



**Meteorological Radars;
Harmonised Standard for access to radio spectrum;
Part 2: Meteorological Radar Sensor operating in the
frequency band 5 250 MHz to 5 850 MHz (C band)**

Reference

DEN/ERM-TGAERO-42-2

Keywords

harmonised standard, radar, radio

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
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

The present document can be downloaded from:

<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at www.etsi.org/deliver.

Users of the present document should be aware that the document may be subject to revision or change of status.

Information on the current status of this and other ETSI documents is available at

<https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:

<https://portal.etsi.org/People/CommiteeSupportStaff.aspx>

Copyright Notification

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2020.

All rights reserved.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.

3GPP™ and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

oneM2M™ logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners.

GSM® and the GSM logo are trademarks registered and owned by the GSM Association.

Contents

Intellectual Property Rights	5
Foreword.....	5
Modal verbs terminology.....	6
1 Scope	7
2 References	7
2.1 Normative references	7
2.2 Informative references.....	8
3 Definition of terms, symbols and abbreviations.....	8
3.1 Terms.....	8
3.2 Symbols.....	10
3.3 Abbreviations	10
4 Technical requirements specifications	11
4.1 Environmental profile.....	11
4.2 Conformance requirements	11
4.2.1 Transmitter requirements	11
4.2.1.1 Frequency Tolerance.....	11
4.2.1.1.1 Definition.....	11
4.2.1.1.2 Limits	11
4.2.1.1.3 Conformance	11
4.2.1.2 Transmitter output power.....	11
4.2.1.2.1 Definition.....	11
4.2.1.2.2 Limits	11
4.2.1.2.3 Conformance	11
4.2.1.3 Measured B ₄₀ Bandwidth	12
4.2.1.3.1 Definition.....	12
4.2.1.3.2 Limits	12
4.2.1.3.3 Conformance	12
4.2.1.4 Out-of-Band emissions.....	12
4.2.1.4.1 Definition.....	12
4.2.1.4.2 Limits	13
4.2.1.4.3 Conformance	14
4.2.1.5 Spurious emissions.....	14
4.2.1.5.1 Definition.....	14
4.2.1.5.2 Limits	15
4.2.1.5.3 Conformance	16
4.2.1.6 Stand-by Mode emissions	16
4.2.1.6.1 Definition.....	16
4.2.1.6.2 Limits	16
4.2.1.6.3 Conformance	16
4.2.2 Receiver Requirements	16
4.2.2.1 Noise Figure.....	16
4.2.2.1.1 Definition.....	16
4.2.2.1.2 Limits	16
4.2.2.1.3 Conformance	16
4.2.2.2 Receiver Selectivity	16
4.2.2.2.1 Definition.....	16
4.2.2.2.2 Limits	17
4.2.2.2.3 Conformance	18
4.2.2.3 Receiver Compression Level	18
4.2.2.3.1 Definition.....	18
4.2.2.3.2 Limits	19
4.2.2.3.3 Conformance	19
5 Testing for compliance with technical requirements.....	19

5.1	General requirements	19
5.2	Environmental conditions for testing	20
5.2.1	Test Conditions	20
5.2.2	Normal temperature and humidity	20
5.2.3	Normal test power supply	20
5.3	Interpretation of the measurements results	20
5.4	Radio test suites.....	20
5.4.1	Transmitter test specification.....	20
5.4.1.1	Frequency Tolerance	20
5.4.1.2	Transmitter Power.....	21
5.4.1.3	Measured B ₋₄₀ Bandwidth	21
5.4.1.4	Out-of-Band emissions.....	22
5.4.1.5	Spurious emissions.....	23
5.4.1.6	Stand-by Mode Emissions.....	25
5.4.2	Receiver Test specification	25
5.4.2.1	Noise Figure	25
5.4.2.2	Receiver Selectivity	26
5.4.2.2.1	General	26
5.4.2.2.2	Receiver unwanted Signal Selectivity	26
5.4.2.3	Receiver Compression	27
5.4.2.3.1	General	27
5.4.2.3.2	Receiver Compression Level.....	27
Annex A (informative):	Relationship between the present document and the essential requirements of Directive 2014/53/EU	28
Annex B (normative):	Calculation of the -40 dB Bandwidth.....	29
Annex C (normative):	Operating frequency and transmitter power measurement setup	31
Annex D (normative):	Spurious and OoB emission measurement setup	32
Annex E (normative):	Receiver selectivity and compression level measurement setup	33
Annex F (informative):	Maximum Measurement Uncertainty.....	34
Annex G (informative):	WR187/WG12 waveguide characteristics.....	35
Annex H (informative):	Checklist	37
History		39

Intellectual Property Rights

Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

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.5] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

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 2 of a multi-part deliverable covering meteorological radar systems for different frequency bands, as identified below:

- Part 1: "Meteorological Radar Sensor operating in the frequency band 2 700 MHz to 2 900 MHz (S band)";
- Part 2: "Meteorological Radar Sensor operating in the frequency band 5 250 MHz to 5 850 MHz (C band)";**
- Part 3: "Meteorological Radar Sensor operating in the frequency band 9 300 MHz to 9 500 MHz (X band)".

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).

"**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 C-band meteorological radar systems intended for the surveillance and classification of hydrometeors with the following characteristics:

- Operating in the following frequency range:
 - 5 250 MHz to 5 850 MHz.
- Utilizing unmodulated pulses or phase/frequency modulated pulses also known as pulse compression.
- The maximum output power (PEP) does not exceed 1 MW (i.e. 90 dBm).
- The transceiver antenna connection and its feeding RF line use a hollow metallic rectangular waveguide.
- The antenna rotates and can be changed in elevation.
- The used waveguide is WR187/WG12 waveguide according to IEC 60153-2 [i.2].
- The antenna feed is waveguide based and the antenna is passive.
- The orientation of the transmitted field from the antenna can be vertical or horizontal orientated or it can be both simultaneously.
- At the transceiver output an RF circulator is used.

NOTE 1: Since at the transceiver output an RF circulator is used, it is assumed that the transceiver characteristics remain independent from the antenna.

NOTE 2: According to provision 5.452 of the ITU Radio Regulations [i.7], ground-based radars used for meteorological purposes in the band 5 600 MHz to 5 650 MHz are authorized to operate on a basis of equality with stations of the maritime radio navigation service.

NOTE 3: Further technical and operational characteristics of meteorological radar systems can be found in Recommendation ITU-R M.1849-1 [i.3].

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

Referenced documents which are not found to be publicly available in the expected location might be found at <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] ERC/Recommendation 74-01 (2019): "Unwanted emissions in the spurious domain".
- [2] ECC/Recommendation (02)05 (2012): "Unwanted emissions".
- [3] Recommendation ITU-R M.1177-4 (04/2011): "Techniques for measurement of unwanted emissions of radar systems".

2.2 Informative references

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

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

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

- [i.1] Directive 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] IEC 60153-2 (Edition 3.0, 2016): "Hollow metallic waveguides. Part 2: Relevant specifications for ordinary rectangular waveguides".
- [i.3] Recommendation ITU-R M.1849-1 (09/2015): "Technical and operational aspects of ground-based meteorological radars".
- [i.4] Recommendation ITU-R SM.1541-6 (08/2015): "Unwanted emissions in the out-of-band domain".
- [i.5] Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.
- [i.6] ETSI EG 203 336 (V1.2.1) (2020-05): "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.7] ITU Radio Regulations (2016).

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

active state: 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. A generic frequency allocation table is also available in the ITU Radio Regulations [i.7].

assigned frequency: centre of the frequency band assigned to a station

NOTE: This definition is taken from the ITU Radio Regulations [i.7].

assigned frequency band: frequency band within which the emission of a station is authorized

NOTE 1: The width of the band equals the necessary bandwidth plus twice the absolute value of the frequency tolerance. Where space stations are concerned, the assigned frequency band includes twice the maximum Doppler shift that may occur in relation to any point of the Earth's surface.

NOTE 2: This definition is taken from the ITU Radio Regulations [i.7].

characteristic frequency: frequency which can be easily identified and measured in a given emission

NOTE 1: A carrier frequency may, for example, be designed as the characteristic frequency.

NOTE 2: This definition is taken from the ITU Radio Regulations [i.7].

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.

frequency tolerance: 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

NOTE 1: The frequency tolerance is expressed in parts in 10^6 or in Hertz.

NOTE 2: This definition is taken from the ITU Radio Regulations [i.7].

idle/standby state: state where the transmitter is available for operation, but is not in the active state

necessary bandwidth B_N : 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 the ITU Radio Regulations [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 the ITU Radio Regulations [i.7].

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.

out-of-band emission: emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions

NOTE: This definition is taken from the ITU Radio Regulations [i.7].

peak envelope power (of a radio transmitter): 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 the ITU Radio Regulations [i.7].

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

pulse duration: time in seconds between the 50 % amplitude (voltage) points of a transmitted pulse

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

receiver selectivity: ability of a receiver to detect and decode a desired signal in the presence of an unwanted interfering signal outside the B_{40} bandwidth

reference frequency: frequency having a fixed and specified position with respect to the assigned frequency

NOTE 1: The displacement of this frequency with respect to the assigned frequency has the same absolute value and sign that the displacement of the characteristic frequency has with respect to the centre of the frequency band occupied by the emission.

NOTE 2: This definition is taken from the ITU Radio Regulations [i.7].

spurious emission: emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information

NOTE 1: Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

NOTE 2: This definition is taken from the ITU Radio Regulations [i.7].

system coupler: directional waveguide coupler with forward and reverse port or only a forward port

NOTE: The system coupler is inserted in the waveguide run between the circulator and the antenna but not directly located behind the antenna. Usually it is located very close behind the circulator.

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
dB/dec	dB per decade
dBpp	dB with respect to peak power
f_c	characteristic frequency
f_{IF}	IF frequency
f_{Image}	Image frequency
f_t	transmitter frequency tolerance
k	Boltzmann's constant
t	Pulse duration
t_r	Pulse rise time

3.3 Abbreviations

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

A/D	Analog to Digital converter
AC	Alternating Current
AM	Amplitude Modulation
CW	Continuous Wave
EFTA	European Free Trade Association
EIA	Electronic Industries Alliance
EM	ElectroMagnetic
ENR	Excessive Noise Ratio
FM	Frequency Modulation
IEC	International Electrotechnical Commission
IF	Intermediate Frequency
LNA	Low Noise Amplifier
LNFE	Low Noise Front End
MDS	Minimum Detectable Signal
MW	MegaWatt
na	not applicable
OoB	Out-of-Band
PEP	Peak Envelope Power
PM	Phase Modulation
ppm	part(s) per million
PRF	Pulse Repetition Frequency
RF	Radio Frequency
UK	United Kingdom
WG	Waveguide
WR	Waveguide Rectangular

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 Frequency Tolerance

4.2.1.1.1 Definition

The transmitter of a pulsed radar system produces microwave pulses, which cause a broad frequency spectrum depending on the pulse duration. The operating frequency is the frequency of the microwave emission during the transmitting pulse and is represented by the spectral line of highest amplitude. For phase/frequency modulated radar systems the operating frequency is to be understood as the centre between the highest and lowest transmitted frequency. The frequency tolerance is the maximum permissible departure from the operating frequency.

