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Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Service; Commercially available amateur radio equipment; Part 1: Technical characteristics and methods of measurement

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Contents

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document is part 1 of a multi-part deliverable covering the Electromagnetic compatibility and Radio spectrum Matters (ERM); Land Mobile Service; Commercially available amateur radio equipment, as identified below:

Part 1: "Technical characteristics and methods of measurement";

Part 2: "Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive".

National transposition dates	
Date of adoption of this EN:	28 June 2010
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Introduction

The present document is the "radio product standard" corresponding to commercially available amateur radio equipment.

1 Scope

The present document applies to the following radio equipment types:

- Radio equipment intended to be used by radio amateurs within the meaning of article 1, definition 53, of the International Telecommunications Union (ITU) Radio Regulations [1] and which is available commercially.

NOTE: It is noted that this sort of equipment is traditionally supplied with an antenna connector.

2 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 reference document (including any amendments) applies.

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

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

2.1 Normative references

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

[1] ITU Radio Regulations (2008).

[2] ANSI C63.5-2006: "American National Standard for Calibration of Antennas Used for Radiated Emission Measurements in Electro Magnetic Interference".

[3] IEC 60489-3 (Edition 2 - 1988): "Methods of measurement for radio equipment used in the mobile services. Part 3: Receivers for A3E or F3E emissions" (appendix F).

2.2 Informative references

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] ITU-R Recommendation SM.329-10 (2003): "Unwanted emissions in the spurious domain".

[i.2] CEPT/ERC/Recommendation 74-01 (2005): "Unwanted emissions in the spurious domain".

[i.3] ETSI TR 100 028 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".

[i.4] ETSI TR 102 273 (all parts): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".

3 Definitions, symbols and abbreviations

3.1 Definitions

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

Single SideBand (SSB): any emission using Single SideBand (SSB) suppressed carrier format

3.2 Symbols

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

Bn	Necessary bandwidth of an emission
PX	Maximum PEP

3.3 Abbreviations

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

AM	Amplitude Modulation
CBW	Channel BandWidth
CSP	Channel SPacing
DC	Direct Current
EUT	Equipment Under Test
FM	Frequency Modulation
HF	High Frequency
OATS	Open Area Test Site
PEP	Peak Envelope Power
RBW	Resolution BandWidth
SSB	Single SideBand
RF	Radio Frequency
SINAD	(Signal + Noise + Distortion) / (Noise + Distortion)
Tx	Transmit
UHF	Ultra High Frequency
VHF	Very High Frequency
VSWR	Voltage Standing Wave Ratio

4 Technical requirements specifications

4.1 Environmental profile

The environmental profile for operation of the equipment 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 required operational environmental profile.

4.2 EUT test frequencies

Testing shall be performed with the EUT set to frequencies as follows:

- single-band equipment: test at the centre of the band;
- double-band equipment: test at the centre of both bands;
- HF multi-band equipment or VHF/UHF multi-band equipment: test at the centre of the lowest, the centre of the middle, and the centre of the highest band;

- HF/VHF, HF/UHF or HF/VHF/UHF combined equipment: test at the centre of the lowest HF band, the centre of the middle HF band, the centre of the highest HF band, the centre of the lowest VHF/UHF band, the centre of the middle VHF/UHF band, and the centre of the highest VHF/UHF band.

4.3 Test power source

During testing the power source of the equipment shall be replaced by a test power source capable of producing the nominal supply voltage for the equipment as declared by the manufacturer. The internal impedance of the test power source shall be low enough for its effect on the test results to be negligible. For the purpose of tests, the voltage of the power source shall be measured at the input terminals of the equipment.

For battery operated equipment the battery shall be removed and the test power source shall be applied as close to the battery terminals as practicable.

During tests of DC powered equipment the power source voltages shall be maintained within a tolerance of < ±1 % relative to the voltage at the beginning of each test. The value of this tolerance is critical for power measurements, using a smaller tolerance will provide better measurement uncertainty values.

4.3.1 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.

4.3.2 Regulated lead-acid battery power sources used on vehicles

When the radio equipment is intended for operation from the usual types of regulated lead-acid battery power source used on vehicles the normal test voltage shall be 1,1 times the nominal voltage of the battery (for nominal voltages of 6 V and 12 V, these are 6,6 V and 13,2 V respectively).

4.3.3 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.

4.4 Testing of equipment that does not have an external 50 Ω RF connector (integral antenna equipment)

Where equipment has an internal 50 Ω connector it shall be permitted to perform the tests at this connector.

Equipment may also have a temporary internal 50 Ω connector installed for the purposes of testing.

No connection shall be made to any internal permanent or temporary antenna connector during the performance of radiated emissions measurements, unless such action forms an essential part of the normal intended operation of the equipment, as declared by the manufacturer.

4.5 Test load (artificial antenna)

For conducted measurements of the transmitter, a power attenuator ("artificial antenna") shall be used, exhibiting a substantially non-reactive, non-radiating load of 50 Ω to the antenna connector and capable of dissipating the transmitter output power.

4.6 PEP

The PEP is the average power in watts supplied to the artificial antenna by a transmitter during one RF cycle at the highest crest of the modulation envelope. For practical purposes the methods of measurements in clause 5.1 should be used.

4.7 Transmitter automatic shut-off facility

If the equipment is fitted with an automatic transmitter shut-off facility it shall be made inoperative for the duration of the type test, unless it has to be left operative to protect the equipment.

4.8 Arrangement for analogue test signals at the input of the transmitter

For the purpose of the present document, in the case of analogue equipment, the transmitter audio frequency modulation signal shall be applied to the terminals of the audio input connector with any microphone disconnected, unless otherwise stated.

4.9 Arrangement for test signals at the input of the receiver

RF test signal sources which are applied to the receiver shall present an impedance of 50 Ω to the receiver input. This requirement shall be met irrespective of whether one or more signals using a combining network are applied to the receiver simultaneously.

The levels of the test signals shall be expressed in terms of the emf at the receiver input connector.

The effects of any intermodulation products and noise produced in the test signal sources shall be negligible.

4.10 Characteristics of test signals at the input of the receiver

Wanted RF test signals applied to the receiver shall have the modulation characteristics as specified in table 1.

