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

Part 5: Harmonized Standard covering the essential requirements

of article 3.2 of the Directive 2014/53/EU

Sub-part 1: receivers and interrogators for

multilateration equipment in A-SMGCS

Although the format of the title should be as indicated, it is recommended that revisions of existing Harmonised Standards preserve the original title provided that references to "essential requirements" and the relevant Directive are present and that the title is not misleading.

<

**HARMONISED EUROPEAN STANDARD**

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# Foreword

This draft Harmonized European Standard (EN) has been produced by ETSI Specialist Task Force 485 under 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 is intended to become a Harmonized Standard, referencing the 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 ("the RE Directive") [i.1].

The requirements relevant to Directive 2014/53/EU [i.1] are summarised in annex A.

NOTE: Other requirements and other EU Regulations and/or Directives may be applicable to the product(s) falling within the scope of the present document.

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.

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.

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

Part 2: "Community Specification for application under the Single European Sky Interoperability Regulation EC 552/2004 for A-SMGCS Level 2 including external interfaces";

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 EN covering the essential requirements of article 3.2 of the RE Directive for multilateration equipment";**

**Sub-part 1: "Receivers and Interrogators";**

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

Part 6: "Harmonized EN covering the essential requirements of article 3.2 of the RE Directive for deployed surface movement radar sensors".

|  |  |
| --- | --- |
| **Proposed national transposition dates** | |
| Date of latest announcement of this EN (doa): | 3 months after ETSI publication |
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# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx) (Verbal forms for the expression of provisions).

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# Executive summary

The present document covers the essential requirements for efficient use of radio spectrum of multilateration sensors in the 1030 MHz and 1090 MHz bands used for Advanced-Surface Movement Guidance and Control Systems.

# Introduction

The present document is part of a set of standards developed by ETSI and is designed to fit in a modular structure to cover all radio and telecommunications terminal equipment within the scope of the RE Directive [i.1].

The present document states the minimum performance requirements for receivers and interrogators used in multilateration equipment in an Advance Surface Movement Guidance and Control System (A-SMGCS) necessary for a harmonised standard covering the RE Directive [i.1].

The present document may be used for the conformity assessment of the performance of the equipment.

# 1 Scope

The present document applies to the following equipment types:

1. Interrogators transmitting in the 1030 MHz band, used in multilateration equipment in an Advanced Surface Movement Guidance and Control System (A-SMGCS);
2. Receivers, receiving in the 1090 MHz band, used in multilateration equipment in an Advanced Surface Movement Guidance and Control System (A-SMGCS);

The present document does not apply to equipment which includes a transponder function.

Note: For purposes of this document, ground vehicle locators and reference transmitters which do not contain receivers for the purpose of replying to interrogation are included in the transponder definition.

Note: EN 303 213-5-2 covers transponder equipment.

The present document states the essential requirements of a harmonized standard for receivers and interrogators used in multilateration equipment in an Advanced Surface Movement Guidance and Control System (A-SMGCS).

This harmonized standard is intended to cover the provisions of Directive 2014/53/EU, article 3.2 [i.1], which states that "... radio equipment shall be so constructed that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.“

In addition to the present document, other ENs that specify technical requirements in respect of essential requirements under other parts of article 3 of the RE Directive [i.1] as well as essential requirements under the Single European Sky Interoperability Regulation (as amended) and related implementing rules may apply to equipment within the scope of the present document.

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

# 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 A-SMGCS".

## 2.2 Informative references

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

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

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

[i.1] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

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

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

[i.4] ITU Recommendation M.1177-4 (2011): "Techniques for measurement of unwanted emissions of radar equipment".

[i.5] ITU-R Recommendation SM.329-12 (2012): “Unwanted emissions in the spurious domain”.

[i.6] ITU Recommendation ITU-R SM.1541-5 (08/2013) “Unwanted emissions in the out-of-band domain”

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in the RE Directive [i.1] and the following 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 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 this 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:** the entire period between transmissions, less 100 μs transition periods preceding and following the transmission.

**integral antenna:** an 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.

**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:** the 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:** a 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 outside the specified spectral mask.

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

**transmission:** continuous radio emission, in the operating channel.

**transmitter:** a 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

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

## 3.2 Symbols and Abbreviations

AC Alternating Current

ADS-B Automatic Dependant Surveillance Broadcast

A-SMGCS Advanced Surface Movement Guidance and Control System

dB deciBel

dBm power in dB relative to 1 milliwatt

DME Distance Measuring Equipment

EUT Equipment Under Test

ICAO International Civil Aviation Organization

IFF Interrogate Friend or Foe

λ Wavelength

µs Microsecond

MLAT Multilateration

MOPS Minimum Operational Performance Specification

Ω Ohm

OoB Out-of-Band

PD Probability of detection

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

t Time

# 4 Technical requirements specifications

## 4.1 Applicability

### 4.1.1 Equipment with multiple functions

Any ground station which includes the interrogator function shall comply with the requirements in section 4.2.

Any ground station which includes the sensor function shall comply with the requirements in section 4.3.

If a ground station includes the sensor function and any transmitter, the [spurious emissions] requirements in section 4.4 shall only apply during the inactive state of the transmitter.

### 4.1.2 Equipment with integral antenna

For the purposes of conducted measurements of EUT with 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.

### 4.1.3 Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the EUT, which shall be declared by the supplier. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the environmental profile.

## 4.2 Transmitter requirements

The transmitter requirements concern interrogators of a multilateration system used in Advanced Surface Movement Guidance and Control Systems.

### 4.2.1 Operating frequency

#### 4.2.1.1 Description

The nominal value of the carrier frequency.

#### 4.2.1.2 Limits

The nominal value of carrier frequency of the interrogation and control transmissions shall be 1030 MHz.

#### 4.2.1.3 Conformance

Conformance tests as defined in clause 5.4.1 shall be carried out.

### 4.2.2 Frequency Error

#### 4.2.2.1 Description

The frequency error is the difference between the actual carrier frequency and its nominal value of 1030 MHz.

#### 4.2.2.2 Limits

The absolute value of the frequency error shall not exceed 0,01 MHz.

#### 4.2.2.3 Conformance

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

NOTE: the test procedure ignores frequency excursions during the phase reversal. Further information is given in 3.1.2.1.1. ICAO Annex 10V4v [n.1].

Conformance shall be established under normal and extreme test conditions.

### 4.2.3 Transmitter peak envelope power

#### 4.2.3.1 Description

Peak envelope power is the average power supplied to the antenna transmission line during one radio frequency cycle at the crest of the modulation envelope.

NOTE: The Transmitter power needs to achieve the value needed to meet operational performance. The Transmitter maximum power must be set up to meet the power limit indicated in the individual Frequency Licence.

#### 4.2.3.2 Limits

The manufacturer shall announce the rated output power of the transmitter.

Note: This figure is required by the operator to determine a minimum distance to receiving units.

The peak envelope power of the transmitter measured under normal test conditions shall not vary by more than 2 dB from the rated output power.

The peak envelope power of the transmitter measured under extreme test conditions shall not vary by more than + 2 dB and -3 dB from the rated output power.

#### 4.2.3.3 Conformance

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

Conformance shall be established under normal and extreme test conditions.

### 4.2.4 Spectrum mask

#### 4.2.4.1 Description

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 +/- 125 MHz about the nominal operating frequency of 1030 MHz. The frequencies below or above 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 OR -13 dBm, whichever is less stringent.



Figure - Required spectrum limits for interrogator transmitter (mask from ICAO Annex 10, Volume 4, figure 3-2 modified to be consistent with IUT-RR article 3)

#### 4.2.4.3 Conformance

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

Conformance shall be established under normal and extreme test conditions.

### 4.2.5 Inter-modulation attenuation

#### 4.2.5.1 Description

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.

#### 4.2.5.2 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. The interfering signal shall have a frequency range from 960MHz to 1215MHz (DME band).

Note: The 60dB limit is consistent with the spurious emissions requirement and with ETSI EN 300 676-1 [ref?])

#### 4.2.5.3 Conformance

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

Conformance shall be established under normal and extreme test conditions.

### 4.2.6 Transmitter duty cycle

#### 4.2.6.1 Description

The duty cycle is determined with the equation:

where

* Ton\_cum is the cumulative duration of the message from the 50% voltage point on the rising edge of the first pulse to the 50% voltage point on the falling edge of the last pulse.
* Tobs.is at least one second and sufficiently long to capture the steady state operation of the transmitter
* Fobs is the frequency band to evaluate centered at 1030 MHz and extending at least +/- 4 MHz

#### 4.2.6.2 Limits

The required duty cycle is a function of the airport and depends on the fit-for-purpose requirements.

