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Advanced Surface Movement Guidance and
Control System (A-SMGCS);

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

Sub-part 2: Reference and Vehicle Transmitters

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**HARMONISED EUROPEAN STANDARD**

Reference

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# Foreword

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

The present document has been prepared under the Commission's standardisation request C (2015) 5376 final [i.3] 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 5, sub-part 2, of a multi-part deliverable covering Advanced Surface Movement Guidance and Control System (A-SMGCS), as identified below.

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

Part 2: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for A-SMGCS airport safety support service";

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

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

**Part 5: "Harmonized Standard for access to radio spectrum for multilateration equipment";**

Sub-part 1: "Receivers and Interrogators";

**Sub-part 2: "Reference and Vehicle Transmitters";**

Part 6: "Harmonized Standard for access to radio spectrum for deployed surface movement radar sensors".

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

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

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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%21/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.

# Introduction

A-SMGCS are systems providing routing, guidance, surveillance and control to aircraft and affected vehicles in order to maintain movement rate under all local weather conditions within the Aerodrome Visibility Operational Level (AVOL) whilst maintaining the required level of safety.

# 1 Scope

The present document specifies technical characteristics and methods of measurements for the following equipment:

1. Devices transmitting in the 1090 MHz band, used as reference transmitters in Mode S multilateration equipment in an Advanced Surface Movement Guidance and Control System (A-SMGCS);
2. Devices transmitting in the 1090 MHz band, used for vehicle tracking in an Advanced Surface Movement Guidance and Control System (A-SMGCS);

Antennas for this equipment are considered to be passive without an additional amplifier.

The present document does not apply to equipment which includes a transponder function which reacts to interrogations with a reply transmission.

Note 1: The relationship between the present document and essential requirements of article 3.2 of Directive 2014/53/EU is given in Annex A.

# 2 References

## 2.1 Normative references

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

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

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

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

[2] EUROCAE ED-117A (September 2016): "MOPS for Mode S Multilateration Systems for Use in Advanced Surface Movement Guidance and Control Systems (A-SMGCS)".

[3] ERC/Recommendation 74-01 (2019): "Unwanted emissions in spurious domain".

## 2.1 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] ITU-R Radio Regulations (2016).

[i.3] 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.4] ECC/Recommendation (02)05 (2012): "Unwanted emissions".

[i.5] ICAO Annex 10, Volume IV, ”Surveillance and Collision Avoidance systems“, 5th edition, July 2014, including amendments up to amendment 90.

[i.7] ICAO Doc-8071 Vol. III, Manual on Testing of Radio Navigation Aids Volume III Testing of Surveillance Radar Systems, edition 1 (1998.4.01), Amendment 1 (9/10/02), Amendment 2 (31/12/06)

[i.8] ICAO Doc 9924 Aeronautical Surveillance Manual, edition 1 2010, edition 2017

[i.9] ICAO Doc-9830 AN/452, Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual, edition 1, 2004

[i.10] Eurocontrol, MODES/SYS/002, Clarification Mode S Transponder in an Airport/A-SMGCS Environment edition 1.13, 2005.5.13,

[i.1] Eurocontrol Guide-178, EUROCONTROL Guidelines on the Assessment of Ground-based Surveillance Interrogations, Eurocontrol, ed1 2019c11, ed2 2020.9.08

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

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

**24 Bit Adress selector** means to select the 24 Bit address used byaES/NT device to allow unique identification of it’s ES squitter transmissions

**conducted measurements:** measurements which are made using a wired connection to the EUT

**duty cycle:** ratio expressed as a percentage, of the cumulative duration of transmissions within an observation interval and the interval itself, as measured in an observation bandwidth

**environmental profile:** range of environmental conditions under which the EUT is declared by the manufacturer to comply with the provisions of the present document

**ground based multilateration equipment or ground station:** aeronautical station equipment intended for use in an A-SMGCS multilateration component

NOTE: A ground station can include sensor, interrogator and/or transponder components. A ground station can be fixed or mobile.

**Enhanced Surveillance for Non Transponder (ES/NT) Device**Non transponder device for stationary or moving surface use having a single transmitter on 1090 MHz and without a receiver designed to receive aeronautical mobile radionavigation service interrogations at 1030 MHz which could trigger replies, designed to produce aeronautical mobile radionavigation service squitter signals of DF18 and DF17 format.

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

**inactive state:** entire period between transmissions, less 100 μs transition periods preceding and following the transmission.

**integral antenna:** antenna which is integrated into the EUT without the use of an external connector, and which is considered to be part of the EUT.

