



**Advanced Surface Movement Guidance and
Control System (A-SMGCS);
Part 5: Harmonised Standard for access to
radio spectrum for Multilateration (MLAT) equipment;
Sub-part 1: Receivers and Interrogators**

Reference

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Foreword

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

The present document has been prepared under the Commission's standardisation request C (2015) 5376 final [i.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 1, of a multi-part deliverable covering Advanced Surface Movement Guidance and Control System (A-SMGCS), as identified below.

- Part 1: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for A-SMGCS surveillance service 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: "Harmonised Standard for access to radio spectrum for multilateration equipment":**
 - Sub-part 1: "Receivers and Interrogators";**
 - Sub-part 2: "Reference and vehicle transmitters".
- Part 6: "Harmonised 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".

Proposed national transposition dates	
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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](#) (Verbal forms for the expression of provisions).

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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) Interrogators transmitting in the 1 030 MHz band, used in Mode S multilateration equipment in an Advanced Surface Movement Guidance and Control System (A-SMGCS);
- 2) Receivers, receiving in the 1 090 MHz band, used in Mode S multilateration equipment in an Advanced Surface Movement Guidance and Control System (A-SMGCS).

Antennas for this equipment are external and passive without an additional amplifier.

The present document does not apply to equipment which includes a transponder function, to ground vehicle locators and to reference transmitters which do not contain receivers for the purpose of replying to interrogation.

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

2 References

2.1 Normative references

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

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

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

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

- [1] ICAO Annex 10, Volume IV: "Surveillance and Collision Avoidance Systems", 5th edition, July 2014, including amendments up to amendment 89.
- [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 the 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 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".

3 Definition of terms, symbols and abbreviations

3.1 Terms

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

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

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

inactive state: entire period between transmissions, less 100 μ s transition periods preceding and following the transmission

interrogator: aeronautical station equipment including at least one transmitter designed to produce aeronautical mobile service signals at 1 030 MHz

Mode S: particular type of transponder uplink or downlink message defined in ICAO Annex 10, Volume IV [1]

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.

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

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 1 030 and/or 1 090 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

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 1 090 MHz and zero or more receivers designed to receive aeronautical mobile radionavigation service signals at 1 030 MHz

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

wanted signal: in-band signal modulated according to the Mode specification

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

3.2 Symbols

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

dB	decibel
dBc	dB relative to carrier
dBm	power in dB relative to 1 milliwatt
dBpp	dB below PEP
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
CRC	Cyclic Redundancy Check
DME	Distance Measuring Equipment
EUT	Equipment Under Test
ICAO	International Civil Aviation Organization
MOPS	Minimum Operational Performance Specification
OC	Operating Channel
OoB	Out-of-Band
PEP	Peak Envelope Power
RBW	Reference BandWidth
RF	Radio Frequency
RMS	Root Mean Square
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 declared by the manufacturer in accordance to the environmental requirements stated 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 declared environmental profile.

4.2 Conformance Requirements

4.2.1 Applicability

4.2.1.1 Equipment with multiple functions

Any ground station which includes the interrogator function shall comply with the requirements in clause 4.2.2 to 4.2.5.

Any ground station which includes the receiver function shall comply with the requirements in clause 4.2.6 to 4.2.12.

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 1 030 MHz.

4.2.2.2 Limits

The nominal value of carrier frequency of the interrogation and control transmissions shall be 1 030 MHz.

The absolute value of the frequency error shall not exceed 0,01 MHz as specified in clause 3.1.2.1.1 of ICAO Annex 10 Volume IV [1].

NOTE: This limit is stricter than the requirement defined in Appendix 2 of the ITU Radio Regulations [i.2].

4.2.2.3 Conformance

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

4.2.3 Spectrum mask

4.2.3.1 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.

The Out of Band domain extends to ± 125 MHz from the nominal operating frequency of 1 030 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.