The manufacturer shall declare the rated duty cycle of the transmitter.

#### 4.2.6.3 Conformance

NOTE: For the purposes of the present document, the rated duty cycle is a limit to be respected during testing in order to avoid damage to the EUT.

### 4.2.7 Residual Power Output

#### 4.2.7.1 Description

The residual power output is the power output when in the inactive state.

#### 4.2.7.2 Limits

The residual power output shall be not greater than -47dBm.

Note: This requirement is taken from ERC REC 74-01 and is more stringent than the recommendation in 3.1.2.11.3.1 of ICAO [1].

#### 4.2.7.3 Conformance

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

## 4.3 Receiver requirements

### 4.3.1 Operating frequency range

#### 4.3.1.1 Description

The operating frequency range is the frequency range around the nominal operating frequency over which reception of signals can be achieved.

#### 4.3.1.2 Limits

Receivers shall operate with the rated sensitivity for signals with a carrier frequency of 1090 MHz and the following frequency offsets:

* Mode 3AC +/- 3 MHz
* Mode S +/- 1 MHz.

#### 4.3.1.3 Conformance

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

### 4.3.2 Adjacent channel selectivity and spurious responses

#### 4.3.2.1 Description

Adjacent channel 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 the 1090 MHz IFF 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.

#### 4.3.2.2 Limits

The EUT shall not respond to valid signals at the frequency offsets and levels in Table 1 or at the frequency offsets given in Table 1, the level of valid signal that the EUT responds to shall be not less than the levels shown in the Table.

Table -minimum input level for messages from outside the desired frequency band

|  |  |
| --- | --- |
| ***Frequency (MHz)*** | ***Minimum Input Level Above Specified Receiver Sensitivity (dB)*** |
| +/- 12.5 | >=3 |
| +/- 19 | >= 20 |
| +/- 29 | >= 40 |
| +/- 46 | >=60 |

#### 4.3.2.3 Conformance

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

### 4.3.3 Inter-modulation response rejection

#### 4.3.3.1 Description

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.

#### 4.3.3.2 Limits

At any frequency combination from -78 MHz to -10 MHz and from +10 MHz to +78 MHz from the receiver frequency of 1090 MHz, the unwanted signals shall not reduce the probability of detection by more than 5 percentage points if their signal level is 12 dB or more below the level of the wanted signal.

#### 4.3.3.3 Conformance

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

### 4.3.4 Co-channel rejection

#### 4.3.4.1 Description

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.

#### 4.3.4.2 Limits

The unwanted signal shall not reduce the rate of correctly received and decoded squitter messages from the wanted Mode S signal by more than 5 %.

#### 4.3.4.3 Conformance

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

### 4.3.5 Blocking

#### 4.3.5.1 Description

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.

#### 4.3.5.2 Limits

The rate of correctly received and decoded squitter messages from the wanted Mode S signal shall be reduced by no more than 5% in the presence of unwanted signals specified in Table 2.

Table -unwanted signal levels

|  |  |
| --- | --- |
| Frequency | Level |
| -78 MHz to -10 MHz relative to 1090 MHz | 20 dB above the level of the wanted signal |
| +10 MHz to +78 MHz relative to 1090 MHz | 20 dB above the level of the wanted signal |

#### 4.3.5.3 Conformance

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

### 4.3.6 Receiver dynamic range / maximum usable sensitivity

#### 4.3.6.1 Description

The receiver dynamic range shall be declared by the manufacturer.

#### 4.3.6.2 Limits

Receivers shall operate throughout the receiver dynamic range for signals with a carrier frequency of 1090 MHz with at least a PD of 90%.

#### 4.3.6.3 Conformance

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

## 4.4 Receiver and transmitter Requirements

### 4.4.1 Spurious emissions

#### 4.4.1.1 Description

Spurious emissions are unwanted emissions in the spurious domain radiated by the equipment or its antenna.

For active transmitters, the spurious domain is all frequencies apart from the operating channel and the Out of Band domain.

For receivers and inactive transmitters the spurious domain is all frequencies.

Note: The residual power output is controlled by the spurious emissions requirement which is more stringent than the recommendation in 3.1.2.11.3.1. of ICAO [1].

#### 4.4.1.2 Limits

The power of any unwanted emission in the spurious domain shall not exceed the values given in Table 3.

Table -maximum power levels for spurious emissions

|  |  |  |  |
| --- | --- | --- | --- |
| Frequency  State | 47 MHz to 74 MHz  87,5 MHz to 118 MHz  174 MHz to 230 MHz  470 MHz to 790 MHz | Other frequencies  below 1 000 MHz | Frequencies  above 1 000 MHz |
| TX mode | -54 dBm | -36 dBm | -30 dBm |
| RX and all other modes | -57 dBm | -57 dBm | -47 dBm |

#### 4.4.1.3 Conformance

The conformance tests for this requirement shall be as defined in clause 5.6.1.

# 5 Testing for compliance with technical requirements

## 5.1 Environmental conditions for testing

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.

If any test is required to be performed under extreme conditions this is specified in the requirements in clause 4.

### 5.1.1 Normal test conditions

#### 5.1.1.1 Normal temperature and humidity

Each test done within the scope of this document is required to be conducted within standard ambient conditions as defined in EN 300 019 1-4.When it is impracticable to carry out tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

#### 5.1.1.2 Normal test power source

##### 5.1.1.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages, for which the equipment was designed.

The frequency of the test power source corresponding to the ac mains shall be between 49 Hz and 51 Hz.

##### 5.1.1.2.2 Lead-acid battery power sources

When the radio equipment is intended for operation with the usual types of lead-acid battery power source, the normal test voltage shall be 1,1 multiplied by the nominal voltage of the battery (e.g. 6 V, 12 V, etc.).

##### 5.1.1.2.3 Other power sources

For operation from other power sources or types of battery (primary or secondary), the normal test voltage shall be that declared by the equipment manufacturer and agreed by the accredited test laboratory. Such values shall be stated in the test report.

### 5.1.2 Extreme test conditions

#### 5.1.2.1 General requirement

Unless stated otherwise, tests performed under extreme test conditions shall apply the worst case temperature and voltage conditions simultaneously.

#### 5.1.2.2 Extreme temperatures

##### 5.1.2.2.1 General requirements

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 shall be switched on for 15 minutes after thermal balance has been obtained, and 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 test 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.

##### 5.1.2.2.2 Procedure for equipment designed for continuous operation

If the manufacturer states that the equipment is designed for continuous operation, the test procedure shall be as follows:

* Before tests at the upper extreme 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 condition for a period of a half hour after which the equipment shall meet the specified requirements.
* For tests at the lower extreme temperature, the equipment shall be left in the test chamber until thermal balance is attained, then switched on for a period of one minute after which the equipment shall meet the specified requirements.

##### 5.1.2.2.3 Procedure for equipment designed for intermittent operation

If the manufacturer states that the equipment is designed for intermittent operation, the test procedure shall be as follows:

* before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained in the oven. The equipment shall then either:
* transmit on and off according to the manufacturers declared duty cycle for a period of five minutes; or
* if the manufacturer's declared on period exceeds one minute, then:
* transmit in the on condition for a period not exceeding one minute, followed by a period in the off or standby mode for four minutes; after which the equipment shall meet the specified requirements;
* for tests at the lower extreme temperature, the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for one minute after which the equipment shall meet the specified requirements.

##### 5.1.2.2.4 Extreme temperature ranges

Tests at extreme temperatures shall be made in accordance with the procedures specified in clause 5.1.2.2 at the upper and lower temperatures of the operational profiles listed below

EUT designed for outdoor use: ambient temperatures of -25°C, 25°C and 40°C surrounding the supplier provided weatherproof enclosure.

EUT designed to be installed in equipment rooms: an ambient temperature of 25°C around the EUT.

#### 5.1.2.3 Extreme test source voltages

##### 5.1.2.3.1 Mains voltage

The extreme test voltages for EUT intended to be connected to an AC mains source shall be the nominal mains voltage ±10 %. For equipment that operates over a range of mains voltages clause 5.1.2.3.4 applies.

##### 5.1.2.3.2 Lead-acid battery power sources

When the EUT is intended for operation from the usual type of lead-acid battery power sources the extreme test voltages shall be 1,3 and 0,9 multiplied by the nominal voltage of the battery (6 V, 12 V, etc.).

For float charge applications using "gel-cell" type batteries the extreme voltage shall be 1,15 and 0,85 multiplied by the nominal voltage of the declared battery voltage.

