Primary Surveillance Radar (PSR);

Part 2: Harmonised Standard covering the Essential Requirements of Article 3.2 of Directive 2014/53/EU for Air Traffic Control (ATC) Primary Surveillance Radar Sensors operating in 2700-3100 MHz frequency band (S band)

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# Foreword

This draft Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic Compatibility and Radio Spectrum Matters (ERM) and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

The present document has been prepared under the Commission's standardisation request Commission Implementing Decision C(2015) 5376 final [i.2] 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 ground based ATC Primary Surveillance Radars (PSR), as identified below:

Part 1: “Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU for Air Traffic Control (ATC) Primary Surveillance Radar sensors operating in 1215-1400 MHz frequency band (L band)”

**Part 2: "Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU for Air Traffic Control (ATC) Primary Surveillance Radar sensors operating in 2700-3100 MHz frequency band (S band)".**

Part 3: “Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU for Air Traffic Control (ATC) Primary Surveillance Radar sensors operating in 8500-10000 MHz frequency band (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 |
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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](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx) (Verbal forms for the expression of provisions).

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

# Scope

The present document specifies technical characteristics and methods of measurements for ground based ATC primary surveillance radars operating in the 2700 MHz to 3100 MHz frequency range

NOTE: According to Article 5 of the ITU Radio Regulations [1] the band 2 700 MHz to 2 900 MHz is allocated to the Aeronautical Radionavigation Service on a primary basis and Radiolocation Service on a secondary basis. The band 2 900 MHz to 3 100 MHz is allocated to the Radiolocation and Radionavigation Services on a co-primary basis.

The present document covers the essential requirements of article 3.2 of Directive 2014/53/EU [i.1] under the conditions identified in annex A.

# References

## Normative references

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

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

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

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

[1] ITU Radio Regulations (2016).

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

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

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

## 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] 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.3] ITU-R Recommendation SM.1541-6 (2015) "Unwanted emissions in the out-of-band domain"

[i.4] ITU-R Recommendation SM.329-12 (2012) "Unwanted emissions in the spurious domain"

[i.5] 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.6] 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.7] IEC 60 153-2 ed. 2.0 1974] (ref in 6.3.5) “Hollow metallic waveguides, Part 2: Relevant specifications for ordinary rectangular waveguides”, (Cut-off frequency).

[i.8] EUROCONTROL Standard Document for Radar Surveillance in En-Route and Major Terminal Areas SUR.ET1.ST01.1000-STD-01-01 Edition: 1.0 Date: March 1997.

[i.9] EUROCONTROL Specification for ATM Surveillance System Performance, SPEC-0147:

* Volume 1 Edition: 1.1 Edition date: September 2015.
* Volume 2 Appendices Edition: 1.1 Edition date: September 2015.

[i.10] Merrill I. Skolnik: "Radar Handbook", 2nd Edition, McGraw Hill publications.

# Definitions, symbols and abbreviations

## Definitions

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

**allocated frequency 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 is normally available from the national radio regulatory authority for each country.

**Detectability Margin:** to add the definition from the book

**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.

**operating channel (OC):** frequency range in which the transmission from the EUT occurs, or in which the EUT is intended to receive transmissions

**operating frequency:** centre of the OC

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

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

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

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

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

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

NOTE 2: 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%

**peak envelope power:** average power supplied to the antenna transmission line by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions

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

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

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

**equipment under test (EUT):** system of constituents provided by the manufacturer for qualification under this document.

**transmit radar sensor:**  all the physical transmitter hardware (including embedded software) to the free space interface (i.e. physical hardware side of antenna to free space interface)

**receive radar sensor:** all the physical receiver hardware (including embedded software) from the free space interface to the physical receiver hardware (including embedded software) output.

**injection of interfering scenarios:** introduction of the interfering signal scenarios into the radar by either free space summation or by direct injection into the radar receiver chain at some point after the antenna

NOTE 1: The injection point may vary from radar to radar but it always includes the signal transiting any hardware components that may contribute to signal performance degradation in the presence of interference signals1.

**inactive state:** entire period between transmissions (preceding and following the transmission).

## Symbols

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

*B-40* -40 dB bandwidth

*BC* Chirp bandwidth

*BN* Necessary bandwidth

*Bres* 3 dB resolution bandwidth of transceiver

dB deciBel

dBm power in dB relative to 1 milliwatt

dB/decdB per decade

*dBpp* dB with respect to peak power

*Dno spur* Detectability Factor

EUT Equipment Under Test

*FAR* False Alarm Rate

*I/N* Interference to Noise ratio

*k* Boltzmann's constant

*NFsys* Noise Factor of the system

*PD* Probability of detection

*PEP* Peak Envelope Power

*Pt* Pulse power of transmission

RF Radio Frequency

*S/N* Signal-to-Noise ratio

*t* Time

*TC* Pulse length (of individual chirp waveforms) in seconds

*tp* Pulse duration

*tr* Pulse rise time

*T0* Temperature in Kelvin

*λ* Wavelength

## Abbreviations

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

AC Alternating Current

ADC Analog to Digital Converter

CW Continuous Wave

EIRP Effective Isotropically Radiated Power

ESASSP EUROCONTROL Specification for ATM Surveillance System Performance

EUT Equipment Under Test

FM-CW Frequency Modulated Continuous Wave

ICAO International Civil Aviation Organization

IRS Interfering radio signal

ITU International Telecommunication Union

LNA Low Noise Amplifier

MDS Minimum Detectable Signal

OoB Out-of-Band

PEP Peak Envelope Power

ppm parts per million

RF Radio Frequency

PSR Primary Surveillance Radar

# Technical requirements specifications

## Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer, but as a minimum, shall be that specified in the test conditions contained in the present document. The equipment shall comply with all the technical requirements of the present document which are identified as applicable in annex A at all times when operating within the boundary limits of the declared operational environmental profile.

