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# Foreword

This draft Harmonised European Standard (EN) has been produced by ETSI Technical Committee EMC 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 to provide a means of conforming to the essential requirements of 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.1].

NOTE 1: The corresponding Commission's standardisation request is expected shortly.

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.

NOTE 2: Meteorological radar systems using FM-CW or pulse compression signals may be covered in the future of this deliverable.

|  |  |
| --- | --- |
| **Proposed national transposition dates** | |
| Date of latest announcement of this EN (doa): | 3 months after ETSI publication |
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# 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](http://portal.etsi.org/Help/editHelp!/Howtostart/ETSIDraftingRules.aspx) (Verbal forms for the expression of provisions).

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# Executive summary

The present document covers the essential requirements for efficient use of radio spectrum used by meteorological radar systems in the band 5 250 MHz – 5 850 MHz using pulsed signals. FM-CW or pulse compression signals will be covered in a later deliverable. The current version includes necessary changes due to adaption to the new Radio Equipment Directive 2014/53/EU [i.1].

# 1 Scope

The present document is applicable to 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
* Transmitter Peak Envelope Power above 1 kW
* The transceiver antenna connection and its feeding RF line are using a hollow metallic rectangular or elliptic waveguide
* The antenna is rotating and can be changed in elevation
* The antenna is waveguide based and 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 a RF circulator is used

NOTE 1: Since transceiver and antenna are based on hollow metallic rectangular waveguide the frequency range for measurements that needs to be addressed covers 3152 MHz to 26 GHz. The lower limit of this frequency range is obtained as the cut-off frequency of the generally used WR187/R48 waveguide according to IEC 60153-2 [i.2]. The upper limit corresponds to the upper limit stated in ERC/Recommendation 74‑01 [i.3].

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: Meteorological radar systems covered by the present document are expected to use the band 5250 MHz to 5850 MHz. According to provision 5.452 of the ITU Radio Regulations [i.5], ground-based radars used for meteorological purposes in the band 5600 MHZ to 5650 MHz are authorized to operate on a basis of equality with stations of the maritime radionavigation service.

NOTE 4: Further technical and operational characteristics of meteorological radar systems can be found in [i.4].

The present document contains requirements to demonstrate that *"... Radio equipment shall be so constructed that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference*", Directive 2014/53/EU [i.1].

In addition to the present document, other ENs that specify technical requirements in respect of essential requirements under other parts of article 3 of the Radio Equipment Directive 2014/53/EU [i.1] may apply to equipment within the scope of the present document.

NOTE 1: A list of such ENs is included on the web site <http://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/index_en.htm>.

NOTE 2: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

# 2 References

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Referenced documents that are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

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

## 2.1 Normative references

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

Not applicable.

## 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 2.0, 1974): "Hollow metallic waveguides. Part 2: Relevant specifications for ordinary rectangular waveguides".

[i.3] ERC/Recommendation 74-01 (2011): "Unwanted emissions in the spurious domain".

[i.4] Recommendation ITU-R M.1849-1 (09/1015): “Technical and operational aspects of ground-based meteorological radars”

[i.5] ITU Radio Regulations (2012).

[i.6] ETSI TR 100 028 (all parts) (V1.4.1): " Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[i.7] ETSI TR 100 028-2 (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".

[i.8] Recommendation ITU-R M.1177-4 (04/2011): "Techniques for measurement of unwanted emissions of radar systems".

[i.9] Recommendation ITU-R SM.1541-5 (09/2013): "Unwanted emissions in the out-of-band domain".

[i.10] ECC/Recommendation (02)05 (2012): "Unwanted emissions".

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply:

**assigned frequency band:** the frequency band within which the emission of a station is authorized; 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: This definition is taken from the ITU Radio Regulations [i.5].

**characteristic frequency:** a frequency which can be easily identified and measured in a given emission. A carrier frequency may, for example, be designed as the characteristic frequency.

NOTE: This definition is taken from the ITU Radio Regulations [i.5].