##### 5.1.2.3.3 Power sources using other types of batteries

The lower extreme test voltages for equipment with power sources using batteries shall be as follows:

* for equipment with a battery indicator, the end point voltage as indicated;
* for equipment without a battery indicator the following end point voltages shall be used:
* for the Leclanché or the lithium type of battery:
* 0,85 multiplied by the nominal voltage of the battery;
* for the nickel-cadmium type of battery:
* 0,9 multiplied the nominal voltage of the battery;
* for other types of battery or equipment, the lower extreme test voltage for the discharged condition shall be declared by the equipment manufacturer.

The upper extreme voltage shall be declared by the equipment manufacturer if different from the nominal voltage.

##### 5.1.2.3.4 Other power sources

For equipment using other power sources, or capable of being operated from a variety of power sources, the extreme test voltages shall be those agreed between the equipment manufacturer and the test laboratory. This shall be recorded in the test report.

## 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;
* the recorded value of the measurement uncertainty shall be, for each measurement, equal to or less than the figures in table <n>.

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

Table <n> is based on such expansion factors.

Table -Maximum measurement uncertainty

|  |  |
| --- | --- |
| Parameter | Uncertainty |
| Adjacent channel power | ±2,5 dB |
| Adjacent channel rejection | ±4 dB |
| Blocking and desensitization | ±4 dB |
| Carrier power (normal and extreme test conditions) | ±0,75 dB |
| Conducted spurious emissions:  below 1 GHz  between 1 GHz and 4 GHz | ±3 dB  ±6 dB |
| Conducted spurious radiation:  below 1 GHz  between 1 GHz and 4 GHz | ±3 dB  ±6 dB |
| Cabinet radiation |  |
| Cross modulation rejection | ±4 dB |
| Frequency error | ±1 × 10‑9 |
| Intermodulation | ±3 dB |
| Intermodulation response rejection | ±3 dB |
| Keying transient frequency behaviour | ±3 dB |
| Receiver dynamic range | ±2 dB |
| Receiver sensitivity | ±3 dB |
| Spurious response rejection | ±4 dB |
| Transient frequency behaviour | ±250 Hz |

## 5.3 Test and General Conditions

### 5.3.1 Transmitter test signals

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 should be capable of generating the following test signals:

* Test signal 1: Maximum duty cycle, short Mode S interrogations with all “0” data content
* Test signal 2: Maximum duty cycle, short Mode S interrogations with all “1” data content
* Test signal 3: Maximum duty cycle, Mode A interrogation

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.

#### 5.3.1.1 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 manufacturer’s rated maximum duty cycle is not exceeded.
* Waveform: Short Mode S Interrogation, reference ICAO Annex 10, Volume 4, sections 3.1.2.1 and 3.1.2.11.4 [n.1].
* Frequency: 1030 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 [n.1]. The P1 and P2 pulses are 0,80 microseconds long and the P6 pulse is 16,25 microseconds long. In total, the short Mode S interrogation results in 17,85 microseconds of active transmission. The maximum transmission rate that does not exceed 1% (i.e., 10 milliseconds per second of transmission time) is 560 Hz.

#### 5.3.1.2 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 manufacturer’s rated maximum duty cycle is not exceeded.
* Waveform: Short Mode S Interrogation, reference ICAO Annex 10, Volume 4, sections 3.1.2.1 and 3.1.2.11.4.
* Frequency: 1030 MHz
* Message content: All “ones” (i.e., the maximum number of phase transitions)
* Amplitude: Maximum rated power level

#### 5.3.1.3 Test signal 3 (Optional)

This test signal shall be used for EUT with Mode A/C interrogation capability. When test signal 3 is specified below, a signal shall be generated with the following characteristics:

* Transmission rate: At least 50 Hz, a higher rate is preferable to increase the speed of test measurements.
* Waveform: Mode A interrogation, reference ICAO Annex 10, Volume 4, sections 3.1.1.1. Note: If the transmitter supports suppression pulses, they shall be included
* Frequency: 1030 MHz
* Message content: Not applicable
* Amplitude: Maximum rated power level for all pulses.

Note: If this will exceed the manufacturer’s rated maximum duty cycle the maximum rated rate shall be used and shall be noted in the test report.

### 5.3.2 Simulated received signals

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. 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.

* Test signal 4: Modulated Mode S Extended Squitter message (desired signal)
* Test signal 5: Unmodulated carrier (undesired signal
* Test signal 6: Modulated Mode S Extended Squitter message (undesired signal)

#### 5.3.1.1 Test signal 4

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

* Transmission rate: 100 Hz
* Waveform: Mode S Extended squitter, reference ICAO Annex 10, Volume 4, section 3.1.2.2.
* Frequency: 1090 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

For example: 0x88234567125054D4C72CF4 is a valid DF-17 squitter with the Aircraft Address of “234567”.

#### 5.3.1.2 Test signal 5

Where test signal 5 is specified below, a signal shall be injected with the following characteristics:

* Transmission rate: Not applicable
* Waveform: Unmodulated carrier
* Frequency: As specified in the test.
* Message content: Not applicable
* Amplitude: As specified by the test
* Pulse on/off ratio: Not applicable

#### 5.3.1.3 Test signal 6

When test signal 6 is specified below, a signal shall be injected with the following characteristics:

* Transmission rate: 6000 Hz
* Waveform: Mode S Extended squitter, reference ICAO Annex 10, Volume 4, section 3.1.2.2.
* 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 shall be distinct from Test signal 4.

For 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 test

#### 5.4.1.1 Description

Requirements to be tested:

* 4.2.1 Operating frequency
* 4.2.2 Frequency Error

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. Since the modulation of the Mode A/C interrogation is a subset of the Mode S interrogation only the Mode S interrogation is tested.

#### 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, as declared by the manufacturer.

#### 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 analyzer 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 for frequencies >= 905 MHz
  + 100 kHz, for frequencies < 905 MHz

#### 5.4.1.4 Measurement procedure

1. Attach the EUT antenna port to the spectrum analyzer 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 analyzer 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 in section 4.

### 5.4.2 Peak envelope power variation test

#### 5.4.2.1 Description

Requirements to be tested:

* 4.2.3 Transmitter peak envelope power

The transmitter peak envelope power is evaluated over various environmental conditions to show that the rated power is achieved within the allowed tolerance.

#### 5.4.2.2 Test conditions

The EUT shall be configured to generate test signal 2 as indicated in the procedure.

The measurement shall be performed with the EUT operating at its maximum rated power level as declared by the manufacturer. The transmitter peak envelope power shall be measured under normal and extreme conditions.

#### 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 2 at the rated power level.
3. Measure the peak envelope power. Verify that the power level is within the allowed tolerance of the rated power.
4. Repeat the measurement for each test condition within the normal and extended environment.
5. Verify that each power level is within the allowed tolerance of the rated power for the respective test condition.

### 5.4.2 Spectrum mask test

#### 5.4.2.1 Description

Requirements to be tested:

* 4.2.4 Spectrum mask

The in band, out of band and spurious frequency domains are measured for compliance of the EUT with the spectrum mask. All tests are performed at the maximum rated transmit power and duty cycle to show that the spectrum is met under these conditions. Since the modulation of the Mode A/C interrogation is a subset of the Mode S interrogation only the Mode S interrogation is tested. It is suggested to perform the test with different transmit power levels to show compliance to the requirement with different power settings. It is encouraged that the system performance is ensured throughout all power settings and throughout all specified environmental conditions.

#### 5.4.2.2 Test conditions

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

When measuring the spurious domain, ITU-R recommendation <REFERENCE> indicates that a spectrum analyzer receiver bandwidth of 1 MHz be used for frequencies of 1 GHz and above, and a bandwidth of 100 kHz 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 shall be used for frequencies of 905 MHz and above. For frequencies lower than 905 MHz the receiver bandwidth shall be 100 kHz. The spurious domain compliance limit will not be adjusted for the change in receiver bandwidth.

The measurement shall be performed with the EUT operating at its maximum rated power level, minimum rated power level and somewhere at a testpoint between minimum and maximum power level, as declared by the manufacturer.

The nominal transmitter output power shall be determined under normal and extreme conditions and with only short Mode S uplink messages. It is recommended to use the same normal and extreme test conditions for transmitter and receiver.

As stated in EG 201 399, clause 7.1.3, conformance tests shall be conducted with maximum output power. If the output levels are configurable, then several levels of output power may be tested. For the purpose of the present document it is normally sufficient to perform the measurements for the lowest and the highest declared output 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.