## Conformance Requirements

### Transmitter requirements

#### Frequency tolerance

##### Definition

The frequency tolerance is the maximum permissible departure by the center 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: this definition is taken from the ITU Radio Regulations [1]

##### Limits

The maximum permissible absolute value of frequency tolerance shall be of 1250 ppm as specified in Appendix 2 of the ITU Radio Regulations [1].

##### Conformance

The conformance tests are specified in clause 5.4.2.

#### Measured B-40 bandwidth

##### Definition

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

##### Limits

The measured B-40 bandwidth of the signal shall be contained completely within the frequency range 2 700 MHz to 3 100 MHz in all operating modes.

In case of multiple-carrier frequencies transmission all measured B-40 emissions shall be contained completely within the frequency range 2 700 MHz to 3 100 MHz.

##### Conformance

The conformance tests are specified in clause 5.4.2.2.

#### Unwanted emissions

##### Unwanted emissions general requirements

The Out-of-Band emission limits and the spurious emission limits are defined based on the calculated B-40 bandwidth (see Annex E).

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

For radars with multiple carrier frequencies, the overall emission mask is obtained by superimposing the emission masks of each individual carrier frequency

TO add figure 1 with 2 overlapping B-40 and different PEP



Figure 2: Example of superimposed (combined) mask from two carrier frequencies.

For radars with multiple carrier frequencies, if 2 or more B-40 overlap, the emissions in the OoB and spurious domains shall be measured taking into account the overall B-40. Whenever the PEP related to 2 adjacent carrier frequencies are different, the combined B-40 shall be related to the higher PEP value (see Figure 1)

For radars with multiple carrier frequencies, if B-40 of the single carriers do not overlap, the emissions in the OoB and spurious domains shall be related to each individual B-40 (see Figure 2).

##### Emissions in the Out-of-Band domain

###### Definition

Emissions in the Out-Of Band (OOB) domain for primary radars are considered to be emissions on a frequency or frequencies immediately outside B-40 but excluding emissions in the spurious domain.

The Out-of-Band (OoB) emission mask is calculated with respect to B-40.

.

###### Limits

For multi-frequency (including frequency diversity) and/or active array radars, the emissions limits in the OoB domain shall be as specified in Table 5.1 of ECC Recommendation 74-01 [3] and table 1 below.

Table 1: Limits for emissions in the OoB domain for multiple frequency and active arrays

|  |  |  |
| --- | --- | --- |
| Frequency offset  relative to B-40 | Limit  dBpp | Slope  dB/decade |
| 0,5 to 2.3 | -40 to -43 - 10\*log(PEP) / -60 (see note 1) | -30 |
| NOTE1: from -40 to -43 - 10\*log(PEP) or -60 dBpp whichever is less stringent | | |

For all other radar systems the emissions limits in the OoB domain shall be as specified in Table 5.1 of ECC Recommendation 74-01 [3] and table 2 below.

Table 2- Limits for emissions in the OoB domain for all other radar systems

|  |  |  |
| --- | --- | --- |
| Frequency offset  relative to B-40 | Limit  dBpp | Slope  dB/decade |
| 0,5 to 5 | -40 to -70 | -30 |
| 5 to 15,8 | -70 to -100 / -30 dBm (See note 1) | -60 |
| NOTE 1: from -70 to -100 or -30 dBm whichever is less stringent | | |

Figure 2 below shows the emissions limits (in bold) in the OoB domain for the radar systems above mentioned.



Figure 2: Emission in the OoB domain (in bold)

###### Conformance

The conformance tests are specified in clause 5.4.2.2.

##### Emissions in the Spurious domain

###### Definition

Spurious emissions are defined as the entity of all emissions in the frequency range of the cut‑off frequency 2,08 GHz of the waveguide section to 15,5 GHz, but outside the OoB-boundaries.

NOTE: The lower limit of this frequency range of 2,08 GHz is obtained as the cut-off frequency of the generally used WR-284/R32 waveguide as defined in IEC 60153-2 [[i.7]]. The upper limit corresponds to the upper limit stated in ERC/Recommendation 74-01 [3] Table 1 (5th harmonic).

Spurious emissions include:

* harmonic emissions (whole multiples of the operating frequency),
* parasitic emissions (independent, accidentally),
* intermodulation (between oscillator- and operation frequency or between oscillator and harmonics),
* emissions caused by frequency conversions.

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



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

###### Limits

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

Table 3 - Limits for emissions in the spurious emissions

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

NOTE 1: A reference bandwidth of 1 MHz is recommended for frequencies above 1 GHz as in ERC/Recommendation 74‑01 [3].

###### Conformance

The conformance tests are specified in clause 5.3.1.4.

#### Residual Power Output

##### Description

The residual power output is the power output when the radar is in standby mode.

##### Limits

The residual power output shall be not greater than -47dBm as specified in Table 5.1 of Annex 5 of REC 74-01 [3] and in Table 4 below

|  |  |
| --- | --- |
| Frequency | Emission limits in standby mode |
| 2.08 GHz <= f0 <= 15.5 GHz (see note 1 & 2) | -47dBm |
| NOTE 1: The lower limit of this frequency range of 2,08 GHz is obtained as the cut-off frequency of the generally used WR-284/R32 waveguide as defined in IEC 60153-2 [[i.7]]. The upper limit corresponds to the upper limit stated in ERC/Recommendation 74-01 [3] Table 1 (5th harmonic).  NOTE 2: no limit within ±250% of the calculated necessary bandwidth (B-20) as defined in ITU-R SM 1541-6 [i.3] | |

##### Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.4.

### Receiver requirements

#### System Noise Figure

##### Definition

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

##### Limits

The system Noise Figure shall not exceed 6 dB.

##### Conformance

The conformance tests are specified in clause 5.4.3.1.

#### Receiver Selectivity

##### Receiver adjacent signal selectivity

###### Definition

###### Limits

###### Conformance

##### Receiver spurious response rejection

###### Definition

###### Limits

###### Conformance

##### Definition

Receiver selectivity is the capability to receive a wanted signal, without exceeding a given degradation, due to the presence of an unwanted signal, which differs in frequency from the wanted signal by a specified amount.