**frequency tolerance:** 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. The frequency tolerance is expressed in parts in 106 or in Hertz.

NOTE: This definition is taken from the ITU Radio Regulations [i.5].

**necessary bandwidth BN:** for a given class of emission, the 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 .

NOTE: This definition is taken from the ITU Radio Regulations [i.5].

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

NOTE 1: Unless otherwise specified in an ITU‑R Recommendation for the appropriate class of emission, the value of β/2 should be taken as 0,5 %.

NOTE 2: This definition is taken from the ITU Radio Regulations [i.5].

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

NOTE: This definition is taken from the ITU Radio Regulations [i.5].

**peak envelope power (of a radio transmitter):** the 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.5].

**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.

**reference frequency:** a frequency having a fixed and specified position with respect to the assigned frequency. 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: This definition is taken from the ITU Radio Regulations [i.5].

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

NOTE: This definition is taken from the ITU Radio Regulations [i.5].

**system coupler:** a high power directional waveguide coupler with forward and reverse port or only a forward port. 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

*BN* Necessary bandwidth

dB/dec dB per decade

*dBpp* dB with respect to peak power

*fc* characteristic frequency

*ft* transmitter frequency tolerance

*t* Pulse duration

*tr* Pulse rise time

## 3.3 Abbreviations

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

AC Alternating Current

A/D Analog to digital converter

EFTA European Free Trade Association

CW Continuous Wave

IF Intermediate frequency

LNFE Low Noise Front End

OoB Out of Band

PEP Peak Envelope Power

PRF Pulse Repetition Frequency

RF Radio Frequency

# 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 supplier, 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 declared operational environmental profile.

## 4.2 Conformance requirements

### 4.2.1 Transmitter requirements

#### 4.2.1.1 Operating frequency

##### 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 operating frequency is to be understood as the frequency of the microwave emission during the transmitting pulse and is represented by the spectral line of highest amplitude.

NOTE: It is only practicable to indicate an operating frequency for radars with unmodulated pulses. In this case a limit for the frequency tolerance is specified. For radars with modulated pulses such a limit is not applicable. In any case the occupied bandwidth is completely contained in the allocated frequency band(s).

##### 4.2.1.1.2 Limits

The frequency tolerance for meteorological radar systems applying unmodulated pulses shall be:

(1)

For all radar types covered by the present documents the occupied bandwidth of the signal shall be contained completely within the frequency ranges 5 250 MHz to 5 850 MHz in all operating modes.

##### 4.2.1.1.2 Conformance

The conformance tests are specified in clause 5.4.1.1.

#### 4.2.1.2 Transmitter Power

##### 4.2.1.2.1 Definition

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 value measured during a period equal to at least one rotation period shall be used.

##### 4.2.1.2.2 Limits

The transmitter power shall be as specified by the manufacturer with an accuracy of at least ±1 dB under normal operating conditions.

Further limits to the peak power do not apply.

##### 4.2.1.2.3 Conformance

The conformance tests are specified in clause 5.4.1.2.

#### 4.2.1.3 Out-of-Band emissions

##### 4.2.1.3.1 Definition

An important parameter of the Out-of-Band (OoB) emissions mask of the radar is the -40 dB bandwidth. Annex 8 of Recommendation ITU R SM.1541 5 [i.9] specifies the -40 dB bandwidth specified for various types of waveforms (e.g. pulsed radar signals). With the following assumptions which apply to most meteorological radar systems these specifications can be further simplified:

* the radar is operating in the frequency range 5 250 MHz to 5 850 MHz
* the radar is utilizing unmodulated pulses
* the pulse power is above 1 kW
* the pulse rise time tr is greater than 0,0094∙t, when = 6,2 where *t* is the pulse duration
* the pulse rise time tr is greater than 0,014∙t, when = 7,6 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. The B-40 bandwidth is the lesser of:

(2)

Where:

* the coefficient is 6.2 for meteorological radars sensors 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.
* *tr* is the rise time in the case of a trapezoidal pulse.