Table 1: Wanted test signal

Mode	Units	Modulation
AM	60	% AM (1 kHz)
FM	60	% of the maximum permissible frequency deviation (1 kHz)
SSB	1 kHz offset	None
Other modes	as declared by the manufacturer	as declared by the manufacturer

4.11 Characteristics of test signals at the input of the transmitter

The manufacturer shall declare details of the modulation scheme used and identify how the percentage modulation can be measured or specified.

Equipment capable of transmission of digital information shall be tested with modulation as specified in clause 4.11.2. Equipment using analogue transmission shall be tested with modulation as specified in clause 4.11.1. Equipment capable of both analogue and digital transmission shall be tested separately in each mode.

4.11.1 Analogue signals

For tests on analogue equipment via the audio input socket terminals, the test signal shall consist of two equal amplitude non harmonically related sinusoidal input signals selected to be in the range 500 Hz to 3 kHz with at least 500 Hz separation between them, each of which would independently drive the transmitter into its compression region. The composite signal level shall be 20 dB higher than the level which produces 60 % modulation unless the output power at this drive level is less than the highest Tx output power in which case the signal level shall be set to produce the highest possible Tx output power.

For tests via any facilities sockets this test signal shall be of the nature described by the manufacturer for the purpose of the socket , at a level which produces the largest value of output power (PEP) possible with analogue modulation.

4.11.2 Digital signals

For tests on digital equipment (including digital speech), the test signal be as declared by the manufacturer, at the appropriate data rate.

If the transmission of a continuous bit stream is not possible, the test signal shall be trains of correctly coded bits or messages.

For the purpose of testing PX in clause 5.1 the test signal shall produce the largest value of output power (PEP) possible with digital modulation. If this is not the case then a test signal that does produce the largest possible value of output power (PEP) with digital modulation should be used in the testing in clause 5.1.

For digital equipments that support adaptive rates, testing is only required at one bit rate. For transmitter tests in this clause this would normally be the highest bit-rate supported by the equipment.

4.12 Reference bandwidths for spurious measurements

The reference bandwidths applicable for all spurious measurement are given in table 2.

Table 2: Reference bandwidths to be used for the measurement of spurious emissions

Frequency range	RBW
9 to 150 kHz	1 kHz
150 kHz to 30 MHz	10 kHz
30 MHz to 1 GHz	100 kHz
Above 1 GHz	1 MHz

4.13 Transmit exclusion bandwidths for spurious measurements

When measuring transmit spurious emissions, an exclusion band centred on the wanted carrier is defined as 250 % of the CSP. The minimum values of necessary bandwidth (Bn) applicable depend on the operating frequency of the equipment as defined in CEPT/ERC/Recommendation 74-01 [i.2]. The combination of 250 % of the CSP and these necessary bandwidths result in the following transmit exclusion bands for spurious measurements in table 3.

Table 3: Transmit exclusion bands for the measurement of spurious emissions

Operating freq	Bn minimum	Tx exclusion band
Below 30 MHz	4 kHz	10 kHz
30 MHz to 1 GHz	25 kHz	62,5 kHz
1 GHz to 26 GHz	100 kHz	250 kHz
Above 26 GHz	1 MHz	2,5 MHz

Where the necessary bandwidth of the emission being measured is greater than the minimum values given in table 3, the transmit exclusion band shall be recalculated using the actual value of Bn.

5 Conformance requirements

5.1 Maximum power (PX) (conducted)

This measurement applies only to equipment with an external 50 Ω antenna connector.

NOTE: PEP measurement is used as a figure of merit; however, it is accepted that for digital modulation the average power is often a more useful parameter.

5.1.1 Definition

The PX of the transmitter is the maximum value of the output PEP for any condition of modulation.

The rated maximum power of the transmitter is that declared by the manufacturer.

5.1.2 Method of measurement

For non-constant envelope modulation equipment, the appropriate test modulation as specified in clause 4.11 shall be applied at the transmitter. For constant envelope modulation schemes it is not required to apply modulation. The modulation used, if any, shall be recorded in the test report.

The transmitter shall be connected to a 50 Ω power attenuator, and the PEP delivered shall be measured. The measuring instrument shall have a measurement bandwidth not less than sixteen times the CBW.

The power measured is recorded as the value PX.

5.2 Unwanted emissions in the spurious domain

5.2.1 Definition

Spurious emissions are emissions on a frequency, or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out of band emissions. For the purpose of the present document the transition point between spurious emissions domain and the out of band emissions domain is taken as 250 % of the CSP (see ITU-R Recommendation SM.329-10 [i.1]). Furthermore, the minimum necessary bandwidths applicable to amateur radio are given by CEPT/ERC/Recommendation 74-01 [i.2] (see clause 4.13).

5.2.2 Method of measurement

5.2.2.1 Method of measuring conducted spurious emissions with an artificial antenna

This method applies only to equipment with an external 50 Ω antenna connector.

Spurious emissions shall be measured as the mean power level of any signal delivered into a 50 Ω load. This may be done by connecting the transmitter output through an attenuator to either a spectrum analyser (see also annex B) or selective voltmeter or by monitoring the relative levels of the spurious signals delivered to an artificial antenna (see clause 4.5).

The transmitter shall be modulated with the same test signal as used in clause 5.1 and the measurements made over the frequency range 150 kHz to 4 GHz.

For equipment operating on frequencies above 470 MHz the measurements shall also be performed over the frequency range 4 GHz to 12,75 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz. If the operating frequency of the EUT is greater than 6,375 GHz, the measurement frequency range shall extend up to and including twice the maximum operating frequency.

The measurements are performed excluding the transmit exclusion band centred on the frequency on which the transmitter is intended to operate (see clause 4.13).

The resolution bandwidth of the measuring receiver should be equal to the reference bandwidth as given in clause 4.12.

The measurement shall be repeated with the transmitter in the "stand-by" position.

5.2.2.2 Method of measuring the effective radiated power with an external antenna connector

This method applies only to equipment with an external antenna connector.

On a test site, selected from annex A, the equipment shall be placed at the specified height on a non-conducting support.

The transmitter antenna connector shall be connected to an artificial antenna (see clause 4.5).

The output of the test antenna shall be connected to a measuring receiver.

The test antenna shall be orientated for vertical polarization and the length of the test antenna shall be chosen to correspond to the instantaneous frequency of the measuring receiver.

