roll-off -30 dB/dec all the way to max. disturbance level (6 dB below compression level for the given receiver design) (Modified requirement)

History

Document history		
V1.1.1	September 2011	Publication
V1.2.1	November 2013	Publication
V2.1.1	May 2016	Publication
V3.1.0	March 2019	EN Approval Procedure AP 20190616: 2019-03-18 to 2019-06-17