4.2.3.2 Limits

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

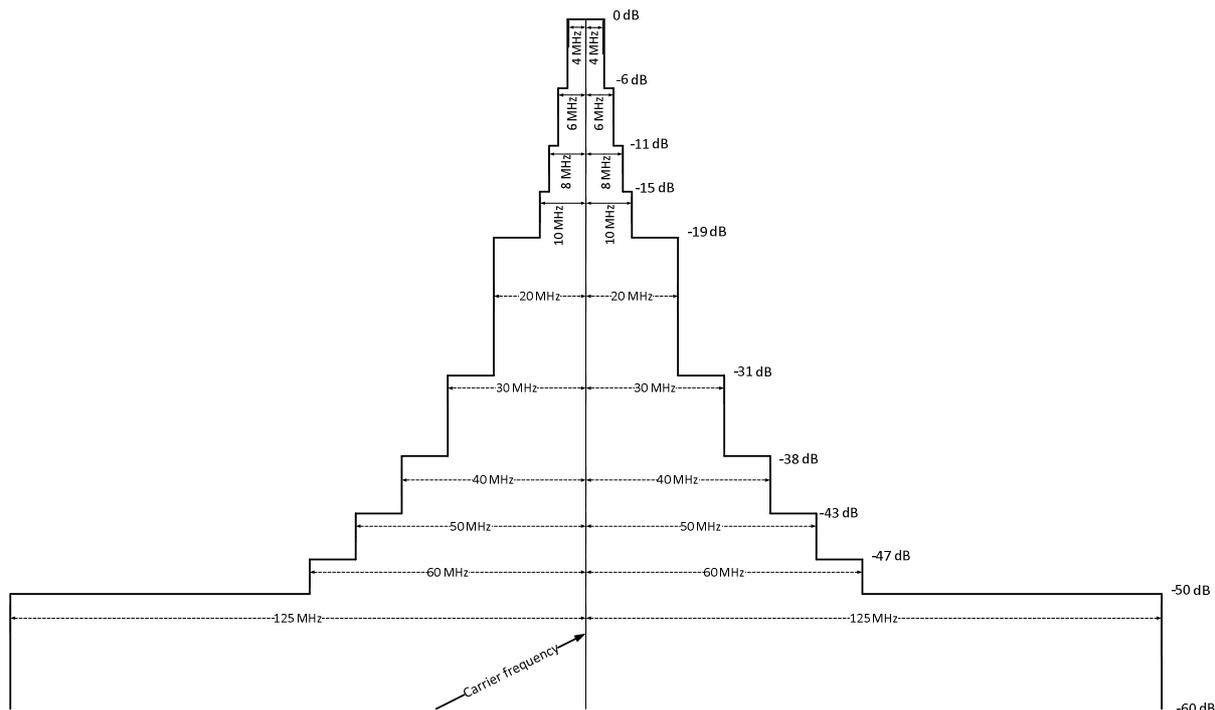


Figure 1: Spectrum mask for an interrogator transmitter

The spectrum mask specified in ICAO Annex 10 Volume 4 Figure 3-2 [1] has been modified in order to be consistent with Appendix 3 of the ITU Radio Regulations [i.2]. The ICAO mask was extrapolated from the last three steps to determine when the mask would intercept the -60 dB point. A value of approximately 125 MHz was reached. 125 MHz is also the point reached when extrapolating the mask from the -40 dB (i.e. 40 MHz) by -40 dB per decade, which is the design objective for the 60 dBpp systems reflected in Table 3 in ECC REC (02) 05 [i.4] until the spurious limit is reached. This is also reflected in Figure A2.1 a) of ECC REC (02)05 [i.4], the Emission Mask for radars.

4.2.3.3 Conformance

The conformance tests shall be as defined in clause 5.4.2.

4.2.4 Residual Power Output

4.2.4.1 Definition

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

4.2.4.2 Limits

The residual power output shall be not greater than -47 dBm above 1 GHz and -57 dBm at and below 1 GHz as specified in Table 15 of Annex 5 of ERC Recommendation 74-01 [3].

4.2.4.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.4.3.

4.2.5 Spurious emissions of transmitter in active mode

4.2.5.1 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.

4.2.5.2 Limits

The power of any unwanted emission in the spurious domain shall not exceed -13 dBm or 60 dB below PEP (whichever is less stringent) as specified in Table 15 of Annex 5 of ERC Recommendation 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 Sensitivity variation over the operating frequency range

4.2.6.1 Definition

The receiver sensitivity is the ability to receive a wanted signal at low input signal levels while providing a pre-determined level of performance. The operating frequency range is the frequency range around the nominal operating frequency over which reception of signals can be achieved.

4.2.6.2 Limits

The sensitivity shall not degrade by more than 3 dB as the incoming signal is offset by a tolerance of 1 MHz.

4.2.6.3 Conformance

The conformance tests shall be as defined in clause 5.5.1

4.2.7 RF selectivity and spurious response rejection

4.2.7.1 Definition

RF selectivity and spurious response rejection are the ability of the EUT to avoid erroneous reception of signals from outside the desired frequency band.

Limits are evaluated assuming the signal is constructed as a valid Mode S waveform except that the frequency is altered. Although a 1 090 MHz system has only a single frequency channel, DME systems may occupy adjacent frequency allocations within the aviation band. It is important that the receiver rejects signals which are out of band while retaining sufficient bandwidth for acceptable multilateration performance.

4.2.7.2 Limits

The EUT shall reject signals such that the signal level of a valid message shall be increased by at least the value given for the frequency offset in Table 1 before the signal is received with a probability of 90 %.