The transmitter shall be modulated with same test signal as used in clause 5.1 and the measurements made over the frequency range 30 MHz to 4 GHz.

For equipment operating on frequencies above 470 MHz the measurements shall also be performed over the frequency range 4 GHz to 12,75 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz. If the operating frequency of the EUT is greater than 6,375 GHz, the measurement frequency range shall extend up to and including twice the maximum operating frequency.

The measurements are performed excluding the transmit exclusion band centred on the frequency on which the transmitter is intended to operate (see clause 4.13).

The resolution bandwidth of the measuring receiver should be equal to the reference bandwidth as given in clause 4.12.

The transmitter shall be switched and the measuring receiver shall be tuned over the frequency range 30 MHz to 4 GHz. At each frequency at which a discrete spurious component is detected, the test antenna shall be raised and lowered through the specified range of heights until a maximum signal level is detected on the measuring receiver.

When a test site according to clause A.1.1 is used there is no need to vary the height of the antenna.

The transmitter shall then be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver.

The measuring receiver shall measure the mean power and this power shall be noted. The horizontal and vertical orientation of the antenna shall also be noted.

The transmitter shall be replaced by a substitution antenna as defined in clause A.1.5.

The substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of the spurious component detected.

The substitution antenna shall be connected to a calibrated signal generator.

The frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected.

The input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver, if necessary.

The test antenna shall be raised and lowered through the specified range of heights to ensure that the maximum signal is received.

When a test site according to clause A.1.1 is used there is no need to vary the height of the antenna.

The input signal to the substitution antenna shall be adjusted to the level that produced a level detected by the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for the change of input attenuator setting of the measuring receiver.

The input level to the substitution antenna shall be recorded as power level.

The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.

The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the antenna if necessary.

The measurement shall be repeated with the transmitter in the "stand-by" position.

5.2.2.3 Method of measuring the effective radiated power with an integral antenna

This method applies only to equipment without an external 50 Ω antenna connector.

The method of measurement shall be performed according to clause 5.2.2.2, except that the transmitter output shall be connected to the integral antenna and not to an artificial antenna.

5.2.3 Limits

The power of any spurious emission, occurring outside the exclusion band centred on the frequency on which the transmitter is intended to operate, shall not exceed the values given in tables 4 and 6 with the transmitter operating and tables 5 and 7 with the transmitter in standby mode.

Table 4: Antenna port limits in transmit mode

Frequency range or operating mode	Test Limits	Remarks
Mobile SSB equipment	-43 dBc	
Below 30 MHz	-(43 + 10 x log(PEP)) or -50 dBc whichever is higher	
Above 30 MHz	-(43 + 10 x log(PEP)) or -70 dBc whichever is higher	(see note)
NOTE: For measurement at frequencies greater than 40 GHz no test limits are specified.		

Table 5: Antenna port limits in transmit standby mode

Frequency Range	Test Limits	Remarks
0,15 MHz to 1 000 MHz	-57 dBm	
> 1 000 MHz	-47 dBm	(see note)
NOTE: For measurement at frequencies greater than 40 GHz no test limits are specified.		

Where limits are stated using dBc, the reference level is PX, measured at the antenna port according to clause 5.1.

Table 6: Enclosure port limits in transmit mode

Frequency range or operating mode	Test Limits	Remarks
Mobile SSB equipment	-43 dBc	
Below 30 MHz	-(43 + 10 x log(PEP)) or -50 dBc whichever is higher	
Above 30 MHz	-(43 + 10 x log(PEP)) or -70 dBc whichever is higher	(see note)
NOTE: For measurement at frequencies greater than 40 GHz no test limits are specified.		

Table 7: Enclosure port limits in transmit standby mode

Frequency Range	Test Limits	Remarks
30 MHz to 1 000 MHz	-57 dBm	
> 1 000 MHz	-47 dBm	(see note)
NOTE: For measurement at frequencies greater than 40 GHz no test limits are specified.		

Where limits are stated using dBc, the reference level is PX, measured at the antenna port according to clause 5.1.

5.3 Conducted RF immunity

5.3.1 Definition

This 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 an unwanted input signal at any frequencies other than those of the spurious responses or the adjacent channels.

This test is applicable to base station, mobile, portable and ancillary equipment.

This test shall not apply to RF low-noise preamplifiers intended for location directly at the antenna.

In normal use, amateur radio transmitting equipment is not collocated with other radio transmitters operating within 10 % of its own carrier frequency, so that inter-transmitter intermodulation will not occur. Therefore immunity testing of the transmitter antenna port is not justified and is not included in the present document.

5.3.2 Method of measurement

5.3.2.1 Method of measurement (analogue)

The measurement procedure shall be as follows:

- Two signal generators, A and B, shall be connected to the receiver via a combining network (see clause 4.9):
  - Signal generator A shall be set to the nominal frequency of the receiver, with normal test modulation, (see table 1) and shall be applied to the receiver input connector via one input of the combining network at a nominal value of 60 dB (or a lower value as declared by the manufacturer) above the maximum usable sensitivity of the EUT as declared by the manufacturer in the product documentation.
  - Signal generator B shall provide the unwanted signal as specified by table 8 and shall be applied to the receiver input connector via one input of the combining network.

The test shall be performed over the frequency range 150 kHz to 1 GHz using stepped increments of maximum 1 % of the momentary frequency with the exception of the exclusion band.

The exclusion band for a receiver and the receiver of a transceiver is determined by the characteristics of the equipment.

In the case of receivers operating on a fixed single frequency, the exclusion band extends from -5 % to +5 % of the fixed single frequency.

In the case of receivers operating, or capable of operating, on a number of spot frequencies in a narrow operating frequency band which is less than 20 % of the centre frequency of the operating band, the exclusion band extends from -5 % of the lowest frequency of the narrow operating frequency band to +5 % of the highest frequency of that band.

In the case of receivers operating, or capable of operating on a number of spot frequencies over a wide frequency band, the exclusion band for each of the wanted signal test frequencies shall extend from -5 % to +5 % of each wanted signal test frequency.

The test shall be applied to the receiver input connector via the second input of the combining network.

Discrete spurious responses shall be ignored.