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

For radars with multiple pulse waveforms, the B-40 bandwidth shall be calculated for each individual pulse length and the maximum B-40 bandwidth obtained shall be used to establish the shape of the emission mask.

For radars with a highly asymmetrical spectrum, the B-40 dB bandwidth can be offset from the frequency of maximum emission level, but the necessary bandwidth, BN and preferably the overall occupied bandwidth should be contained completely within the allocated band as stipulated in section 4 of Annex 8 of Recommendation ITU R SM.1541 5 [i.9].

The application of this rule is illustrated in Figure 1.



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

##### 4.2.1.3.2 Limits

NOTE 1: In a future version of the present document more stringent requirements for OoB Emissions based on the design objective case in ECC/Recommendation (02)05 [i.10] (the solid line in figure A2.1c of [i.10] with a slope of 40 dB/decade) may need to be considered.

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. The roll-off of the OoB mask beyond the -40 dB 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. Further details to the level can be found in chapter 4.2.1.4.2 Limits.

NOTE 2: The -100 dBpp mask corresponds to the dashed line in figure A2.1c and the -90 dBpp corresponds to the figure A2.1b of unwanted emissions in Annex 2 of the ECC/Recommendation (02)05 [i.10].

NOTE 3: ERC/Recommendation 74‑01 [i.3] stipulates in its Table 5.1 for fixed radars a spurious emission limit in the reference bandwidth of "‑30 dBm or 100 dB/90 dB, whichever is less stringent".

Table 1: Limits for unwanted emissions with a PEP of greater than 150 kW

|  |  |  |
| --- | --- | --- |
| Frequency offset  relative to B-40 | Limit  dBpp | Slope  dB/decade |
| 0 to 0,5 | 0 | 0 |
| 0,5 | -40 | -∞ |
| 0,5 to 5 | -40 to -70 | -30 |
| 5 to 10,8 | -70 to -90 or -30 dBm | -60 |
| 10,8 to ∞ | -90 or -30 dBm | 0 |

Table 2: Limits for unwanted emissions with a PEP of equal or lower than 150 kW

|  |  |  |
| --- | --- | --- |
| Frequency offset  relative to B-40 | Limit  dBpp | Slope  dB/decade |
| 0 to 0,5 | 0 | 0 |
| 0,5 | -40 | -∞ |
| 0,5 to 5 | -40 to -70 | -30 |
| 5 to 15,8 | -70 to -100 or -30 dBm | -60 |
| 15,8 to ∞ | -100 or -30 dBm | 0 |

Figure 2: OoB emission limit masks

##### 4.2.1.3.3 Conformance

The conformance tests are specified in clause 5.4.1.3.

#### 4.2.1.4 Spurious emissions

##### 4.2.1.4.1 Definition

Spurious emissions are defined as the entity of all emissions in the frequency range from the cut-off frequency 3152 MHz of the waveguide section to 26 GHz, but outside the OoB domain and B-40 boundaries.

NOTE: The lower limit of this frequency range is obtained as the cut-off frequency of the generally used WR187/R48 waveguide according to IEC 60153-2 [i.2]. The upper limit corresponds to the upper limit stated in ERC/Recommendation 74‑01 [i.5 ].

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 ECC/Recommendation (02)05 [i.10] reaches the spurious emission limit of -100 dBpp or -90 dBpp according to ERC/Recommendation 74-01 [i.3]. This is illustrated in Figure 3.



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

##### 4.2.1.4.2 Limits

For meteorological radar systems the spurious emission limits are related to the PEP. The limits can be taken from ERC/Recommendation 74-01 (2011) [i.3] Annex 5. For meteorological radar systems with a PEP greater than 150 kW the limits for spurious emissions or 90 dB below the PEP supplied to the antenna. For lower powered radar sensors with a PEP of equal to or less than 150 kW but more than 1 kW the limits are -30 dBm or 100 dB below the PEP supplied to the antenna port. If an absolute limit of -30 dBm can be more easily achieved, this limit applies instead of the 100 dB value.