**interrogator:** aeronautical station equipment including at least one transmitter designed to produce aeronautical mobile service signals at 1030 MHz.

**multilateration:** surveillance technique which provides position derived from the secondary surveillance radar (SSR) transponder signals (replies or squitters) primarily using time difference of arrival (TDOA) techniques.

NOTE: Additional information, including identification, can be extracted from the received signals.

**Mode S:** particular type of aeronautical transponder message format defined in ICAO Annex 10, Volume IV [1]

**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

**out of band emissions:** power transmitted at frequencies outside the OC but within the specified spectral mask

**probability of detection:** rate of correctly received and decoded squitter messages

**radiated measurements:** measurements which involve the measurement of a radiated field in the vicinity of the EUT

**receiver:** EUT which includes the capability to convert RF signals into binary content.

**resolution bandwidth:** bandwidth that is used for measurements used for spectral measurements.

**sensor:** aeronautical station equipment including at least one receiver designed to receive aeronautical mobile service signals at 1030 and/or 1090 MHz.

**spurious emissions:** power transmitted at frequencies below or above the Out of Band domain.

NOTE: Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and
frequency conversion products, but exclude Out of Band emissions.

**transmission:** radio emission consisting of one uplink or downlink Mode S message.

**transmission:** radio emission consisting of a Mode S message.

**transmitter:** EUT which includes the capability to convert binary content into RF signals.

**transponder:** aeronautical station equipment including at least one transmitter designed to produce aeronautical mobile radionavigation service signals at 1090 MHz and zero or more receivers designed to receive aeronautical mobile radionavigation service signals at 1030 MHz

**unwanted signal:** any signal other than the wanted signal or as described in a specific test case

**wanted signal**: an in-band signal modulated according to the Mode Specification.

**wanted signal**: in-band signal modulated according to the Mode S specification for 1090 MHz.

NOTE: some manufacturers may also accept Mode 3A/C and other modulations which is beyond the scope of the
 present document.

## 3.2 Symbols

dB deciBel

dBc power in dB relative to carrier

dBi antenna gain in decibel relative to isotropic antenna

dBm power in dB relative to 1 milliwatt

f measurement frequency

µs microsecond

Ω Ohm

PD Probability of Detection

## 3.3 Abbreviations

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

ADS-B Automatic Dependant Surveillance Broadcast

A-SMGCS Advanced Surface Movement Guidance and Control System

AVOL Aerodrome Visibility Operational Level

CEPT European Conference of Postal and Telecommunications Administration

DME Distance Measuring Equipment

Doc dOCUMENT

ECC Electronic Communications Committee of CEPT

ES/NT Enhanced Surveillance for Non Transponder device

EIRP Effective Isotropic Radiated Power

EUROCAE European Organization for Civil Aviation Equipment

EURCONTROL European Organisation for the Safety of Air Navigation

EUT Equipment Under Test

ICAO International Civil Aviation Organization

ITU International Telecommunication Union

ITU-R ITU-Recommendation

MOPS Minimum Operational Performance Specification

OC Operating Channel

OoB Out-of-Band

PAPR Peak to average Ratio

PEP Peak Envelope Power

RBW Resolution Bandwidth (Measurement Bandwidth for emission measurement)

RBWref Reference Bandwidth

RED Radio Equipment Directive

RF Radio Frequency

SSR Secondary Surveillance Radar

# 4 Technical requirements specifications

## 4.1 Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be in accordance with its intended use but, as a minimum, shall be that specified in EUROCAE ED-117A [2], Chapter 4 (Requirements [REQ 73.] to [REQ 78.]. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the operational environmental profile defined by its intended use.

## 4.2 Conformance Requirements

### 4.2.1 Equipment with integral antenna

For the purposes of conducted measurements on an EUT with an integral antenna, a 50 Ω RF connection point shall be provided for test purposes. The connection point should correspond to the input of the integral antenna. The connection point may be a modification made for the purposes of testing and need not be a permanent part of the EUT when made available for sale.

### 4.2.2 Transmitter operating frequency and frequency error

#### 4.2.2.1 Definition

The operating frequency is the nominal value of the carrier frequency.

The frequency error is the difference between the actual carrier frequency and its nominal value of 1090 MHz.

#### 4.2.2.2 Limits

The nominal value of carrier frequency of the interrogation and control transmissions shall be 1090 MHz.

The absolute value of the frequency error shall not exceed 1 MHz.

Note: The requirements are derived from clause 3.1.2.2.1 of ICAO Annex 10 Volume IV [i.5] as well as from ITU-R M.2413-0 [i.6].