NOTE 1: The limits were derived from receiver Out-of-Band rejection characteristics that are used within the industry for receivers that are used for both ADS-B and multilateration.

NOTE 2: These limits use valid Mode S signals in order to be a more stringent requirement for the receiver rejection.

Table 1: Minimum rejection level for messages

Frequency (MHz)	Minimum Rejection level (dB)
±12,5	3
±19	20
±29	40
±46	60

EXAMPLE: Assume the EUT receives a valid signal at 1 090 MHz with 90 % PD at a level of -80 dBm. A similar signal offset by 19 MHz would need to be injected at least 20 dB higher (i.e. ≥ -60 dBm) before the same 90 % PD was achieved. This shows that the receiver has at least 20 dB of rejection at the 19 MHz frequency offset.

4.2.7.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.5.2.

4.2.8 Inter-modulation response rejection

4.2.8.1 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.

4.2.8.2 Limits

At any frequency combination from -78 MHz to -20 MHz and from +20 MHz to +78 MHz from the receiver frequency of 1 090 MHz, the unwanted signals shall not reduce the probability of detection by more than 5 percentage points if their signal level is 40 dB above the reference sensitivity.

4.2.8.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.5.3.

4.2.9 Co-channel rejection

4.2.9.1 Definition

Co-channel rejection is the receiver's ability to receive a wanted signal in the presence of an unwanted signal, with both signals being at the nominal receiver frequency. An unwanted signal is a signal that has a signal level 12 dB or more below the level of the wanted signal.

4.2.9.2 Limits

The unwanted signal shall not reduce the rate of correctly received and decoded wanted Mode S signals by more than 5 percentage points.

4.2.9.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.5.4.

4.2.10 Blocking

4.2.10.1 Definition

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

4.2.10.2 Limits

The rate of correctly received and decoded wanted Mode S signals shall be reduced by no more than 5 percentage points in the presence of unwanted signals specified in Table 2.

Table 2: Unwanted signal characteristics

Frequency	Level
-78 MHz to -15 MHz relative to 1 090 MHz	20 dB above the level of the wanted signal
+15 MHz to +78 MHz relative to 1 090 MHz	20 dB above the level of the wanted signal
NOTE: The level of the wanted signal is defined in clause 5.5.5.4.	

4.2.10.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.5.5.

4.2.11 Sensitivity

4.2.11.1 Definition

The receiver sensitivity is the ability to receive a wanted signal at low input signal levels while providing a pre-determined level of performance.

4.2.11.2 Limits

Receivers shall operate for signals with a carrier frequency of 1 090 MHz with a PD of not less than 90 % at a desired signal level of -72 dBm.

NOTE: This number reflects a number for surveillance systems in order to support the requirements for Probability of Target Reports in EUROCAE ED-117A [2].

4.2.11.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.5.1.

4.2.12 Receiver spurious emissions

4.2.12.1 Definition

Spurious emissions are unwanted emissions in the spurious domain. For Receivers the spurious domain is all frequencies, as they are not supposed to transmit any signal.

4.2.12.2 Limits

The power of any unwanted emission in the spurious domain shall not exceed -47 dBm above 1 GHz and -57 dBm at and below 1 GHz as specified defined in Table 15 of Annex 5 of ERC/Recommendation 74-01 [3].

4.2.12.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.5.6

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 declared operational environmental profile.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the declared operational environmental profile) 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 1: Maximum duty cycle, short Mode S interrogations with all "0" data content - see clause 5.3.1.2
- Test signal 2: Maximum duty cycle, short Mode S interrogations with all "1" data content - see clause 5.3.1.3

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 1

When test signal 1 is specified below, a signal shall be generated with the following characteristics:

- Transmission rate: Maximum constant rate such that the rated maximum duty cycle is not exceeded.
- Waveform: Short Mode S Interrogation as defined in clauses 3.1.2.1 and 3.1.2.11.4 of ICAO Annex 10, Volume 4 [1].
- Frequency: 1 030 MHz
- Message content: All "zeroes" (i.e. the minimum number of phase transitions)
- Amplitude: Maximum rated power level

NOTE: The following example shows the calculation for a rated maximum duty cycle of 1 %. The short Mode S interrogation contains the P1, P2 and P6 pulses as defined in Figure 3-4 of ICAO Annex 10 Volume 4 [1]. The cumulative time from the 50 % point of the rising edge of P1 to the 50 % point on the falling edge of P6 is 19,75 microseconds. The maximum transmission rate that does not exceed 1 % (i.e. 10 milliseconds per second of transmission time) is 506 Hz.