5.3.2.2 Method of measurement (digital)

For digital equipment that supports adaptive rates, testing is only required at the maximum bit rate that the manufacturer declares is compliant to the present document.

The measurement procedure shall be as follows:

- Two signal generators, A and B, shall be connected to the receiver via a combining network (see clause 4.9):
  - Signal generator A shall be set to the nominal frequency of the receiver, with normal test modulation, (see table 1) and shall be applied to the receiver input connector via one input of the combining network at a nominal value of 60 dB (or a lower value as declared by the manufacturer) above the maximum usable sensitivity of the EUT as declared by the manufacturer in the product documentation.
  - Signal generator B shall provide the unwanted signal as specified by table 8 and shall be applied to the receiver input connector via one input of the combining network.

The test shall be performed over the frequency range 150 kHz to 1 GHz using stepped increments of maximum 1 % of the momentary frequency with the exception of the exclusion band.

The exclusion band for a receiver and the receiver of a transceiver is determined by the characteristics of the equipment.

In the case of receivers operating on a fixed single frequency, the exclusion band extends from -5 % to +5 % of the fixed single frequency.

In the case of receivers operating, or capable of operating, on a number of spot frequencies in a narrow operating frequency band which is less than 20 % of the centre frequency of the operating band, the exclusion band extends from -5 % of the lowest frequency of the narrow operating frequency band to +5 % of the highest frequency of that band.

In the case of receivers operating, or capable of operating on a number of spot frequencies over a wide frequency band, the exclusion band for each of the wanted signal test frequencies shall extend from -5 % to +5 % of each wanted signal test frequency.

The test shall be applied to the receiver input connector via the second input of the combining network.

Discrete spurious responses shall be ignored.

5.3.2.3 Unwanted signal parameters (analogue and digital)

The unwanted signal specified in clauses 5.3.2.1 and 5.3.2.2 shall have the parameters given in table 8.

Table 8: Unwanted signal parameters

Operating frequency range of EUT	Characteristics of the unwanted signal	Units
< 30 MHz	90 80 0,15 to 1 000	dBµV emf % AM (400 Hz) MHz
> 30 MHz	80 80 0,15 to 1 000	dBµV emf % AM (400 Hz) MHz

5.3.3 Limit

Application of the test signal shall not cause the demodulated receiver output to:

- be reduced to less than 12 dB SINAD for analogue speech equipment; or
- be reduced to less than 80 % of the original data throughput for non-speech equipment; or
- be degraded to a level declared by the manufacturer as appropriate for the type of signal conveyed.

5.4 Spurious radiations

5.4.1 Definition

Spurious radiations from the receiver are components at any frequency, radiated by the equipment and antenna.

For equipment with an external 50 Ω antenna connector, the levels of spurious radiations are considered to be either:

a) their power level in a specified load (conducted spurious emission); and

b) their effective radiated power when radiated by the cabinet and structure of the equipment (cabinet radiation).

For equipment without an external antenna connector, spurious radiations are considered to be:

c) their effective radiated power when radiated by the cabinet and the integral antenna, in the case of handportable equipment fitted with such an antenna and no external RF connector.

5.4.2 Methods of measurement

5.4.2.1 Method of measuring the power level in a specified load

For digital equipment that supports adaptive rates, testing is only required at the maximum bit rate that the manufacturer declares is compliant to the present document.

This method applies only to equipment with an external 50 Ω antenna connector.

Spurious radiations shall be measured as the power level of any discrete signal at the input terminals of the receiver. The receiver input terminals are connected to a spectrum analyser or selective voltmeter having an input impedance of 50 Ω and the receiver switched on.

If the detecting device is not calibrated in terms of power input, the level of any detected components shall be determined by a substitution method using a signal generator.

For equipment operating on frequencies above 470 MHz the measurements shall also be performed over the frequency range 4 GHz to 12,75 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz. If the operating frequency of the EUT is greater than 6,375 GHz, the measurement frequency range shall extend up to and including twice the maximum operating frequency.

At each frequency at which a spurious component is detected, the power level shall be recorded as the spurious level delivered into the specified load.

5.4.2.2 Method of measuring the effective radiated power

For digital equipment that supports adaptive rates, testing is only required at the maximum bit rate that the manufacturer declares is compliant to the present document.

This method applies only to equipment having an external antenna connector.

The measurement procedure shall be as follows:

a) A test site which fulfils the requirements for the specified frequency range of this measurement shall be used (see annex A).

   The equipment shall be placed at the specified height on a non-conducting support and in the position closest to normal use as declared by the manufacturer.

b) The receiver antenna connector shall be connected to an artificial antenna (see clause 4.5):

   - the test antenna shall be orientated for vertical polarization and the length of the test antenna shall be chosen to correspond to the instant frequency of the measuring receiver;

   - the output of the test antenna shall be connected to a measuring receiver.

c) Radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 30 MHz to 4 GHz. For equipment operating on frequencies above 470 MHz the measurements shall also be performed over the frequency range 4 GHz to 12,75 GHz if emissions are detected within 10 dB of the of the specified limit between 1,5 GHz and 4 GHz. If the operating frequency of the EUT is greater than 6,375 GHz, the measurement frequency range shall extend up to and including twice the maximum operating frequency.

d) At each frequency at which a component is detected the test antenna shall be raised and lowered through the specified range of height until a maximum signal level is detected by the measuring receiver.

   When a test site according to clause A.1.1 is used, there is no need to vary the height of the antenna.

e) The receiver shall then be rotated through 360° in the horizontal plane until the maximum signal level detected by the measuring receiver.

   The maximum signal level detected by the measuring receiver shall be noted.

f) The receiver shall be replaced by a substitution antenna as defined in clause A.1.5.

   The substitution antenna shall be orientated for vertical polarization and the length of the substitution antenna shall be adjusted to correspond to the frequency of the spurious component detected.

g) The substitution antenna shall be connected to a calibrated signal generator.

   The frequency of the calibrated signal generator shall be set to the frequency of the spurious component detected.

h) The input attenuator setting of the measuring receiver shall be adjusted in order to increase the sensitivity of the measuring receiver if necessary.

i) The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received.

   The input signal to the substitution antenna shall be adjusted to the level that produces a level detected by the measuring receiver, that is equal to the level noted while the spurious component was measured, corrected for the change of input attenuator setting of the measuring receiver.