4.2.1.1.2 Limits

The frequency tolerance for meteorological radar systems at the defined operating frequency shall not exceed 1 250 ppm:

NOTE: This value is specified in Appendix 2 of ITU Radio Regulations [i.7].

4.2.1.1.3 Conformance

The conformance tests are specified in clause 5.4.1.1.

The results obtained for all available pulse length settings shall not exceed the limits specified in clause 4.2.1.1.2.

4.2.1.2 Transmitter output power

4.2.1.2.1 Definition

The transmitter power is considered to be the peak value (PEP) of the transmitter pulse power during the transmission pulse.

4.2.1.2.2 Limits

The transmitter power shall not exceed 1 MW (i.e. 90 dBm).

4.2.1.2.3 Conformance

The conformance tests are specified in clause 5.4.1.2.

The results obtained for all available pulse length settings shall not exceed the limits specified in clause 4.2.1.2.2.

4.2.1.3 Measured B_{-40} Bandwidth

4.2.1.3.1 Definition

The measured -40 dB bandwidth is the measured bandwidth of the emission 40 dB below the PEP.

4.2.1.3.2 Limits

For all radar types covered by the present document the measured B_{-40} 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 in the declared band.

NOTE: The declared band is always contained in the 5 250 MHz to 5 850 MHz frequency range.

4.2.1.3.3 Conformance

The conformance tests are specified in clause 5.4.1.3.

The results obtained shall not exceed the limits specified in clause 4.2.1.3.2.

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 clause 4.2.1.5.1 for the definition of spurious region).

For meteorological radar systems with multiple pulse length, the B_{-40} bandwidth is calculated for each individual used pulse length and the maximum B_{-40} bandwidth obtained is used to establish the shape of the emission mask.

NOTE: The shortest pulse length used is usually 500 ns.

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.

The applicable formulae for the calculation of the B_{-40} bandwidth are described in Annex B.

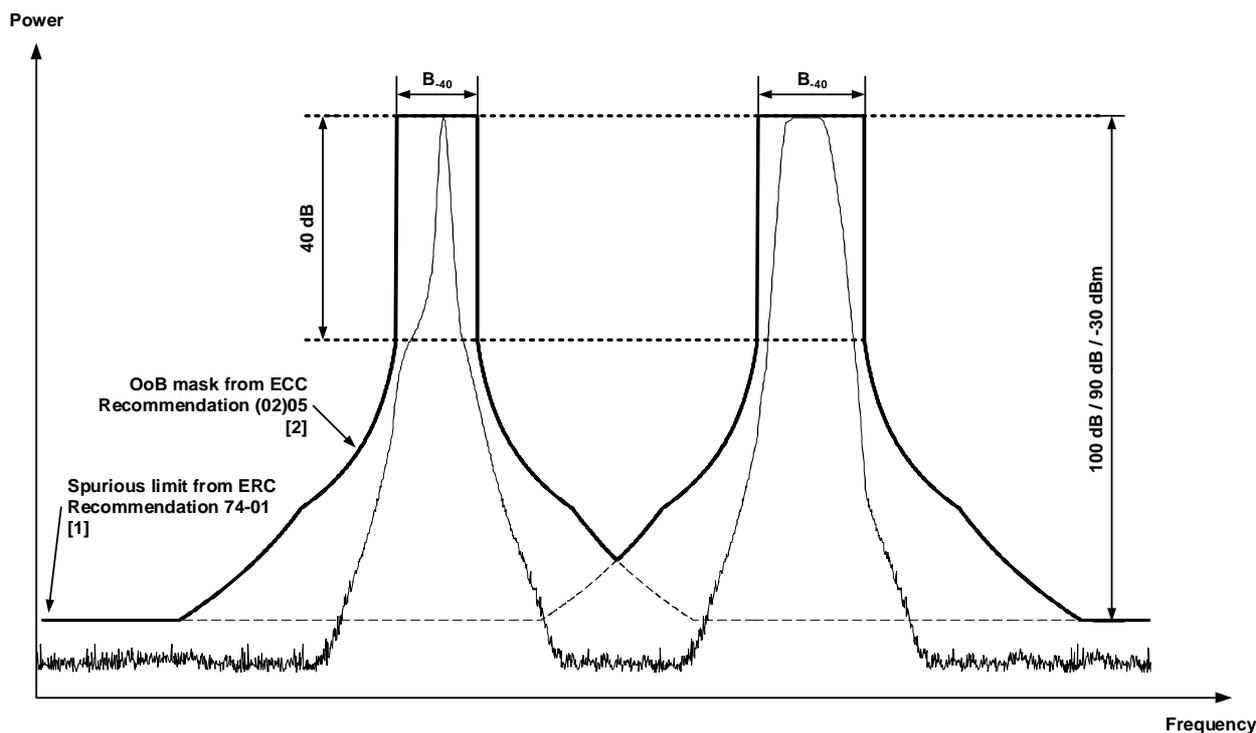


Figure 1: Example of superimposed (combined) mask from two carrier frequencies

4.2.1.4.2 Limits

Depending on the PEP power the maximum OoB emission power level shall not exceed the limits stated in Table 1 or Table 2 and shall not exceed the corresponding mask depicted in Figure 2 as specified in Annex 2 in ECC/Recommendation (02)05 [2]. The roll-off of the OoB mask beyond the B_{-40} bandwidth in relation to B_{-40} is specified as follows:

- The mask has a roll-off at 30 dB/dec from the calculated (identified) B_{-40} bandwidth to a level of -70 dBpp.
- The mask then continues to roll-off at 60 dB/dec to a spurious emission limit level of -100 dBpp or -90 dBpp with regard to the PEP.

NOTE 1: The -100 dBpp mask corresponds to the dashed line in Figure A2.1c and the -90 dBpp corresponds to the dashed line in Figure A2.1b of unwanted emissions in Annex 2 of the ECC/Recommendation (02)05 [2].

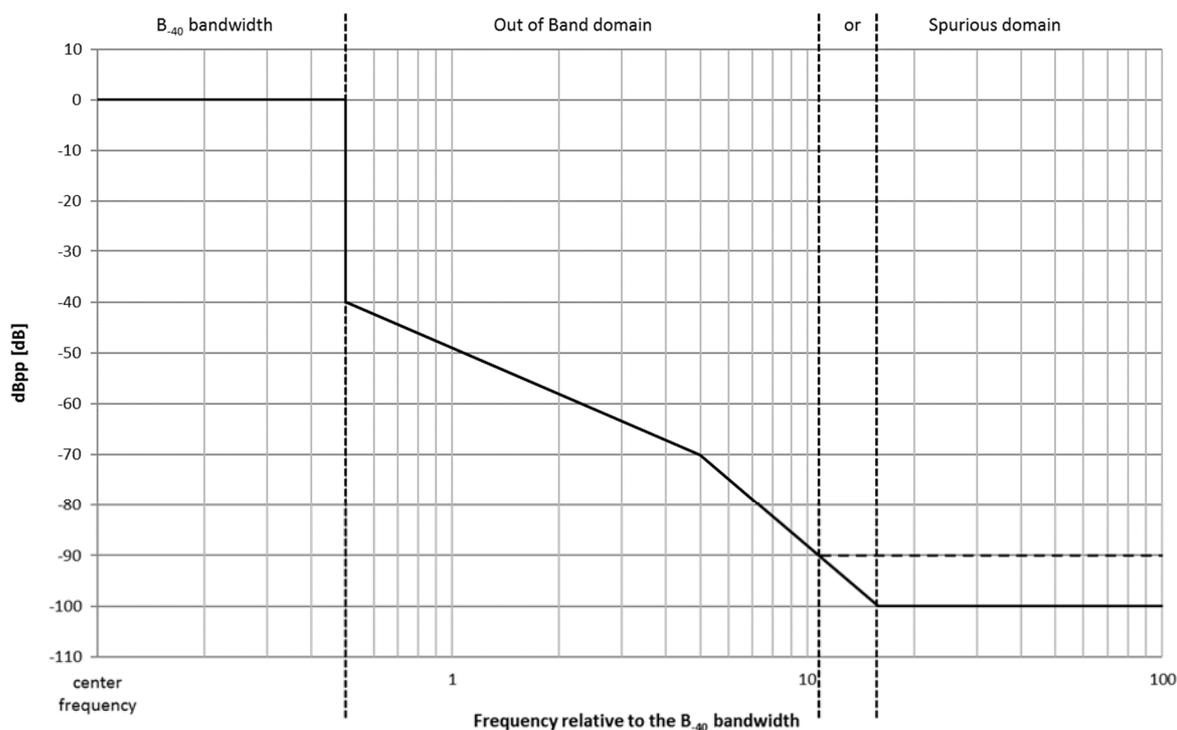
NOTE 2: ERC/Recommendation 74-01 [1] stipulates in its Table 15 for meteorological radars a spurious emission limit of "-30 dBm or 100 dB/90 dB below PEP, whichever is less stringent".

Table 1: Limits for Out-of-Band emissions for a PEP greater than 150 kW

Multiple of the B_{-40} bandwidth	Limit dBpp	Slope dB/decade
0,5	-40	$-\infty$
0,5 to 5	-40 to -70	-30
5 to 10,8	-70 to -90	-60

Table 2: Limits for Out-of-Band emissions for a PEP equal to or less than 150 kW

Multiple of the B_{-40} bandwidth	Limit dBpp	Slope dB/decade
0,5	-40	$-\infty$
0,5 to 5	-40 to -70	-30
5 to 15,8	-70 to -100 or -30 dBm, see note	-60
NOTE: -70 dBpp to -100 dBpp or -30 dBm whichever is less stringent.		

**Figure 2: Unwanted emission limit masks**

4.2.1.4.3 Conformance

The conformance tests are specified in clause 5.4.1.4.

The results obtained shall not exceed the limits specified in clause 4.2.1.4.2.

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 as shown in Figure 3 below.

They include:

- harmonic emissions (whole multiples of the operating frequency)
- parasitic emissions (independent, accidental)
- 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 Annex 2 in ECC/Recommendation (02)05 [2] reaches the spurious emission limit shown in Table 3 according to ERC/Recommendation 74-01 [1], Table 15. This is illustrated in Figure 3.