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 or increased harmonics due to non-linear effects in the test equipment. For example, a notch filter at 1030 MHz may be necessary for accurate measurements in the spurious domain. Particular care should also be taken at the harmonics of the transmit frequency.

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 for frequencies >= 905 MHz

100 kHz, for frequencies < 905 MHz

#### 5.4.2.4 Measurement procedure

1. Attach the EUT antenna port to the spectrum analyzer with appropriate attenuation, see note above.
2. Configure the EUT to produce test signal 1 at the power level corresponding to the requirement and duty cycle.
3. Set up the spectrum analyzer with a receiving bandwidth of 1 MHz and a video bandwidth of 1 MHz.
4. Measure the spectrum from 905 MHz to 1155 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 1155 MHz and compare it to the spectrum mask.
7. Measure from 1155 MHz to 6,2 GHz (fifth harmonic) and compare to the spectrum mask.
8. Switch the spectrum analyzer to a receiving bandwidth of 100 kHz and a video bandwidth of 100 kHz
9. Measure from 30 MHz to 905 MHz and compare to the lower frequency limit of the spectrum mask.
10. Repeat this test with each applicable power level and environmental condition to cover all the requirements for the spectrum mask.

### 5.4.3 Inter-modulation attenuation

#### 5.4.3.1 Description

Requirements to be tested:

* 4.2.5 Inter-modulation 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.

#### 5.4.3.2 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.

#### 5.4.3.3 Method of measurement



Figure : 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 may be either a transmitter providing the same power output as the transmitter under test and be of a similar type or 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.

#### 5.4.3.4 Measurement procedure

1. The transmitter under test shall be set to transmit test signal 2 and the spectrum analyser adjusted to give a maximum indication with a frequency scan width of 500 kHz.
2. The interfering test signal source shall be unmodulated (CW) and the frequency shall be within 10 MHz to 185 MHz above the frequency of the transmitter under test.
3. The frequency shall be chosen in such a way that the intermodulation components to be measured do not coincide with other spurious components.
4. The power output of the interfering test signal source shall be adjusted to the carrier power level of the transmitter under test by the use of a power meter.
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 within 10 MHz to 70 MHz below the frequency of the transmitter under test.
7. Verify that for each frequency, the inter-modulation attenuation ratio is at least the level required.

### 5.4.4 Residual power output

#### 5.4.4.1 Description

Requirement to be tested:

* 4.2.7 Residual Power Output
* 4.2.3 Spectrum mask

This test will verify that the output power of the transmitter between transmit bursts does not exceed the specified maximum.

#### 5.4.4.2 Test conditions

The measurement shall be performed with the EUT operating.

#### 5.4.4.3 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.

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 for frequencies >= 905 MHz
  + 100 kHz, for frequencies < 905 MHz

5.4.4.4 Measurement procedure

1. Connect the power measuring equipment to EUT antenna connector. Switch on the EUT and set it into standard operating mode (i.e. transmitting) at the lowest possible interrogation rate.
2. Measure the power of the output signal over the period between transmission bursts, starting 10 µs after the end of one interrogation and ending 10 µs prior to the start of the next interrogation.
3. The power is determined by calculating the RMS value of the signal during the measurement time.

## 5.5 Receiver Requirements

### 5.5.1 Operating frequency range

#### 5.5.1.1 Description

Requirements to be tested:

* 4.3.1 Operating frequency range

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.

#### 5.5.1.2 Test conditions

External test equipment will be used to stimulate the EUT with test signal 4 at the amplitudes indicated in the procedure. External test equipment will 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 will be collected and the average rate of message receipt will 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 4 at the manufacturer’s rated sensitivity and inject messages 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 (section 4.3.2) was 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 (section 4.3.2) was achieved will be used as the reference amplitude for the following steps and subsequent tests.
8. Repeat the test with the signal generator configured to produce test signal 4 with the following modifications:
   1. Change the signal level to reference sensitivity plus 3 dB
   2. Change the frequency to operating frequency plus tolerance (section 4.3.1)
9. Verify that at least the required PD (section 4.3.2) is achieved.
10. Repeat the test with the signal generator configured to produce test signal 4 with the following modifications:
    1. Change the signal level to reference sensitivity plus 3 dB
    2. Change the frequency to operating frequency minus tolerance (section 4.3.1)
11. Verify that at least the required PD (section 4.3.2) is achieved.

### 5.5.2 Adjacent channel selectivity and spurious responses

#### 5.5.2.1 Description

Requirements to be tested:

* 4.3.2 Adjacent channel selectivity and spurious responses

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.

Table -references for receiver pass band and receiver selectivity

| **Frequency** | **Amplitude Relative to Rated Sensitivity in dB** | **Reference** |
| --- | --- | --- |
| +/- 12.5 MHz | >=3 | Alt ED-129 2.6.2 Table 2 for MLAT |
| +/- 19 MHz | >= 20 | Alt ED-129 2.6.2 Table 2 for MLAT |
| +/- 29 MHz | >= 40 | Alt ED-129 2.6.2 Table 2 for MLAT |
| +/- 46 MHz | >=60 | Alt ED-129 2.6.2 Table 2 for MLAT  Alt ED-129 2.6.2 is consistent with ICAO Annex 10 [n.1] at +/- 46MHz |

#### 5.5.2.2 Test conditions

External test equipment will be used to stimulate the EUT with test signal 4 at the amplitudes and frequencies indicated in the procedure. External test equipment will 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 will be collected and the average rate of message receipt will be calculated.

#### 5.5.2.4 Measurement procedure

1. Record the reference sensitivity as determined in test 5.5.1 Operating Frequency.
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 4 at 3 dB higher than the reference sensitivity at 1102,5 MHz and inject messages 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 probability of detection was reduced.
7. Repeat steps 4 through 6 for the following frequencies and amplitudes.

Table -input levels for receiver sensitivity test

|  |  |
| --- | --- |
| ***Frequency (MHz)*** | ***Injected Input Level Above Rated Receiver Sensitivity (dB)*** |
| 1077,5 | 3 |
| 1109 | 20 |
| 1071 | 20 |
| 1119 | 40 |
| 1061 | 40 |
| 1136 | 60 |
| 1044 | 60 |

### 5.5.3 Inter-modulation response rejection

#### 5.5.3.1 Description

Requirements to be tested:

* 4.3.3 Inter-modulation response rejection

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

This test will be performed under normal test conditions.

#### 5.5.3.3 Method of measurement



Figure -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 4.
* The first unwanted signal, provided by signal generator B, shall be unmodulated and adjusted to a frequency f1 at 10 MHz above the nominal frequency of the receiver.
* The second unwanted signal, provided by signal generator C, shall be modulated with test signal 6 and adjusted to a frequency f2 at 20 MHz above the nominal frequency of the receiver.

1. 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 manufacturer’s rated sensitivity. -

1. Signal generators B and C shall then be switched on; the levels of the two unwanted signals shall be maintained equal and shall be adjusted until a successful message ratio of less than 5 % is obtained or the operating limit of the receiver is reached;
2. The normal test signal shall then be transmitted repeatedly whilst observing the successful message reception ratio;

* The levels of the unwanted signals shall be reduced together in steps by 1 dB.
* The procedure shall be continued until the successful message ratio is above 95%. The level of the input signals shall then be noted.

1. For each configuration of the unwanted signals, the intermodulation response rejection shall be expressed as the ratio, in dB, of the level noted in step 4. to the level of the wanted signal, at the receiver input. This ratio shall be recorded.
2. The measurement shall be repeated with the unwanted signal generator B at the frequency 10 MHz below that of the wanted signal and the frequency of the unwanted signal generator C at the frequency 20 MHz below that of the wanted signal.
3. Repeat the test steps 1. to 6. with the following frequency combinations that fulfil

fc = 2 \* f1 - f2

with an offset of f2 in the range of +20MHz to +78MHz and -20MHz to -78MHz.

f1 = 1051, f2 = 1012

f1 = 1060, f2 = 1030

f1 = 1129, f2 = 1168

...

1. The intermodulation response rejection of the EUT is the lowest of the values recorded in step 5.

### 5.5.4 Co-channel rejection

#### 5.5.4.1 Description

Requirements to be tested:

* 4.3.4 Co-channel rejection

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 specified limit.

#### 5.5.4.2 Test conditions

This test will be performed under normal test conditions.