For the spurious emissions the following requirement based on Table 5.1 in annex 5 for the case of fixed stations in ERC/Recommendation 74-01 [i.3] shall apply:

* All spurious emission levels of the radar system shall:
* have a minimum attenuation of 100 dB or 90 dB depending on the PEP or a maximum power of -30 dBm, whichever is less stringent
* be measured as PEP in the reference bandwidth of 1 MHz

NOTE: In the case of occurrence of interferences caused by unwanted emissions of the radar transmitter, much higher suppression of Out-of-Band or spurious emissions may be required during measurement. Therefore, it is desirable that it is possible to attenuate or to suppress parts of the emitted signal in the feeder line to the measurement equipment.

##### 4.2.1.4.3 Conformance

The conformance tests are specified in clause 5.4.1.3.

### 4.3.2 Receiver Requirements

#### 4.3.2.1 Receiver selectivity

##### 4.3.2.2.1 Definition

The input selectivity characteristic of the radar receiver shall be commensurate with the requirements for the spectrum of the emitted signal.

##### 4.3.2.2.2 Limit

NOTE : In a future version of the present document more stringent requirements for OoB Emissions based on the design objective case in ECC/Recommendation (02)05 [i.10] (the solid line in figure A2.1b of [i.10] with a slope of 40 dB/decade) may need to be considered.

The sensitivity of the radar system shall decrease in the same degree as the permitted emission spectrum with a limit of -90 dBpp. The -90 dBpp curve corresponds to the dashed line in figure A2.1b of unwanted emissions in Annex 2 of the ECC/Recommendation (02)05 [i.10].

The receiver selectivity shall be verified in the OoB and spurious domain covering the frequency range from 3152 MHz to 26 GHz.

NOTE: The lower limit of this frequency range is obtained as the cut-off frequency of the generally used WR187/R48 waveguide according to IEC 60153-2 [i.2]. The upper limit corresponds to the upper limit stated in ERC/Recommendation 74‑01 [i.5 ].



Figure 4: Definition of disturbing signal level (Not to scale).

##### 4.3.2.2.3 Conformance

The conformance tests are specified in clause 5.5.1.

# 5 Testing for compliance with technical requirements

## 5.1 General requirements

For the purpose of the compliance tests described in the present document, the radar under test shall be set up in a realistic operation mode. This means that the transceiver shall be operating and set-up with parameters which produce the worst-case spectrum (e.g. shortest pulse length, highest peak frequency deviation). Furthermore, the radar shall be supplied with all the necessary signals (e.g. antenna azimuth encoder signal, safety loop signals,) to simulate normal operation.

NOTE: The standard operating parameters depend very much on the type of the radar. In the test report the mode of operation applied for the tests shall be documented.

## 5.2 Environmental conditions for testing

Tests defined in the present document shall be carried out at representative points within the boundary limits of the manufacturer declared operational environmental profile.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the manufacturer declared operational environmental profile) to give confidence of compliance for the affected technical requirements.

### 5.2.1 Normal temperature and humidity

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

1. temperature: +15°C to +25°C
2. relative humidity: 20 % to 75 %

Actual values shall be stated in the test report.

### 5.2.2 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 ±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.

## 5.3 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 included in the test report
* the recorded value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in Table 3

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated and shall correspond to an expansion factor (coverage factor) k = 1,96 or k = 2 (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028 [i.6], in particular in annex D of the ETSI TR 100 028-2 [i.7].

Table 3: Maximum measurement uncertainty

|  |  |
| --- | --- |
| Parameter | Uncertainty |
| Transmitter measurements | |
| Operating frequency | ±1∙10-5 MHz |
| Transmitter power | ±1,5 dB |
| Out-of-Band emissions | ± 4 dB |
| Spurious emissions | ± 4 dB |
| **Receiver measurements** | |
| Receiver Selectivity | ± 4 dB |

## 5.4 Radio test suites

### 5.4.1 Transmitter test specification

#### 5.4.1.1 Operating frequency

The antenna shall either be replaced by a suitable high power dummy load or pointing 90 degree upwards. The forward port of the system coupler shall be used and shall have an adequate attenuation. An optional reverse port shall be terminated with an appropriate 50 Ω terminator.