#### 4.2.2.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.1.

### 4.2.4 Spectrum mask

#### 4.2.4.1 Definition

A spectrum mask is a set of limit lines applied to a plot of a transmitter spectrum. The purpose is to constrain emissions at frequencies in the Out of Band domain which lies immediately outside the intended Operating Channel.

For the purposes of the present document, the Out of Band domain extends to +/- 78 MHz from the nominal operating frequency of 1090 MHz. The frequencies outside the Out of Band domain are defined as the spurious domain.

The definition of the spectrum mask is chosen as an alternative method to the specification of Out of Band domain emissions.

#### 4.2.4.2 Limits

The measured spectrum shall be below the limit lines shown in Figure 1

 

Figure 1 - Spectrum mask for a 1090 MHz transmitter

NOTE 1: The spectrum mask is consistent with the mask specified in ICAO Annex 10 Volume 4 Figure 3.5 [1].

#### 4.2.4.3 Conformance

The conformance tests shall be as defined in clause 5.4.3.

### 4.2.5 Residual Power Output

#### 4.2.5.1 Definition

The residual power output is the power output when not in the active state (i.e. between transmissions)

#### 4.2.5.2 Limits

The residual power output shall be not greater than -47dBm above 1GHz and -57dBm at and below 1GHz.

NOTE: These are the same limits as specified in Table 5.1 of REC 74-01 [3].

#### 4.2.5.3 Conformance

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

### 4.2.6 Spurious emissions of transmitter in active mode

#### 4.2.6.1 Definition

Spurious emissions are unwanted emissions in the spurious domain. For active transmitters, the spurious domain is all frequencies apart from the operating channel and the Out of Band domain.

#### 4.2.6.2 Limits

The power of any unwanted emission in the spurious domain shall not exceed -13dBm or 60dB below PEP (whichever is less stringent).

NOTE: These are the same limits as specified in Table 5.1 of Annex 5 of REC 74(01) [3].

#### 4.2.6.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.5.

### 4.2.7 Transmitter Intermodulation attenuation

#### 4.2.7.1 Definition

Intermodulation attenuation is the capability of a transmitter to avoid the generation of signals in the nonlinear elements caused by the presence of the carrier and an interfering signal entering the transmitter via the antenna.

It is specified as the ratio, in dB, of the carrier power level to the power level of the third order intermodulation product.

#### 4.2.7.2 Limits

The intermodulation attenuation ratio shall be at least 60 dB in the presence of an interfering signal at equal power level as the carrier and within a frequency range from 962 MHz to 1215 MHz (DME band).

Note: The 60 dB limit is consistent with the spurious emissions requirement.

#### 4.2.7.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.6.

### 4.2.8 Duty Cycle (Surface position Squitter Rate)

#### 4.2.8.1 Definition

The duty cycle is controlled to limit the impact of each transmitter in a multi transmitter environment. Duty cycle is defined in section 3.1.

#### 4.2.8.2 Limits

Transmitters used for this purpose are expected to comply with squitter message types specified in ICAO Annex 10 section 3.1.2.8

The average surface position squitter rates specified in Doc-9924ed2, App-K11are

a. Non transponder device stationary v=0 kn
 1) position squitter once per 5 seconds; and
 2) identity squitter once per 10 seconds;

b. Non transponder device moving, v >0 kn
 1) position squitter twice per second; and
 2) identity squitter once per 5 seconds;

  *Note: bullet a) above referes to* stationary *Reference and Vehicle Transmitters with v = 0 kn, while b) applies only to Vehicle Transmitters which are in movement with v > 0kn*

 Squitters are scheduled with some randomness so any individual second may vary.

The average duty cycle of the transmitter shall not exceed 0.00348%. for a stationary non transponder device (v=0 kn)and 0.0255 % for a non transponder devices during movements (v>0 kn) The duty cycle is calculated based on the half power point of the individual pulses within a message with the maximum number of allowable pulses. This threshold takes into account maximum allowable pulse widths and expected random variation in transmission timing.

As specified in ICAO Annex 10 section 3.1.2.8 [xx] and Eurocae ED-102A [yy] clause 2.2.3.3.2.10, the average squitter rate for transmitters used for this purpose is 6.2 messages per second.

Squitters are scheduled with some randomness so any individual second may vary. The average squitter rate of the transmitter will not exceed 6.2 messages per second.

The average duty cycle of the transmitter shall not exceed 0.040%. The duty cycle is calculated based on the half power point of the individual pulses within a message with the maximum number of allowable pulses. This threshold takes into account maximum allowable pulse widths and expected random variation in transmission timing.

