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Radio Equipment and System (RES);
Radio transmitters and receivers at aeronautical stations
of the aeronautical mobile service
operating in the VHF band (118 MHz - 137 MHz)
using amplitude modulation and 8,33 kHz channel spacing;
Technical characteristics and methods of measurement

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New presentation - see History box

Contents

Foreword

This draft European Telecommunication Standard (ETS) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now submitted for the Public Enquiry phase of the ETSI standards approval procedure.

Proposed transposition dates	
Date of latest announcement of this ETS (doa):	3 months after ETSI publication
Date of latest publication of new National Standard	6 months after doa
or endorsement of this ETS (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	

Introduction

This draft ETS states the minimum performance requirements for radio transmitters and receivers at aeronautical stations of the aeronautical mobile service operating in the VHF band (118 MHz - 137 MHz), using Double Sideband Amplitude Modulation with 8,33 kHz channel spacing.

This ETS may be used by accredited test laboratories for the assessment of the performance of the equipment. The performance of the equipment submitted for type testing should be representative for the performance of the corresponding production model.

This ETS has been written on the assumption that:

- the type test measurements will be performed only once, in one of the accredited test laboratories and the measurements accepted by the various authorities in order to grant type approval;

- if equipment available on the market is required to be checked it will be tested in accordance with the methods of measurement specified in this ETS.

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1 Scope

This draft ETS states the minimum performance requirements for radio transmitters and receivers at aeronautical stations operating in the VHF band (118 MHz - 137 MHz) allocated to the aeronautical mobile service. The allotment of 8,33 KHz channels in the VHF band has been decided by the International Civil Aviation Organization (ICAO) and may be found in ICAO Annex 10 Volume I, Part I and II [1].

This draft ETS applies only to Double Side Band (DSB) Amplitude Modulation (AM) systems, with channel separations of 8,33 kHz intended for analogue speech. Offset carrier operation is not intended in a 8,33 kHz channel separation environment. A system can exist of a combination of the single transmitter or a single receiver or a transceiver. The scope of this standard is limited to ground base stations.

2 Normative references

This ETS incorporates by dated or undated reference provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent references to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1]   ICAO Annex 10 Volume I Parts I and II: "Air ground VHF communication system characteristics".

   NOTE: Before ICAO Annex 10 is amended with the 8,33 kHz channel spacing characteristics, Appendix B of agenda item 6 of the 1995 ICAO Special COM/OPS Divisional meeting report can be used as a reference.

[2]   ETR 028: "Radio Equipment and Systems (RES); Uncertainties in the measurement of mobile radio equipment characteristics".

[3]   CCITT Recommendation P.53 (1988): "Psophometers (apparatus for the objective measurement of circuit noise)".

3 Definitions, abbreviations and symbols

3.1 Definitions

For the purposes of this ETS, the following definitions apply:

Types of measurements:

conducted measurements: Measurements which are made using a direct RF connection to the equipment under test.

radiated measurements: Measurements which involve the measurement of a radiated field.

aeronautical mobile service: A mobile service between aeronautical stations and aircraft stations, or between aircraft stations, in which survival craft stations may participate. Emergency position-indicating radio beacon stations may also participate in this service on designated distress and emergency frequencies.

Type of station:

aeronautical station: A land station in the aeronautical mobile service.

ground base station: Aeronautical station equipment fitted with an external 50 Ω antenna socket or connector, for use with an external antenna and intended for use at a fixed location.

3.2 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

AF	Audio Frequency
AGC	Automatic Gain Control
AM	Amplitude Modulation
dBc	dB relative to the carrier power
DSB	Double Side Band
emf	electro-motive force
ICAO	International Civil Aviation Organization
IF	Intermediate Frequency
RF	Radio Frequency
rms	root mean square
SINAD	(Signal+Noise+Distortion)/(Noise+Distortion)
VSWR	Voltage Standing Wave Ratio

4 General requirements

4.1 Construction

The mechanical and electrical construction and finish of the equipment shall conform in all respects to good engineering practice, and the equipment shall be suitable as part of a ground installation.

All controls shall enable the control functions to be easily performed and the number of controls should be the minimum necessary for simple and satisfactory operation.

All parts of the equipment to be checked during inspection or maintenance operations shall be readily accessible. Components shall be readily identifiable.

Technical documentation (e.g. operating instructions) shall be supplied with the equipment.

The VHF aeronautical mobile service uses only single-frequency channels with simplex operation.

The equipment shall be able to operate on all channels in the list of assignable frequencies defined in Group F (paragraph 4.1.8.1.2) of the ICAO Annex 10 volume I Part II [1].

It shall not be possible to transmit while any frequency synthesizer used within the transmitter is out of lock.

It shall not be possible to transmit during channel switching operations.

4.2 Controls and indicators

The equipment shall have the following controls and indicators:

- a visual indication that the installation is in operation;

- a squelch control including on/off switch and a squelch level adjustment;

- a visual indication that the carrier is being produced.

The equipment shall also meet the following requirements:

- the equipment shall be integrated in a system that shall be end-to-end compatible with the ICAO annex 10 characteristics of the aeronautical mobile service using 8,33 kHz channel spacing [1];

- the user shall not have access to any control which, if wrongly set, might impair the technical characteristics of the equipment;

- the equipment shall provide a remote control capability.

4.3 Safety precautions

Measures shall be taken to protect the equipment against the effects of overcurrent or overvoltage.

4.4 Class of emission and modulation characteristics

The equipment shall use Double Side Band (DSB) Amplitude Modulation (AM), A3E, for speech.

The equipment shall be designed to operate satisfactorily with a channel separation of 8,33 kHz (25/3 kHz).

4.5 Warm up

After being switched on the equipment shall be operational within five seconds and shall meet the requirements of this ETS within one minute under normal conditions.

If the equipment includes parts which require to be heated in order to operate correctly (e.g. crystal ovens) a warming-up period of 30 minutes to those parts shall be allowed.

5 Test conditions, power sources and ambient temperatures

5.1 Normal and extreme test conditions

Measurements shall be made under normal test conditions (subclause 5.3) and also, where stated, under extreme test conditions (subclauses 5.4.1 and 5.4.2 applied simultaneously).

5.2 Test power source

During testing, the equipment shall be supplied from a test power source capable of producing normal and extreme test voltages as specified in subclauses 5.3.2 and 5.4.2.

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 testing the power source voltage shall be measured at the input terminals of the equipment.