#### 5.5.4.3 Method of measurement



Figure -measurement arrangement

#### 5.5.4.4 Measurement procedure

1. Two signal generators A and B shall be connected to the test fixture 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 2).
2. The unwanted signal, represented by signal generator B, shall be modulated with the same signal.
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 manufacturer’s rated sensitivity.
6. The unwanted signal from generator B shall then be switched on and its level shall be adjusted until a successful response ratio of less than 10 % is obtained.
7. The normal test signal 1 shall be transmitted repeatedly whilst observing the successful message reception ratio.
8. The level of the unwanted signal shall be reduced by 1 dB for each occasion that a successful response is not obtained.
9. The procedure shall be continued until a rate of 95% is achieved.
10. The level of the input signal shall then be noted.
11. For each frequency of the unwanted signal, the co-channel rejection ratio shall be expressed as the ratio, in dB, of the average level recorded in step 10. to the level of the wanted signal.
12. The measurement shall be repeated for displacements of the unwanted signal of ±1.2 MHz.
13. The co-channel rejection ratio of the equipment under test shall be expressed as the lowest of the three values expressed in dB, recorded in step 12.

### 5.5.5 Blocking

#### 5.5.5.1 Description

Requirements to be tested:

* 4.3.5 Blocking

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 specified limit.

#### 5.5.5.2 Test conditions

This test will be performed under normal test conditions.

#### 5.5.5.3 Method of measurement



Figure -measurement arrangement

#### 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 2)
3. The unwanted signal, provided by signal generator B, shall be unmodulated and shall be at a frequency from 10 MHz to 78 MHz away from the nominal frequency of the receiver.
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 20 dB above the manufacturer’s rated sensitivity.
6. The unwanted signal shall then be switched on and its level shall be adjusted until a successful reception ratio of less than 10 % is obtained.
7. The normal test signal 2 shall be transmitted repeatedly whilst observing the successful reception rate.
8. The level of the unwanted signal shall be reduced in steps by 1 dB.
9. The procedure shall be continued until the successful reception rate is above 95%.
10. The level of the input signal shall then be noted.
11. For each frequency, the blocking or desensitization shall be expressed as the level in dB noted in step 10.
12. The measurement shall be repeated for frequencies within the range defined in step 3 at 1 MHz steps.
13. The blocking or desensitization of the equipment under test shall be expressed as the level of the unwanted signal, at the receiver location, corresponding to the lowest value recorded in step 11.

### 5.5.6 Receiver dynamic range / Maximum usable sensitivity Test

#### 5.5.6.1 Description

Requirements to be tested:

* 4.3.6 Receiver dynamic range / maximum usable sensitivity

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

#### 5.5.6.2 Test conditions

External test equipment will be used to stimulate the EUT with desired test signal 4 at the amplitudes indicated in the procedure. External test equipment will be used to collect the reception reports for each injected message.

#### 5.5.6.3 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 will be collected and the average rate of message receipt will be calculated.

#### 5.5.6.4 Measurement procedure

1. Record the reference sensitivity as determined in test 5.5.1 Operating Frequency.
2. Configure the EUT to receive and report messages for recording.
3. Configure the recording device to record message reports.
4. Verify that no message reports are being generated.
5. Configure the signal generator to produce test signal 4 at the power level of the reference sensitivity and inject messages for at least 100 seconds.
6. Review the recorded reports to count the number of reports which match the expected message content.
7. 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 (4.3.2) was achieved.
8. Repeat the test at the midpoint and maximum amplitude of the manufacturer’s declared dynamic range.

### 5.6 Receiver and transmitter tests

### 5.6.1 Spurious emissions

#### 5.6.1.1 Description

Spurious emissions are unwanted emissions in the spurious domain radiated by the equipment or its antenna.

For transmitters, or EUT in transmit mode,, the spurious domain is all frequencies apart from the channel on which the transmitter is intended to operate and the Out of Band domain.

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

#### 5.6.1.2 Test conditions

The EUT shall be configured and operated in modes representative of normal operation.

For transmitters, measurements shall be performed with the EUT operating at its maximum operating power level.

#### 5.6.1.3 Method of measurement

For all EUT the spurious emissions levels shall be established as:

i) the conducted measurement procedure in clause 5.6.1.3.1; and

ii) the radiated measurement procedure in clause 5.6.1.3.2, with the antenna port terminated in a dummy load.

##### 5.6.1.3.1 Conducted measurement

The antenna port of the EUT shall be connected to the dummy load and the output of the dummy load connected to the measuring receiver.

The measuring receiver shall be tuned over the frequency range shown in table xx.

Table xx: Conducted Spurious Radiations Measurement Frequency Range

|  |  |  |
| --- | --- | --- |
| Operating Mode | Frequency Range | RBWREF  (see note 2) |
| Transmit mode | 9 kHz ≤ f < 150 kHz | 1 kHz |
| 150 kHz ≤ f < 30 MHz | 10 kHz |
| 30 MHz ≤ f < fm1 | 100 kHz |
| fm2 < f ≤ 12.75 GHz | 1 MHz |
| Receive mode  Transmitter Idle mode  All other modes | 9 kHz ≤ f < 150 kHz | 1 kHz |
| 150 kHz ≤ f < 30 MHz | 10 kHz |
| 30 MHz ≤ f ≤ 1 GHz | 100 kHz |
| 1 GHz < f ≤ 12.75 GHz | 1 MHz |
| NOTE 1: f is the measurement frequency.  fm1 is the lower edge of the Out of Band Domain.  fm1 is the upper edge of the Out of Band Domain.  The Out of Band Domain is defined in clause 4.2.3 Spectrum mask  NOTE 2: See clause 8.3.6 if the value of RBW used for measurement is different from RBWREF. | | |

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.

##### 5.6.1.3.2 Radiated measurement

A suitable test site shall be selected from those described in clause B.1.

The EUT antenna port shall be connected to a dummy load or dummy antenna.

The measurements shall be performed using the appropriate radiated measurement methods described in clause B.6.

The measuring receiver shall be tuned over the frequency range shown in table xx+1.

Table xx+1: Radiated Spurious Radiations Measurement Frequency Range

|  |  |  |
| --- | --- | --- |
| Operating Mode | Frequency Range | RBWREF  (see note 2) |
| Transmit mode | 25 MHz ≤ f < fm1 | 100 kHz |
| fm2 < f ≤ 12.75 GHz | 1 MHz |
| Receive mode  Transmitter Idle mode  All other modes | 9 kHz ≤ f < 150 kHz | 1 kHz |
| 150 kHz ≤ f < 30 MHz | 10 kHz |
| 30 MHz ≤ f ≤ 1 GHz | 100 kHz |
| 1 GHz < f ≤ 12.75 GHz | 1 MHz |
| NOTE 1: f is the measurement frequency.  fm1 is the lower edge of the Out of Band Domain.  fm1 is the upper edge of the Out of Band Domain.  The Out of Band Domain is defined in clause 4.2.3 Spectrum mask  NOTE 2: See clause 8.3.6 if the value of RBW used for measurement is different from RBWREF. | | |

At each frequency at which a spurious component is detected, the spurious emission power level shall be established using the procedures described in clause B.6.

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

The present document has been prepared by ETSI in response to mandate M/405 from the European Commission to provide a means of conforming to the essential requirements of Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC radio Equipment Directive [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 <NUMBER> | | | | |
| --- | --- | --- | --- | --- |
| Requirement | | | Requirement Conditionality | |
| No | Description | Reference: Clause No | U/C | Condition |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| … |  |  |  |  |

**Key to columns:**

**Requirement:**

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

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

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

**Requirement Conditionality:**

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

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

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

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

Annex B (normative):

Test sites and arrangements for radiated measurement

# B.1 General Considerations

This annex introduces three most commonly available test sites, to be used in the radiated measurements in accordance with the present document.

Subsequently the following items will be described:

* Open Area Test Site (OATS);
* Semi Anechoic Room (SAR);
* Fully Anechoic Room (FAR);

These are generally referred to as free field test sites. Both absolute and relative measurements can be performed on these sites. They will be described in clause B.2. Clause B.3 describes the antennas used in these test sites.

Where absolute measurements are to be carried out, the test site should be verified. A detailed verification procedure is described in clause 6 of ETSI TR 102 273-4 [i.5] for the OATS, in clause 6 of ETSI TR 102 273-3 [i.5] for the SAR, and in clause 6 of ETSI TR 102 273-2 [i.5] for the FAR.

Information for calculating the measurement uncertainty of measurements on one of these test sites can be found in ETSI TR 100 028‑1 [i.10] and ETSI TR 100 028-2 [i.10], ETSI TR 102 273-2 [i.5], ETSI TR 102 273-3 [i.5] and ETSI TR 102 273-4 [i.5].

# B.2 Radiation test sites

## B.2.1 Open Area Test Site (OATS)

An Open Area Test Site comprises a turntable at one end and an antenna mast of variable height at the other end above a ground plane which, in the ideal case, is perfectly conducting and of infinite extent. In practice, while good conductivity can be achieved, the ground plane size has to be limited. A typical Open Area Test Site is shown in figure B.1.