#### 4.2.8.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.7.

### 4.2.9 Peak Output Power

#### 4.2.9.1 Definition

The peak output power is the power level measured at the highest point in the time domain of the power envelope of the transmitted message.

#### 4.2.9.2 Limits

The peak transmit power of

* vehicle ES-NT devises shall have a minimum output power sufficient to achieve a minimum peak absolute EIRP of 40 dBm and be adjustable up to a maximum EIRP no greater than necessary to achieve a peak absolute EIRP 48.5 dBm (70 W) including for measurement error, peak antenna gain (dBi) and where applicable losses between transmitter output and antenna input.
* Reference ES-NT devises shall have an adjustable output power sufficient to enable associated MLAT sensor detection under all operational weather conditions up to a maximum peak absolute EIRP of 48.5 dBm (70 W) including for measurement error, peak antenna gain (dBi) and where applicable losses between transmitter output and antenna input.

The absolute peak EIRP may be further limited by local regulation as defined in the liscense .

For a reference transmitter, the peak output power shall not exceed 57 dBm (500 W). This limit is consistent with ICAO Annex 10 clause 3.1.1.7.11.1 and Tables 5-1 and 5-2,.

For a ground vehicle tracking transmitter, the peak output power shall not exceed 50dBm (100 W).

#### 4.2.9.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.2.

### 4.2.9 Absolute EIRP

#### 4.2.9.1 DefinitionTo limit the impact on the 1090 MHz SSR environment the absolute EIRP of a ES/NT device is limited to 40 dBm to 48.5 dBm including measurement error.

# 5 Testing for compliance with technical requirements

## 5.1 Environmental conditions for testing

### 5.1.1 General requirements

Tests defined in the present document shall be carried out at representative points within the boundary limits of the operational environmental profile defined by its intended use.

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 operational environmental profile defined by its intended use) to give confidence of compliance for the affected technical requirements.

### 5.1.2 Procedure for Tests

#### 5.1.2.1 All Equipment

Before measurements are made, the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilizing period. In the case of equipment containing temperature stabilization circuits designed to operate continuously, the temperature stabilization circuits may be switched on for 15 minutes after thermal balance has been obtained, the equipment shall then meet the specified requirements. If the thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour, or such period as may be decided by the testing laboratory shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

#### 5.1.2.2 Equipment including Transmitters

Before tests at the upper temperature, the equipment shall be placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on in the transmit state for a period of 30 minutes after which the equipment shall meet the specified requirements.

## 5.2 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;

## 5.3 Test and General Conditions

### 5.3.1 Transmitter test signals

#### 5.3.1.1 General Considerations

For the purposes of the present document a transmitter test signal is a modulated carrier generated by the EUT to facilitate a particular test. The EUT shall be capable of generating the following test signals:

* Test signal A: see clause 5.3.1.2

Test signals may be generated autonomously by the EUT when configured for test mode, or by applying external commands or other stimulation. Operation in a test mode may involve suitable temporary internal modifications of the EUT or the use of special software. Details of the method chosen and the test signals shall be recorded in the test report.

#### 5.3.1.2 Test signal A

When test signal A is specified below, a signal shall be generated with the following characteristics:

* Transmission rate: Maximum transmission rate supported by the equipment, or stationary 0.3 messages per second and moving 2.2 messages per second
* Waveform: Long (112 bit) Mode S Message as defined in clauses 3.1.2.2 of ICAO Annex 10, Volume 4[1].
* Frequency: 1090 MHz
* Message content: DF18 and constant data content with valid parity, CL= 0 and IC = 0.
* Amplitude: Maximum rated power level
* EXAMPLE: 0x90BADBADC1123480101D00675B4B is a valid DF-18 squitter with the Aircraft Address of “BADBAD”.

Note 1: The following example shows the calculation for a rated maximum duty cycle of 0.00348%. for a stationary non transponder device (v=0 kn)and 0.0255 % for a non transponder devices during movements (v>0 kn) . The short Mode S interrogation contains the preamble and data pulses as defined in Figure 3-6 of ICAO Annex 10 [1]. The cumulative time from the 50% power point of the rising edge of P1 to the 50% power point on the falling edge of the last data pulse with maximum allowable pulse width is 63.8 microseconds. The maximum transmission rate that does not exceed 0.00348%. for a stationary non transponder device (v=0 kn)and 0.0255 % for a non transponder devices during movements (v>0 kn) (i.e., 128 microseconds on time per second of transmission time) is 2.2 Hz.