##### The spurious response rejection is a measure of the capability of the receiver to receive a wanted signal without exceeding a given degradation due to the presence of an unwanted signal at any frequency at which a response is obtained. The frequencies of the adjacent channels are excluded.Spurious response rejection includes all possible spurious responses of the receiver but more specifically image-rejection ratio and intermediate-frequency rejection ratio. Receivers with multiple intermediate-frequencies will have image responses and intermediate-frequency responses for each intermediate-frequencyLimit

Limits are evaluated assuming the signal is constructed as a valid waveform except that the frequency is altered. It is important that the receiver rejects signals which are out of band while retaining sufficient bandwidth for acceptable detection performance.

The input selectivity characteristic of the radar receiver shall correspond to the requirements for the spectrum of the emitted signal as specified in clause 4.2.1.3. It shall correspond to the requirements shown in Figure 1.

The receiver selectivity shall be at least verified in the Out-of-Band region (i.e. in the range of ±30 MHz from the operating frequency for the multiple frequency or phased array radars, or in the range of ±200 MHz from the operating frequency for other radars).

In the spurious region, the receiver selectivity shall ensure at least 60 dB suppression of image or IF signals (e.g. at Fc+IFH/2, IFH being the receiver higher intermediate frequency).

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 maximum input power of the receiver shall be no more than 6 dB below the compression level for the given receiver design.



Figure 1: Resulting receiver selectivity mask (not to scale). The maximum disturbance level was set at -30dBm.

The derivation of the receiver Out-of-Band selectivity curve is described in clause 5.3.2.2.

##### Conformance

The conformance tests are specified in clause 5.4.3.3.

### Receiver blocking

#### Definition

Blocking is a measure of the capability of the receiver to receive a wanted signal without exceeding a given degradation in the presence of a strong unwanted signal.

#### Limits

The rate of correctly detected wanted signals shall be reduced by no more than 50% in the presence of unwanted signals specified in Table 2. *The detection coverage shall be reduced by no more than 30% in the presence of unwanted signals as specified in Table 2*.

Table 3 - unwanted signal levels

|  |  |
| --- | --- |
| Frequency | Level |
|  | tbd |
|  | tbd |

#### Conformance

The conformance tests are specified in clause 5.3.2.3.

### Receiver desensitization

#### Definition

Desensitization is a degradation of receiver sensitivity caused by the presence of a large unwanted signal. The term is most commonly applied when an unwanted signal is present in the receiver which is above a receiver’s linear “dynamic range” resulting in desensitization for example by the process of gain compression. It should be noted that gain compression can occur in any stage of the receiver.

#### Limits

Unwanted signals as specified in table 4 shall be rejected below the 1-dB compression point of the receiver. This may require the use of a special RF filter in front of the receiver. The manufacturer shall declare the portion of the operating frequency band that can be used with such a filter (e.g. 2720 MHz to 3080 MHz).

Table 4 - unwanted signal levels

|  |  |
| --- | --- |
| Frequency | Level |
| 2570 MHz to 2690 MHz | Strong wideband: 5 dBm/m2 in 120 MHz bandwidth at antenna input (tbc)  Medium limited band (e.g. 10 MHz): -30 dBm/m2 (tbc) |
| 3410 MHz to 3600 MHz | Strong wideband: 5 dBm/m2 in 190 MHz bandwidth at antenna input (tbc)  Medium limited band (e.g. 10 MHz): -30 dBm/m2 (tbc) |

NOTE: This RF filter may not be needed if the level of the interfering signals in the vicinity of the radar are not saturating. Then, the lower end (respectively the higher end) of the as-designed frequency range can be used operationally.

#### Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.3.4

### Inter-modulation response rejection

#### Definition

The intermodulation response rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship relative to the receiver frequency (i.e. that of the wanted signal).

#### Limits

At any frequency combination from 2570 MHz to 2690 MHz and from 3410 MHz to 3600 MHz (tbc), the unwanted signals shall not reduce the probability of detection of wanted signals by more than 15 % (tbc) if their signal level is up to 12 dB or more below the level of the wanted signal at the receiver RF input.

The two-tone linearity of the receiver, for two signals with a frequency distance of IFH or IFL (or third order intercept point), measured at receiver output for a signal at 3 dB below ADC full scale, shall be greater than 50 dB (tbc) when the receiver is set to its nominal gain.

NOTE: IFH and IFL being respectively the receiver higher and lower intermediate frequencies.

The unwanted signals shall not increase the false alarm rate by more than a ratio of 2.

#### Conformance

The conformance tests for this requirement shall be as defined in clause 0.

# Testing for compliance with technical requirements

## General requirements

The manufacturer shall ensure that all operating modes and product configurations are in compliance with the technical requirements in the present document. This can be achieved by testing only those operating modes and product configurations that the manufacturer believes are relevant for presumption of conformity against the technical requirements of the present document.

The operating modes and product configurations tested shall be set up with parameters which produce the worst case spectrum (e.g. shortest pulse length, highest peak frequency deviation).

## Environmental conditions for testing

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer, but as a minimum, shall be that specified in the test conditions contained in the present document. The equipment shall comply with all the technical requirements of the present document which are identified as applicable in annex A at all times when operating within the boundary limits of the declared operational environmental profile.

### Introduction

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

### Normal temperature and humidity

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

1. temperature: +15 oC to +35 oC;
2. relative humidity: up to 75 %.

### Normal test power supply

The test voltage for equipment to be connected to an AC supply shall be the nominal mains voltage declared by the manufacturer -10 % to +10 %. For the purpose of the present document, the nominal voltage shall be the declared voltage or each of the declared voltages for which the equipment is indicated as having been designed. The frequency of the test voltage shall be 50 Hz ± 1 Hz.