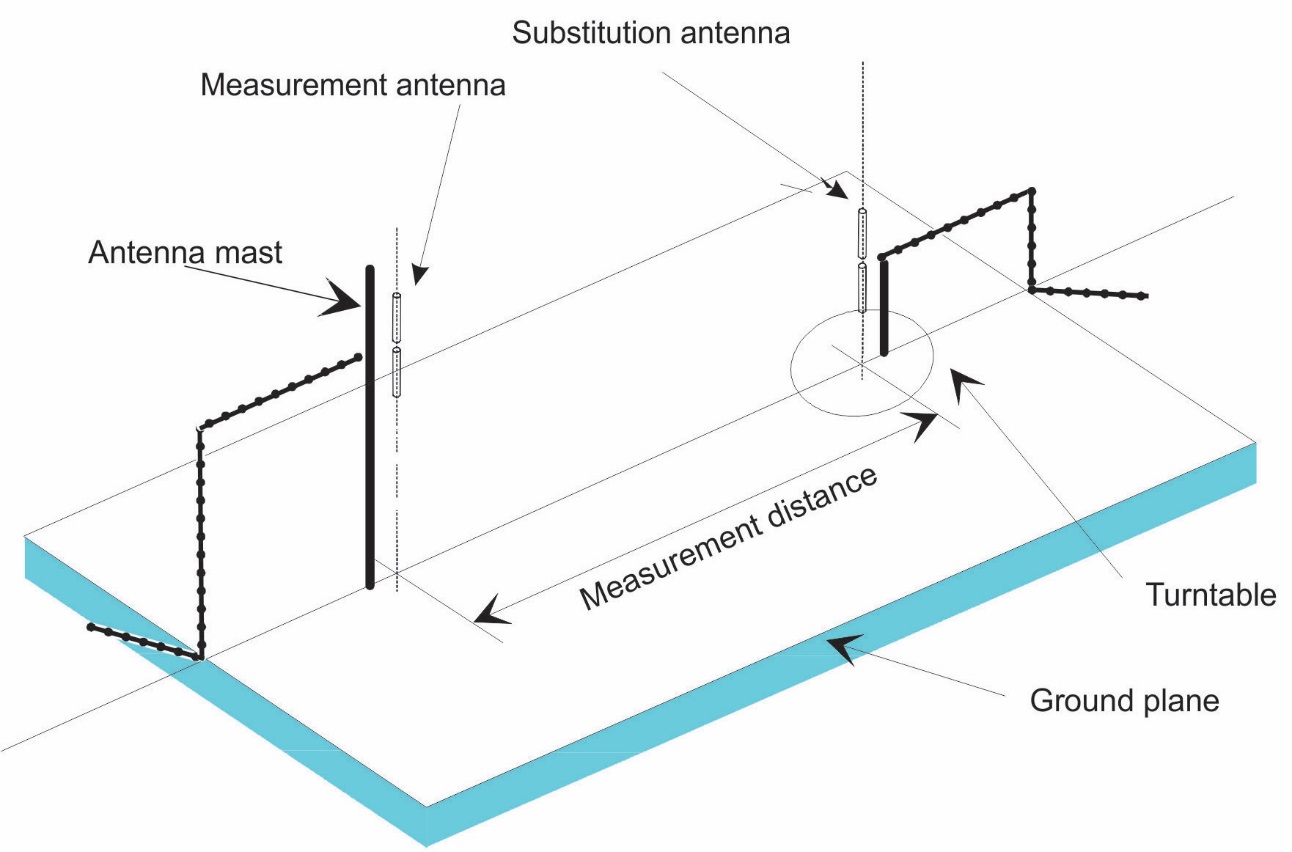


Figure B.1: A typical Open Area Test Site

The ground plane creates a wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals received from the direct and reflected transmission paths. The phasing of these two signals creates a unique received level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

The antenna mast provides a variable height facility (from 1 m to 4 m) so that the position of the measurement antenna can be optimized for maximum coupled signal between antennas or between a EUT and the measurement antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane.

The measurement distance and minimum chamber dimensions can be found in clause B.2.4. The distance used in actual measurements shall be recorded with the test results.

Further information on Open Area Test Sites can be found in ETSI TR 102 273-4 [i.5].

## B.2.2 Semi Anechoic Room

A Semi Anechoic Room - or anechoic chamber with a conductive ground plane - is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material. The floor, which is metallic, is not covered by absorbing material and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other end. A typical anechoic chamber with a conductive ground plane is shown in figure B.2.

This type of test chamber attempts to simulate an ideal Open Area Test Site, whose primary characteristic is a perfectly conducting ground plane of infinite extent.

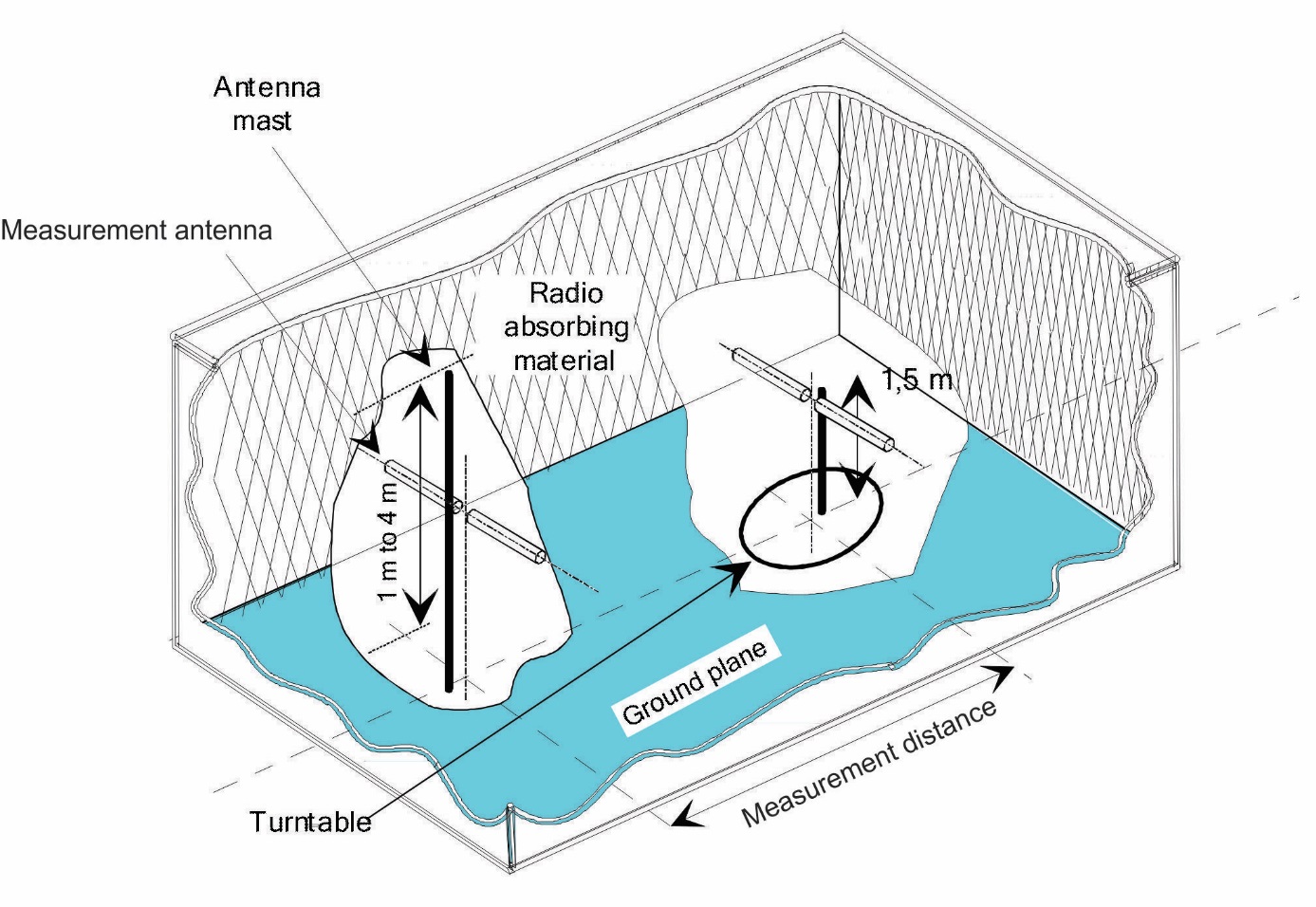


Figure B.2: A typical Semi Anechoic Room

In this facility the ground plane creates a wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals received from the direct and reflected transmission paths. The phasing of these two signals creates a unique received level for each height of the transmitting antenna (or EUT) and the receiving antenna above the ground plane.