Note 2: Due to pulse merging and pulse tolerances that occurs in the data pulses, the cumulative time may be slightly less for different data content.

* Transmission rate: Maximum transmission rate supported by the equipment, or 6.7 messages per second whichever is smaller.
* Waveform: Long (112 bit) Mode S Message as defined in clauses 3.1.2.2 of ICAO Annex 10, Volume 4[1].
* Frequency: 1090 MHz
* Message content: DF18 and constant data content with valid parity, CL= 0 and IC = 0.
* Amplitude: Maximum rated power level
* EXAMPLE: 0x90BADBADC1123480101D00675B4B is a valid DF-18 squitter with the Aircraft Address of “BADBAD”.

Note 1: The following example shows the calculation for a rated maximum duty cycle of 0.04%. The short Mode S interrogation contains the preamble and data pulses as defined in Figure 3-6 of ICAO Annex 10 [1]. The cumulative time from the 50% power point of the rising edge of P1 to the 50% power point on the falling edge of the last data pulse with maximum allowable pulse width is 63.8 microseconds. The maximum transmission rate that does not exceed 0.04% (i.e., 40 microseconds per second of transmission time) is 6.3 Hz.

Note 2: Due to pulse merging and pulse tolerances that occurs in the data pulses, the cumulative time may be slightly less for different data content.

### 5.4 Transmitter tests

### 5.4.1 Operating frequency and frequency error

#### 5.4.1.1 Description

The purpose of this test is to establish that the transmitter is operating at the correct frequency and within the required frequency error.

#### 5.4.1.2 Test conditions

The EUT shall be configured to generate test signal A.

The measurement shall be performed with the EUT operating at its maximum rated power level.

#### 5.4.1.3 Method of measurement

The measurement shall be a conducted measurement using a connection to the EUT antenna interface.

Unless otherwise noted below, the spectrum analyser shall be configured to the following settings:

* Trigger level: As appropriate for input power and attenuation.
* Trace properties: Normal (e.g., not max hold)
* Sweep properties: As needed to capture a waveform without interruptions due to duty cycle

#### 5.4.1.4 Measurement procedure

1. Attach the EUT antenna port to the spectrum analyser with appropriate attenuation.
2. Configure the EUT to produce test signal A at the maximum rated power level.
3. Set up the spectrum analyser with a receiver bandwidth of 1 kHz and a video bandwidth of 1 kHz.
4. Measure the frequency of the peak of the spectrum and compare to limits defined in clause 4.2.2.2.

### 5.4.2 Transmitter power

#### 5.4.2.1 Description

The transmitter peak envelope power is evaluated over various environmental conditions to show that the rated power is below the specified maximum.

#### 5.4.2.2 Test conditions

The EUT shall be configured to generate test signal A.

The measurement shall be performed with the EUT operating at its maximum rated power level.

#### 5.4.2.3 Method of measurement

The measurement shall be a conducted measurement using a connection to the EUT antenna interface. All amplitudes shall be adjusted for cable loss to be representative of the antenna interface of the EUT.

#### 5.4.2.4 Measurement procedure

1. Attach the EUT antenna port to the power meter with appropriate attenuation to keep the power level in the acceptable range for the power meter.
2. Configure the EUT to produce test signal A.
3. Measure the peak envelope power.
4. Verify that the power level is below the allowed maximum power as defined in clause 4.2.9.2.

### 5.4.3 Spectrum mask

#### 5.4.3.1 Description

The in band and Out of Band domains are measured for compliance of the EUT with the spectrum mask. All tests shall be performed at the maximum rated transmit power and duty cycle.

#### 5.4.3.2 Test conditions

The EUT shall be configured to generate test signal A..

The measurement shall be performed with the EUT operating at its maximum rated power level, minimum rated power level and at a power level between minimum and maximum power level, as determined by the test lab.

For conformance testing a video bandwidth and resolution bandwidth of 1MHz for the spectrum analyser shall be used.

#### 5.4.3.3 Method of measurement

The measurement shall be a conducted measurement using a connection to the EUT antenna interface. All amplitudes shall be adjusted for cable loss to be representative of the antenna interface of the EUT.

Note: Care should be taken that the peak level of the signal into the test equipment is not so high as to cause broadening of the spectrum due to non-linear effects in the test equipment.