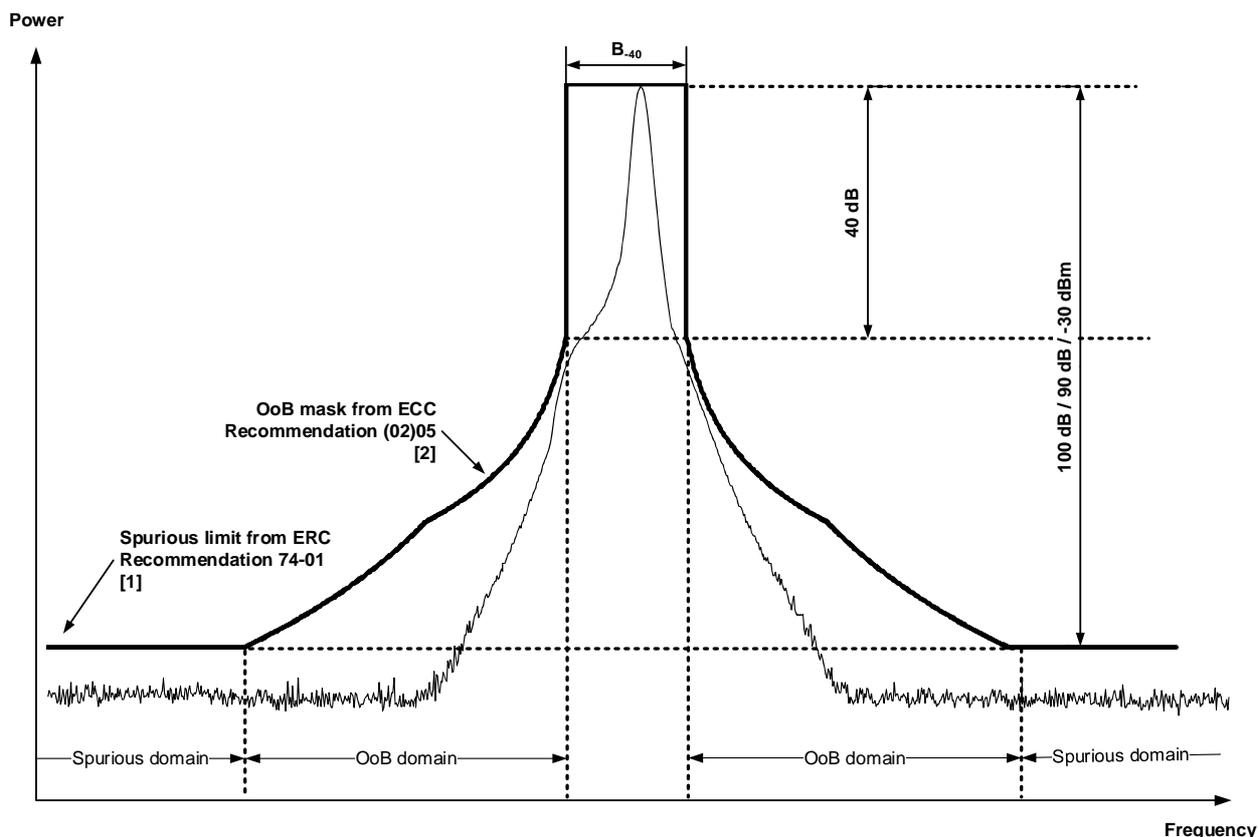


Figure 3: Definition of OoB and spurious emission domains for non FM/PM pulsed radar (Not to scale)

4.2.1.5.2 Limits

For meteorological radar systems the spurious emission limits are related to the PEP. The limits shall be as specified in ERC/Recommendation 74-01 [1], Annex 5, Table 15 also shown in Table 3 below.

The spurious emission limits specified in Table 3 are either absolute levels or attenuation (dB) below the PEP supplied to the antenna port.

Table 3: Spurious emission levels

Transmitter PEP	Spurious emission limits
< 10 kW	-30 dBm
10 kW ≤ PEP ≤ 150 kW	100 dB
> 150 kW	90 dB

4.2.1.5.3 Conformance

The conformance tests are specified in clause 5.4.1.5.

The results obtained shall not exceed the limits specified in clause 4.2.1.5.2.

4.2.1.6 Stand-by Mode emissions

4.2.1.6.1 Definition

The idle/standby state is defined as the state where the transmitter is available for operation but is not in the active state. The receiver shall be activated.

4.2.1.6.2 Limits

The maximum allowed power level shall be -47 dBm as specified in Table 15 in ERC/Recommendation 74-01 [1].

The radars covered by the present document use WR187/WG12 waveguides to transfer power between the transmitter and the antenna and the waveguide cut-off frequency is 3 152 MHz. Therefore, measurements below this frequency do not provide valid results since the waveguide is unable to support power transfer along its length below the cut-off frequency.

4.2.1.6.3 Conformance

The conformance tests are specified in clause 5.4.1.6.

The results obtained shall not exceed the limits specified in clause 4.2.1.6.2.

4.2.2 Receiver Requirements

4.2.2.1 Noise Figure

4.2.2.1.1 Definition

The receiver 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 receiver noise figure shall not exceed 6 dB.

4.2.2.1.3 Conformance

The conformance test is specified in clause 5.4.2.1.

The results obtained shall not exceed the limits specified in clause 4.2.2.1.2.

4.2.2.2 Receiver Selectivity

4.2.2.2.1 Definition

The receiver selectivity is the ability of a receiver to detect and decode a desired signal in the presence of an unwanted interfering signal 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 Limits

The receiver selectivity of the radar shall correspond to the requirements shown in Figure 4. The maximum power level of the unwanted signal, measured at the output of the digital signal processing as shown in Figure E.1, shall be no more than 12 dB above the calculated MDS level.

EXAMPLE 1: If the calculated MDS of the radar system is -102 dBm, then the maximum level of unwanted signals at the output of the digital signal processing is -90 dBm.

For radars with an asymmetrical spectrum, the calculated B_{-40} bandwidth can be offset from the operating frequency. The operating frequency shall be kept inside the calculated B_{-40} bandwidth.

The receiver selectivity shall be at least verified in the range of:

- Lower B_{-40} to (Lower B_{-40} – 500 MHz)
- Upper B_{-40} to (Upper B_{-40} + 500 MHz)

The B_{-40} bandwidth shall be excluded from the receiver selectivity measurement.

EXAMPLE 2: If the meteorological radar operates at 5 640 MHz and the B_{-40} is equal to 20 MHz then the lower frequency limit of the disturbing signal is 5 130 MHz. The upper limit is equal to 6 150 MHz.

The manufacturer shall ensure that the swept frequency span encompasses all image frequencies present in the receiver design. If the image frequencies are not covered by the verified frequency range as defined above the range shall be extended to cover the image frequencies accordingly.

The image frequency can be calculated as:

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

The measurement of the receiver selectivity shall be done at the output of the digital signal processing as shown in Figure E.1.

In order to determine if the receiver selectivity follows the required selectivity mask, a disturbance signal level at the MDS level plus the required attenuation shall be applied. The minimum input level is the MDS level and is calculated by the following formula:

$$MDS(dBm) = -174 \text{ dBm} + NF_{(dB)} + BW_{(dB)} \quad (2)$$

Where:

- -174 dBm is the noise power value in dBm, measured with 1 Hz bandwidth (B_N) at 290° Kelvin and derived from the available noise power N_i on the receiver input. $N_i = k \times T_0 \times B_N$. Where:
 - k Boltzmann constant = $1,38064852 \times 10^{-23} \frac{J}{K}$.
 - T_0 Temperature in Kelvin.
- $NF_{(dB)}$ is the receiver noise figure in dB. Measurement of the noise figure is described in clause 5.4.2.1.
- $BW_{(dB)}$ is the matched filter bandwidth in dB. Calculated as: $10 \log(BW_{(Hz)})$.

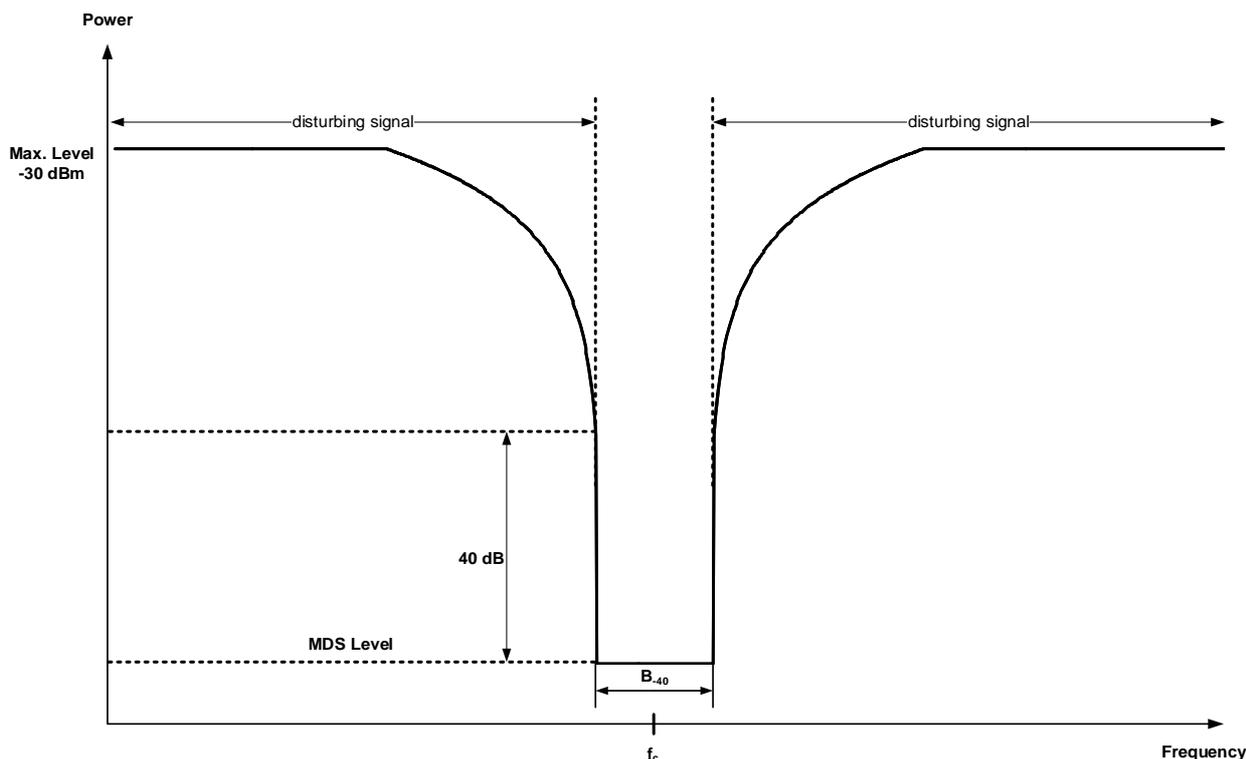
NOTE: The matched filter bandwidth usually corresponds to the transmitted pulse length and is usually the inverse of the pulse length. For example, a 0,8 μ s pulse length results in a 1,25 MHz matched filter bandwidth.

The applied power level at the lower and upper B_{-40} frequency shall be the MDS level + 40 dB as shown in Figure 4.

The receiver selectivity mask shall be as shown in Table 4. The input power of the receiver shall not exceed -30 dBm.