5.3.1.3 Test signal 2

When test signal 2 is specified below, a signal shall be generated with the following characteristics:

- Transmission rate: Maximum rate such that the rated maximum duty cycle is not exceeded.
- Waveform: Short Mode S Interrogation as defined in clauses 3.1.2.1 and 3.1.2.11.4 of ICAO Annex 10, Volume 4 [1].
- Frequency: 1 030 MHz.
- Message content: All "ones" (i.e. the maximum number of phase transitions).
- Amplitude: Maximum rated power level.

5.3.2 Simulated received signals

5.3.2.1 General Considerations

For the purposes of the present document a receiver test signal is an unmodulated or modulated carrier applied to the EUT to facilitate a particular test. The EUT shall be capable of tolerating the following test signals:

- Test signal 3: Modulated Mode S Extended Squitter message (desired signal) - see clause 5.3.2.2.
- Test signal 4: Modulated Mode S Extended Squitter message (undesired signal) - see clause 5.3.2.3.

When multiple test signals are used in the same test, the frequency sources for each test signal shall be non-coherent.

The EUT shall be able to report each message received. The report shall include the complete Mode S message and the time of receipt at the receiver or the recording device with at least 10 millisecond resolution. Message reports from multilateration receivers can generally be collected using a computer and standard communication network analysis software. Operation of the EUT in a test mode is permissible and may involve suitable temporary internal modifications of the EUT or the use of special software. Details of the method chosen and how the reports were collected shall be recorded in the test report.

5.3.2.2 Test signal 3

When test signal 3 is specified below, a signal shall be injected with the following characteristics:

- Transmission rate: 100 Hz.
- Waveform: Mode S Extended squitter as defined in clause 3.1.2.2 of ICAO Annex 10, Volume 4 [1].
- Frequency: 1 090 MHz, unless otherwise specified by the test.
- Message content: Arbitrary data content with a known Aircraft Address and valid CRC.
- Amplitude: As specified by the test.
- Pulse on/off ratio: At least 40 dB.

EXAMPLE: 0x88234567125054D4C72CF4 is a valid DF-17 squitter with the Aircraft Address of "234567".

5.3.2.3 Test signal 4

When test signal 4 is specified below, a signal shall be injected with the following characteristics:

- Transmission rate: 6 000 Hz.
- Waveform: Mode S Extended squitter as defined in clause 3.1.2.2 of ICAO Annex 10, Volume 4 [1].
- Frequency: As specified by the test.
- Message content: Arbitrary data content with a known Aircraft Address and valid CRC.
- Amplitude: As specified by the test.
- Pulse on/off ratio: At least 40 dB.

NOTE: The data content is distinct from Test signal 3.

EXAMPLE: 0x90BADBADC1123480101D00675B4B is a valid DF-18 squitter with the Aircraft Address of "BADBAD".

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. All tests are performed at the maximum rated transmit power and duty cycle to show that the frequency is correct under these conditions.

5.4.1.2 Test conditions

The EUT shall be configured to generate test signal 1 as indicated in the procedure.

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

NOTE: The test procedure ignores frequency excursions during the phase reversal. Further information is given in clause 3.1.2.1.1 of ICAO Annex 10 Volume IV [1].

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 1 at the maximum rated power level and duty cycle.
- 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 Spectrum mask

5.4.2.1 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.

5.4.2.2 Test conditions

The EUT shall be configured to generate test signals 1 and 2 as indicated in the procedure.

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 1 MHz for the spectrum analyser shall be used.

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.

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 bandwidth, resolution bandwidth and video bandwidth: 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.

5.4.2.4 Measurement procedure

- 1) Attach the EUT antenna port to the spectrum analyser with appropriate attenuation.
- 2) Configure the EUT to produce test signal 1 at the power level corresponding to the rated peak power level and maximum duty cycle.

- 3) Set up the spectrum analyser with a receive bandwidth of 1 MHz and a video bandwidth of 1 MHz.
- 4) Measure the spectrum from 905 MHz to 1 155 MHz and record the peak amplitude of the spectrum as a reference for 0 dBc.
- 5) Switch the EUT to produce test signal 2 at the same power level and duty cycle.
- 6) Measure the spectrum from 905 MHz to 1 155 MHz and compare it to the spectrum mask limits defined in clause 4.2.3.2

5.4.3 Residual power output

5.4.3.1 Description

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

5.4.3.2 Test conditions

The measurement shall be performed with the EUT operating at maximum allowed duty cycle or 1 % duty cycle, whichever is lower.

5.4.3.3 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.