## Interpretation of the measurement results

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as follows:

* the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;
* the value of the measurement uncertainty for the measurement of each parameter shall be included in the test report;
* the recorded value of the measurement uncertainty shall be, for each measurement, equal to or less 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 characterising the actual measurement uncertainties are normal (Gaussian)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028 [i.5], in particular in annex D of the ETSI TR 100 028-2 [i.6].

Table 5: Maximum measurement uncertainty is based on such expansion factors.

Table 5: Maximum measurement uncertainty

|  |  |
| --- | --- |
| Parameter | Uncertainty |
| Transmitter measurements | |
| frequency tolerance \*) | ±1 ppm |
| Transmitter power | ±0,75 dB |
| Out-of-Band emissions | ± 4 dB \*\*) |
| Spurious emissions | ± 4 dB \*\*) |
| **Receiver measurements** | |
| Receiver Selectivity | ± 4 dB \*\*\*) |
| Noise Figure | ± 1dB |

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

\*\*) Required between 0 and -30dBc for CW signals

\*\*\*) Required between 0 and -20dBm

## Radio test suites

### Transmitter test specification

### Frequency Tolerance

In order to measure the frequency tolerance, the measurement is done on the antenna interface. The antenna shall be replaced by a suitable adapter to adapt the rotary joint to a waveguide with a plane flange. On that flange a high-power directional coupler will be mounted with its main port terminated by a matching high-power dummy load. The coupled port shall have an adequate attenuation within the whole frequency band 2 300 MHz to 3 500 MHz (400 MHz outside edges of allocated bands) to protect the measurement equipment.

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

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

#### Transmitter power

The antenna shall be replaced by a suitable adapter to adapt the rotary joint to a waveguide with a plane flange. On that flange a high-power directional coupler will be mounted with its main port terminated by a matching high-power dummy load. The coupled port shall have a sufficient attenuation within the whole frequency band 2 300 MHz to 3 500 MHz to avoid saturation of the measurement equipment

To determine the Peak Envelope Power of the pulse a peak power meter with direct reading of the transmitter peak power should be used.

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

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

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

#### Out-of-Band-emissions

The so-called indirect method as specified in clause 6 of Annex 2 of Recommendation ITU‑R M.1177‑4 [4] shall be applied for the measurement of unwanted emissions of radar systems. The transmitter spectrum shall be measured at the output port of the transmitter as illustrated in figure B.1.

For multi-frequency and active array radars the Out-of-Band power emission shall be measured in the frequency bands given in table 6.For all other radar systems the Out-of-Band power emission shall be measured in the frequency bands given in table 7.

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

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: These OoB-boundaries are taken from ECC/Recommendation (02)05 [2].

Table 6: Out-of-Band emissions boundaries for multiple frequency and active arrays

|  |  |
| --- | --- |
| Lower OoB boundary | Upper OoB boundary |
| Centre frequency -2,3 *B-40* | Centre frequency + 2,3 *B-40* |
| NOTE 1: the values are taken from ECC Recommendation (02)05  NOTE 2: measurements below the waveguide cut-off frequency are not necessary | |

Table 7: Out-of-Band emissions boundaries for all other radar systems

|  |  |
| --- | --- |
| Lower OoB boundary | Upper OoB boundary |
| Carrier frequency -15,8 *B-40* | Carrier frequency + 15,8 *B-40* |
| NOTE 1: the values are taken from ECC Recommendation (02)05  NOTE 2: measurements below the waveguide cut-off frequency are not necessary | |

To be reviewed in order to take into account frequency diversity (multiple discontinuous B-40).

NOTE 3: Typical radar parameters are e.g. a centre frequency of 2,8 GHz, a pulse duration of t = 100 µs and a rise time of tr = 200 ns, the 40 dB bandwidth calculated applying the equation from clause 4.2.1.1.1 is ≈ 10MHz depending on the modulation bandwidth. This leads to OoB boundaries at 15,8 × 10 MHz = 158 MHz away from the centre frequency (figure 4). For this example, the absolute boundaries between out-of-band emission and spurious emission are: 2,8 GHz – 0,158 GHz = 2,642 GHz and 2,8 GHz + 0,158 GHz = 2,958 GHz (see figure 5 below).

Figures 4 and 5 depict the calculated emission masks for the aforementioned parameters of a typical radar applying the mask specification in clause 4.2.1.3 which is corresponding to the standard mask in figure A2.1c of ECC/Recommendation (02)05 [2].



Figure 4: Calculated emission mask for typical pulse duration of *t* = 100 µs  
and rise time of *tr* = 200 ns



Figure 5: Calculated emissions mask for pulse duration of *t* = 100 µs  
and rise time of *tr* = 200 ns at centre frequency of 2,8 GHz

#### Spurious emissions

For the spurious emission measurements the aforementioned indirect method shall be used. To perform the measurement the radar and the measuring equipment shall be installed as displayed in figure B.1. The spurious power emission shall be measured in frequency ranges outside the Out-of-Band emissions boundaries (see table 5).

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

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

Table 5: Spurious emissions measurement bands

|  |  |
| --- | --- |
| Lower measurement band | Upper measurement band |
| From 2,08 GHz  to the lower OoB boundary | From the upper OoB boundary  to 15,5 GHz |
| NOTE 1: the lower limit correspond to the cut-off frequency of the waveguide  NOTE 2: the upper limit is taken from ECC Recommendation (74) 01 with transmitter frequency set to 3,1 GHz | |

### Receiver test specification

#### System Noise Figure

##### General

The system noise figure is measured along the complete receiving signal chain (as close as possible, but excluding

antenna & waveguide or RF coax, and noise processing). It shall be measured using a noise source (which may be built into the system) and a detector (which may be built into the system as well).

One recommended measurement method for the System Noise Figure is the Y-factor method. A noise source is

connected in lieu of the antenna to the radar receiver input port. The System Noise Figure is then determined from the

ratio between the noise power values at output of the intermediate frequency stage (or its digitized equivalent) with

noise source on and noise source off.