Table 4: Receiver selectivity mask

Frequency offset relative to f_c by multiple of the B_{-40} bandwidth	Maximum interfering power level dB above MDS	Slope dB/decade
0 to 0,5	None	0
0,5	40	$-\infty$
0,5 to 5	+40 to 70 or -30 dBm	-30
5 to 10,8	70 to 90 or -30 dBm	-60
10,8 to ∞	-30 dBm	0



**Figure 4: Resulting receiver selectivity mask (not to scale) -
The maximum disturbance level was set to -30 dBm**

4.2.2.2.3 Conformance

The conformance tests are specified in clause 5.4.2.2.

The results obtained shall not exceed the limits specified in clause 4.2.2.2.2.

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 nonlinear thereby causing distortion and other non-linear effects that prevents proper operation of the receiver.

The receiver input compression level is defined as when the receiver output is 1 dB into compression as can be seen in Figure 5.

The compression level shall be measured at the nominal receiver frequency which is used to detect the desired signal generated by the transmitter.

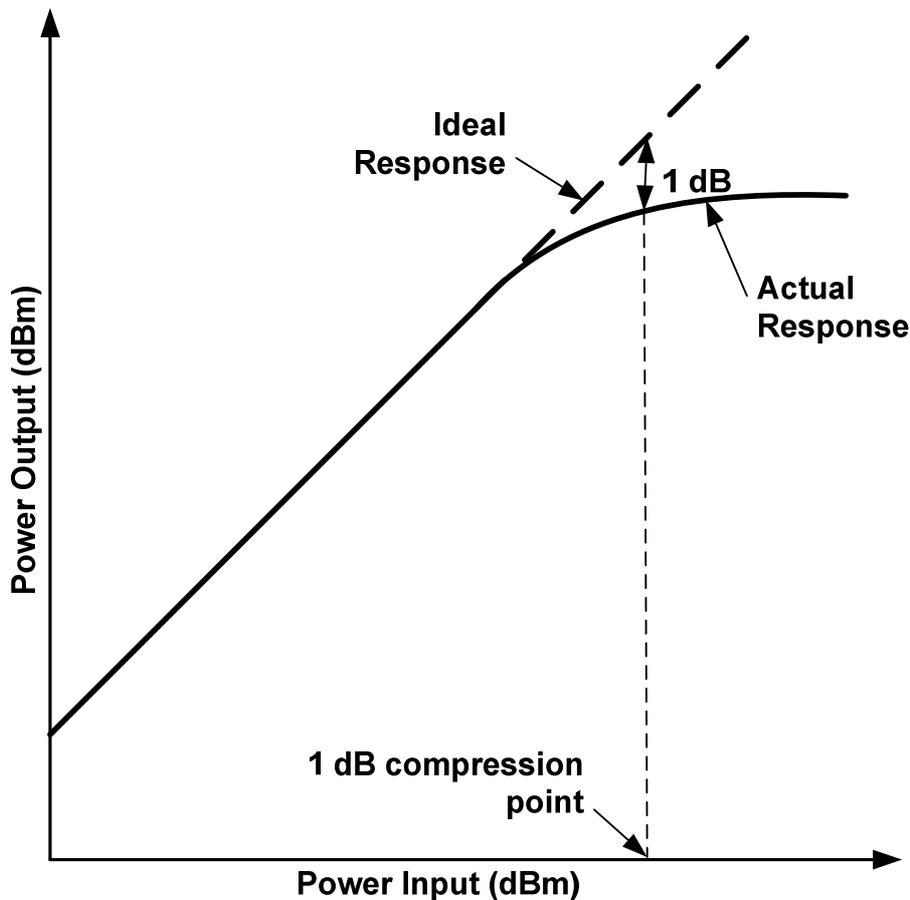


Figure 5: Illustration of finding the LNA input 1 dB compression point

4.2.2.3.2 Limits

The input of the radar shall be able to handle signal levels up to at least -35 dBm without being in compression.

NOTE 1: A high compression level corresponds to high immunity against blocking. Blocking is the effect when a strong Out-of-Band or spurious signal degrades the receiver ability to detect the wanted signal.

NOTE 2: Outside the B_{40} bandwidth the maximum disturbance level is -30 dBm as stated in clause 4.2.2.2.2.

The measurement of the saturation signal shall be done at the output of the digital signal processing as shown in Figure E.1.

4.2.2.3.3 Conformance

The conformance tests are specified in clause 5.4.2.3.

The results obtained shall not exceed the limits specified in clause 4.2.2.3.2.

5 Testing for compliance with technical requirements

5.1 General requirements

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

5.2 Environmental conditions for testing

5.2.1 Test Conditions

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

5.2.2 Normal temperature and humidity

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

- a) temperature: +15 °C to +35 °C.
- b) relative humidity: not exceeding 75 %.

5.2.3 Normal test power supply

The test voltage for the equipment to be connected to an AC supply shall be the nominal mains voltage declared by the manufacturer including a variation of $\pm 10\%$. 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 $50 \text{ Hz} \pm 1 \text{ Hz}$.

5.3 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 documented in the test report.

Recommended values for the maximum measurements uncertainty figures can be found in Annex F.

5.4 Radio test suites

5.4.1 Transmitter test specification

5.4.1.1 Frequency Tolerance

The antenna shall be replaced by a dummy load. The forward port of the system coupler shall be used. If a reverse port is available on the system coupler, it shall be terminated with a 50Ω termination.

To measure the frequency tolerance a spectrum analyser shall be used. An additional attenuator shall be used if needed in order to protect the spectrum analyser input from the high power RF pulses. The measurement setup from Annex C shall be used.

The frequency measurements shall be performed with all available pulse length settings. The corresponding PRF shall be chosen in order to get the maximum possible duty cycle for each pulse length. After the frequencies for the maximum duty cycles are measured, the measurements shall be repeated with the lowest duty cycle. The lowest duty cycle is defined as the combination of shortest pulse length and lowest PRF. The lowest PRF shall be the one, which will be generally used in meteorological radar systems during normal operation.

NOTE: A typical lower value for the PRF is 250 Hz as mentioned in Recommendation ITU-R M.1849-1 [i.3].

Between each measurement, a waiting period shall be observed, so as to achieve thermal stability. Thermal stability is achieved if the temperature of the final RF power amplifier (klystron or solid state amplifier) or power oscillator (magnetron) does not change by more than 2 K per minute. The waiting period shall be at least 20 minutes. During this time, the transmitter shall be in operation and transmitting with the new pulse length and PRF values.

A spectrum analyser shall be used to display the frequency spectrum in order to obtain the centre between the highest and lowest frequencies.

When measuring the frequency tolerance for radars with a phase or frequency modulated pulse the tolerance is measured on the frequency reference(s) used for generating the radar output signal. If frequency multiplication in the process of generating the output signal is used, then the frequency tolerance shall be divided by the used multiplication factor.

5.4.1.2 Transmitter Power

The antenna shall be replaced by a dummy load. If the meteorological radar system is equipped with dual polarization capability, the single polarization mode shall be activated and shall be used for the measurements. If only permanent dual polarization mode is available and no coupler in front of the power divider is available, the coupling ratio from the power divider shall be added to the power measurement. The forward port of the system coupler shall be used. If a reverse port is available on the system coupler, it shall be terminated with a 50 Ω termination. The measurement from Annex C shall be used.

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 or elevation movement of the antenna, the highest PEP value measured during a period equal to at least one azimuth rotation period and between the lowest and highest elevation shall be used.

The transmitter power measurements shall be performed with all available pulse length settings. The corresponding PRF shall be chosen in order to get the same duty cycle for each pulse length setting.

To determine the PEP of the pulse a peak power meter with direct reading of the transmitter pulse power shall be used. The PEP shall be measured at the 50 % point of the pulse length. If the transmitter pulse is rippled the average over the pulse shall be used as can be seen in Figure 6.

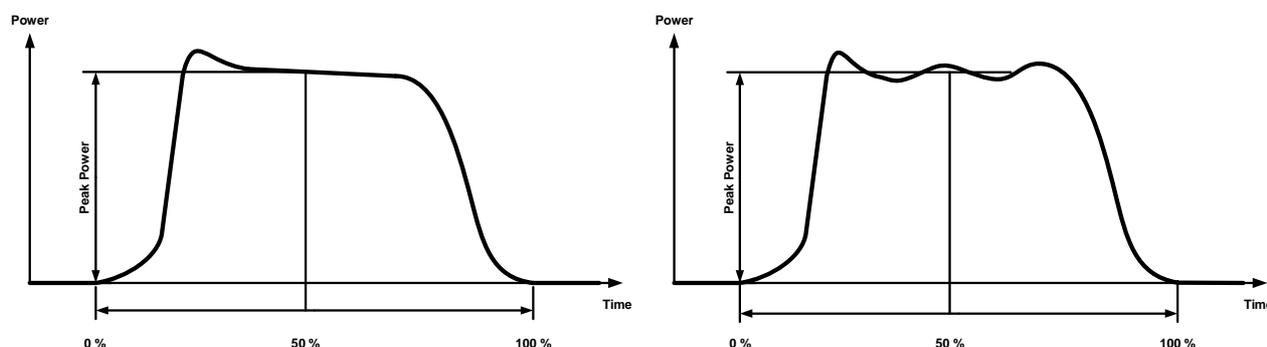


Figure 6: Transmitter output power

To reference the indicated transmitter power to the transmitter output flange the coupling factor of the system coupler shall be added to the power measurement. If an additional attenuator or RF cable has been inserted between the system coupler forward port and the power meter this shall be added to the power measurement. If the power meter does not allow for compensation of the coupling loss and additional attenuator, then the coupling loss and attenuator value shall be added to the meter reading.

5.4.1.3 Measured B₋₄₀ Bandwidth

The measurements of the -40 dB bandwidth shall be performed with the same settings as in clause 5.4.1.4.

The bandwidth of the emissions 40 dB below PEP shall be measured. Measurement setup shall be as described in Annex D.

5.4.1.4 Out-of-Band emissions

For meteorological radar systems with multiple pulse length, the B_{-40} bandwidth shall be calculated for each individual used pulse length as described in Annex B and the maximum B_{-40} bandwidth obtained shall be used to establish the shape of the emission mask. An example of the mask can be seen in Figure 7.

The receiver shall be replaced by a dummy load. If the meteorological radar system is equipped with dual polarization capability, the single polarization mode shall be activated and shall be used for the measurements. If only permanent dual polarization mode is available and no coupler in front of the power divider is available, the coupling ratio from the power divider shall be added to the measurement. The forward port of the system coupler shall be used. If a reverse port is available on the system coupler, it shall be terminated with a 50Ω termination.

The so-called indirect method specified in Annex 1 of Recommendation ITU-R M.1177-4 [3] shall be applied for the measurement of unwanted emissions of radar systems. The transmitter output spectrum shall be measured at the system coupler of the transmitter as illustrated in Annex D.

A margin of at least 10 dB between the Out-of-Band emission mask and the noise floor measurement device shall be achieved.