During testing, the power source voltages shall be maintained within a tolerance of ± 3 % relative to the voltage level at the beginning of each test.

5.3 Normal test conditions

5.3.1 Normal temperature and humidity

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

    temperature: + 15°C to + 35°C;

    relative humidity: 20 % to 75 %.

5.3.2 Normal power sources

5.3.2.1 Mains voltage and frequency

The normal test voltage shall be the nominal mains voltage, 230 V + 10 %/- 6 % (253,0 to 216,2 V).

The frequency of the test voltage shall be 50 Hz ± 1 Hz.

5.3.2.2 Battery power source

The normal test voltage shall be the nominal voltage of the battery (24 V).

5.4 Extreme test conditions

5.4.1 Extreme temperatures

For tests at extreme temperatures, measurements shall be made in accordance with subclause 5.5, at a lower temperature of - 20°C and an upper temperature of + 55°C.

5.4.2 Extreme values of test power sources

5.4.2.1 Mains voltage

The extreme test voltages shall be the nominal mains voltage ± 10 %.

The frequency of the test voltage shall be 50 Hz ± 1 Hz.

5.4.2.2 Battery power source

The extreme test voltages shall be between 21,6 V and 31,2 V.

5.5 Procedure for tests at extreme temperatures

The equipment shall be switched off during the temperature stabilising periods.

For tests at the upper temperature, the equipment shall be placed in the test chamber and left until thermal equilibrium is reached. The equipment shall then be switched on for 30 minutes in the highest power transmit condition before any measurements are made.

For tests at the lower temperature, the equipment shall be left in the test chamber until thermal equilibrium is reached. The equipment shall then be switched on for one minute in the stand-by or receive condition before any measurements are made.

5.6 Environmental tests

5.6.1 General

Environmental tests shall be carried out before any other tests. The protection of the transmitter shall be checked before the environmental tests.

5.6.2 Performance check

For the purpose of this ETS, the term "performance check" shall be taken to mean the following measurements and limits:

- for the transmitter:

    - frequency error:

        with the transmitter connected to an artificial antenna (subclause 6.2.1), the frequency error (subclause 7.1) shall be within ± 1,5 ppm;

    - carrier power:

        with the transmitter connected to an artificial antenna (subclause 6.2.1), the transmitter shall be keyed without modulation and the output power (subclause 7.2) shall not vary by more than + 2 dB and - 3 dB from the rated maximum output power.

- for the receiver:

    - maximum usable sensitivity:

        with the Automatic Gain Control (AGC) operative, a normal test signal (subclause 6.1.4) shall be applied to the receiver. The level of the input test signal shall be adjusted until the SINAD at the output of the receiver is 20 dB and the receiver output power is at least the normal audio output power (subclause 6.1.6). The level of the input signal shall be less than + 26 dBμV emf.

5.6.3 Temperature tests

5.6.3.1 Dry heat

The equipment shall be placed in a chamber at normal room temperature. The temperature shall then be raised to, and maintained, at + 70°C (± 3°C) for a period of at least 10 hours.

The chamber shall then be cooled down to + 55°C (± 3°C). After temperature balance the equipment shall then be switched on and shall be kept operating continuously for two hours with a 50 % duty cycle period equal to 8 minutes. The temperature of the chamber shall be maintained at + 55°C (± 3°C) during the two hour period. During this period, the equipment shall be subjected to a performance check.

At the end of the test and with the equipment still in the chamber, the chamber temperature shall be brought to room temperature in not less than one hour. The equipment shall then be exposed to normal room temperature and humidity for not less than three hours before the next test is carried out.

5.6.3.2 Damp heat

The equipment shall be placed in a chamber at normal room temperature and humidity which shall be heated steadily over a period of three hours (± 30 minutes), to + 40°C (± 3°C). During this period, the relative humidity shall be brought to 93 % (± 2 %) so that excessive condensation is avoided.

The conditions shall be maintained for a period of at least 10 hours.

30 minutes later the equipment shall be switched on and shall be kept operating continuously for two hours. The equipment shall be subjected to a performance check during this two hour period.

The temperature and relative humidity of the chamber shall be maintained at + 40°C (± 3°C) and 93 % (± 2 %) during the period of 2 hours and 30 minutes.

At the end of the test and with the equipment still in the chamber, the chamber shall be brought to room temperature in not less than one hour. The equipment shall then be exposed to normal room temperature and humidity for not less than three hours, or until moisture has dispersed, which ever is longer, before the next test is carried out.

5.6.3.3 Low temperature

The equipment shall be placed in a chamber at normal room temperature. The temperature shall then be reduced to and maintained at - 30°C (± 3°C) for a period of at least 10 hours.

The temperature of the chamber shall then be maintained at - 20°C (± 3°C). After temperature balance the equipment shall be switched on and shall be kept operating continuously for a period of 1 hour and 30 minutes. The temperature of the chamber shall be maintained at - 20°C (± 3°C) during the 1 hour and 30 minutes period. The equipment shall be subjected to a performance check during the last 30 minutes of the test.

At the end of the test and with the equipment still in the chamber, the chamber temperature shall be brought to room temperature in not less than one hour. The equipment shall then be exposed to normal room temperature for not less than three hours, or until the moisture has dispersed, whichever is longer, before the next test is carried out.

6 General conditions of measurement

6.1 Receiver test signal arrangement

6.1.1 Test signal sources

Test signal sources shall be connected to the receiver input in such a way that the impedance presented to the receiver input is 50 Ω, irrespective of whether one or more test signals are applied to the receiver simultaneously.

6.1.2 Level

The level of the test signals shall be expressed in terms of the emf at the terminals to be connected to the receiver.

6.1.3 Nominal frequency

The nominal frequency of the receiver is the carrier frequency of the selected channel.

6.1.4 Normal test signal

The normal test signal shall be a Double Side Band signal with carrier amplitude modulated with 1 000 Hz (± 1 Hz) to a modulation depth of 30 %.

6.1.5 Squelch

Unless otherwise stated the receiver squelch facility shall be made inoperative for the duration of the tests.

6.1.6 Normal audio output power

The rated audio frequency output power is the value stated by the manufacturer to be the maximum power available at the output, for which all the requirements of this ETS are met.

The rated audio frequency output power shall be at least:

- 500 mW in a loudspeaker (8 Ω);

- 2 mW in the handset earphone (150 Ω);

- 1 mW into a 600 Ω (line input).