The system noise figure shall be measured for four frequencies across the operating frequency band.

For phased arrays, the recommended measurement method for the System Noise Figure is….

#### Receiver Sensitivity & Dynamic Range

##### Description

The purpose of this test is to establish the sensitivity and dynamic range of the receiver at the intended operating frequency. Although the sensitivity and the dynamic range are declared by the manufacturer, the levels are needed as a reference for other tests.

##### Test conditions

External test equipment will be used to stimulate the EUT with desired test signal 3 at the amplitudes indicated in the procedure. External test equipment will be used to collect the reception reports for each injected message.

##### Method of measurement

The test waveform shall be injected using conduction into the EUT antenna interface. All amplitudes shall be adjusted for cable loss to be representative of the antenna interface of the EUT. The message receipt reports will be collected and the average rate of message receipt will be calculated.

##### Measurement procedure

To be developed.

#### Receiver Selectivity

##### General

For modern solid state digital radars the emitted signals may be very complicated and include both phase-modulation, frequency-hopping and -sweeping and pulse width modulation. This makes a single definition of MDS and interfering signal difficult. The following is a generalized approach based upon a calculated MDS value [i.10]:



Where:

*MDS* Minimum Detectable Signal

*k* Boltzmann constant

*T0* Temperature in Kelvin

*Bres* 3 dB resolution bandwidth of transceiver

*NFsys* Noise Factor of the system

*Dno spur* Detectability Factor (function of *PD & Pfa*)

[i.10]*PD* Probability of detection = 10-3 (selected value)

*PFA* Probability of false detection = 10-3 (selected value)

*TC* Pulse length (of individual chirp) in seconds

*BC* modulation bandwidth

*M* Test margin = 0,1 (Without this margin the receiver should give a detectable signal)

##### Receiver Out-of-Band selectivity

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

**Disturbing Test Signal**

The disturbance signal shall be a sinusoidal pulsed signal with pulse duration of 1 µs and a pulse repetition frequency of 1 kHz.

**Maximum Level of Disturbing Signal**

The maximum level of the disturbing signal shall be selected such that the receiver will not be saturated (e.g. at -50dBm) The selected test signal level shall be up to 6 dB below compression level for the given receiver design.

**Roll off of Disturbing Test Signal**

From each edge of B-40 the signal strength shall increase from MDS level by 30dB per decade and from 70dB above MDS level the signal strength shall increase by 60dB per decade (if maximum level has not been reached). This is illustrated in figure 6 below.

**Test Pass Criteria**

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

**Measurement Points**

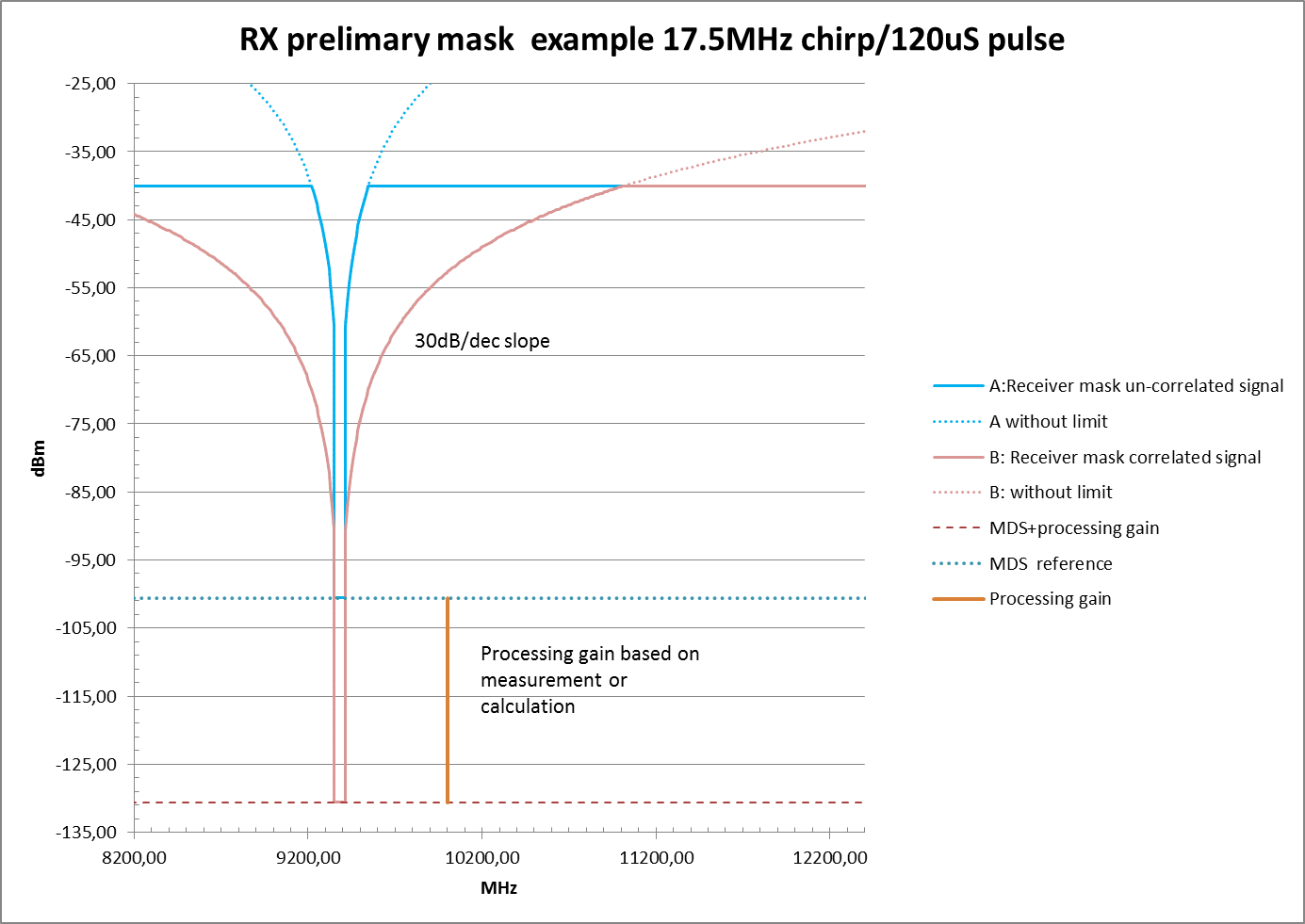
The selected disturbance test signal shall be swept over the complete frequency span of the Out of Band domain. The spurious domain is not checked due to it being unlikely that the receiver is sensitive that far from the used band.