NOTE 1: Further information how to perform the measurement can be found in Recommendation ITU-R M.1177-4 [3].

The OoB power emission shall be measured in the frequency bands given in Table 5 or Table 6 depending on the PEP. If the PEP is greater than 150 kW the Table 5 shall be used and for powers equal to or less than 150 kW the Table 6 shall be used.

Table 5: OoB emission boundaries for -90 dBpp

Lower OoB boundary	Upper OoB boundary
Carrier frequency - $10,8 \times B_{-40}$	Carrier frequency + $10,8 \times B_{-40}$
NOTE: The values are taken from Table 1 in ECC/Recommendation (02)05 [2].	

Table 6: OoB emission boundaries for -100 dBpp

Lower OoB boundary	Upper OoB boundary
Carrier frequency - $15,8 \times B_{-40}$	Carrier frequency + $15,8 \times B_{-40}$
NOTE: The values are taken from Table 1 in ECC/Recommendation (02)05 [2].	

EXAMPLE: Typical meteorological radar system parameters are e.g. a centre frequency of 5 640 MHz, transmitter power of 250 kW, a pulse duration of $t = 500$ ns and a rise time of $t_r = 100$ ns. The 40 dB bandwidth calculated applying the equation from Annex B is 27,7 MHz. This leads to OoB boundaries at $10,8 \times 27,7$ MHz = 299,2 MHz away from the operating frequency. For this example the absolute boundaries between OoB emissions and spurious emissions are:
 $5\,640$ MHz - 299,2 MHz = 5 340,8 MHz and $5\,640$ MHz + 299,2 MHz = 5 939,2 MHz
 (see Figure 7).

Figure 7 shows the calculated emission masks for the aforementioned parameters of a typical meteorological radar system applying the mask specification in clause 4.2.1.3 which is corresponding to the dashed line in Figure A2.1b of ECC/Recommendation (02)05 [2].

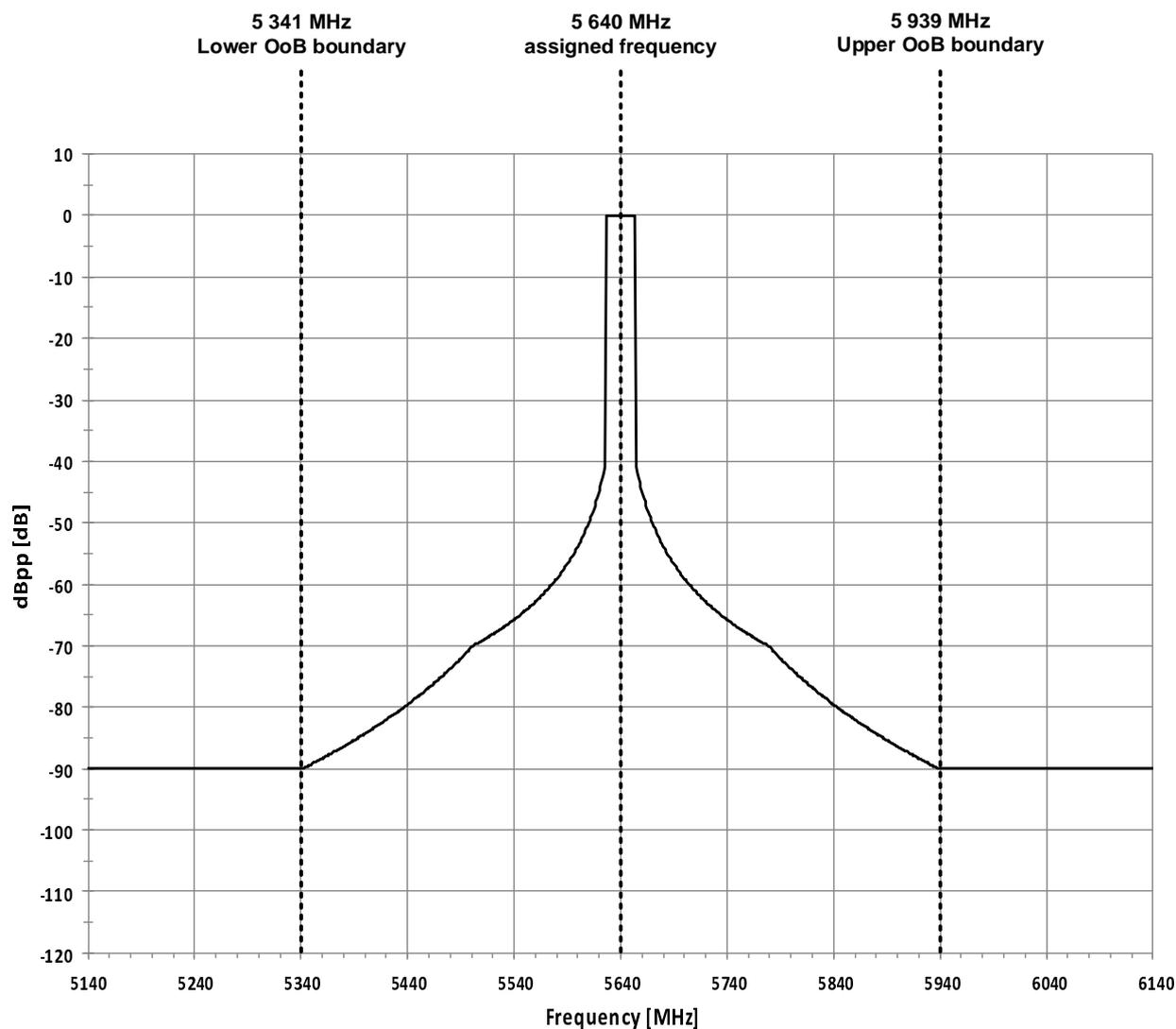


Figure 7: Example of a calculated emissions mask for pulse duration $t = 500$ ns and rise time $t_r = 100$ ns at centre frequency of 5 640 MHz

For the measurements below 5 850 MHz, a WR187/WG12 waveguide shall be used as indicated in Table 7. Therefore the lower measurement frequency shall be equal to the cut-off frequency of 3 152 MHz while the upper boundary is defined in Table 1 of ERC/Recommendation 74-01 [1] (see Table 8).

NOTE 2: The radars covered by the present document use WR187/WG12 waveguides to transfer power between the transmitter and the antenna and the waveguide cut-off frequency is 3 152 MHz as shown in Table 7. Therefore, measurements below this frequency do not provide valid results since the waveguide is unable to support power transfer along its length below the cut-off frequency.

All measurements of Out-of-Band emissions shall be made with a measurement bandwidth equal to the reference bandwidth of 1 MHz according to Annex 2 of Recommendation ITU-R M.1177-4 [3].

5.4.1.5 Spurious emissions

For the spurious emission measurements the so-called indirect method specified in clause 6.4.3 of Annex 1 of Recommendation ITU-R M.1177-4 [3] shall be used. To perform the measurements, the radar system and the measuring equipment shall be set up as displayed in Annex D. The spurious power emissions shall be measured in the frequency ranges outside the OoB emissions boundaries.

Depending on the setup of the meteorological radar system the location where the measurement setup will be installed may be close to the antenna. This ensures that band-limiting components like circulator, rotary joint or waveguide filter are included in the measurement.

Wave propagation in the waveguide is not possible below a certain cut-off frequency where the attenuation of the waveguide is very high. Beyond a certain upper frequency limit, several propagation modes are possible so that the behaviour of the waveguide is no longer unambiguous. In the unambiguous range of a rectangular waveguide, only $TE_{1,0}$ waves are capable of propagation. In the WG16 waveguide the cut-off frequency is 6 556 MHz which is higher than the operating frequency of the C-Band meteorological radar systems. Therefore, at least a 15 cm long WG16 waveguide shall be inserted in the measurement setup in order to protect the measurement device from the operating frequency in the WG16 and higher waveguide bands. The waveguide acts as a high pass in this setup.

Due to the ambiguous propagation modes of the used C-Band waveguide for higher frequencies, smaller waveguides with linear tapers shall be used for the measurement of higher frequencies. These frequency ranges are also referred to as waveguide bands as described in Table 7.

Each waveguide band shall be measured with its corresponding waveguide resulting in unambiguously measurements for the spurious measurements.

EXAMPLE: For the measurement of the frequency range 8,2 GHz to 12,4 GHz the following setup is used: a taper from WG12 to WG14, followed by a second taper from WG14 to WG16 waveguide, followed by at least 15 cm of WG16 waveguide terminated with a WG16 to coax transition.

Table 7: Waveguide bands and associated waveguides

Waveguide band	Frequency	Cut-off frequency	Waveguide designation		
			EIA	UK	R
C	3 950 MHz to 5 850 MHz	3 152 MHz	WR187	WG12	R48
	5 850 MHz to 8 200 MHz	4 300 MHz	WR137	WG14	R70
X	8 200 MHz to 12 400 MHz	6 556 MHz	WR90	WG16	R100
Ku	12 400 MHz to 18 000 MHz	9 486 MHz	WR62	WG18	R140
K	18 000 MHz to 26 500 MHz	14 051 MHz	WR42	WG20	R220

A margin of at least 10 dB below the spurious emission levels of -100 dBpp or -90 dBpp and the noise floor of the measurement device shall be achieved.

In the taper from the WG14 to the WG16 waveguide the operating frequency is completely reflected. If the used circulator as shown in Annex D is the internal one, as mentioned in the scope and has not been installed purely for the measurement, it transfers the signal to the receiver input. Therefore, the LNFE shall be replaced by a dummy load.

Table 8: Spurious emissions measurement bands

Lower measurement band	Upper measurement band
From 3 152 MHz to the lower OoB boundary	From the upper OoB boundary to 26 000 MHz

For the measurements below 5 850 MHz, a WR187/WG12 waveguide shall be used as indicated in Table 7, the lower measurement frequency shall be equal to the cut-off frequency of 3 152 MHz while the upper boundary is defined in Table 1 of ERC/Recommendation 74-01 [1] (see Table 8).

NOTE: The radars covered by the present document use WR187/WG12 waveguides to transfer power between the transmitter and the antenna and the waveguide cut-off frequency is 3 152 MHz as shown in Table 7. Therefore, measurements below this frequency do not provide valid results since the waveguide is unable to support power transfer along its length below the cut-off frequency.

All measurements of spurious emissions shall be made with a measurement bandwidth equal to the reference bandwidth of 1 MHz according to Annex 2 of Recommendation ITU-R M.1177-4 [3].

5.4.1.6 Stand-by Mode Emissions

For the spurious emission measurements, the method shown in Annex D shall be used. The dummy load shall be replaced with the receiver. To perform the measurement the radar system and the measuring equipment shall be installed as shown in Figure D.1 and the radar system shall be placed in stand-by mode.

The spurious power emission shall be measured in frequency ranges outside the Out-of-Band emissions boundaries (see Table 8).