5.4.3.4 Measurement procedure

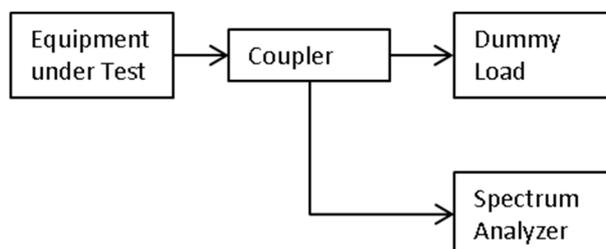


Figure 2: Test setup for residual power output test

- 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 μ s after the end of one interrogation and ending 100 μ s 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 4.2.4.2 when the spectrum analyser is tuned over the frequency range shown in Table 3 below.

All measurements shall be made with a reference bandwidth as shown in Table 3.

Table 3: Reference Bandwidths

Frequency Range	RBW
$9 \text{ kHz} \leq f < 150 \text{ kHz}$	1 kHz
$150 \text{ kHz} \leq f < 30 \text{ MHz}$	10 kHz
$30 \text{ MHz} \leq f < f_{m1}$	100 kHz
$f_{m2} < f \leq 5 \text{ 150 MHz}$	1 MHz

NOTE 1: f is the measurement frequency.
NOTE 2: f_{m1} is the lower edge of the Out-of-Band Domain and equals $f_c - 125 \text{ MHz}$.
NOTE 3: f_{m2} is the upper edge of the Out-of-Band Domain and equals $f_c + 125 \text{ MHz}$.
NOTE 4: The Out-of-Band Domain is defined in clause 4.2.3 (Spectrum mask).
NOTE 5: 5 150 MHz corresponds to the 5th harmonic of the Interrogator transmitting at 1 030 MHz.

5.4.4 Spurious emissions of transmitter in active mode

5.4.4.1 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.

5.4.4.2 Test conditions

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

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

5.4.4.3 Method of measurement

For all EUT the spurious emissions levels shall be established as the conducted measurement procedure in clause 5.4.4.4.

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

5.4.4.4 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)

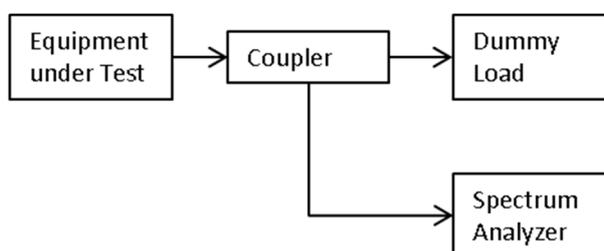


Figure 3: Measurement Arrangement for Spurious emissions of transmitter measurement

- 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 4.
- 3) Note the detected power levels at the spectrum analyser.
- 4) Compare the power levels to the limits specified in clause 4.2.5.2.

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

Table 4: Reference Bandwidths

Frequency Range	RBW
$9 \text{ kHz} \leq f < 150 \text{ kHz}$	1 kHz
$150 \text{ kHz} \leq f < 30 \text{ MHz}$	10 kHz
$30 \text{ MHz} \leq f < f_{m1}$	100 kHz
$f_{m2} < f \leq 5 \text{ 150 MHz}$	1 MHz

NOTE 1: f is the measurement frequency.
 NOTE 2: f_{m1} is the lower edge of the Out-of-Band Domain and equals $f_c - 125 \text{ MHz}$.
 NOTE 3: f_{m2} is the upper edge of the Out-of-Band Domain and equals $f_c + 125 \text{ MHz}$.
 NOTE 4: The Out-of-Band Domain is defined in clause 4.2.3 (Spectrum mask).
 NOTE 5: 5 150 MHz corresponds to the 5th harmonic of the Interrogator transmitting at 1 030 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.

5.5 Receiver Tests

5.5.1 Sensitivity variation over the operating frequency range

5.5.1.1 Description

The purpose of this test is to establish that the receiver is operating at the intended frequency and is able to tolerate a certain degree of frequency offset. The receiver sensitivity is also established.

5.5.1.2 Test conditions

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

5.5.1.3 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 shall be collected and the average rate of message receipt shall be calculated at each amplitude and frequency.

5.5.1.4 Measurement procedure

- 1) Configure the EUT to receive and report messages for recording.
- 2) Configure the recording device to record message reports.
- 3) Verify that no message reports are being generated.
- 4) Configure the signal generator to produce test signal 3 at the amplitude specified in clause 4.2.11.2. Inject at least 1 000 messages per second for at least 100 seconds.
- 5) Review the recorded reports to count the number of reports which match the expected message content.
- 6) Divide the number of successfully received messages by the expected number of input messages (i.e. elapsed time multiplied by message rate) and verify that the required PD (clause 4.2.11.2) is achieved.
- 7) Decrease the signal level in 1 dB steps until the probability of detection is no longer achieved. The lowest amplitude at which the required PD (clause 4.2.11.2) is achieved will be used as the reference signal level (i.e. the reference sensitivity) for the following steps and subsequent tests.