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

**The Case of Multi-Frequency and/or Chirping Radars**

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

In cases of separate bands of frequency used there will be a separate B-40 where full sensitivity is allowed for each.



#### Spurious response rejection

To be developed

#### Receiver blocking

To be developed.

#### Receiver desensitization

To be developed.

#### Intermodulation response rejection

NOTE: The intermodulation distortion level can be derived from the knowledge of the receiver third-order intercept point. For two equal amplitude test tones, the power of the intermodulation product is equal to three times the power of a single test tone minus two times the third-order intercept point:

Pim (dBm) = 3 x Ptone (dBm) – 2 x Ptoip (dBm)

Where :

Pim = power of the intermodulation product

Ptone = power of a single test tone

Ptoip = power of third order intercept point

All powers expressed in dBm

To be further developed.

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.2] 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 303 364-2 | | | | |
| --- | --- | --- | --- | --- |
| Requirement | | | Requirement Conditionality | |
| No | Description | Reference: Clause No | U/C | Condition |
| 1 |  |  |  |  |
| 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 | System Noise Figure | 4.2.2.1 | U |  |
| 6 | Receiver Selectivity and spurious response rejection | 4.2.2.2 | U |  |
| 7 | Receiver Blocking & Desensitization | 4.3.3.2 | U |  |
| 8 | Intermodulation response rejection | 4.3.4.2 | 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.

**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 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):  
Transmitter power and unwanted emissions of radar systems with indirect methods



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

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

Annex C (normative): Definition of receiver test measurement scenario

### Method 1

Figure 2 shows the version of test scenario generation where external interference signal and external target RF generation is use. There are two continuous (in frequency and time) stationary interference signals generated [S1] and [S2]. In addition a simulated radar target is generated.

The mean signal strength for both [S1] and [S2] at [A] is 5 dBm when integrated across the particular band.

The method to establish this is by direct field strength measurement or by measurement at [B] where the transition to the radar system has been achieved by antenna and feed structures.

The lower beam [L] shall use the maximum lower beam gain [Ga(1)] to establish the signal in the radar in the lower beam channel

The upper beam [H] shall use the maximum upper beam gain to establish the signal in the radar [Ga(2)].

If there are other receive beams they should be analysed is the same manner.

Each beam (either conventional or selected digitally beam formed beams) can be assessed individually

The simulated target signal [S3] should be set at a level that allows any loss in radar sensitivity to be determined (usually by setting Pd to be in the region 0.6 to 0.9 at the stated operating range of the radar and the target can be ‘flown in to closure ranges).

The measurement may be absolute performance or showing insignificant change from ‘no interference’ to ‘interference conditions’

The receiver chain shall be assessed as per below (number to be clarified on reformatting)

|  |
| --- |
|  |
| Figure 2. Free space test scenarios and free space test target generation block diagram for conventional rotation PSR (two receive beams shown) |

### Method 2

Figure 3 shows the version of test scenario generation where external interference signal is generated and internal target RF generation is use.

|  |
| --- |
|  |
| Figure 3. Free space interference scenarios and internal injected target generation diagram for conventional rotating PSR |

There are two continuous (in frequency and time) interference signals generated [S1] and [S2]. In addition a simulated radar target is generated.

The mean signal strength for both [S1] and [S2] at [A] is 5 dBm when integrated across each band.

The method to establish this is by direct field strength measurement or by measurement at [B] where the transition to the radar system has been achieved by antenna and feed structures.

The lower beam [L] shall use the maximum gain [Ga(1)] to establish the signal in the radar in the lower beam channel

The upper beam [H] shall use the horizontal gain to establish the signal in the radar [Ga(2)].

The simulated target signal [S3] shall be generated by a radar target generation by sampling the radar waveform and be capable of generating simulated target with range rate and Doppler characteristics that are appropriate for the PSR under test to be able to detect the target

The effective RCS should be set at a level that allows any loss in radar sensitivity to be determined (usually by setting Pd to be in the region 0.6 to 0.9). at the stated operating range of the radar and the target can be ‘flown in to closure ranges).

The measurement may be absolute performance or showing insignificant change from ‘no interference’ to ‘interference conditions’

Each beam (either conventional or selected digitally beam formed beams) can be assessed individually

The RF losses from [B] to [F] should be accounted for especially the additional loss due to the coupler [C] to [E] (including connector losses).

### Method 3

Ref. [i.x] hows the version of test scenario generation where internal interference signal is generated and internal target RF generation is use.

|  |
| --- |
|  |
| Figure 4. Injected Test signal and target generation diagram for conventional rotating PSR |

There are two continuous (in frequency and time) stationary interference signals generated [S1] and [S2]. In addition a simulated radar target is generated.

The mean signal strength for both [S1] and [S2] at [D] is the value equivalent to 5 dBm when integrated across each band as would be measured at [B].

The method to establish this is by direct field strength measurement or by measurement at [B] where the transition to the radar system has been achieved by antenna and feed structures.

The lower beam [L] shall use the maximum gain [Ga(1)] to establish the signal in the radar in the lower beam channel

The upper beam [H] shall use the Horizon/maximum gain [Ga(2)] to establish the signal in the radar.