To measure the operating frequency a suitable frequency meter shall be used. It shall be capable of measuring the short RF pulses. An additional attenuator shall be used if needed in order to protect the frequency meter input from the high power RF pulses.

The frequency measurements shall be performed will 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 [i.4].

Between each measurement, a waiting period of at least 20 minutes shall be applied. During this time, the transmitter shall be in operation and transmitting with the new pulse length and PRF values. This will give the transmitter enough time to adjust thermally. If the transmitter has not thermally adjusted the waiting period shall be extended until the frequency drift has come to an end.

The results obtained for all available pulse length settings shall be compared with the limits in clause 4.2.1.1.2 in order to prove compliance with the requirement.

To measure the frequency stability a frequency counter with a frequency stability of equal to or better than 10 ppm is connected to the radar transmitter via suitable couplers.

#### 5.4.1.2 Transmitter Power

The antenna shall be replaced by a suitable high power dummy load or pointing 90 degree upwards. 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 polarisation mode is available and no coupler in front of the power divider is available, the coupling ratio from the power divider shall be taken into account for. The forward port of the system coupler shall be used and shall have an adequate attenuation. An optional reverse port shall be terminated with an appropriate 50 Ω terminator. The coupling factor shall be known in the allocated band with an accuracy of 0,5 dB or better.

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 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 of the system coupler shall be taken into account. If an additional attenuator or RF cable is installed between the system coupler forward port and power meter this shall be taken into account. 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.

Further explaination of power measurement needs to be added. What is actually meant by PEP? What is “the crest here? Is it the absolute maximum peak, in case there is some overshoot during the pulse? Or is it the average during the pulse?

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

#### 5.4.1.3 Out-of-Band emissions

The antenna shall be replaced by a suitable high power dummy load or pointing 90 degree upwards. 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 polarisation mode is available and no coupler in front of the power divider is available, the coupling ratio from the power divider shall be taken into account. The forward port of the system coupler shall be used and shall have an adequate attenuation. An optional reverse port shall be terminated with an appropriate 50 Ω terminator. The coupling factor shall be known in the allocated frequency band with an accuracy of 0,5 dB or better.

The measurement bandwidth shall be according to Recommendation ITU‑R M.1177‑4 [i.8].

The so-called indirect method 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 Figure 6.

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

Further information how to perform the measurement can be found in Recommendation ITU‑R M.1177‑4 [i.8]. The OoB power emission shall be measured in the frequency bands given in Table 4 or Table 5 depending on the PEP. The results obtained shall be compared to the limits in clause 4.2.1.3.2 and depicted in Figure 2 in order to prove compliance with the requirement.

NOTE 2: The following OoB-boundaries are taken from ECC/Recommendation (02)05 [i.10].

Table 4: OoB emissions boundaries for -90 dBpp

|  |  |
| --- | --- |
| Lower OoB boundary | Upper OoB boundary |
| Carrier frequency – 10,8 × B-40 | Carrier frequency + 10,8 × B-40 |

Table 5: OoB emissions boundaries for -100 dBpp

|  |  |
| --- | --- |
| Lower OoB boundary | Upper OoB boundary |
| Carrier frequency – 15,8 × B-40 | Carrier frequency + 15,8 × B-40 |

NOTE 3: Typical meteorological radar system parameters are e.g. a centre frequency of 5640 MHz, transmitter power of 250 kW, a pulse duration of t = 500 ns and a rise time of tr = 100 ns. The 40 dB bandwidth calculated applying the equation from clause 4.2.1.3.1 is 27,7 MHz. This leads to OoB boundaries at 10,8 × 27,7 MHz = 299,2 MHz away from the operating frequency. For this example the absolute boundaries between OoB emissions and spurious emissions are: 5640 MHz – 299,2 MHz = 5340,8 MHz and 5640 MHz + 299,2 MHz = 5939,2 MHz (see Figure 5).