6.2 Transmitter test signal arrangement

6.2.1 Artificial antenna

When tests are carried out with an artificial antenna, this shall be a non-reactive, non radiating 50 Ω load, with a mismatch ≤ 1,2 :1.

6.2.2 Signal sources

The audio frequency modulating signals shall be applied to the transmitter through the line input.

6.2.3 Normal test signal

The normal test signal shall be an audio frequency signal at 1 000 Hz.

6.3 Test channels

Tests shall be carried out on at least three channels:

- 136,875 MHz (the highest 8,33 kHz channel spacing frequency within the equipment's frequency band);

- 118,000 MHz (the lowest 8,33 kHz channel spacing frequency within the equipment's frequency band);

- 127,000 MHz (an intermediate channel).

7 Transmitter

All tests on the transmitter shall be carried out with the output power set at its maximum except where otherwise stated.

7.1 Frequency error

7.1.1 Definition

The frequency error is the difference between the measured carrier frequency and its nominal value.

7.1.2 Method of measurement

The carrier frequency shall be measured in the absence of modulation, with the transmitter connected to an artificial antenna (subclause 6.2.1). Measurements shall be made under normal test conditions (subclause 5.3) and under extreme test conditions (subclauses 5.4.1 and 5.4.2 applied simultaneously).

This test shall be carried out with the output power set at maximum and minimum.

7.1.3 Limits

The frequency error shall be within ± 1 ppm under normal test conditions and under test conditions with extended temperature range from 0°C to + 40°C.

The frequency error shall be within ± 1,5 ppm under extreme test conditions.

7.2 Carrier power

7.2.1 Definitions

The carrier power is the mean power delivered to the artificial antenna during transmission in the absence of modulation.

The output power shall be adjustable to meet installation specific losses in the antenna feeder. The rated maximum output power is the maximum value of the carrier power stated by the manufacturer.

7.2.2 Method of measurement

The transmitter shall be connected to an artificial antenna (subclause 6.2.1) and the output power delivered to this artificial antenna shall be measured at the output connector. The measurements shall be made under normal test conditions (subclause 5.3) and under extreme test conditions (subclauses 5.4.1 and 5.4.2 applied simultaneously).

For practical reasons measurements shall be made at least on the test channels (subclause 6.3).

7.2.3   Limits

7.2.3.1   Normal test conditions

The carrier power measured under normal test conditions with the output power adjusted to maximum, shall not vary by more than ± 1,5 dB from the rated maximum output power.

7.2.3.2   Extreme test conditions

The carrier power measured under extreme test conditions with the output power adjusted to maximum, shall not vary by more than + 2 dB and - 3 dB from the rated maximum output power.

Operating into any reactive load shall not permanently damage the transmitter output stage or lead to uncontrolled radiation.

7.3   Amplitude modulation characteristic

7.3.1   Modulation depth

7.3.1.1   Definition

The amplitude modulation depth is the fractional ratio, expressed as a percentage, of the difference and the sum of the numerical values of the largest and smallest amplitudes encountered in one cycle of the modulating waveform (i.e. modulation percentage = (A-B)/(A+B) x 100, see figure 1).
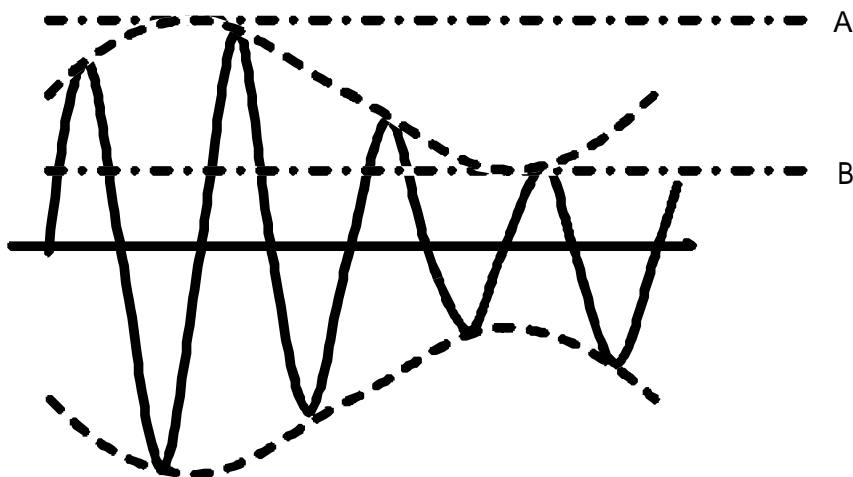
Figure 1: Depth of modulation

7.3.1.2   Method of measurement

A test signal of 1 kHz shall be applied to the line input of the transmitter. The compression level shall be determined by increasing the input signal level until the relation between input signal level and resulting modulation depth is no longer linear. The test signal level shall then be set at a level 3 dB above the compression level.

The modulation depth shall be measured at the output of the transmitter connected to an artificial antenna (subclause 6.2.1), by means of a modulation analyzer capable of measuring the modulation depth.

7.3.1.3   Limits

The amplitude modulation depth shall be at least 85 %.

7.3.2 Modulation compression

7.3.2.1 Definition

Modulation compression is the reduction of the modulation sensitivity at input signal levels above the compression level determined in subclause 7.3.1.

7.3.2.2 Method of measurement

A test signal of 1 kHz shall be applied to the line input of the transmitter.

The modulation depth shall be measured at the output of the transmitter connected to an artificial antenna by means of a modulation analyzer capable of measuring the maximum amplitude modulation depth.

7.3.2.3 Limits

The modulation compression shall be linear up to at least 85 %.

The maximum usable modulation depth shall not exceed 95 %.

7.3.3 Amplitude modulation distortion

7.3.3.1 Definition

The amplitude modulation distortion is defined as the ratio of the total rms voltage of all the harmonics of the modulated waveform to the total rms voltage.

7.3.3.2 Method of measurement

A test signal of 1 kHz set at a level 3 dB above the compression level determined in subclause 7.3.1 shall be applied to the line input of the transmitter.

The modulation distortion shall be measured at the output of the transmitter connected to an artificial antenna (subclause 6.2.1), by means of a distortion analyzer.

7.3.3.3 Limits

The amplitude modulation distortion shall be less than 10 %.

7.3.4 Audio frequency response

7.3.4.1 Definition

The audio frequency response expresses the ability of the transmitter to operate without excessive degradation of its frequency response as a function of the modulation frequency.