The simulated target signal [S3] shall be generated by a radar target generation by sampling the radar waveform and be capable of generating simulated target with range rate and Doppler characteristics that are appropriate for the PSR under test to be able to detect the target

The effective RCS should be set at a level that allows any loss in radar sensitivity to be easily determined (usually by setting Pd to be in the region 0.6 to 0.9) at the stated operating range of the radar and the target can be ‘flown in to closure ranges). The FAR should be set to meet the requirements without interfering signals.

The measurement may be absolute performance or showing insignificant change from ‘no interference’ to ‘interference conditions’

The RF losses from [B] to [F] should be accounted for especially the additional loss due to the coupler [C] to [E] (including connector losses).

The signal levels [S1] and [S2] should use the following method to establish the [S1] and [S2] mean levels.

Use the nominal gains of the lower and upper beams to establish an antenna effective area ‘Aeff’ for both the lower [Aeff(1)] and upper beams [Aeff (2)] using Equation 1. The gain used shall be the maximum gain of the particular antenna beam (L or H or other if more than two beams)

…… Equation 1

This allows the interference to be calculated at [B].

The losses shall be applied so the signal levels are reduced by the losses from [B] to [F].

Receiver chain assessment (note: should be C.4)

There shall be an assessment of the critical elements of the receiver chain and any element that can cause S/N loss shall be included in any measurement (Plot or track).

### Method 4

Phased Array measurement

|  |
| --- |
|  |
| Figure 4. Phased array diagram for target insertion and processing points |

### Measurement type 1

The first type of measurement can be a RF / IF, measurement at [G] (this point must be justified by the manufacturer[[1]](#footnote-2)) where the criteria shall be that any increase in noise, i.e. loss in signal to noise is sufficiently low in the presence of the interfering scenarios 1& 2 such that the declared operational performance (by the manufacturer) would be maintained. There could be a loss in performance but this would have to translate into the declared operational performance still being met. THIS IS NOT AGREED - FOR DISCUSSION. ULTIMATELY THIS MAY DISAPPEAR

### Measurement type 2

A second type of measurement can be at [] (this point must be justified by the manufacturer ) where the criteria shall be that any increase in false plots [I] is within the declared false plot performance of the radar and the simulated target probability of detection is maintained to be consistent with the declared Pd detection performance specification, i.e. the radar maintains its’ declared Pd and Pfa performance in in the presence of the interfering and target scenarios, 1 & 2 such that the declared operational performance (by the manufacturer) would be maintained. There could be a loss in performance but this would have to translate into the declared operational performance still being met.

### Measurement type 3

A third type of measurement can be at [J] (this point must be justified by the manufacturer ) where the criteria shall be that any increase in false [J] tracks is within the declared false track performance of the radar and the simulated target probability of detection is maintained to be consistent with the declared track initiation and track continuity specification, i.e. the radar maintains it operational performance in in the presence of the interfering and target scenarios, 1 & 2 such that the declared operational performance (by the manufacturer) would be maintained. There could be a loss in performance but this would have to translate into the declared operational performance still being met.

Coupler specification insertion

|  |
| --- |
|  |
| Figure 5. Injected test scenarios and injected target generation diagram for phased array receive antenna |

|  |
| --- |
|  |
| Figure 6. Possible external interference signal scenario generation |

|  |
| --- |
|  |
| Figure 7. Scenario 1 - Adjacent band test signals (i.e. interference out of allocated radar band) |

|  |
| --- |
|  |
| Figure 8. Scenario 2 – In radar band sharing with ‘no implicit‘ IF filter measurement (interference in-band and continuous in frequency across full radar band |

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Scenario** | **Characteristics** |
| (a) | 1 | The signal in (a) shall be based on a field strength and a statistical signal type. Gaussian voltage assumption  IF(1) = 2.57 GHz  IF(2) = 2.69 GHz  Total Field Strength at [A] (integrated power (mean) over entire band (2.570 GHz to 2.69 GHz) = 5 dBm/m2  Amplitude statistics = I,Q Gaussian |
| (b) | 2 | The signal in (b) shall be based on a field strength and a statistical signal type.  IF(3) = 3.41 GHz  IF(4) = 3.6 GHz  Total Field Strength at [A] (integrated power (mean) over entire band (3.41 GHz to 3.6 GHz)) = 5 dBm/m2  Amplitude statistics = I,Q Gaussian |
| (c) | 3 | The signal in (c) shall be based on a field strength and a statistical signal type  RF(1) = 2.7 GHz  RF(2) = 3.1 GHz  Field Strength equivelent power at [A] = -131 dBm/MHz/m2 at appropriate frequencies across 400 MHz band (2.7 GHz to 3.1 GHz)  Amplitude statistics = I,Q Gaussian |
| (d) | 3 | The signal in (d) shall be based on a field strength and a statistical signal type  IF(1) = somewhere in region 2.7 to 3.1 GHz  IF(2) = somewhere in region 2.7 to 3.1 GHz  Field Strength equivelent power at [A] = -131 dBm/MHz/m2 at appropriate frequencies across 400 MHz band (2.7 GHz to 3.1 GHz)  Amplitude statistics = I,Q Gaussian |
| (e) | 3 | The signal in (e) shall be based on a field strength and a statistical signal type.  RF(5) = somewhere in region 2.7 to 3.1 GHz  RF(6) = somewhere in region 2.7 to 3.1 GHz  Field Strength equivalent power at [A] = -131 dBm/MHz/m2 at appropriate frequencies across 400 MHz band (2.7 GHz to 3.1 GHz)  Amplitude statistics = I,Q Gaussian |
| Table 6: All scenario –Field strength equivalent power at [A] definitions of all values TBD | | |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **2570 – 2690 MHz Interfering signal** | **2700 - 2900** **MHz Interfering signal** | **3410 - 3600** **Interfering signal** |
| **Variable (a)** | **Variable (c), (d) and (e)** | **Variable (b)** |
| **Power flux density threshold for Signals in the 2570-2690 MHz band (dBm/m2) [1,2,3]** | **Noise spectral power flux density threshold at 2720 MHz to 3100 MHz (dBm/MHz/m2) [1,2]** | **Power flux density threshold for Signals in the 3410-3600 MHz band  (dBm/m2) [1,2,3]** |
| Interference Scenarios | 5 | -131 | 5 |
|  |  |  |  |
| Note **[1]**: The protection thresholds are defined at the peak of the radar beam.  Note **[2]**: The protection thresholds are defined during the ‘on’ period of the transmit signal.  Note **[3]**: the value is for the full band transmission signal | | | |
| Table 7: Scenario - parameters (a), (b), (c), (d) and (e) (TBA) | | | |