Unless otherwise noted below, the spectrum analyser shall be configured to the following settings:

* Trigger level: As appropriate for input power and attenuation.
* Trace properties: Normal (e.g., not max hold)
* Sweep properties: As needed to capture a waveform without interruptions due to duty cycle
* Receiver BW, resolution BW and video BW: 1 MHz

Note: ERC recommendation 74 (01) [3] indicates that a spectrum analyser receiver bandwidth of 1 MHz should be used for frequencies of 1 GHz and above, and a bandwidth of 100 kHz should be used below 1 GHz. However, since the spectrum mask of the desired signal spans the 1 GHz boundary, a receiver bandwidth of 1 MHz will be used for frequencies of 905 MHz and above.

#### 5.4.3.4 Measurement procedure

1. Attach the EUT antenna port to the spectrum analyser with appropriate attenuation.
2. Set up the spectrum analyser with a receiving bandwidth of 1 MHz and a video bandwidth of 1 MHz.
3. Configure the EUT to produce test signal A at the power level corresponding to the rated peak power level.
4. Measure the spectrum from 1012 MHz to 1168 MHz and record the peak amplitude of the spectrum as a reference for 0 dBc.
5. Also compare the measurement to the spectrum mask limits defined in clause 4.2.4.2

 Repeat the test with each applicable environmental condition.

### 5.4.4 Residual power output

#### 5.4.4.1 Description

The purpose of this test is to verify that the output power of the transmitter between transmissions does not exceed the specified maximum.

#### 5.4.4.2 Test conditions

The measurement shall be performed with the EUT operating at maximum allowed duty cycle or 0.1% duty cycle, whichever is lower.

#### 5.4.4.3 Method of measurement

The measurement shall be a conducted using a connection to the EUT antenna interface. All amplitudes shall be adjusted for cable loss to be representative of the antenna interface of the EUT.

#### 5.4.4.4 Measurement procedure



Figure 2 - test setup for residual power output test

1. Connect the power measuring equipment to EUT antenna connector with appropriate attenuation to keep the power level in the acceptable range for the power measuring equipment.
2. Configure the EUT to repeatedly transmit test signal 2.
3. Measure the power of the output signal over the period between transmissions, starting 100 µs after the end of one interrogation and ending 100 µs prior to the start of the next interrogation. The power is determined by calculating the RMS value of the signal during the measurement time.
4. Verify that the residual power output does not exceed the limit specified in clause 4.2.5.2 when the measuring receiver is tuned over the frequency range shown in table 4 below.

All measurements shall be made with a reference bandwidth as shown in Table 4.

Table 1: Reference Bandwidths

|  |  |
| --- | --- |
| Frequency Range | RBWREF |
| 9 kHz ≤ f < 150 kHz | 1 kHz |
| 150 kHz ≤ f < 30 MHz | 10 kHz |
| 30 MHz ≤ f < fm1 | 100 kHz |
| fm2 < f ≤ 5450 MHz | 1 MHz |
| NOTE 1: f is the measurement frequency.NOTE 2: fm1 is the lower edge of the Out of Band Domain and equals fc – 78 MHz.NOTE 3: fm2 is the upper edge of the Out of Band Domain and equals fc + 78 MHz.NOTE 4: The Out of Band Domain is defined in clause 4.2.3 (Spectrum mask)NOTE 5: 5450 MHz corresponds to the 5th harmonic of the transmitter transmitting at 1090 MHz |

### 5.4.5 Spurious emissions of transmitter in active mode

#### 5.4.5.1 Description

The spurious domain is all frequencies apart from the channel on which the transmitter is intended to operate and the Out of Band domain.

#### 5.4.5.2 Test conditions

The EUT shall be configured and operated in modes representative of normal operation as defined in ED-117A clause 1.6 [2].

Measurements shall be performed with the EUT operating at its maximum operating power level at peak duty cycle.

#### 5.4.5.3 Method of measurement

For all EUT the spurious emissions levels shall be established as the conducted measurement procedure in clause 5.4.5.4.

All amplitudes shall be adjusted for cable loss to be representative of the antenna interface of the EUT.

#### 5.4.5.4 Measurement Procedure

The antenna port of the EUT shall be connected to the spectrum analyser via an appropriate directional coupler and a dummy load (see figure 3)



Figure 3: Measurement Arrangement for Spurious emissions of transmitter measurement

1. Connect the spectrum analyser to the EUT antenna connector with appropriate attenuation to keep the power level in the acceptable range for the spectrum analyser.
2. Tune the spectrum analyser subsequently to the frequency range shown in Table 5.
3. Activate the EUT
4. Note the detected power levels at the spectrum analyser
5. Compare the power levels to the limits specified in clause 4.2.6.2.

All measurements shall be made with a reference bandwidth as shown in Table 5.