The antenna mast provides a variable height facility (from 1 m to 4 m) so that the position of the measurement antenna can be optimized for maximum coupled signal between antennas or between a EUT and the measurement antenna.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane.

The measurement distance and minimum chamber dimensions can be found in clause B.2.4. The distance used in actual measurements shall be recorded with the test results.

Further information on Semi Anechoic Rooms can be found in ETSI TR 102 273-3 [i.5].

B.2.3 Fully Anechoic Room (FAR)

A Fully Anechoic Room is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material. The chamber usually contains an antenna support at one end and a turntable at the other end. A typical Fully Anechoic Room is shown in figure B.3.

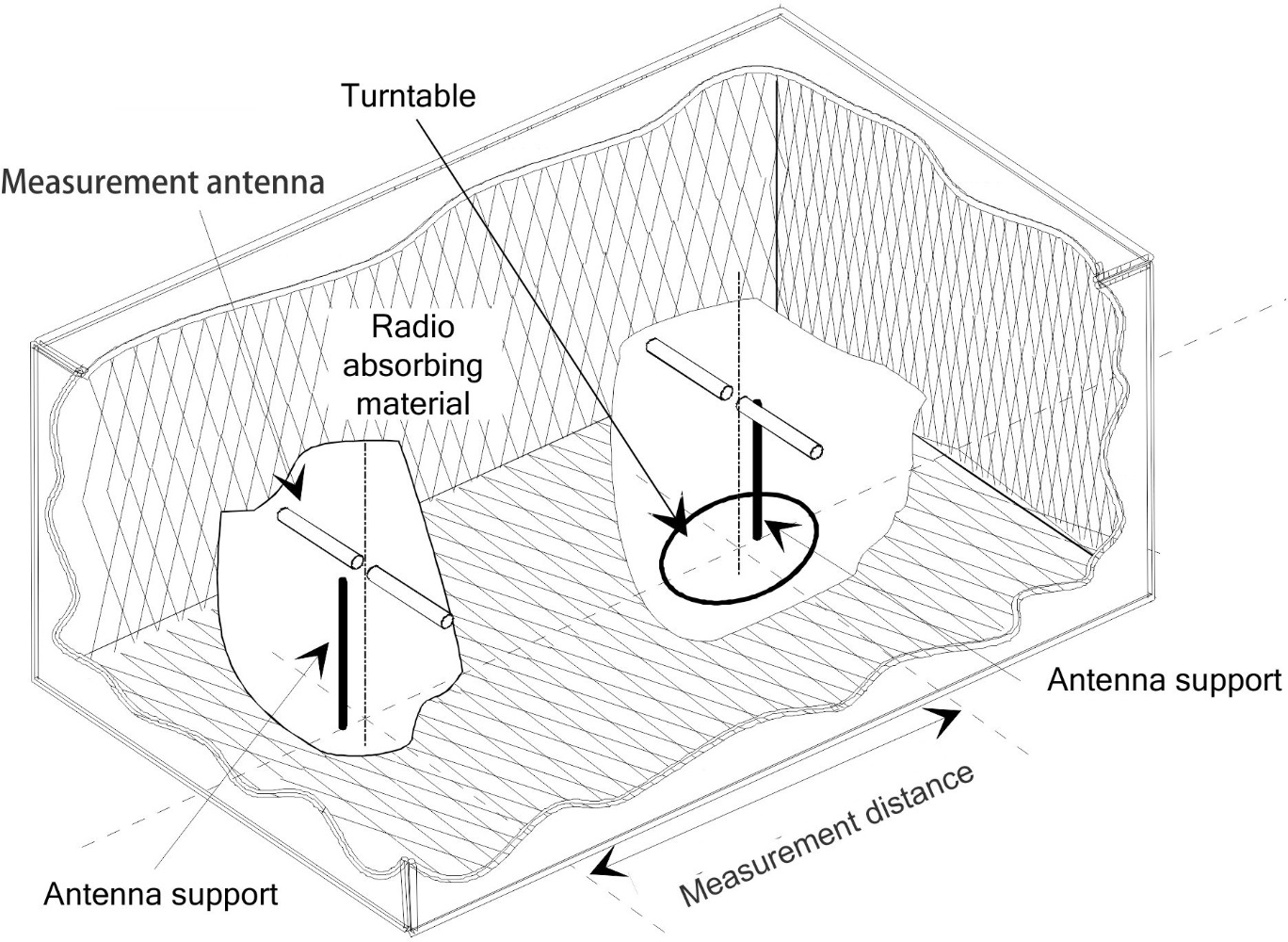


Figure B.3: A typical Fully Anechoic Room

The chamber shielding and radio absorbing material work together to provide a controlled environment for testing purposes. This type of test chamber attempts to simulate free space conditions.

The shielding provides a test space, with reduced levels of interference from ambient signals and other outside effects, whilst the radio absorbing material minimizes unwanted reflections from the walls and ceiling which can influence the measurements. The shielding should be sufficient to eliminate interference from the external environment that would mask any signals that have to be measured.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the EUT at a suitable height (e.g. 1 m) above the ground plane.

The measurement distance and minimum chamber dimensions can be found in clause B.2.4. The distance used in actual measurements shall be recorded with the test results.

Further information on Fully Anechoic Rooms can be found in ETSI TR 102 273-2 [i.5].

B.2.4 Measurement Distance

The measurement distance should be chosen in order to measure the EUT at far-field conditions. The minimum measurement distance between the equipment and the measurement antenna should be λ or rm >> , whichever is the greater.

λ = wavelength in m

rm = minimum measurement distance between EUT and measurement antenna in m

D = largest dimension of physical aperture of the largest antenna in the measurement setup, in m

For those measurements where these conditions cannot be fulfilled and where the measurement distance would result in measurements in the near field (e.g. while measuring spurious emissions), this should be noted in the test report and the additional measurement uncertainty should be incorporated into the results.

# B.3 Antennas

## B.3.1 General considerations

Antennas are needed for the radiated measurements on the three test sites described in clause B.2. Depending on its use, the antenna will be designated as "measurement antenna" or "substitution antenna".

## B.3.2 Measurement antenna

In emission tests the measurement antenna is used to detect the field from the EUT in one stage of the measurement, and from the substitution antenna in the other stage. When the test site is used for the measurement of receiver characteristics, the antenna is used as the transmitting device.

The measurement antennashould be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization. Additionally, on an OATS or SAR, the height of the centre of the antenna above the ground should be variable over the specified range (usually 1 m to 4 m).

In the frequency band 30 MHz to 1 000 MHz, biconical or logarithmic periodic dipole antennas (LPDA) are recommended. Above 1 GHz, horn antennas or logarithmic periodic dipole antennas are recommended.

For spurious emission testing, however, a combination of biconical antennas (commonly termed "bicones") and log periodic dipole array antennas (commonly termed "log periodics") could be used to cover the entire 30 MHz to 1 000 MHz band.

The measurement antenna does not require an absolute calibration.

## B.3.3 Substitution antenna

The substitution antenna shall be used to replace the EUT in substitution measurements.

It shall be suitable for the frequency range and the return loss of the antenna shall be taken into account when calculating the measurement uncertainty.

An antennas with a phase centre that changes as a function of frequency (such as a LPDA) is not suitable as a substitution antenna.

The reference point of the substitution antenna shall coincide with the volume centre of the EUT when its antenna is internal, or with the volume centre of a dedicated antenna, or the external antenna connector as appropriate.

The distance between the lower extremity of the antenna and the ground shall be at least 30 cm.

The substitution antenna shall be calibrated. Below 1 GHz, the calibration is relative to a half wave dipole, while above 1 GHz, an isotropic radiator is the reference.

NOTE: Calibration figures intended for use above a reflective surface cannot be used in an anechoic chamber or vice versa.

# B.4 Guidance on the use of radiation test sites

## B.4.1 General considerations

This clause details procedures, test equipment arrangements and verification that should be carried out before any of the radiated test are undertaken. These schemes are common to all types of test sites described in clause B.2.

Where necessary, a mounting bracket of minimal size should be available for mounting the EUT on the turntable. This bracket should be made from low conductivity, low relative permittivity (i.e. < 1,5) material(s) such as expanded polystyrene, balsawood, etc.

## B.4.2 Power supplies for the battery powered EUT

In the case of battery-only powered EUT, the preferred method is to perform testing using the EUT’s battery.