7.3.4.2 Method of measurement

The normal test signal shall be used (subclause 6.1.4).

The modulation frequency shall then be varied between 300 Hz and 4 kHz, with the level of the audio frequency signal being kept constant and equal to the value specified above.

7.3.4.3 Limits

The ratio of the maximum and minimum modulation depth as measured over the Audio Frequency (AF) modulating frequency range of 350 Hz to 2 500 Hz shall be less than + 1 dB and - 5 dB (reference to 1 kHz).

At 3 200 Hz the ratio shall be at least 45 dB.

7.3.5 Unwanted frequency modulation

7.3.5.1 Definition

Unwanted frequency modulation is the residual frequency modulation in Hz of the modulated RF signal.

7.3.5.2 Method of measurement

A test signal of 1 kHz set at 80 % modulation depth shall be applied to the line input of the transmitter.

The unwanted frequency modulation shall be measured at the output of the transmitter connected to an artificial antenna (subclause 6.2.1), by means of a frequency demodulator analyzer.

7.3.5.3 Limits

The unwanted frequency modulation shall not exceed ± 1 000 Hz.

7.4 Adjacent channel power

7.4.1 Definition

The adjacent channel power is that part of the total power output of a transmitter under defined conditions of modulation, which falls within a specified passband centred on the nominal frequency of either of the adjacent channels. This power is the sum of the mean power produced by the modulation, hum and noise of the transmitter.

7.4.2 Measurement

The adjacent channel power shall be measured with a power measuring receiver, here referred to as the "receiver", conforming to annex B:

a)   the transmitter shall be operated at the carrier power determined in subclause 7.2 under normal test conditions. The output of the transmitter shall be linked to the input of the "receiver" by a connecting device such that the impedance presented to the transmitter is 50 Ω and the level at the "receiver" input is appropriate;

b)   with the transmitter unmodulated, the tuning of the "receiver" shall be adjusted so that a maximum response is obtained. This is the 0 dB response point. The "receiver" attenuator setting and the reading of the meter shall be recorded.

  The measurement may be made with the transmitter modulated with the normal test signal (subclause 6.1.4), in which case this fact shall be recorded with the test results;

c)   the tuning of the "receiver" shall be adjusted away from the carrier so that the "receiver" - 6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency of 4,83 kHz;

d)   the transmitter shall be modulated with a signal at 1 kHz at a level required to produce a modulation depth of 85 %;

e)   the "receiver" variable attenuator shall be adjusted to obtain the same meter reading as in step b) or a known relation to it;

f)   the ratio of adjacent channel power to carrier power is the difference between the attenuator settings in steps b) and e), corrected for any differences in the reading of the meter;

g)   the measurement shall be repeated with the "receiver" tuned to the other side of the carrier.

7.4.3 Limits

The adjacent channel power shall not exceed a value of 50 dB below the carrier power of the transmitter.

7.5   Conducted spurious emissions

7.5.1   Definition

Conducted spurious emissions are conducted 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. Conducted spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out of band emissions.

7.5.2   Method of measurement

Conducted spurious emissions shall be measured with the unmodulated transmitter connected to the artificial antenna (subclause 6.2.1).

The measurements shall be made over a range from 9 kHz to 4 GHz, excluding the channel on which the transmitter is operating and its adjacent channels.

The measurements for each spurious emission shall be made using a tuned radio measuring instrument or a spectrum analyzer.

The measurements shall be repeated with the transmitter in standby mode.

7.5.3   Limits

When the transmitter is operating:

-        the power of any conducted spurious emission on any frequency between 9 kHz and 1 GHz shall not exceed 0,25 μW (- 36 dBm) within a bandwidth of 1 kHz;

-        the power of any conducted spurious emission on any frequency above 1 GHz to 4 GHz shall not exceed 1 μW (- 30 dBm) within a bandwidth of 10 kHz.

When the transmitter is on standby:

-        the power of any conducted spurious emission on any frequency between 9 kHz and 1 GHz shall not exceed 2 nW (- 57 dBm) within a bandwidth of 1 kHz;

-        the power of any conducted spurious emission on any frequency above 1 GHz to 4 GHz shall not exceed 20 nW (- 47 dBm) within a bandwidth of 10 kHz.

7.6   Cabinet radiation

7.6.1   Definition

Cabinet radiation consists of emissions at frequencies, other than those of the carrier and the sideband components resulting from the wanted modulation process, which are radiated by the equipment cabinet and structures.

7.6.2   Method of measurement

On a test site, selected from 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.

The transmitter antenna connector shall be connected to an artificial antenna (subclause 6.2.1).

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

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

The transmitter shall be switched on without modulation, and the measuring receiver shall be tuned over the frequency range 30 MHz to 4 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

At each frequency at which a 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.

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

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

The transmitter shall be replaced by a substitution antenna as defined in subclause A.2.3.

The substitution antenna shall be orientated for vertical polarisation 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.

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

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

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 measurements shall be repeated with the transmitter in stand-by mode.

7.6.3 Limits

The power of any radiated spurious emission on any frequency between 30 MHz and 1 GHz shall not exceed 0,25 μW (- 36 dBm) within a bandwidth of 1 kHz.

The power of any radiated spurious emission on any frequency above 1 GHz to 4 GHz shall not exceed 1 μW (- 30 dBm) within a bandwidth of 10 kHz.

7.7 Intermodulation attenuation

7.7.1 Definition

Intermodulation attenuation is the capability of a transmitter to avoid the generation of signals in the non-linear 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 power level of the third order intermodulation product to the carrier power level.

7.7.2 Method of measurement
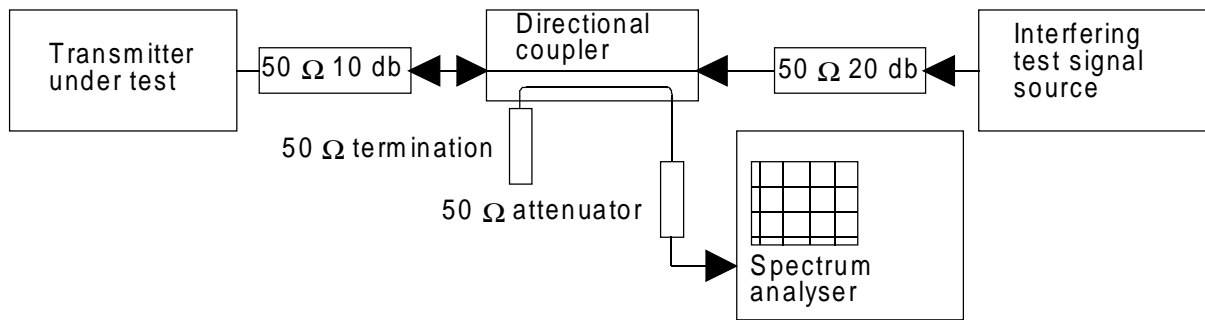
Figure 2: Measurement arrangement

The measurement arrangement shown in figure 2 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.