**Table 5: Reference Bandwidths**

|  |  |
| --- | --- |
| Frequency Range | RBWREF |
| 9 kHz ≤ f < 150 kHz | 1 kHz |
| 150 kHz ≤ f < 30 MHz | 10 kHz |
| 30 MHz ≤ f < fm1 | 100 kHz |
| fm2 < f ≤ 5450 MHz | 1 MHz |
| NOTE 1: f is the measurement frequency.NOTE 2: fm1 is the lower edge of the Out of Band Domain and equals fc – 78 MHz.NOTE 3: fm2 is the upper edge of the Out of Band Domain and equals fc + 78 MHz.NOTE 4: The Out of Band Domain is defined in clause 4.2.3 (Spectrum mask)NOTE 5: 5450 MHz corresponds to the 5th harmonic of the transmitter transmitting at 1090 MHz |

At each frequency at which a spurious component is detected, the spurious emission power level shall be noted as the average power level delivered into the dummy load.

### 5.4.6 Transmitter Intermodulation attenuation

#### 5.4.6.1 Description

Requirements to be tested:

* 4.2.7 Transmitter Intermodulation Attenuation

The purpose of this test is to establish that the transmitter does not generate unwanted signals in the presence of an interfering signal entering the transmitter via the antenna due to inter-modulation effects in the transmitter's non-linear elements.

#### 5.4.6.2 Test Conditions

External test equipment will be used to create an interfering test signal with amplitudes and frequencies indicated in the procedure. External test equipment will be used for analysing the resulting transmitter output signal.

#### 5.4.6.3 Method of Measurement



Figure 1: Measurement Arrangement

The measurement arrangement shown in Figure 1 shall be used.

The transmitter shall be connected to a 50 Ω 10 dB power attenuator and via a directional coupler to a spectrum analyser. An additional attenuator may be required between the directional coupler and the spectrum analyser to avoid overloading the spectrum analyser.

The interfering test signal source is connected to the other end of the directional coupler via a 50 Ω 20 dB power attenuator.

The interfering signal source should be a signal generator and a linear power amplifier capable of delivering the same output power as the transmitter under test.

The directional coupler shall have an insertion loss of less than 1 dB, a sufficient bandwidth and a directivity of more than 20 dB.

The EUT and the test signal source shall be physically separated in such a way that the measurement is not influenced by direct radiation.

#### 5.4.6.4 Measurement Procedure

1. The transmitter under test shall be set to transmit test signal A and the spectrum analyser adjusted to give a maximum indication with a resolution band width of 1 MHz and a scan range of 1090 MHz +/- 260 MHz.
2. The interfering test signal source shall be unmodulated (CW) and the frequency shall be within 10 MHz to 125 MHz above and 10 MHz to 128 MHz below the frequency of the transmitter under test (1090 MHz).
3. The power output of the interfering test signal source shall be adjusted to the same as the carrier power level of the transmitter under test by the use of a power meter.
4. The interfering signal frequency shall be set to 1100 MHz and then increased in steps of 1 MHz up to 1215 MHz (but omitting frequencies where the intermodulation components to be measured coincide with other spurious components).
5. The intermodulation component shall be measured by direct observation on the spectrum analyser and the ratio of the largest third order intermodulation component to the carrier recorded.
6. This measurement shall be repeated with the interfering test signal source at a frequency starting at 962 MHz and then increased in steps of 1 MHz up to 1080 MHz (but omitting frequencies where the intermodulation components to be measured coincide with other spurious components).
7. Verify that for each frequency, the inter-modulation attenuation ratio is at least the level required.

### 5.4.7 Duty Cycle

#### 5.4.7.1 Description

The transmitter duty cycle is evaluated to be below the specified maximum.

#### 5.4.7.2 Test conditions

The EUT shall be configured to generate test signal A as indicated in the procedure.

The measurement shall be performed with the EUT operating at its maximum rated power level.

#### 5.4.7.3 Method of measurement

The measurement shall be a conducted measurement using a connection to the EUT antenna interface. All amplitudes shall be adjusted for cable loss to be representative of the antenna interface of the EUT.

#### 5.4.7.4 Measurement procedure

1. Attach the EUT antenna port to a diode detector rated for the transmit power and frequency.
2. Attach the output of the diode detector to a digital counter with a bandwidth of at least 100 MHz. Attenuate the signal level so as to match the input of the digital counter. Configure the counter to accumulate the time when signal is present from the EUT at above the half power level.

NOTE: Some counters may support a duty cycle measurement directly.