For the measurements below 5 850 MHz, a WR187/WG12 waveguide shall be used as indicated in Table 7, the lower measurement frequency shall be equal to the cut-off frequency of 3 152 MHz while the upper boundary is defined in Table 1 of ERC/Recommendation 74-01 [1] (see Table 8).

NOTE: The radars covered by the present document use WR187/WG12 waveguides to transfer power between the transmitter and the antenna and the waveguide cut-off frequency is 1 GHz as shown in Table 7. Therefore, measurements below this frequency do not provide valid results since the waveguide is unable to support power transfer along its length below the cut-off frequency.

All measurements of stand-by mode emissions shall be made with a measurement bandwidth equal to the reference bandwidth of 1 MHz according to Annex 2 of Recommendation ITU-R M.1177-4 [3].

5.4.2 Receiver Test specification

5.4.2.1 Noise Figure

The receiver noise figure is measured along the complete receiver (as close as possible to the input of the receiver, but excluding antenna and waveguide). It shall be measured using a calibrated noise source and a power detector. The ENR of the noise source shall be known. The receiver frequency shall be tuned to the centre frequency of ground-based radars used for meteorological purposes which is usually at 5 640 MHz. The receiver frequency shall be documented in the test report.

The Y-factor method described below for the measurement of the receiver noise figure shall be used. A noise source is connected to the radar receiver input port. The receiver noise figure is then determined from the ratio between the noise power values at the output of the intermediate frequency stage (or its digitized equivalent) with noise source on and noise source off.

The Noise Figure can be calculated as:

$$\text{Noise Figure} = 10 \times \log_{10} \left(\frac{10^{\left(\frac{\text{ENR}}{10}\right)}}{\frac{Y}{10\left(\frac{Y}{10}\right) - 1}} \right) \quad (3)$$

and

$$Y = \frac{N_{\text{on}}}{N_{\text{off}}} \quad (4)$$

where:

- ENR is the Excessive Noise Ratio of the used noise source.
- N_{on} is the output noise power with the noise source on.
- N_{off} is the output noise power with the noise source off.

5.4.2.2 Receiver Selectivity

5.4.2.2.1 General

The radar receiver shall be setup in the operating mode used for the reception of signals during the test and the transmitter shall be deactivated. The receiver frequency shall be tuned to the centre frequency of ground-based radars used for meteorological purposes which is usually at 5 640 MHz. The used receiver frequency shall be documented in the test report. The upper and lower frequency limits of the disturbing signal mentioned in clause 4.2.2.2.2 shall be adjusted accordingly.

Compliance shall be tested by applying the test signal into the LNFE in conjunction with its connecting waveguide. Depending on the radar setup the waveguide components between the LNFE and the antenna may have bandwidth limiting functions and should be incorporated in the receiver selectivity measurement. The measurement setup from Figure E.1 shall be used. The coupling ratio from the waveguide coupler shall be added to the measurement.

All available receivers in the meteorological radar system shall be measured and documented.

5.4.2.2.2 Receiver unwanted Signal Selectivity

Frequencies inside the B_{-40} receiver bandwidth need not to be tested because this is the receiving frequency range of the meteorological radar system. No rejection of the unwanted signals in the LNFE is possible in this frequency range. The LNFE output power shall be measured at the above mentioned centre or operating frequency in order to get a reference level for the evaluation of rejection levels in the defined bandwidth.

The measurement test setup and the results of the unwanted signal rejection shall be documented in the test report. Furthermore, the test procedure shall also be documented in the test report.

With modern solid-state 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 the disturbing signal difficult.

The disturbing signal for a meteorological radar system shall have the following characteristics:

- The disturbing signal shall be formatted as the emission pattern of the radar under test in order to be detectable by the receiver system and shall increase from each edge of the B_{-40} from the MDS level by 30 dB per decade to a maximum of -30 dBm. See Figure 4 for an example.
- The discrete frequency steps shall be equal to or less than 1 MHz.

The selected disturbing signal shall be documented in the test report.

The disturbance signals shall be applied either directly to the LNFE input or shall be applied to the connecting waveguide of the LNFE as can be seen in Figure E.1. If the disturbance signal is applied to the connecting waveguide the limited frequency range of the C-Band waveguide shall be taken into account. Due to the ambiguous propagation modes of the used C-Band waveguide for higher frequencies, smaller waveguides with linear tapers shall be used for the measurement of higher frequencies. These frequency ranges are also referred to as waveguide bands as can be seen in Table 7.

Each waveguide band shall be measured with its corresponding waveguide resulting in unambiguously measurements for the spurious measurements.

The corresponding output power shall be measured at the output of the digital signal processing as shown in Figure E.1. This procedure shall be repeated for all discrete frequency steps. The frequency span of the measurement device shall be equal to or higher than 1 MHz.

After all frequency steps have been applied and its corresponding output powers have been recorded, the output power levels shall be set in relation to the output power at the operating frequency.

The output of the signal generator shall be checked to see if spurious signals are present. If spurious signals from the signal generator are present, they shall be documented in the test report.

5.4.2.3 Receiver Compression

5.4.2.3.1 General

The receiver frequency shall be tuned to the centre frequency of ground-based radars used for meteorological purposes which is usually at 5 640 MHz. The receiver frequency shall be documented in the test report.

5.4.2.3.2 Receiver Compression Level

A CW test signal shall be injected into the LNFE input directly and the output values shall be read at the output of the digital signal processing. The gain response curve of the LNFE and digital signal processing shall be measured and the 1 dB compression point shall be noted.

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.5] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.1].

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 303 347-2					
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 output power	3.2	4.2.1.2	U	
3	Measured B ₋₄₀ 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	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): Calculation of the -40 dB Bandwidth

Annex 8 of Recommendation ITU-R SM.1541-6 [i.4] specifies the B_{-40} bandwidth for various types of waveforms (e.g. pulsed radar signals).

The B_{-40} bandwidth for non-FM/PM pulse radars is the lesser of:

$$B_{-40} = \frac{K}{\sqrt{t} \times t_r} \text{ or } \frac{64}{t} \quad (\text{B.1})$$

Where:

- The coefficient K is 6,2 for meteorological radar systems with operating power greater than 100 kW and 7,6 for lower-power radars.
- t is the pulse duration between the 50 % amplitude (voltage) points in seconds.
- t_r is the rise time in the case of a trapezoidal pulse.

NOTE 1: For typical values of a pulse duration of $t = 500$ ns and a rise time of $t_r = 100$ ns with a PEP of 250 kW the formula above yields a 40 dB bandwidth value of 27,7 MHz.

For frequency modulated pulse radar systems the B_{-40} bandwidth is:

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

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.
- $B_{rise} = \frac{1}{\sqrt{\tau} \times t_r}$ to account for the rise time.
- $B_{fall} = \frac{1}{\sqrt{\tau} \times t_f}$ to account for the fall time.
- $B_{rise\&fall} = \frac{1}{\sqrt[3]{\tau \times t_r \times t_f}}$ to account for both the rise and fall times combination.
- t_r is the rise time.
- t_f is the fall time.

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

- 1) the product $B_C \times \text{Minimum}(t_r, t_f)$ is greater than or equal to 0,10 and
- 2) that the product of $B_C \times \tau$ or compression ratio is greater than 10.

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

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

Where:

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

NOTE 2: 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 $B_C \times t$, is small or moderate and the rise time is short.

For radars with an asymmetrical spectrum, the calculated B_{-40} bandwidth can be offset from the frequency of maximum emission level. The application of this rule is illustrated in Figure B.1.