In order to reduce the influence of mismatch errors it is important that the 10 dB power attenuator is coupled to the transmitter under test with the shortest possible connection.

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

The transmitter under test shall be unmodulated and the spectrum analyser adjusted to give a maximum indication with a frequency scan width of 500 kHz.

The interfering test signal source shall be unmodulated and the frequency shall be within 150 kHz to 200 kHz above the frequency of the transmitter under test.

The frequency shall be chosen in such a way that the intermodulation components to be measured do not coincide with other spurious components.

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.

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.

This measurement shall be repeated with the interfering test signal source at a frequency within 150 kHz to 200 kHz below the frequency of the transmitter under test.

7.7.3   Limits

The intermodulation ratio shall be at least 40 dB.

7.8   RF power attack time and release time

7.8.1   Definitions

The transmitter power attack time (t_a) is the time which elapses between:

- $t_{on\ L}$: defined by the condition when the transmitter output power, measured at the antenna terminal, exceeds - 20 dBc;

- $t_{on\ H}$: defined by the condition when the transmitter output power has reached - 1,5 dBc.

The transmitter release time (t_r) is the time which elapses between:

- $t_{off\ H}$: defined by the condition when the transmitter output power falls below - 1,5 dBc;

- $t_{off\ L}$: defined by the condition when the transmitter output power has reached - 20 dBc.

The measured value of t_a and t_r are respectively t_{am} and t_{rm}; the limits are respectively t_{al} and t_{rl}.

7.8.2   Method of measurement

7.8.2.1   Attack time

a)   The transmitter is connected to a RF detector via a matched test load. The attenuation of the test load shall be chosen in such a way that the input of the RF detector is protected against overload and the detector operates correctly in the limiting range as soon as the transmitter carrier power (before attenuation) exceeds 1 mW.

A dual trace storage oscilloscope (or a transient recorder) records the amplitude transient from the detector on a logarithmic scale.

A trigger device may be required to ensure that the start of the sweep of the oscilloscope timebase occurs the instant at which the "transmitter $t_{on\ L}$" function is initiated.

A spectrum analyser can also be used;

b)   the traces of the oscilloscope shall be calibrated in power (Y axis) and in time (X axis), using the signal generator.

c)   the transmitter attack time shall be measured by direct reading on the oscilloscope while the transmitter is unmodulated.

7.8.2.2   Release time

a)   The transmitter is connected to a RF detector via a matched test load. The attenuation of the test load shall be chosen in such a way that the input of the RF detector is protected against overload and the detector operates correctly in the limiting range as soon as the transmitter carrier power (before attenuation) exceeds 1 mW.

A dual trace storage oscilloscope (or a transient recorder) records the amplitude transient from the detector on a logarithmic scale.

A trigger device may be required to ensure that the start of the sweep of the oscilloscope timebase

occurs the instant at which the "transmitter $t_{off\ H}$" function is initiated.

A spectrum analyser can also be used;

b)   the traces of the oscilloscope shall be calibrated in power (Y axis) and in time (X axis), using the signal generator;

c)   the transmitter release time shall be measured by direct reading on the oscilloscope while the transmitter is unmodulated.

7.8.3   Limits

t_{al} shall be between 300 μs and 20 ms.

t_{rl} shall be between 300 μs and 10 ms.

7.9   Transient frequency behaviour of the transmitter

7.9.1   Definitions

The transient frequency behaviour of the transmitter is the variation in time of the transmitter frequency difference from the nominal frequency of the transmitter when the RF output power is switched on and off.

t_{on}:   according to the method of measurement described in subclause 7.9.2 the switch-on instant t_{on} of a transmitter is defined by the condition when the output power, measured at the antenna terminal, exceeds 0,1 % of the nominal power;

t_1:   period of time starting at t_{on} and finishing according to table 1;

t_2:   period of time starting at the end of t_1 and finishing according to table 1;

t_{off}:   switch-off instant defined by the condition when the nominal power falls below 0,1 % of the nominal power;

t_3:   period of time starting according to the table 1 and finishing at t_{off}.

7.9.2 Method of measurement
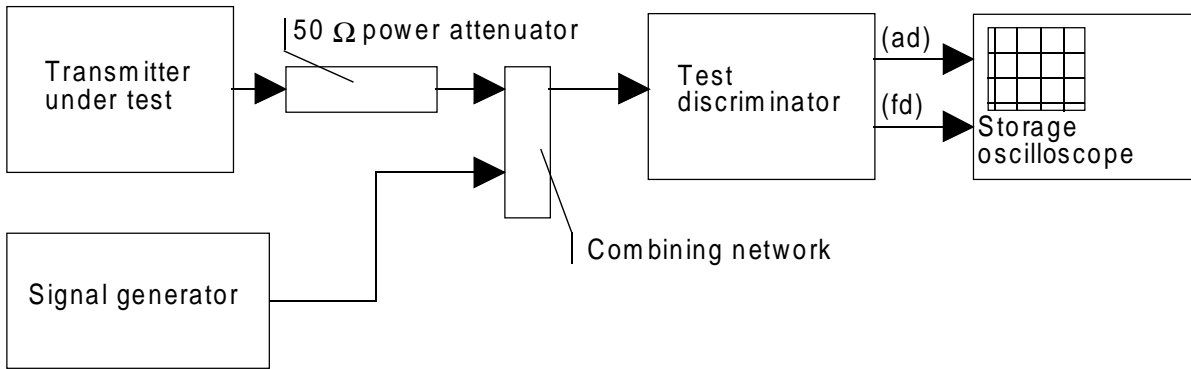
Figure 3: Measurement arrangement

Two signals shall be connected to the test discriminator via a combining network.

The transmitter shall be connected to a 50 Ω power attenuator.

The output of the power attenuator shall be connected to the test discriminator via one input of the combining network.