   The input level of the substitution antenna shall be recorded as a power level, corrected for the change of input attenuator setting of the measuring receiver.

j) The measurement shall be repeated with the test antenna and the substitution antenna orientated for horizontal polarization.

k) The measure of the effective radiated power of the spurious components is the larger of the two power levels recorded for each spurious component at the input to the substitution antenna, corrected for the gain of the antenna if necessary.

5.4.2.3 Method of measuring the effective radiated power

For digital equipment that supports adaptive rates, testing is only required at the maximum bit rate that the manufacturer declares is compliant to the present document.

This method applies only to equipment without an external antenna connector.

The method of measurement shall be performed according to clause 5.4.2.2, except that the equipment and its antenna shall be mounted in a normal installation in its normal operating position.

5.4.3 Limits

The power of any spurious radiations shall not exceed the values given in table 9.

Table 9: Antenna port and enclosure port limits in receive mode

Frequency Range	Test Limits	Remarks
0,15 MHz to 1 000 MHz	-57 dBm	
> 1 000 MHz	-47 dBm	(see note)
NOTE: For measurement at frequencies greater than 40 GHz no test limits are specified.		

In the case of radiated measurements for handportable stations the following conditions apply:

- internal integral antenna: the normal antenna shall be connected;
- external antenna connector: an artificial load shall be connected to the connector for the test.

6 Measurement uncertainty

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

- the measured value related to the corresponding limit shall 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 separately included in the test report;
- the value of the measurement uncertainty should be, for each measurement, equal to or lower than the figures in table 10.

Table 10: Measurement uncertainty

Parameter	Uncertainty
Radio Frequency	$\pm 1 \times 10^{-7}$
RF Power (up to 160 W)	±0,75 dB
Radiated RF power	±6 dB
Conducted spurious emission of transmitter valid up to 12,75 GHz	±4 dB
Conducted spurious emission of receiver, valid up to 12,75 GHz	±7 dB
Two-signal measurement, valid up to 4 GHz	±4 dB
Radiated emission of the transmitter, valid up to 4 GHz	±6 dB
Radiated measurement of receiver, valid up to 4 GHz	±6 dB
NOTE: Valid up to 1 GHz for the RF parameters unless otherwise stated.	

For the test methods, according to the present document the uncertainty figures shall be calculated according to the principles of the methods described in the TR 100 028 [i.3] 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 case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Table 10 is based on such expansion factors.

The particular expansion factor used for the evaluation of the measurement uncertainty shall be stated.

Annex A (normative): Radiated measurement

A.1 Test sites and general arrangements for measurements involving the use of radiated fields

This normative annex introduces three most commonly available test sites, an anechoic chamber, an anechoic chamber with a ground plane and an Open Area Test Site (OATS), which may be used for radiated tests. These test sites are generally referred to as free field test sites. Both absolute and relative measurements can be performed in these sites. Where absolute measurements are to be carried out, the chamber should be verified. A detailed verification procedure is described in TR 102 273 [i.4], relevant parts 2, 3 and 4.

NOTE: To ensure reproducibility and traceability of radiated measurements only these test sites should be used in test measurements.

A.1.1 Anechoic chamber

An anechoic chamber is an enclosure, usually shielded, whose internal walls, floor and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The chamber usually contains an antenna support at one end and a turntable at the other. A typical anechoic chamber is shown in figure A.1.

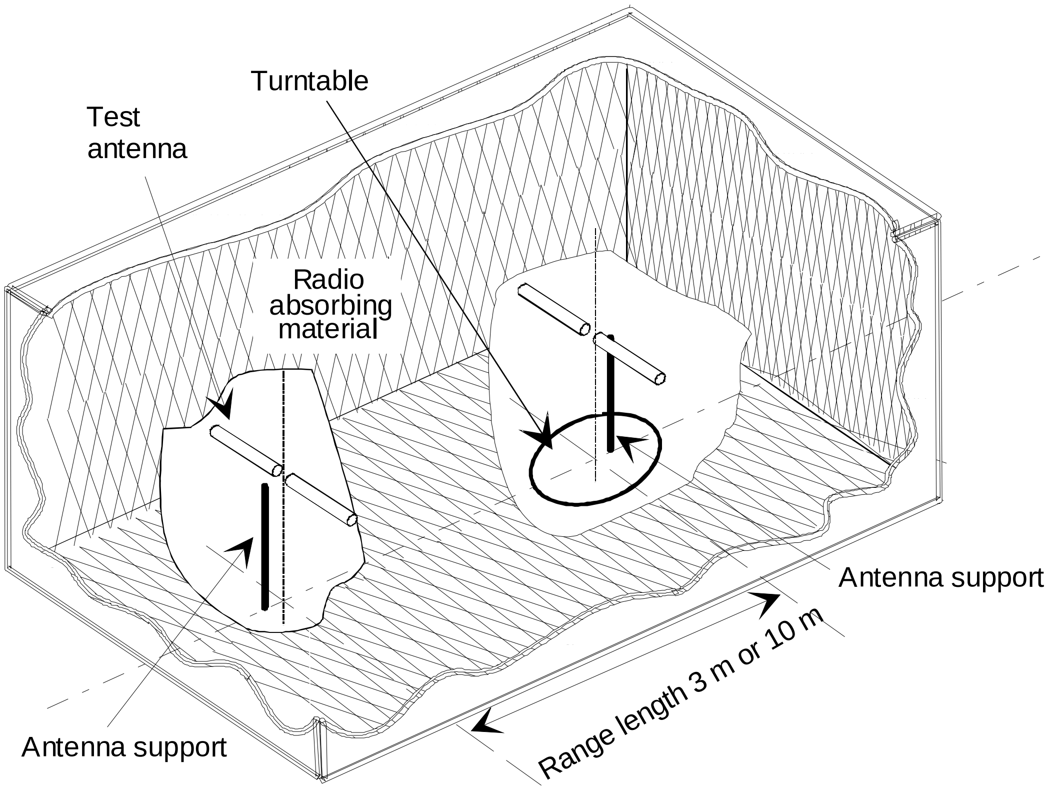

Figure A.1: A typical anechoic chamber

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. In practice it is relatively easy for shielding to provide high levels (80 dB to 140 dB) of ambient interference rejection, normally making ambient interference negligible.