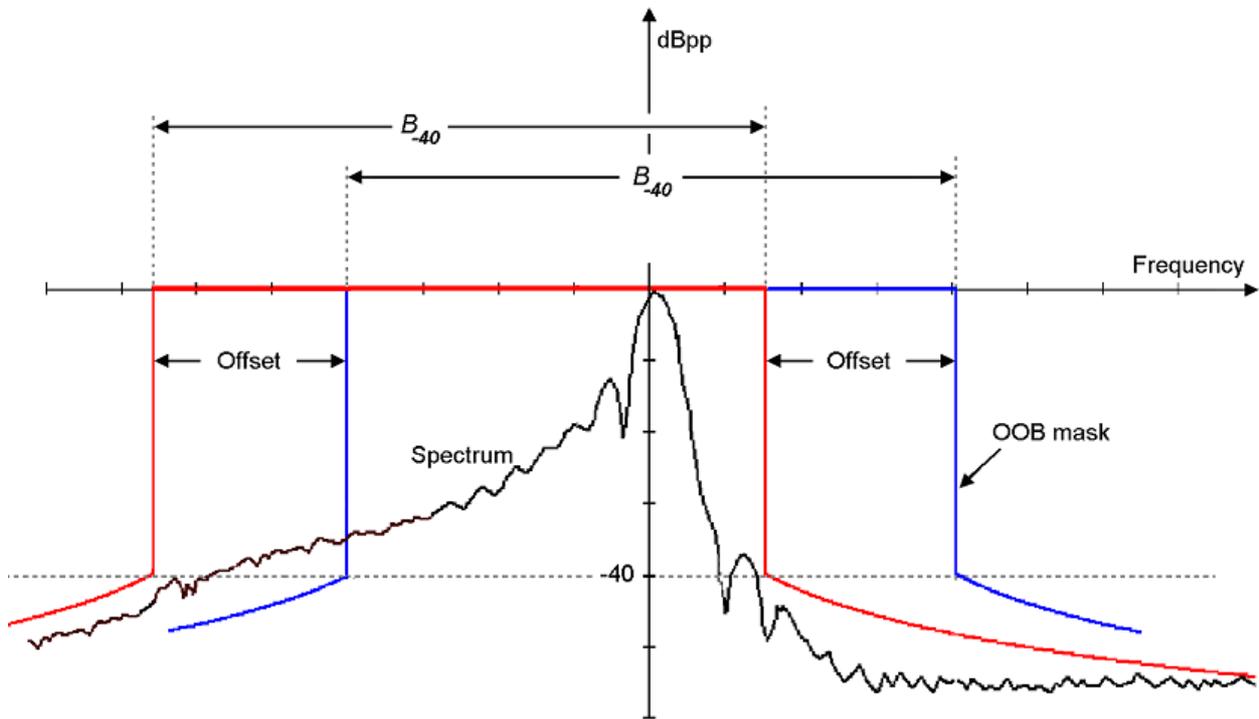


Figure B.1: Application of the offset-rule for the OoB emission limit mask

Annex C (normative): Operating frequency and transmitter power measurement setup

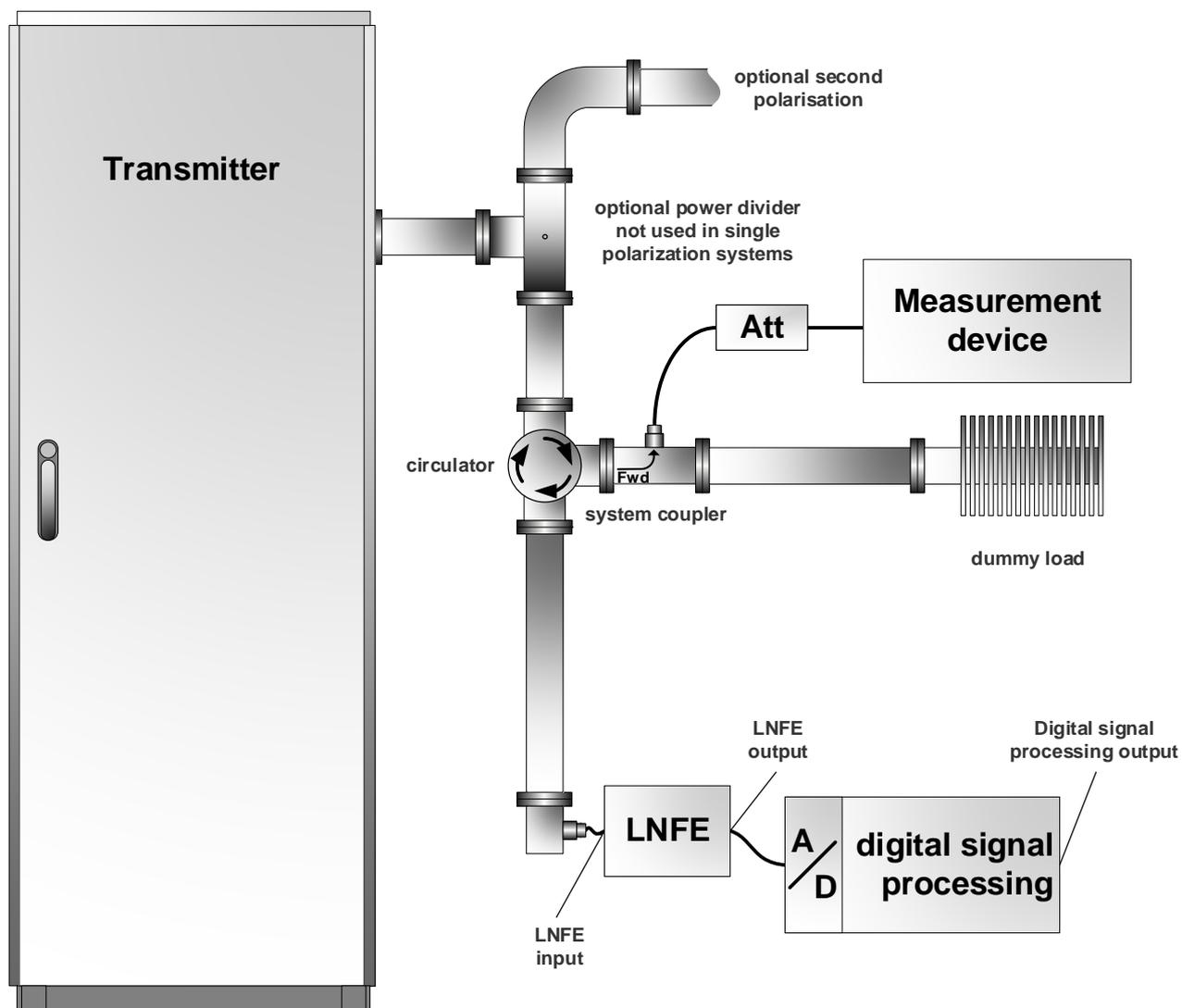


Figure C.1: Indirect method for operating frequency and transmitter power measurement

The method for measurement of the operating frequency and the transmitter power shown in Figure C.1 shall be applied.

Annex D (normative): Spurious and OoB emission measurement setup

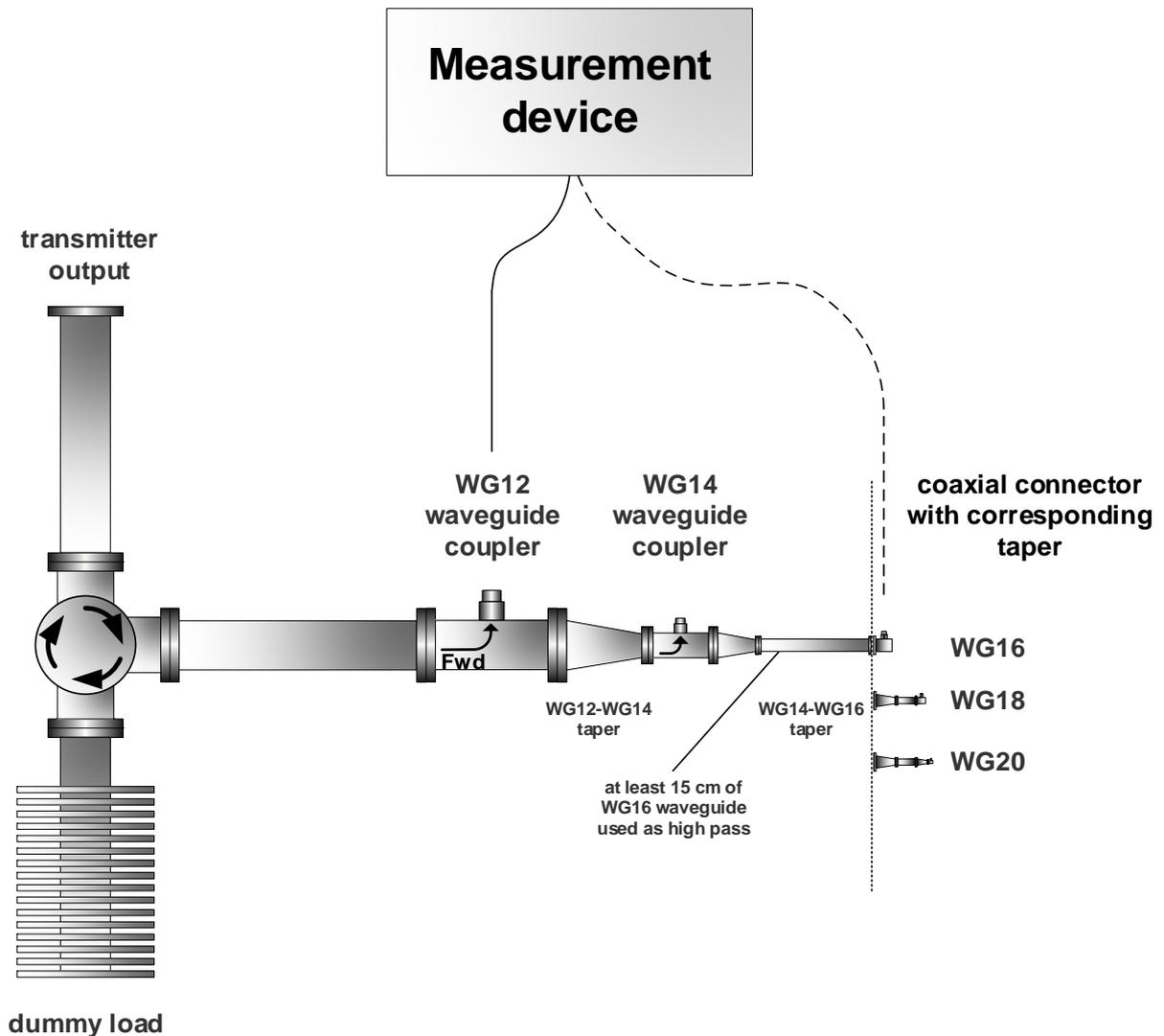


Figure D.1: Indirect method for spurious emission measurement

Figure D.1 shows a single polarization meteorological radar system measurement setup. If a dual polarized system is used the single polarization mode shall be activated. If only permanent dual polarization mode is possible and no coupler in front of the power divider is available, the coupling ratio from the power divider shall be added to the measurement.

The frequency ranges of the shown waveguide to coaxial coupler can be seen in Figure 7.

Annex E (normative): Receiver selectivity and compression level measurement setup

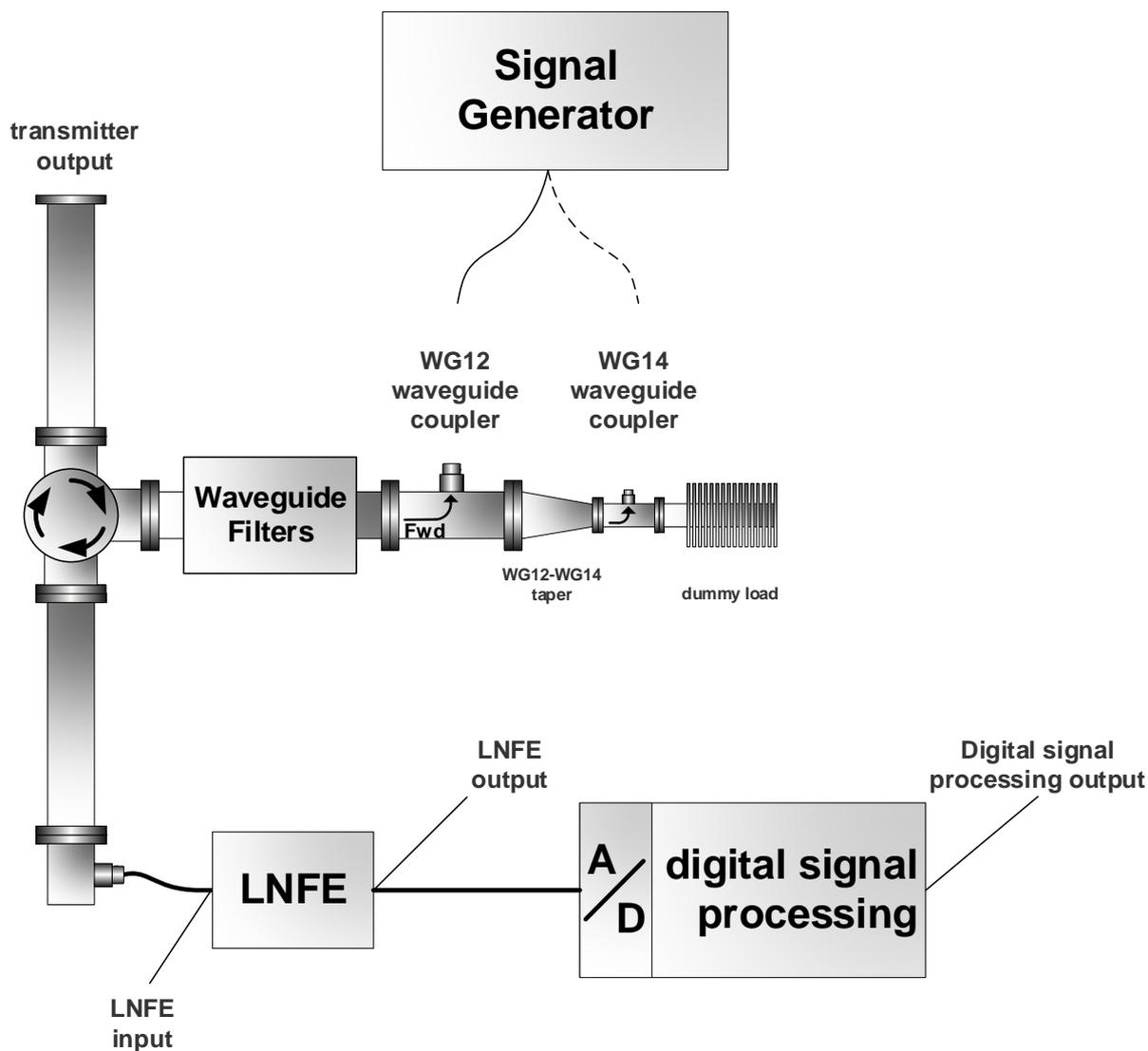


Figure E.1: Measurement method for receiver selectivity measurement

Figure E.1 shows a single polarization meteorological radar system. If a dual polarized system is used the single polarization mode shall be activated.