A test signal generator shall be connected to the second input of the combining network.

The test signal shall be adjusted to the nominal frequency of the transmitter.

The test signal shall be modulated by a frequency of 1 kHz with a modulation depth of 30 %.

The test signal level shall be adjusted to correspond to 0,1 % of the power of the transmitter under test measured at the input of the test discriminator. This level shall be maintained throughout the measurement.

The amplitude difference (ad) and the frequency difference (fd) output of the test discriminator shall be connected to a storage oscilloscope.

The storage oscilloscope shall be set to display the channel corresponding to the (fd) input up to ± 1 channel frequency difference, corresponding to the relevant channel separation, from the nominal frequency.

The storage oscilloscope shall be set to a sweep rate of 10 ms/division and set so that the triggering occurs at 1 division from the left edge of the display.

The display shows the 1 kHz test signal continuously.

The storage oscilloscope shall then be set to trigger on a rising edge on the channel corresponding to the amplitude difference (ad) input at a low input level.

The transmitter shall then be switched on, without modulation, to produce the trigger pulse and a picture on the display.

The result of the change in the ratio of power between the test signal and the transmitter output will, due to the capture ratio of the test discriminator, produce two separate "sides" on the picture, one showing the 1 kHz test signal, the other the frequency difference of the transmitter versus time.

The moment when the 1 kHz test signal is completely suppressed is considered to provide t_{on}.

The periods of time t_1 and t_2 as defined in table 1 shall be used to define the appropriate template.

During the period of time t_1 and t_2 the frequency difference shall not exceed the values given in table 1.

The frequency difference, after the end of t_2, shall be within the limit of the frequency error, subclause 7.1.

The result shall be recorded as frequency difference versus time.

The transmitter shall remain switched on.

The storage oscilloscope shall be set to trigger on a falling edge on the channel corresponding to the amplitude difference (ad) input at a high input level, and set so that the triggering occurs at 1 division from the right edge of the display.

The transmitter shall then be switched off.

The moment when the 1 kHz test signal starts to rise is considered to provide t_{off}.

The period of time t_3 as defined in table 1 shall be used to define the appropriate template.

During the period of time t_3 the frequency difference shall not exceed the values given in table 1.

Before the start of t_3 the frequency difference shall be within the limit of the frequency error, subclause 7.1.

The result shall be recorded as frequency difference versus time.

Figure 4 represents the storage oscilloscope view t_1, t_2, t_3.

If the display of the oscilloscope shows a large impulse immediately after the end of the calibration signal, there is a risk that this signal may have been caused by the phase shift between the calibration signal and the transmitter.

To identify the source of the impulse, the following method can be used.

The impulse can be evaluated by repeating the test, e.g. for three times.

If the impulse remains constant in amplitude and exceeds the limit then the transmitter fails to meet the requirement.

If the impulse changes amplitude it is a phase shift occurring from the method of testing and this impulse shall be disregarded in the assessment of the test results.

Switch on condition t $_{on}$, t $_1$ and t $_2$

+Δ f=1 channel
separation

+Δ f=½ channel
separation

- nominal
frequency

-Δ f=½ channel
separation

-Δ f=1 channel
separation

ms   10   20   30   40   50   60   70   80   90   100

t $_1$ t $_2$

t $_{on}$

Switch off condition t $_3$, t $_{off}$

+Δ f=1 channel
separation

+Δ f=½ channel
separation

- nominal
frequency

-Δ f=½ channel
separation

-Δ f=1 channel
separation

ms   10   20   30   40   50   60   70   80   90   100

t $_3$ t $_{off}$

Figure 4: Storage oscilloscope view t1, t2 and t3

7.9.3   Limits

Table 1: Transient frequency behaviour of the transmitter

t_1 (ms)	5,0
t_2 (ms)	20,0
t_3 (ms)	5,0
NOTE 1: During the periods t_1 and t_3 the frequency difference shall not exceed the value of 1 channel separation.	
NOTE 2: During the period t_2 the frequency difference shall not exceed the value of half a channel separation.	

7.10   Protection of the transmitter

7.10.1   Definition

The protection of the transmitter represents the ability of the transmitter to be protected against malfunction due to faults in the antenna system.

7.10.2   Method of measurement

While the transmitter is transmitting at the rated output power, the antenna port shall first be short-circuited and then open-circuited, in each case for a period of 5 minutes. This test shall be performed on one frequency only.

7.10.3   Requirement

This test shall not result in any damage to the transmitter. After removal of the short-circuit and open-circuit conditions, the transmitter shall be able to operate normally when rekeyed.

8   Receiver

8.1   Maximum usable sensitivity

8.1.1   Definition

The maximum usable sensitivity of the receiver is the minimum level of the signal (emf) at the nominal frequency of the receiver which, when applied to the receiver input with normal test modulation (subclause 6.1.4), produces:

-        in all cases, an audio frequency output power not less than 50 % of the rated output power (subclause 6.1.6); and

-        a SINAD ratio of 20 dB, measured at the receiver output using a psophometric telephone filtering network as described in CCITT Recommendation P.53 [3].

8.1.2   Method of measurement

A normal test signal (subclause 6.1.4) at a carrier frequency equal to the nominal frequency of the receiver shall be applied to the receiver input. An audio frequency load and a measuring instrument for measuring the SINAD ratio (through a psophometric network) shall be connected to the receiver output terminals.

The level of the test signal shall be adjusted until a SINAD ratio of 20 dB is obtained, using the psophometric network and with the receiver's audio frequency power control adjusted to produce 50 % of the rated output power. Under these conditions, the level of the test signal at the input is the value of the maximum usable sensitivity.

The measurements shall be made under normal test conditions (subclause 5.3) and under extreme test conditions (subclauses 5.4.1 and 5.4.2 applied simultaneously).

A receiver output power variation of ± 3 dB relative to 50 % of the rated output power may be allowed for sensitivity measurements under extreme test conditions. The measurements shall be performed at all test channels (subclause 6.3).

8.1.3 Limits

The maximum usable sensitivity shall not exceed + 20 dBμV emf under normal test conditions and + 26 dBμV emf under extreme test conditions.

8.2 Harmonic distortion

8.2.1 Definition

The harmonic distortion at the receiver output is defined as the ratio, expressed as a percentage, of the total rms voltage of all the harmonic components of the modulation audio frequency to the total rms voltage of the signal delivered by the receiver.