A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a suitable height (e.g. 1 m) above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2/\lambda$ (m), whichever is greater (see clause A.2.5). The distance used in actual measurements shall be recorded with the test results.

The anechoic chamber generally has several advantages over other test facilities. There is minimal ambient interference, minimal floor, ceiling and wall reflections and it is independent of the weather. It does however have some disadvantages which include limited measuring distance and limited lower frequency usage due to the size of the pyramidal absorbers. To improve low frequency performance, a combination structure of ferrite tiles and urethane foam absorbers is commonly used.

All types of emission, sensitivity and immunity testing can be carried out within an anechoic chamber without limitation.

A.1.2 Anechoic chamber with a ground plane

An anechoic chamber with a ground plane is an enclosure, usually shielded, whose internal walls and ceiling are covered with radio absorbing material, normally of the pyramidal urethane foam type. The floor, which is metallic, is not covered and forms the ground plane. The chamber usually contains an antenna mast at one end and a turntable at the other. A typical anechoic chamber with a ground plane is shown in figure A.2.

This type of test chamber attempts to simulate an ideal OATS whose primary characteristic is a perfectly conducting ground plane of infinite extent.

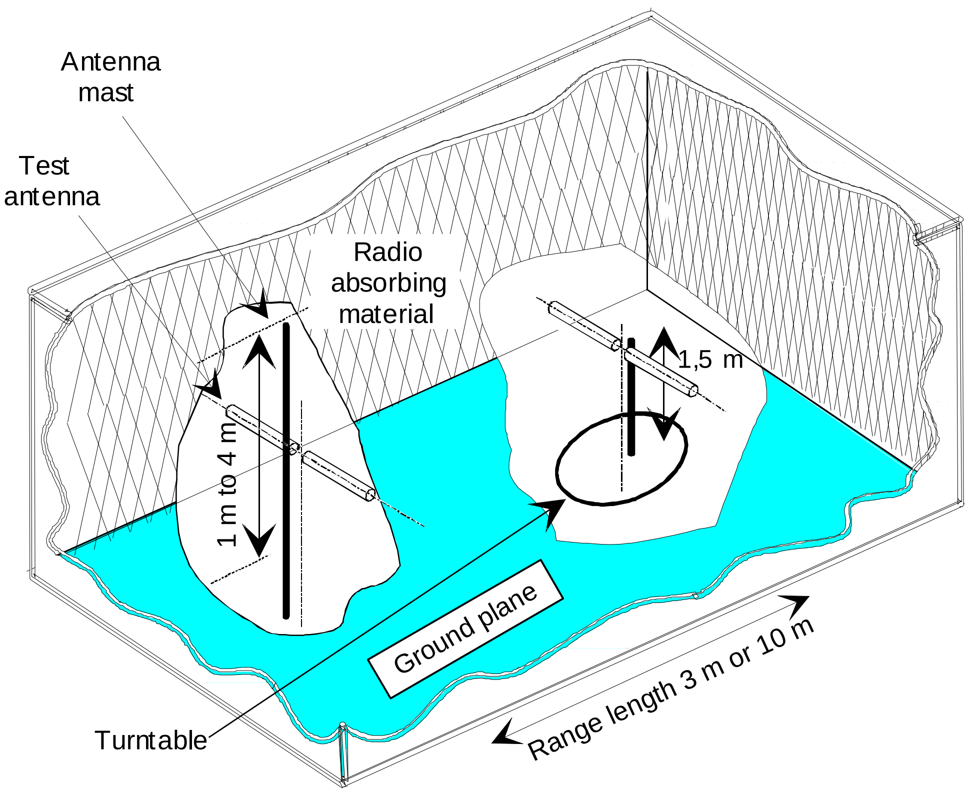

Figure A.2: A typical anechoic chamber with a ground plane

In this facility the ground plane creates the wanted reflection path, such that the signal received by the receiving antenna is the sum of the signals from both the direct and reflected transmission paths. This creates a unique received signal 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 test antenna can be optimized for maximum coupled signal between antennas or between an EUT and the test 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 chamber shall be large enough to allow the measuring distance of at least 3 m or $2(d_1+d_2)^2/\lambda$ (m), whichever is greater (see clause A.2.5). The distance used in actual measurements shall be recorded with the test results.

Emission testing involves firstly "peaking" the field strength from the EUT by raising and lowering the receiving antenna on the mast (to obtain the maximum constructive interference of the direct and reflected signals from the EUT) and then rotating the turntable for a "peak" in the azimuth plane. At this height of the test antenna on the mast, the amplitude of the received signal is noted. Secondly the EUT is replaced by a substitution antenna (positioned at the EUT's phase or volume centre) which is connected to a signal generator. The signal is again "peaked" and the signal generator output adjusted until the level, noted in stage one, is again measured on the receiving device.

Receiver sensitivity tests over a ground plane also involve "peaking" the field strength by raising and lowering the test antenna on the mast to obtain the maximum constructive interference of the direct and reflected signals, this time using a measuring antenna which has been positioned where the phase or volume centre of the EUT will be during testing. A transform factor is derived. The test antenna remains at the same height for stage two, during which the measuring antenna is replaced by the EUT. The amplitude of the transmitted signal is reduced to determine the field strength level at which a specified response is obtained from the EUT.

A.1.3 OATS

An OATS 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, whilst good conductivity can be achieved, the ground plane size has to be limited. A typical OATS is shown in figure A.3.