- 8) Repeat the test with the signal generator configured to produce test signal 3 with the following modifications:
 - a) Change the signal level to the reference sensitivity plus the degradation level specified in clause 4.2.6.2
 - b) Change the frequency to operating frequency plus the tolerance specified in clause 4.2.6.2.
 - c) Verify that at least the required PD (clause 4.2.11.2) is achieved.
 - d) Change the frequency to operating frequency minus the tolerance specified in clause 4.2.6.2.
 - e) Verify that at least the required PD (clause 4.2.11.2) is achieved.

5.5.2 RF selectivity and spurious response rejection

5.5.2.1 Description

The purpose of this test is to establish the selectivity of the receiver by measuring the rate of detection of properly formed messages injected outside of the intended operating frequency. The amplitude of injected messages is adjusted to verify that an appropriate number of messages are rejected.

5.5.2.2 Test conditions

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

5.5.2.3 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 shall be collected and the average rate of message receipt shall be calculated.

5.5.2.4 Measurement procedure

- 1) Note the reference sensitivity as determined in the test described in clause 5.5.1 (Sensitivity variation over the operating frequency range).
- 2) Configure the EUT to receive and report messages for recording.
- 3) Configure the recording device to record message reports.
- 4) Configure the signal generator to produce test signal 3.
- 5) Set the frequency offset from 1 090 MHz according to the first row in Table 1, clause 4.2.7.2.
- 6) Set the amplitude to the reference sensitivity plus the corresponding rejection value in Table 1, clause 4.2.7.2.
- 7) Inject at least 1 000 messages per second for at least 100 seconds.
- 8) Review the recorded reports to count the number of reports which match the expected message content.
- 9) Divide the number of successfully received messages by the expected number of input messages (i.e. elapsed time multiplied by message rate).
- 10) Verify that the probability of detection is no higher than 90 %.
- 11) Repeat steps 5 through 10 for the frequency offsets and rejection levels listed in Table 1, clause 4.2.7.2.

5.5.3 Inter-modulation response rejection

5.5.3.1 Description

The purpose of this test is to establish that inter-modulation caused by two unwanted Out-of-Band signals does not degrade the reception probability when their signal level is below the specified limit.

5.5.3.2 Test conditions

None.

5.5.3.3 Method of measurement

The method of measurement is shown in Figure 4 below.

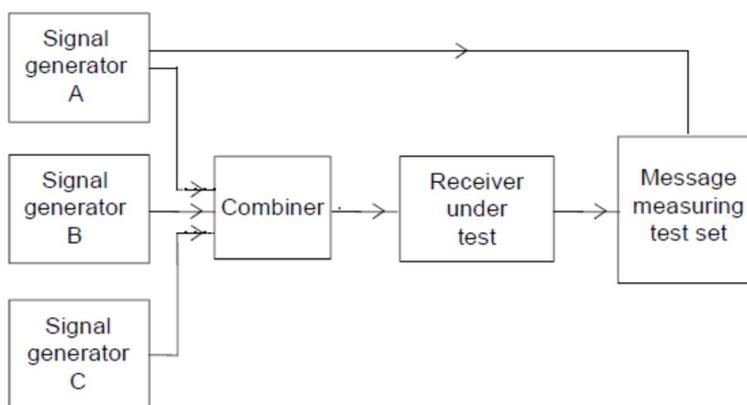


Figure 4: Measurement arrangement

5.5.3.4 Measurement procedure

The measurement procedure shall be as follows:

- 1) Three signal generators, A, B and C, shall be connected to the receiver via a combining network.
 - The wanted signal, provided by signal generator A, shall be at the nominal frequency of the receiver and shall produce test signal 3.
 - The first unwanted signal, provided by signal generator B, shall be unmodulated and adjusted to a frequency f_1 at 20 MHz above the nominal frequency of the receiver.
 - The second unwanted signal, provided by signal generator C, shall be modulated with test signal 4 and adjusted to a frequency f_2 at 40 MHz above the nominal frequency of the receiver.
- 2) Initially, signal generators B and C (unwanted signals) shall be switched off (maintaining the output impedance).
 - The level of the wanted signal from generator A shall be adjusted to the level which is 20 dB above the reference sensitivity measured in the test specified in clause 5.5.1 (Sensitivity variation over the operating frequency range).
- 3) Record the PD of the wanted signal.
- 4) Signal generators B and C shall then be switched on; and set to a level 40 dB above the reference sensitivity measured (see clause 5.5.1) as referenced to the input of the receiver under test.
- 5) Record the PD of the wanted signal.
- 6) Verify that the PD from step 5 is degraded by no more than the limit specified in clause 4.2.8.2.