8.2.2 Method of measurement

The normal test signal (subclause 6.1.4) at levels of + 60 dBμV emf and + 100 dBμV emf, at a carrier frequency equal to the nominal frequency of the receiver shall be applied in succession to the receiver input under the normal test conditions specified in subclause 5.3.

The audio output level shall be set to approximately 30 % of the rated output power for the output under test (loudspeaker, headset with volume control, line output with internal adjustment). A resistive load modelling the normal audio output load shall be connected.

Any AF automatic gain control shall be switched off.

The audio distortion shall be measured at 30 % (normal) and 90 % modulation depth of the input test signal and shall be recorded by a distortion meter.

8.2.3 Limits

The harmonic distortion shall not exceed 5 % at 30 % modulation depth and 10 % at 90 % modulation depth.

8.3 Audio frequency response

8.3.1 Definition

The audio frequency response expresses the ability of the receiver to operate without excessive degradation of its frequency response as a function of the audio frequency.

8.3.2 Method of measurement

A test signal (subclause 6.1) at a level of + 60 dBμV emf at a carrier frequency equal to the nominal frequency of the receiver shall be applied to the receiver input under normal test conditions specified in subclause 5.3.

The AF automatic gain control shall be switched off.

The audio frequency shall then be varied between 300 Hz and 4 kHz, with the level of the test signal being kept constant and equal to the value specified above.

8.3.3 Limits

The audio output power shall not vary by more than 6 dB within the audio frequency range of 350 Hz to 2 500 Hz.

8.4 Audio noise

8.4.1 Definition

The audio noise is defined as the ratio, in dB, of the audio-frequency power of the noise to the audio-frequency power produced by the normal test signal (subclause 6.1) applied to the receiver input weighted according CCITT Recommendation P.53 [3].

8.4.2 Method of measurement

A test signal (subclause 6.1) at a level of + 100 dBμV emf at a carrier frequency equal to the nominal frequency of the receiver shall be applied to the receiver input under normal test conditions specified in subclause 5.3. Modulation depth shall be set at 90 %.

The audio output level shall be set to the rated output power for the output under test (loudspeaker, headset, line output). A resistive load modelling the normal audio output load shall be connected.

Any AF automatic gain control shall be switched off.

The output signal including noise (S+N) shall be measured by a rms voltmeter and recorded.

Then the modulation of the test signal shall be switched off and the audio-frequency output level (N) shall be measured.

The measurements shall be made using psophometric filtering network, CCITT Recommendation P.53 [3].

8.4.3 Limits

The ratio N/(S+N) shall be better than 40 dB on all output types under test.

8.5 Adjacent channel selectivity

8.5.1 Definition

The adjacent channel selectivity 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 modulated signal which differs in frequency from the wanted signal by 8,33 kHz.

8.5.2 Method of measurement

The two input signals shall be applied to the receiver input via a combining network. An rms voltmeter shall be connected to the receiver output terminals via a psophometric filter.

The wanted normal test signal (subclause 6.1.4), at the nominal frequency of the receiver, at a level of + 20 dBμV emf, the value of the limit for the maximum usable sensitivity (subclause 8.1), shall be applied to the receiver input via one input of the combining network.

The unwanted signal at the frequency of one channel separation above the nominal frequency of the receiver, modulated with a frequency of 400 Hz with 60 % modulation depth shall be applied to the receiver input via the second input of the combining network.

The amplitude of the unwanted signal shall be adjusted until the SINAD ratio, psophometrically weighted, at the output of the receiver is reduced to 14 dB.

The measurement shall be repeated with an unwanted signal at the frequency of the channel below that of the wanted signal.

The adjacent channel selectivity shall be expressed as the lower value of the ratios in dB for the upper and lower adjacent channels of the level of the unwanted signal to the level of the wanted signal.

The measurements shall then be repeated under extreme test conditions (subclauses 5.4.1 and 5.4.2 applied simultaneously) with the wanted signal set to + 26 dBμV emf, the value corresponding to the maximum usable sensitivity under these conditions.

8.5.3 Limits

The adjacent channel selectivity shall be not less than 50 dB under normal test conditions and not less than 40 dB under extreme test conditions.

8.6 Spurious response rejection

Spurious responses may occur at all frequencies throughout the frequency spectrum and the requirements of this ETS shall be met for all frequencies. However, for practical reasons the measurements for type testing shall be performed as specified in this ETS. More specifically, this method of measurement is not intended to capture all spurious responses but selects those that have a high probability of being present. However, in a limited frequency range close to the nominal frequency of the receiver, it has been considered impossible to determine the probability of a spurious responses and therefore a search shall be performed over this limited frequency range. This method provides a high degree of confidence that the equipment also meets the requirements at frequencies not being measured.

8.6.1 Definition

The spurious response rejection is a measure of the capability of the receiver to discriminate between the wanted modulated signal at the nominal frequency and an unwanted signal at any other frequency at which a response is obtained.

8.6.2 Introduction to the method of measurement

To determine the frequencies at which spurious responses can occur the following calculations shall be made:

a)   calculation of the "limited frequency range";

The limited frequency range is defined as the frequency of the local oscillator signal (f_{LO}) applied to the first mixer of the receiver plus or minus the sum of the intermediate frequencies ($f_{i1}...f_{in}$) and a half of the maximum frequency range (fr_m) of the receiver.

Hence the frequency f_L of the limited frequency range is:

$$f_{LO} - \sum_{j=1..n} f_{ij} - fr_m / 2 \le f_L \le f_{LO} + \sum_{j=1..n} f_{ij} + fr_m / 2$$

b)   calculation of frequencies outside the limited frequency range.

The frequencies outside the limited frequency range determined in a) are equal to the harmonics of the frequency of the local oscillator signal (f_{LO}) applied to the first mixer of the receiver plus or minus the first intermediate frequency (f_{i1}) of the receiver.

Hence the frequencies of these spurious responses are $nf_{LO} \pm f_{i1}$, where n is an integer greater than or equal to 2.

The measurement of the first image response of the receiver shall initially be made to verify the calculation of spurious response frequencies.

For calculations a) and b), the manufacturer shall state the frequency of the receiver, the frequency of the local oscillator signal (f_{LO}) applied to the first mixer of the receiver, the intermediate frequencies (f_{i1}, f_{i2} etc.), and the maximum frequency range (fr_m) of the receiver.

8.6.3   Method of search of the limited frequency range

The test signal shall be at the nominal frequency and amplitude modulated by 1 000 Hz at a modulation depth of 30 %.