Figure 5 show 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 [i.10].



Figure 5: Calculated emissions mask for pulse duration t = 500 ns and rise time tr = 100 ns at centre frequency of 5640 MHz

#### 5.4.1.4 Spurious emissions

For the spurious emission measurements the aforementioned indirect method shall be used. To perform the measurements the radar system and the measuring equipment shall be set up as displayed in Figure 7. The spurious power emissions shall be measured in the frequency ranges outside the OoB emissions boundaries.

NOTE: 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 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 H10 waves are capable of propagation. In the WG16 waveguide the cut-off frequency is 6556 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 appropriate 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 6.

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 – 12,4 GHz the following setup will be 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 6: Waveguide bands and associated waveguides

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Waveguide band | Frequency | Cut-off frequency | Waveguide designation | |
| EIA | UK |
| C | 3,95 – 5,85 GHz | 3,152 GHz | WR187 | WG12 |
|  | 5,85 – 8,2 GHz | 4,300 GHz | WR137 | WG14 |
| X | 8,2 – 12,4 GHz | 6,556 GHz | WR90 | WG16 |
| Ku | 12,4 – 18,0 GHz | 9,486 GHz | WR62 | WG18 |
| K | 18,0 – 26,5 GHz | 14,051 GHz | WR42 | WG20 |

A noise margin of at least 10 dB below the spurious emission levels of -100 dBpp or -90 dBpp shall be achieved. A notch filter for the operating frequency shall be used to achieve the required dynamic amplitude range.

NOTE: In the taper from the WG14 to the WG16 waveguide the operating frequency will be completely reflected. If the connected circulator is the internal one and has not been installed purely for the measurement it will transfer the signal to the receiver input. Therefore the LNFE shall be replaced by a suitable high power dummy load.

The obtained results shall be compared to the limits in clause 4.2.1.4.2 in order to prove compliance with the requirement.

Table 7: Spurious emissions measurement bands

|  |  |
| --- | --- |
| Lower measurement band | Upper measurement band |
| From 3152 MHz  to the lower OoB boundary | From the upper OoB boundary  to 26 GHz |

### 5.5.1 Receiver Test specification

#### 5.5.1.1 Receiver Selectivity

##### 5.5.1.1.1 General

The radar transceiver is setup in normal operating mode during the test. The receiver frequency should be tuned to the centre frequency of ground-based radars used for meteorological purposes which is at 5625 MHz. If the meteorological radar system is operating outside the abovementioned range is shall be tested at the actual operating frequency.

Compliance shall be tested by subjecting the LNFE input directly, or in conjunction with its connecting waveguide, to signals at discrete frequency steps within the spurious and OoB domain. 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. An example of the measurement setup can be seen in Figure 7.

The LNFE input is defined as the coaxial input port, which is connected directly via a short RF cable to the waveguide-coax transition in normal operation of the radar system. The IF output of the LNFE is defined as the port which is connected directly via a RF cable to the A/D converter of the digital receiver on normal operation of the radar system. Both ports can be seen in Figure 6.

NOTE: Usually the IF frequency prior the A/D converter is 60 MHz.

If the meteorological radar system has two independent receiving channels for each polarization, the one with the highest sensitivity shall be chosen. If direct conversion receivers with I and Q mixer are used the selectivity shall be measured at both channels.

##### 5.5.1.1.2 Receiver OoB selectivity and spurious rejection

Frequencies inside the B-40 bandwidth need not to be tested because this is the receiving frequency range of the meteorological radar system. No rejection of unwanted signals in the LNFE is possible in this frequency range. The LNFE output power shall be measured at the abovementioned centre or operating frequency in order to get a reference level for the evaluation of rejection levels in the OoB and spurious domain.

NOTE 1: Due to a possible saturation of the LNFE at the operating frequency, it may be necessary to decrease the LNFE input power. The maximum LNFE input power shall be below its upper limit of the linear operation range to prevent saturation.