- 7) The measurement shall be repeated with the unwanted signal generator B at the frequency 20 MHz below that of the wanted signal and the frequency of the unwanted signal generator C at the frequency 40 MHz below that of the wanted signal.
- 8) Repeat the test steps 1 to 7 with at least 3 other of the following frequency combinations that fulfil

$$f_c = 2 * f_1 - f_2$$

with an offset of f_1 and f_2 in the range of +20 MHz to +78 MHz and -20 MHz to -78 MHz.

The frequency $f_2 = 1\,030$ MHz shall be included since it corresponds to another interrogator.

Since there are potential DME interferers at 1 MHz steps from 962 MHz to 1 213 MHz, any frequency in that range is valid for testing.

Examples:

- $f_1 = 1\,051$, $f_2 = 1\,012$ ($f_2 = 1\,090$ MHz - 78 MHz)
- $f_1 = 1\,060$, $f_2 = 1\,030$ ($f_2 = 1\,090$ MHz - 60 MHz)
- $f_1 = 1\,129$, $f_2 = 1\,168$ ($f_2 = 1\,090$ MHz + 78 MHz)

5.5.4 Co-channel rejection

5.5.4.1 Description

This test verifies that the receiver's reception probability is not degraded in the presence of an unwanted modulated signal at the same frequency when its signal level is below the limit specified in clause 4.2.9.2.

5.5.4.2 Test conditions

None.

5.5.4.3 Method of measurement

The method of measurement is shown in Figure 5 below.

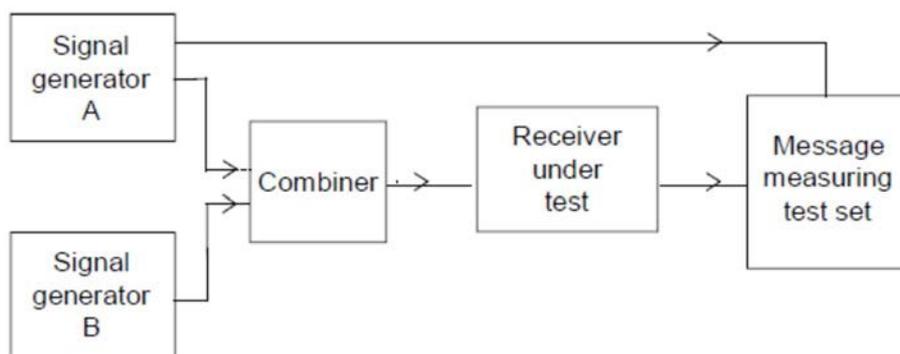


Figure 5: Measurement arrangement for co-channel rejection measurement

5.5.4.4 Measurement procedure

- 1) Two signal generators A and B shall be connected to the receiver via a combining network. The wanted signal, represented by signal generator A, shall be at the nominal frequency of the receiver and shall have normal test modulation (test signal 3).
- 2) The unwanted signal, represented by signal generator B, shall be modulated with the test signal 4.
- 3) Both input signals shall be at the nominal frequency of the receiver under test.

- 4) Initially the unwanted signal shall be switched off (maintaining its output impedance).
- 5) The level of the wanted signal from generator A shall be adjusted to a level which is 20 dB above the reference sensitivity measured in the test specified in clause 5.5.1 (Sensitivity variation over the operating frequency range).
- 6) Record the PD for the wanted signal.
- 7) The unwanted signal from generator B shall then be switched on and its level shall be adjusted to 12 dB below the wanted signal as referenced at the input of the receiver under test.
- 8) Record the PD for the wanted signal.
- 9) Verify that the PD from step 8 is degraded by no more than the limit specified in clause 4.2.9.2.
- 10) The measurement shall be repeated for displacements of the unwanted signal of $\pm 1,2$ MHz.

5.5.5 Blocking

5.5.5.1 Description

With this test it will be verified that a single unwanted Out-of-Band signal cannot degrade the reception probability when its signal level is below the limit specified in clause 4.2.10.2.

5.5.5.2 Test conditions

None.

5.5.5.3 Method of measurement

The method of measurement is shown in Figure 6 below.