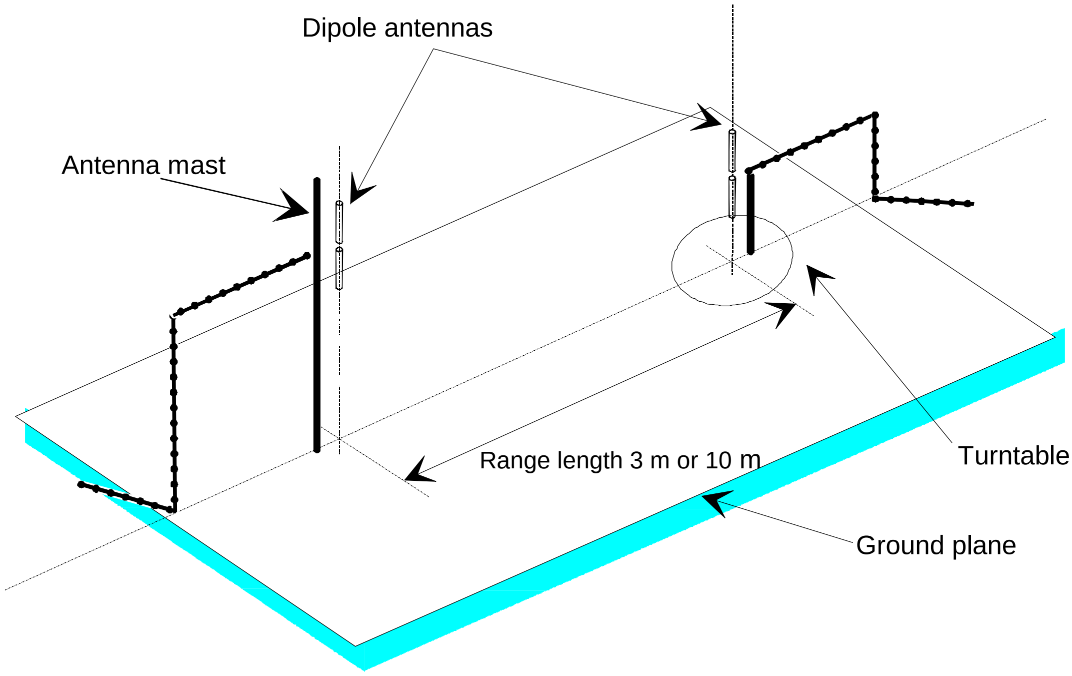

Figure A.3: A typical OATS

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.

Site qualification concerning antenna positions, turntable, measurement distance and other arrangements are same as for anechoic chamber with a ground plane. In radiated measurements an OATS is also used by the same way as anechoic chamber with a ground plane.

Typical measuring arrangement common for ground plane test sites is presented in figure A.4.

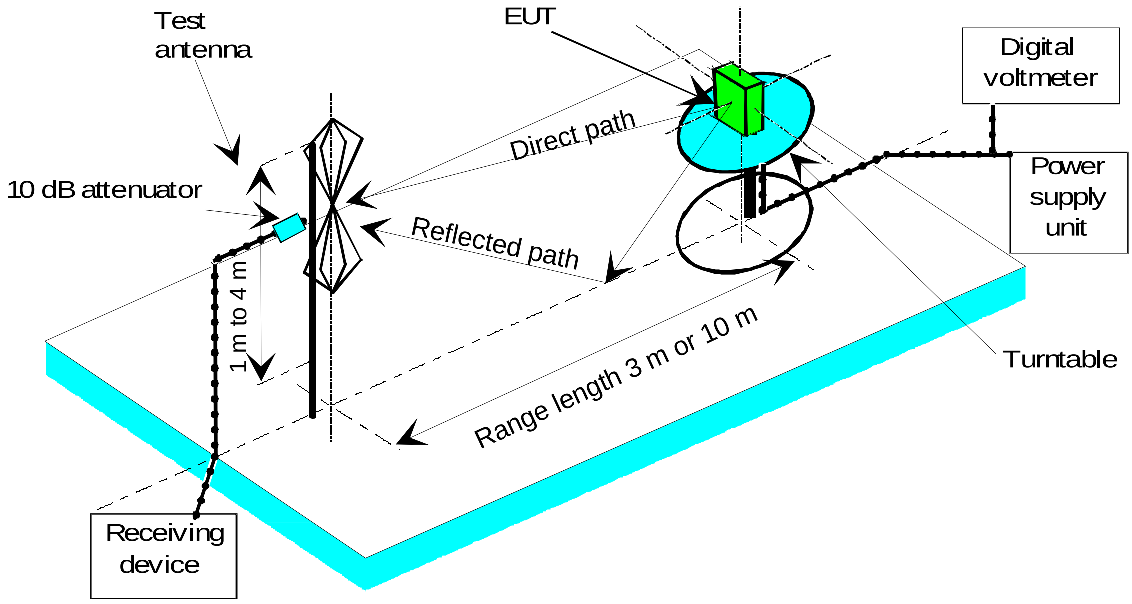

Figure A.4: Measuring arrangement on ground plane test site (OATS set-up for spurious emission testing)

A.1.4 Test antenna

A test antenna is always used in radiated test methods. In emission tests (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) the test 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 (i.e. sensitivity and various immunity parameters) the antenna is used as the transmitting device.

The test antenna should be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization which, on ground plane sites (i.e. anechoic chambers with ground planes and OATS), should additionally allow the height of its centre above the ground to be varied over the specified range (usually 1 m to 4 m).

In the frequency band 30 MHz to 1 000 MHz, dipole antennas (constructed in accordance with ANSI C63.5 [2]) are generally recommended. For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For spurious emission testing, however, a combination of 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. Above 1 000 MHz, waveguide horns are recommended although, again, log periodics could be used.

NOTE: The gain of a horn antenna is generally expressed relative to an isotropic radiator.

A.1.5 Substitution antenna

The substitution antenna is used to replace the EUT for tests in which a transmitting parameter (i.e. frequency error, effective radiated power, spurious emissions and adjacent channel power) is being measured. For measurements in the frequency band 30 MHz to 1 000 MHz, the substitution antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [2]). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. For measurements above 1 000 MHz, a waveguide horn is recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT it has replaced.

A.1.6 Measuring antenna

The measuring antenna is used in tests on an EUT in which a receiving parameter (i.e. sensitivity and various immunity tests) is being measured. Its purpose is to enable a measurement of the electric filed strength in the vicinity of the EUT. For measurements in the frequency band 30 MHz to 1 000 MHz, the measuring antenna should be a dipole antenna (constructed in accordance with ANSI C63.5 [2]). For frequencies of 80 MHz and above, the dipoles should have their arm lengths set for resonance at the frequency of test. Below 80 MHz, shortened arm lengths are recommended. The centre of this antenna should coincide with either the phase centre or volume centre (as specified in the test method) of the EUT.

A.2 Guidance on the use of radiation test sites

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 this annex.