Annex D (normative): Definition of test measurement methodologies

### D1. Transmitter Function

See individual clauses

### D2. Receiver Function

The test methodology will be based on the use of the test scenarios 1, 2 and 3 with signal levels defined in dBm/MHz/m2 or dBm/m2 for all the interference scenario signals at the antenna.

The method of injection may be by free space summation before the antenna [A] or the injection of the signal behind the antenna point [C / D] but before the critical components and calculated by measured RF losses in the radar and assuming the horizontal gain of the antenna to derive the effective aperture ( radar measurements and a technical file shall justify the values used.

Polarisation shall be taken into account by assuming any incident signal on the radar will be assumed co-linear in the case of linear polarised radar and arbitrary when circular polarisation is used.

Annex E (informative): B-40 calculation

Annex 8 of Recommendation ITU‑R SM.1541‑6 [i.3] defines B-40 for various types of waveforms (e.g. pulsed radar signals). Assuming that:

* the radar is operating in the band 2 700 MHz to 3 100 MHz;
* the pulse rise time *tr* is greater than 0,0094∙*t*, where *t* is the pulse duration.

For primary non-FM pulse radars B-40 is determined as follows:

 (1)

Where:

*t* is the pulse duration.

*tr* is the rise time in the case of a trapezoidal pulse.

NOTE: For non-FM pulse PSR radars, typical values of a pulse duration of *t* = 1µs and a rise time of *tr =* 200 ns the formula above yields a ‑40 dB bandwidth value of 17 MHz.

For pulse FM radars, two formulas are specified in ITU‑R SM.1541‑6 [i.3] for B-40:

(2)

Where:

* B-40 is the -40 dB bandwidth in Hz;
* BC is the bandwidth of the frequency deviation (total frequency shift during the pulse generation);
* τ is the pulse length including rise & fall times;
* to account for the rise time. (3)
* to account for the fall time. (4)
* to account for both the rise and fall times combination. (5)
* tr is the rise time in seconds;
* tf is the fall time in seconds,

(6)

Where:

* K = 7.6 and A = 0,065

NOTE: The term A/tr adjusts the value of B−40 to account for the influence of the rise time, which is substantial when the time-bandwidth product Bc ∙ t, is small or moderate and the rise time is short.

NOTE: For FM pulse PSR radars, typical values for a pulse duration of t = 100µs and a rise time of tr = 200 ns the formulas above yield a ‑40 dB bandwidth value of ≈10 MHz depending on the modulation bandwidth.

Equation (2) is only valid when the following conditions are both met:

1. The product BC ∙ Minimum (tr, tf) is greater than or equal to 0.10 and
2. the product of BC ∙ τ or compression ratio is greater than 10.

In all other cases, equation (6) is used.

For radars with an asymmetrical spectrum (e.g. magnetron based radars), the B-40 bandwidth can be offset from the frequency of maximum emission level, but the necessary bandwidth, *B*N and preferably the overall occupied bandwidth should be contained completely within the allocated band as stipulated in section 4 of Annex 8 of recommendation ITU‑R SM.1541‑6 [i.3].

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



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

Annex E (informative): Bibliography

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| Draft new Recommendation ITU-R P.[BLM] | ‘Method for point-to-area predictions for terrestrial services in the frequency range 30 to 3 000 MHz’ (Doc. 3/BL/26) |
| Rec. ITU-R P. 452-10 | ‘Prediction procedure for the evaluation of microwave interference between stations on the surface of the Earth at frequencies above 0.7 GHz |
| SE 21 ECC Report 174 | Compatibility between the mobile service in the band 2500-2690 MHz and the radiodetermination service in the band 2700-2900 MHz March 2012 |
| ~~CEPT ERC Rec. 74-01~~ | ~~CEPT ERC Rec. 74-01~~ |
| ITU-R SM.1539 | Variation of the boundary between the out-of-band and spurious domains required for the application of Recommendations ITU-R SM.1541 and ITU-R SM.329 |
| ITU-R M.1460 | Technical and operational characteristics and protection criteria of radiodetermination and meteorological radars in the 2900 – 3100 MHz band |
| Rec. ITU-R M.1461 | ‘Procedures for determining the potential for interference between radars operating in the Radiodetermination Service and systems in other Services’ |
| ITU-R M.1463 | Characteristics and protection criteria for radars operating in the radiodetermination service in the frequency band 1215 – 1400 MHz |
| ITU-R M.1464 | ‘Characteristics of and protection criteria for radionavigation and meteorological radars operating in the frequency band 2700-2900 MHz’ |
| ITU-R M.1465 | Characteristics and protection criteria for radars operating in the radiodetermination service in the frequency band 3100 – 3700 MHz |
| ETSI EG 201 399 | "Electromagnetic compatibility and Radio spectrum Matters (ERM); A guide to the production of candidate Harmonized Standards for application under the RE Directive". |
| CISPR 16-1-1:2015 | "Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus". |
| Table 8: Bibliography | |

Annex F (informative):  
Change history

| Version | Information about changes |
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| **Document history** | | |
| <Version> | <Date> | <Milestone> |
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1. The technical file must show there will be no further degradation in radar performance caused by subsequent processing [G] to [I] to [J] [↑](#footnote-ref-2)