Annex F (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 F.1 shows the recommended values for the maximum measurement uncertainty figures.

Table F.1: Maximum measurement uncertainty

Parameter	Uncertainty
Transmitter measurements	
Frequency tolerance	$\pm 0,1$ ppm
Transmitter power	$\pm 0,75$ dB
Out-of-Band emissions	± 4 dB
Spurious emissions	± 4 dB
Receiver measurements	
Noise Figure	± 1 dB
Receiver selectivity	± 4 dB
Receiver compression level	± 3 dB
General	
Temperature	± 1 °C
Humidity	± 5 %
Voltage	± 2 %

Annex G (informative): WR187/WG12 waveguide characteristics

The cut-off frequency (TE_{10}) of a WR187/WG12 waveguide is 3 152 MHz. EM Fields below this frequency will not propagate through the waveguide, corresponding to a fast exponential decrease of the fields. The theoretical waveguide loss inside a waveguide will behave asymptotical at the cut off frequency as shown in Figure G.1 below.

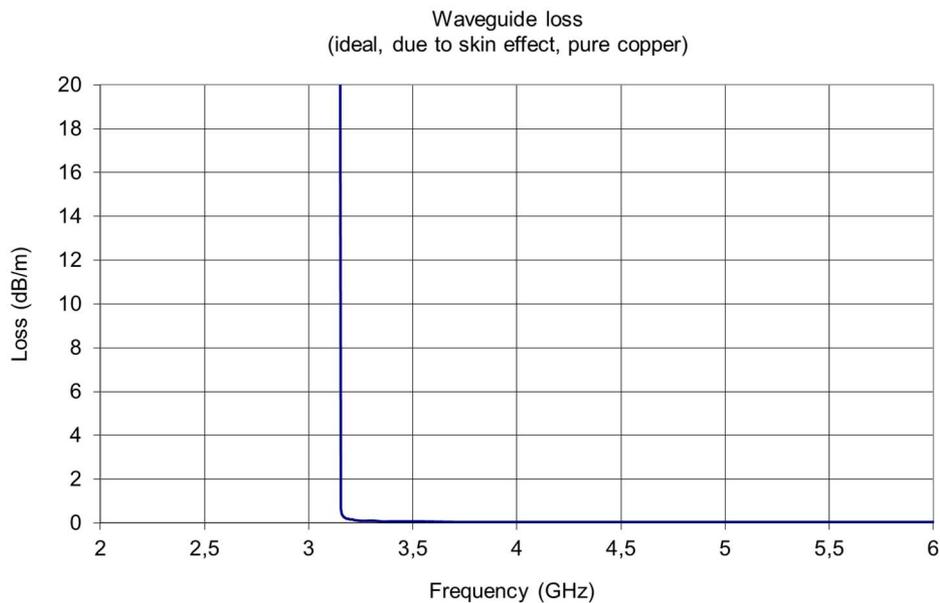


Figure G.1: attenuation for an ideal waveguide

This is also confirmed by a practical measurement. As shown in Figure G.2 below, the measurement of a 90 cm long WR187/WG12 waveguide (with flanges) has produced an attenuation of at least 110 dB below the cut-off frequency. Since what is shown on the left side of Figure G.2 represents noise (thermal noise and the noise floor of the measurement instrument) the real attenuation below the cut-off frequency is greater than 110 dB. The following has to be pointed out:

- 1) An attenuation of 110 dB below PEP is already sufficient to fulfil the unwanted emission requirement specified in Table 15 of ERC/Recommendation 74-01 [1].
- 2) A radar system can have several meters of waveguide between the transmitter and the antenna resulting in a still higher attenuation of the emissions below the cut-off frequency.

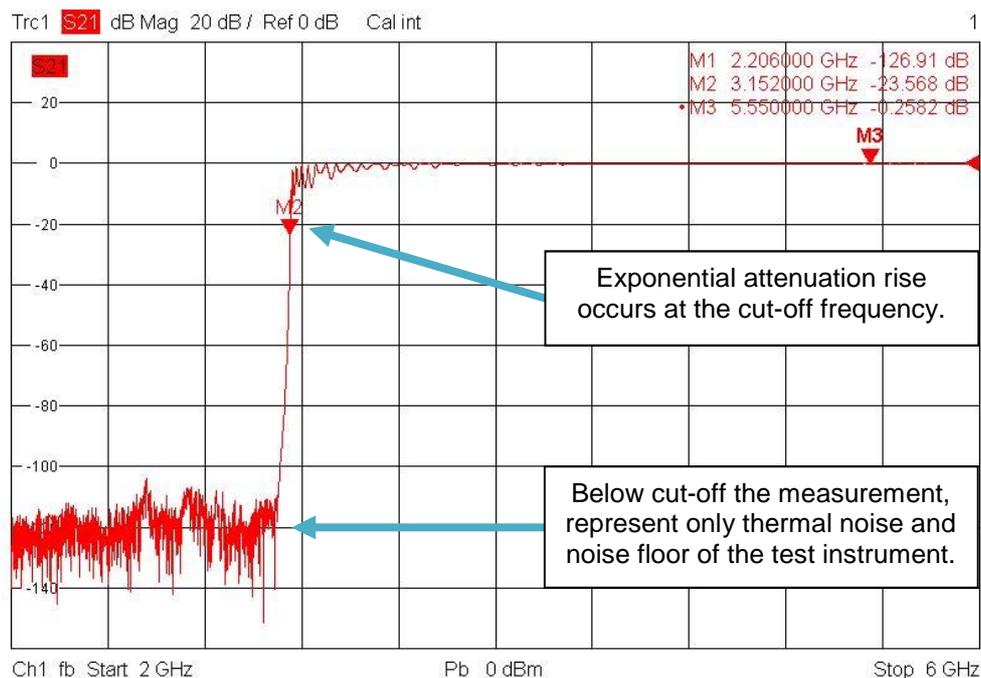


Figure G.2: Measured waveguide attenuation for a length of 90 cm

It can therefore be inferred that:

- A C-Band meteorological radar using waveguide transmission lines to the antenna is not able to transmit any disturbances below the cut-off frequency and so cause harmful interference. The emissions below cut-off will be immeasurably low due to the strong attenuation of EM fields below the cut-off frequency.
- Any emissions below the cut-off frequency produced by the transmitter cannot be conducted to the test equipment, and so cannot even be measured.

Annex H (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.6] 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.1] defined in ETSI EG 203 336 [i.6] 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.6] is covered by an alternative technical requirement.

Some technical parameters defined in ETSI EG 203 336 [i.6] are applicable only to communication systems and not to non-cooperative radar systems such as meteorological radar systems. Non-cooperative radar systems are different from radio communication 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 H.1: Checklist

Technical Parameters defined in EG 203 336 [i.6]	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	Spectrum mask is a generic term applied to the technique of defining transmitter spectral power requirements by specifying permitted power levels as a function of frequency. Transmit requirements are specified in unwanted emissions below.
Transmitter Frequency stability	4.2.1.1	
Transmitter Intermodulation attenuation	na	At the transceiver output an RF circulator is used as indicated in the Scope. This prevents an interfering signal entering from the antenna into the transmitter. The circulator operates only in one way (transmitter to antenna) and suppresses interfering signals entering the transmitter via the antenna.
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	Meteorological radar systems are not able to share the used frequency spectrum as commonly used with communication systems. Otherwise the reception of the echoes would not be possible if another system transmitted during its reception.
Transmitter Transients	4.2.1.4 4.2.1.5 4.2.1.6	Unwanted emission during turn on turn off are covered by the unwanted emission measurement in the OoB and spurious domain.
Receiver Parameters		
Receiver sensitivity	4.2.2.1	The radar output power is not varied as a result of the received signal strength of a single target, which means that it does not affect the efficient use of the radio spectrum. Nevertheless an integral part of the receiver sensitivity is the noise figure. A low Noise Figure implies good receiver sensitivity.
Receiver co-channel rejection	na	Meteorological radar systems are not able to share the used frequency spectrum as commonly used with communication systems. Otherwise the reception of the echoes would not be possible if another system transmits during its reception.

Technical Parameters defined in EG 203 336 [i.6]	Clauses of the present document	Comments
Receiver selectivity		
Adjacent channel/band selectivity	4.2.2.2	Meteorological radar systems are not operating in a channelized environment, but in accordance to national frequency plan taking into account geographical distances between all radars. Therefore, the requirements for selectivity differ from scenarios with channelization. Adjacent signal/channel selectivity is not only addressed by requiring a sufficiently high compression level in the receiver but also the receiver selectivity.
Receiver blocking	4.2.2.3	Receiver Blocking is addressed by requiring a sufficiently high compression level in the receiver.
Spurious response Rejection		
Receiver radio-frequency intermodulation	na	The testing of receiver radio-frequency intermodulation is limited mainly to systems using analogue AM modulation. This is because with constant envelope modulations and super heterodyne receivers cross modulation is very unlikely to be a cause of receiver degradation. Meteorological radar systems use unmodulated pulses or phase/frequency modulated pulses where AM modulation is not used. Receiver radio-frequency intermodulation is also addressed by requiring a sufficiently high compression level in the receiver.
Receiver unwanted emissions in the spurious domain	4.2.1.6	This test is covered by the Stand-by mode emission measurement where the receiver is also activated.
Other receiver effects		
Receiver dynamic range	4.2.2.1 4.2.2.3	The lower end of the receiver dynamic range is addressed by the maximum noise figure. The upper end is addressed by the receiver compression level.
Reciprocal mixing	4.2.2.2 4.2.2.3	Interference characteristics are specified in terms of selectivity and/or blocking requirements, thus removing the need for this parameter to be included, as the effects of receiver selectivity and reciprocal mixing cannot be separated. Requiring a sufficiently high compression level in the receiver also reduces the susceptibility to reciprocal mixing.

History

Document history				
V1.1.0	April 2019	EN Approval Procedure	AP 20190714:	2019-04-15 to 2019-07-15
V1.1.3	June 2020	EN Approval Procedure	AP 20200907:	2020-06-09 to 2020-09-07