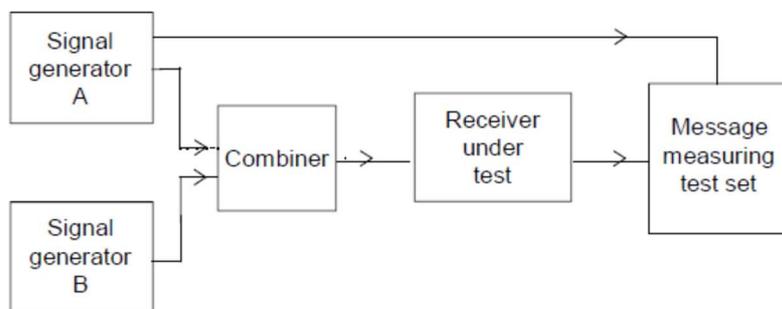


Figure 6: Arrangement for blocking measurement

5.5.5.4 Measurement procedure

- 1) Two signal generators A and B shall be connected to the receiver via a combining network.
- 2) The wanted signal, represented by signal generator A, shall be at the nominal frequency of the receiver and shall have normal test modulation (test signal 3).
- 3) The unwanted signal, provided by signal generator B, shall be unmodulated and at the minimum frequency specified in clause 4.2.10.2 (i.e. $1\,090\text{ MHz} - 78\text{ MHz} = 1\,012\text{ MHz}$).
- 4) Initially the unwanted signal shall be switched off.
- 5) The level of the wanted signal from generator A shall be adjusted to a level which is 6 dB above the reference sensitivity measured in the test described in clause 5.5.1.
- 6) Record the PD of the wanted signal.

- 7) The unwanted signal shall then be switched on and its level shall be adjusted to the level specified in clause 4.2.10.2.
- 8) Record the PD of the wanted signal.
- 9) Verify that the PD from step 8 is degraded by no more than the limit specified in clause 4.2.10.2.
- 10) The measurement shall be repeated for frequencies throughout the range defined in clause 4.2.10.2 at 1 MHz steps.

5.5.6 Receiver spurious emissions

5.5.6.1 Description

For receivers, or EUT in receive mode, the spurious domain is all frequencies.

5.5.6.2 Test conditions

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

5.5.6.3 Method of measurement

For all EUT the spurious emissions levels shall be established as the conducted measurement procedure in clause 5.5.6.4.

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

5.5.6.4 Measurement Procedure

The antenna port of the EUT shall be connected to the spectrum analyser via an appropriate directional coupler and a dummy load.

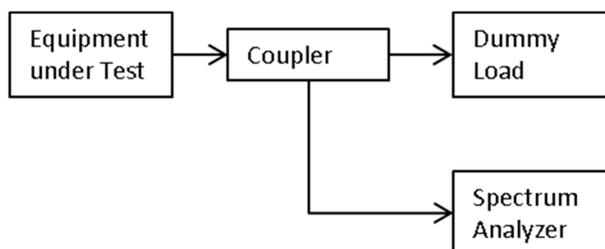


Figure 7: Measurement arrangement for receiver spurious emissions measurement

- 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) Note the detected power levels at the spectrum analyser.
- 4) Compare the power levels to the limits specified in clause 4.2.12.2.

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

Table 5: Reference Bandwidths

Frequency Range	RBW
$9 \text{ kHz} \leq f < 150 \text{ kHz}$	1 kHz
$150 \text{ kHz} \leq f < 30 \text{ MHz}$	10 kHz
$30 \text{ MHz} \leq f \leq 1 \text{ GHz}$	100 kHz
$1 \text{ GHz} < f \leq 5\,450 \text{ MHz}$	1 MHz
NOTE 1: f is the measurement frequency.	
NOTE 2: 5 450 MHz corresponds to the 5 th harmonic of 1 090 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.

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 [i.1]

Harmonised Standard ETSI EN 303 213-5-1					
Requirement				Requirement Conditionality	
No	Description	Essential requirements of Directive	Clause(s) of the present document	U/C	Condition
1	Transmitter operating frequency	3.2	4.2.2	C	Equipment with the interrogator function
2	Transmitter spectrum mask	3.2	4.2.3	C	Equipment with the interrogator function
3	Transmitter residual power output	3.2	4.2.4	C	Equipment with the interrogator function
4	Spurious emissions of transmitter in active mode	3.2	4.2.5	C	Equipment with the interrogator function
5	Receiver sensitivity variation over the operating frequency range	3.2	4.2.6	C	Equipment with the receiver function
6	Receiver RF selectivity and spurious response rejection	3.2	4.2.7	C	Equipment with the receiver function
7	Receiver inter-modulation response rejection	3.2	4.2.8	C	Equipment with the receiver function
8	Receiver co-channel rejection	3.2	4.2.9	C	Equipment with the receiver function
9	Receiver blocking	3.2	4.2.10	C	Equipment with the receiver function
10	Receiver sensitivity	3.2	4.2.11	C	Equipment with the receiver function
11	Receiver spurious emissions	3.2	4.2.12	C	Equipment with the receiver function

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): Bibliography

- 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			
V1.0.0	December 2019	EN Approval Procedure	AP 20200308: 2019-12-09 to 2020-03-09