A.2.1 Verification of the test site

No test should be carried out on a test site which does not possess a valid certificate of verification. The verification procedures for the different types of test sites described in this annex (i.e. anechoic chamber, anechoic chamber with a ground plane and OATS) are given in TR 102 273 [i.4], parts 2, 3 and 4, respectively.

A.2.2 Preparation of the EUT

The manufacturer should supply information about the EUT covering the operating frequency, polarization, supply voltage(s) and the reference face. Additional information, specific to the type of EUT should include, where relevant, carrier power, CSP, whether different operating modes are available (e.g. high and low power modes) and if operation is continuous or is subject to a maximum test duty cycle (e.g. 1 m on, 4 m off).

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 dielectric constant (i.e. less than 1,5) material(s) such as expanded polystyrene, balsawood, etc.

A.2.3 Power supplies to the EUT

All tests should be performed using power supplies wherever possible, including tests on EUT designed for battery-only use. In all cases, 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 equipment, possibly by putting tape over its contacts.

The presence of these power cables can, however, 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 and down to the either the screen, ground plane or facility wall (as appropriate) by the shortest possible paths. 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).

Details shall be included in the test report.

A.2.4 Volume control setting for analogue speech tests

Unless otherwise stated, in all receiver measurements for analogue speech the receiver volume control where possible, should be adjusted to give at least 50 % of the rated audio output power. In the case of stepped volume controls, to volume control should be set to the first step that provides an output power of at least 50 % of the rated audio output power. This control should not be readjusted between normal and extreme test conditions in tests.

A.2.5 Range length

The range length for all these types of test facility should be adequate to allow for testing in the far-field of the EUT i.e. it should be equal to or exceed:

$$\frac{2(d_1+d_2)^2}{\lambda}$$

where:

- d_1 is the largest dimension of the EUT/dipole after substitution (m);
- d_2 is the largest dimension of the test antenna (m);
- λ is the test frequency wavelength (m).

It should be noted that in the substitution part of this measurement, where both test and substitution antennas are half wavelength dipoles, this minimum range length for far-field testing would be:

$$2\lambda$$

It should be noted in the test report when either of these conditions is not met so that the additional measurement uncertainty can be incorporated into the results.

NOTE 1: **For the fully anechoic chamber**, no part of the volume of the EUT should, at any angle of rotation of the turntable, fall outside the "quiet zone" of the chamber at the nominal frequency of the test.

NOTE 2: The "quiet zone" is a volume within the anechoic chamber (without a ground plane) in which a specified performance has either been proven by test, or is guaranteed by the designer/manufacture. The specified performance is usually the reflectivity of the absorbing panels or a directly related parameter (e.g. signal uniformity in amplitude and phase). It should be noted however that the defining levels of the quiet zone tend to vary.

NOTE 3: **For the anechoic chamber with a ground plane**, a full height scanning capability, i.e. 1 m to 4 m, should be available for which no part of the test antenna should come within 1 m of the absorbing panels. For both types of **anechoic chamber**, the reflectivity of the absorbing panels should not be worse than -5 dB.

NOTE 4: **For both the anechoic chamber with a ground plane and the OATS**, no part of any antenna should come within 0,25 m of the ground plane at any time throughout the tests. Where any of these conditions cannot be met, measurements should not be carried out.

A.2.6 Site preparation

The cables for both ends of the test site 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 OATS**) 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 immediately 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.

A.3 Coupling of signals

A.3.1 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 and acoustic coupling).

A.3.2 Data signals

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

A.3.3 Speech and analogue signals

Where an audio output connector is not available an acoustic coupler should be used.

When using the acoustic coupler, care should be exercised that possible ambient noise does not influence the test result.

A.3.3.1 Acoustic coupler description

The acoustic coupler comprises a plastic funnel, an acoustic pipe and a microphone with a suitable amplifier. The materials used to fabricate the funnel and pipe should be of low conductivity and of low relative dielectric constant (i.e. less than 1,5).

- The acoustic pipe should be long enough to reach from the EUT to the microphone which should be located in a position that will not disturb the RF field. The acoustic pipe should have an inner diameter of about 6 mm and a wall thickness of about 1,5 mm and should be sufficiently flexible so as not to hinder the rotation of the turntable.
- The plastic funnel should have a diameter appropriate to the size of the loudspeaker in the EUT, with soft foam rubber glued to its edge, it should be fitted to one end of the acoustic pipe and the microphone should be fitted to the other end. It is very important to fix the centre of the funnel in a reproducible position relative to the EUT, since the position of the centre has a strong influence on the frequency response that will be measured. This can be achieved by placing the EUT in a close fitting acoustic mounting jig, supplied by the manufacturer, of which the funnel is an integral part.
- The microphone should have a response characteristic flat within 1 dB over a frequency range of 50 Hz to 20 kHz, a linear dynamic range of at least 50 dB. The sensitivity of the microphone and the receiver audio output level should be suitable to measure a signal to noise ratio of at least 40 dB at the nominal audio output level of the EUT. Its size should be sufficiently small to couple to the acoustic pipe.
- The frequency correcting network should correct the frequency response of the acoustic coupler so that the acoustic SINAD measurement is valid (see IEC 60489-3 [3], appendix F).

A.3.3.2 Calibration

The aim of the calibration of the acoustic coupler is to determine the acoustic SINAD ratio which is equivalent to the SINAD ratio at the receiver output.

Annex B (normative): Spectrum analyser specification

Where methods of measurements refer to the use of a spectrum analyser, the characteristics of the spectrum analyser shall meet at least the following requirements:

- the reading accuracy of the frequency marker shall be within ±100 Hz;
- the accuracy of relative amplitude measurements shall be within ±3,5 dB.

It shall be possible to adjust the spectrum analyser to allow the separation on its screen of two equal amplitude components with a frequency difference of 100 Hz.

For statistically distributed modulations, the spectrum analyser and the integrating device (when appropriate) need to allow determination of the power spectral density (energy per time and bandwidth), which has to be integrated over the bandwidth in question.

The spectrum analyser should have a dynamic range greater than 90 dB.

Annex C (informative): Bibliography

ETSI EN 301 489-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements".

ETSI EN 301 489-15: "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 15: Specific conditions for commercially available amateur radio equipment".

Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive).

History

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