1. Configure the EUT to produce test signal A.
2. Stop transmissions after no less than 300 seconds.
3. Calculate the duty cycle by dividing the counter accumulated time by the overall transmission time.
4. Verify that the duty cycle is below the allowed duty cycle threshold defined in clause 4.2.8.2.

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

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

Table A.1: Relationship between the present document and
the essential requirements of Directive 2014/53/EU

| Harmonised Standard ETSI EN 303 213-5-1 |
| --- |
| Requirement | Requirement Conditionality |
| No | Description | Essential requirements of Directive 2014/53/EU | Clause(s) of the present document | U/C | Condition |
| 1 | Transmitter operating frequency and frequency error | 3.2 | 4.2.2 | U |  |
| 2 | Transmitter power stability over environmental conditions | 3.2 | 4.2.3 | U |  |
| 3 | Spectrum mask | 3.2 | 4.2.4 | U |  |
| 4 | Residual power output | 3.2 | 4.2.5 | U |  |
| 5 | Spurious emissions of transmitter in active mode | 3.2 | 4.2.6 | U |  |
| 6 | Transmitter Intermodulation attenuation | 3.2 | 4.2.7 | U |  |
| 7 | Duty Cycle | 3.2 | 4.2.8 | U |  |

**Key to columns:**

**Requirement:**

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

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

**Essential requirements of Directive**

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

**Clause(s) of the present document**

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

**Requirement Conditionality:**

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

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

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

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

# Annex B (informative): Checklist

This annex provides a traceability of the technical parameters for article 3.2 of Directive 2014/53/EU [i.1] defined in ETSI EG 203 336 [i.5] with the technical requirements for conformance defined in clause 4 of the present document.

If a technical parameter for article 3.2 of Directive 2014/53/EU [i.1] defined in ETSI EG 203 336 [i.5] has not been included in the present document, an explanation is provided.

An explanation is also provided whenever a technical parameter defined in ETSI EG 203 336 [i.5] is covered by an alternative technical requirement.

Table B.1: Checklist

|  |  |  |
| --- | --- | --- |
| **Technical Parameters defined in EG 203 336 [i.11]** | **Clauses of the present document** | **Comments** |
| **Transmitter Parameters** |
| Transmit power (and possible accuracy) | 4.2.34.2.9 | Transmit power is subject to national regulations |
| Spectrum mask | 4.2.4 |  |
| Transmitter Frequency stability | 4.2.2 |  |
| Transmitter Intermodulation attenuation | 4.2.7 |  |
| Unwanted emissions (OOB and spurious domains) | 4.2.44.2.64.2.5 |  |
| Transmitter Time domain characteristics (e.g. the duty cycle, turn-on and turn-off, frequency hopping cycle, dynamic changes ofmodulation scheme and others) | 4.2.8 |  |
| Transmitter Transients | 4.2.4 | Transmitter transients are covered by the spectrum mask |
| **Receiver Parameters** |
| Receiver sensitivity | NA | The equipment is transmit only |
| Receiver co-channel rejection | NA | The equipment is transmit only |
|  |
| Adjacent band/channel Selectivity | NA | The equipment is transmit only |
| Spurious response Rejection | NA | The equipment is transmit only |
|  |
| Receiver blocking | NA | The equipment is transmit only |
| Receiver radio-frequency intermodulation | NA | The equipment is transmit only |
| Receiver dynamic range | NA | The equipment is transmit only |
| Reciprocal mixing | NA | The equipment is transmit only |
| Desensitization | NA | The equipment is transmit only |
| Receiver unwanted emissions in the spurious domain | NA | The equipment is transmit only |

# Annex C (informative):Bibliography

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.

* ITU Recommendation M.1177-4 (2011): "Techniques for measurement of unwanted emissions of radar equipment".
* ITU Recommendation SM.329-12 (2012): “Unwanted emissions in the spurious domain”.
* ITU Recommendation ITU-R SM.1541-5 (08/2013) “Unwanted emissions in the out-of-band domain”
* EUROCAE ED-73E (2011): "MOPS for Secondary Surveillance Radar Mode S Transponders".
* EUROCAE ED-129B (March 2016): Technical Specification for a 1090 MHz Extended Squitter ADS-B Ground System
* 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".

# Annex C (informative):Change history

| Version | Information about changes |
| --- | --- |
| 1.1.1 | First stable draft to be presented to TG AERO |

# History

|  |
| --- |
| **Document history** |
| <Version> | <Date> | <Milestone> |
| X.X.X | 05.03.2019 | Document construction from latest ETSI TG AERO edition of EN 303 213-5-1. |
| 0.0.7 | 29.05.2020 | Comments incorporated, corrections |
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