Where this is not practical, tests may be performed using power supplies. Power leads should be connected to the EUT's supply terminals (and monitored with a digital voltmeter) but the battery should remain present, electrically isolated from the rest of the EUT, possibly by putting tape over its contacts. The requirements of clause B.5 should be noted.

## B.4.3 Site preparation

The cables to the measuring and substitution antenna should be routed horizontally away from the testing area for a minimum of 2 m (unless, in the case both types of anechoic chamber, a back wall is reached) and then allowed to drop vertically and out through either the ground plane or screen (as appropriate) to the test equipment. Precautions should be taken to minimize pick up on these leads (e.g. dressing with ferrite beads, or other loading). The cables, their routing and dressing should be identical to the verification set-up.

NOTE: For ground reflection test sites (i.e. anechoic chambers with ground planes and Open Area Test Sites) which incorporate a cable drum with the antenna mast, the 2 m requirement may be impossible to comply with.

Calibration data for all items of test equipment should be available and valid. For test, substitution and measuring antennas, the data should include gain relative to an isotropic radiator (or antenna factor) for the frequency of test. Also, the VSWR of the substitution and measuring antennas should be known.

The calibration data on all cables and attenuators should include insertion loss and VSWR throughout the entire frequency range of the tests. All VSWR and insertion loss figures should be recorded in the log book results sheet for the specific test.

Where correction factors/tables are required, these should be available.

For all items of test equipment, the maximum errors they exhibit should be known along with the distribution of the error e.g.:

* cable loss: ±0,5 dB with a rectangular distribution;
* measuring receiver: 1,0 dB (standard deviation) signal level accuracy with a Gaussian error distribution.

At the start of measurements, system checks should be made on the items of test equipment used on the test site.

# B.5 Coupling of signals

## B.5.1 General

The presence of leads in the radiated field may cause a disturbance of that field and lead to additional measurement uncertainty. These disturbances can be minimized by using suitable coupling methods, offering signal isolation and minimum field disturbance (e.g. optical coupling).

## B.5.2 Data Signals

Isolation can be provided by the use of optical, ultrasonic or infra-red means. Field disturbance can be minimized by using a suitable fibre optic connection. Ultrasonic or infra-red radiated connections require suitable measures for the minimization of ambient noise.

### B.5.3 Power cables

The presence of power cables can affect the measured performance of the EUT. For this reason, they should be made to be "transparent" as far as the testing is concerned. This can be achieved by routing them away from the EUT horizontally away from the test area and down to either the screen, ground plane or facility wall (as appropriate). Precautions should be taken to minimize pick-up on these leads (e.g. the leads could be twisted together, loaded with ferrite beads at 0,15 m spacing or otherwise loaded).

# B.6 Measurement procedures for radiated measurement

## B.6.1 General considerations

This clause gives the general procedures for radiated measurements using the test sites and arrangements described in clause B.2.

Preferably, radiated measurements shall be performed in a FAR, see clause B.6.3. Radiated measurements in an OATS or SAR are described in clause B.6.2.

## B.6.2 Radiated measurements in an OATS or SAR

Radiated measurements shall be performed with the aid of a measurement antenna and a substitution antenna. The measurement set-up shall be calibrated according to the procedure defined in this annex. The EUT and the measurement antenna shall be oriented such as to obtain the maximum emitted power level. This position shall be recorded in the measurement report.

1. The measurement antenna (device 2 in figure B.4) shall be oriented initially for vertical polarization unless otherwise stated and the EUT (device 1 in figure B.4) shall be placed on the support in its standard position and switched on.
2. The measurement equipment (device 3 in figure B.4) shall be connected to the measurement antenna and  
   set-up according to the specifications of the test.



1) EUT

2) Measurement antenna

3) Measurement equipment

Figure B.4: Measurement arrangement No.1

1. The EUT shall be rotated through 360° in a horizontal plane until the maximum signal is received.
2. The measurement antenna shall be raised or lowered again through the specified height range until the maximum is obtained. This level shall be recorded.
3. This measurement shall be repeated for the other polarization (horizontal or vertical) of the measurement antenna.

NOTE: The maximum may be a lower value than the value obtainable at heights outside the specified limits.

## B.6.3 Radiated measurements in a FAR

For radiated measurements using a FAR, the procedure is identical to the one described in clause B.6.2, except that the height scan is omitted.

## B.6.4 Substitution measurement

To determine the absolute measurement value a substitution measurement is performed after the measurement of the EUT. The following steps shall be performed:

1. Replace the EUT that is depicted as device 1 in figure B.4 with the substitution antenna. The substitution antenna shall have the same polarization as the measurement antenna.
2. Connect a signal generator to the substitution antenna, and adjust it to the measurement frequency. The requirements of clause B.5 should be noted.
3. If an OATS or a SAR is used, the measurement antenna shall be raised or lowered within the specified limits, to ensure that the maximum signal is received.
4. Subsequently, the power of the signal generator is adjusted until the same level as was obtained with the EUT is obtained again at the measurement equipment.
5. The radiated power is equal to the power supplied by the signal generator, increased by the substitution antenna gain and lowered by the cable losses.
6. If necessary the measurement shall be repeated with the other polarization.

NOTE: For test sites with a fixed setup of the measurement antenna(s) and a reproducible positioning of the EUT, correction values from a verified site calibration can be used alternatively.

## B.6.5 Radiated measurements for receivers

Preferably, radiated measurements shall be performed in a FAR.

Measurements on receiving equipment are essentially the reverse of measurements on transmitters, with a signal generator connected to the measuring antenna. Determination of absolute values relies on the principle of replacing the EUT with a substitution antenna and suitable measuring equipment.

Clause B.3.3 Substitution antenna applies.

NOTE: This does not require an actual half wave dipole, only an antenna with known gain relative to a half wave dipole.

Where a result equivalent to a conducted measurement is required, for instance with values in terms of receiver input power, there are two methods:

1. Connect the substitution antenna to a measuring receiver and read the result directly.
2. Measure the path loss from the measurement antenna to the substitution antenna and subtract this from the signal generator level to reach the measurement result.

For method a) the level received in some measurements is likely to be too low, so it may be necessary to raise the signal generator by a suitable amount and apply an equivalent offset to the measurement result.

Method b) means that one calibration measurement can be used for multiple tests.

In each case, the measured value shall be adjusted by the gain of the substitution antenna and the cable losses.

Annex C (informative):  
Bibliography

This Bibliography identifies additional reading material not mentioned within the document. Those publications might or might not be publicly available.

The Bibliography includes lists of standards, books, articles, or other sources on a particular subject which are not referenced in the document:

* 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.
* Regulation (EC) 552/2004 of the European Parliament and Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (the interoperability Regulation). Official Journal L 096, 31/03/2004 P. 0026 - 0042.
* 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".
* ECC/Recommendation (02)05 (2012): "Unwanted emissions".
* ERC/Recommendation 74-01 (2011): "Unwanted emissions in spurious domain".
* ITU Recommendation M.1177-4 (2011): "Techniques for measurement of unwanted emissions of radar equipment".
* ITU-R Recommendation SM.329-12 (2012): “Unwanted emissions in the spurious domain”.

NOTE: More stringent requirements envisioned for future versions of ITU-R Recommendations, ECC/Recommendations and ERC Recommendations may need to be considered in a future version of the present document.

* Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services as amended by Directive 98/48/EC of the European Parliament and of the Council of 20 July 1998 and by Council Directive 2006/96/EC of 20 November 2006.
* ITU Recommendation ITU-R SM.1541-5 (08/2013) “Unwanted emissions in the out-of-band domain”
* ETSI TR 100 028(V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".
* EUROCAE ED-73E (2011): "MOPS for Secondary Surveillance Radar Mode S Transponders".
* Recommendation ITU-R SM.1541-5 (2013): "Unwanted emissions in the out-of-band domain".
* ETSI TR 100 028 (all parts) (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".
* ETSI TR 100 028-2 (V1.4.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".
* Regulation (EC) 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC.
* 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.

Annex D (informative):  
Change history

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

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| --- | --- | --- |
| **Document history** | | |
| <Version> | <Date> | <Milestone> |
|  |  |  |
|  |  |  |
| 0.0.9 | 05.02.2015 | Complete document review during STF Meeting (STF 485) |
| 0.0.10 | 13.03.2015 | Early internal draft for internal STF discussion (STF 485) |
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|  |  |  |
|  |  |  |
| 0.0.26 | 07.02.2017 | Major document restructuration and adoption of new skeleton |

*Latest changes made on 2017-02-07*