If the LNFE input power has been reduced, the obtained results shall be corrected in relation to the LNFE input power.

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 8. 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 appropriate 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 6.

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

The disturbing signal shall have the following characteristics:

* the sinusoidal CW signal in the OoB domain shall increase in the same degree as the permitted emission spectrum with a limit of -90 dBpp. See Figure 4 for an example.
* the sinusoidal CW signal in the spurious domain shall have a maximum amplitude of -30 dBm
* the discrete frequency steps shall be equal to 1 MHz

An appropriate measurement device shall be connected to the LNFE output and shall have the following characteristics:

* the frequency span shall be equal to 1 MHz

NOTE 2: Due to the huge amount of frequency steps that shall be checked it is recommended to use a computer aided measurement system to decrease the measurement time.

The corresponding output power shall be measured at the LNFE output. This procedure will be repeated for all discrete frequency steps in the OoB and spurious domain.

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 of the operating frequency.

NOTE 3: If the limit of 90 dBpp has not been achieved at some frequencies, the output of the signal generator should be checked to see if spurious signals are present.

If spurious signals from the signal generator are present they shall be stated in the test report.

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

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

The present document has been prepared to provide a means of conforming to the essential requirements of 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.1].

NOTE: The corresponding Commission's standardisation request is expected shortly.

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 [i.1]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Harmonised Standard ETSI EN 303 347  The following requirements are relevant to the presumption of conformity under the article 3.2 of Directive 2014/53/EU [i.1] | | | | |
| Requirement | | | Requirement Conditionality | |
| No | Description | Reference: Clause No | U/C | Condition |
| 1 | Operating frequency | 4.2.1.1 | U |  |
| 2 | Transmitter power | 4.2.1.2 | U |  |
| 3 | Out-of-Band emissions | 4.2.1.3 | U |  |
| 4 | Spurious emissions | 4.2.1.4 | U |  |
| 5 | Receiver Selectivity | 4.2.2.1 | U |  |

**Key to columns:**

**Requirement:**

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

**Description** A textual reference to the requirement.

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

**Requirement Conditionality**:

**U/C** Indicates whether the requirement shall be unconditionally applicable (U) or is conditional upon the manufacturers claimed functionality of the equipment (C).

**Condition** Explains the conditions when the requirement shall or shall not be applicable for a 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):  
Operating frequency, transmitter power and OoB measurement setup



Figure 6: Indirect method for operating frequency and transmitter power measurement

The method for measurement of the operating frequency and the transmitter power shown in Figure 6 shall be applied.

Note: Figure 6 shows for simplicity a single polarization meteorological radar system. If a dual polarized system is used the single polarization mode shall be activated. If only permanent dual polarisation mode is available and no coupler in front of the power divider is available, the coupling ratio from the power divider shall be taken into account.

Annex C (normative):  
Spurious emission measurement setup



Figure 7: Indirect method for spurious emission measurement

The coupling factor of the used couplers shall be known in the allocated frequency band with an accuracy of at least 0,5 dB or better.

Note: Figure 7 shows for simplicity a single polarization meteorological radar system. If a dual polarized system is used the single polarization mode shall be activated. If only permanent dual polarisation mode is possible and no coupler in front of the power divider is available, the coupling ratio from the power divider shall be taken into account.

Annex D (normative):  
Receiver selectivity measurement setup



Figure 8: Measurement method for receiver selectivity measurement

# History

|  |  |  |
| --- | --- | --- |
| **Document history** | | |
| V0.0.1 | November 2015 | Starting of draft version (MP) |
| V0.1.2 | December 2015 | * Clarification in OoB and spurious emissions conformance requirements. Added reference. (MP) * Change of operating frequency measurement procedure. |
| V0.1.3 | April 2016 | Clarification added for dual pol systems only, transmitter power measurement uncertainty changed and error corrections. |
| V0.2.4 | May 2016 | Added the description of receiver measurement with waveguide, Annex D. Minor corrections. Changed spectrum mask figures. |
|  |  |  |