The test signal shall be adjusted to a level corresponding to a S+N/N ratio of 20 dB and recorded as the reference level.

The input level of the test signal shall then be adjusted to 70 dB above the reference level.

The frequency shall be varied continuously over the limited frequency range determined in subclause 8.6.2 a) and over the frequencies outside the frequency range in accordance with the calculations in subclause 8.6.2 b).

The frequency of any spurious responses detected during the search shall be recorded for the use in the measurement described in the following subclause.

8.6.4   Method of measurement

The test signal from a signal generator shall be applied to the receiver input. An rms voltmeter shall be connected to the receiver output via a psophometric filter.

The test signal shall be a normal test signal (subclause 6.1.4) at the nominal frequency of the receiver.

The RF signal level shall be adjusted to produce a S+N/N ratio according of 20 dB, recorded as the reference level.

The signal generator shall then be tuned to a calculated spurious response frequency and modulated with normal test modulation.

The level of the RF signal is increased until the receiver output signal produces an S+N/N ratio of 20 dB.

This RF signal level shall be recorded as the unwanted signal level.

The spurious response rejection ratio is the ratio in dB of the unwanted signal level to the reference level.

This measurement shall be made for each calculated frequency.

8.6.5 Limit

At any frequency separated from the nominal frequency of the receiver by more than two channels, the spurious response rejection ratio shall be not less than 60 dB.

8.7 Intermodulation response rejection

8.7.1 Definition

The intermodulation response rejection is the capability of a receiver to receive a wanted modulated signal at the nominal frequency, without exceeding a given degradation due to the presence of two or more unwanted signals with a specific frequency relationship to the wanted signal frequency.

8.7.2 Method of measurement

The wanted signal from signal generator A, at the nominal frequency and producing a normal test signal (subclause 6.1.4) shall be applied to the input of the receiver via a combining network.

The unwanted signal from signal generator B, at the frequency 25 kHz above the nominal frequency of the receiver and without modulation shall be applied to the receiver via the second input of the combining network.

The audio output of the receiver shall be monitored by an rms voltmeter.

With the unwanted signal switched off, the level of the wanted signal shall be set to 1 mV and the receiver volume control adjusted to obtain approximately 50 % of the rated audio output power.

The level of the wanted signal shall be reduced until a S+N/N ratio of 14 dB is obtained.

The level of the wanted signal under these conditions shall be recorded (x).

The frequency of the wanted signal shall then be changed to the carrier frequency of the channel, 50 kHz above the nominal channel of the receiver. This signal now constitutes the second unwanted signal.

The level of the two unwanted signals shall be kept equal and increased in level until a S+N/N ratio of 14 dB is again obtained. If necessary the frequency of either signal shall be varied slightly to obtain the maximum value of this ratio, their levels being re-adjusted to restore the S+N/N ratio to 14 dB.

The level of the two signals under these conditions shall be recorded (y).

The ratio, in dB, of the levels of the unwanted signals (y) to that recorded for the wanted signal (x) is the intermodulation response rejection ratio.

8.7.3 Limit

The intermodulation response rejection ratio shall be greater than 55 dB.

8.8 Blocking or desensitisation

8.8.1 Definition

Blocking 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 of the adjacent channels.

8.8.2 Method of measurement

Two input signals shall be applied to the receiver via a combining network. An rms voltmeter shall be connected to the receiver output terminals via a psophometric filter.

The wanted normal test signal (subclause 6.1), at the nominal frequency of the receiver, at a level of + 20 dBμV emf, the value of the limit of the maximum usable sensitivity (subclause 8.1), shall be applied to the receiver input connector via one of the inputs of the combining network.

Where possible, the receiver volume control shall be adjusted to give at least 50 % of the rated output power (subclause 6.1.6).

The unwanted signal shall be unmodulated and the frequency shall be swept between + 1 MHz and + 10 MHz, and also between - 1 MHz and - 10 MHz, relative to the nominal frequency of the receiver. The input level of the unwanted signal, at all frequencies in the specified ranges, shall be so adjusted until:

a)   the audio output level of the wanted signal is reduced by 3 dB; or

b)   the SINAD ratio, psophometrically weighted, at the receiver output is reduced to 14 dB.

The measure of the blocking or desensitisation is the ratio in dB of the level of the unwanted test signal to the level of the wanted test signal at the receiver input for which the specified reduction in audio output level or in the SINAD ratio occurs.

8.8.3 Limit

The blocking ratio, for any frequency within the specified ranges, shall not be less than 80 dB, except at frequencies on which spurious responses are found.

8.9 Conducted spurious emissions

8.9.1 Definition

Conducted spurious emissions from the receiver are components at any frequency, radiated by the antenna.

The level of spurious radiations shall be measured by their power level at the antenna connector.

8.9.2 Method of measuring the power level

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 is 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.

The measurements shall extend over the frequency range of 9 kHz to 4 GHz.

8.9.3 Limits

The power of any conducted spurious emission shall not exceed the values given below:

-       between 9 kHz and 1 GHz: 2 nW (- 57 dBm), within a bandwidth of 1 kHz;

-       above 1 GHz to 4 GHz: 20 nW (- 47 dBm), within a bandwidth of 10 kHz.

8.10 Radiated spurious emissions

8.10.1 Definition

Radiated spurious emissions (cabinet radiations) from the receiver are components at any frequency, radiated by the cabinet and structure of the equipment.

The level of spurious emissions shall be measured using their effective radiated power.

8.10.2 Method of measuring the effective radiated power

On a suitable test site (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.

The receiver antenna connector shall be connected to an artificial antenna, subclause 6.2.1.

The test antenna shall be orientated for vertical polarisation 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.

The receiver shall be switched on and the measuring receiver shall be tuned over the frequency range 30 MHz to 4 GHz.

At each frequency at which a spurious 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.

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

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

The receiver shall be replaced by a substitution antenna as defined in subclause A.2.3.

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

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

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.

8.10.3 Limits

The power of any spurious radiation shall not exceed the values given below:

- between 30 MHz and 1 GHz: 2 nW (- 57 dBm), within a bandwidth of 1 kHz;

- above 1 GHz to 4 GHz: 20 nW (- 47 dBm), within a bandwidth of 10 kHz.

8.11 Squelch operation

8.11.1 Definition

The purpose of the squelch facility is to mute the receiver audio output signal when the level of the signal at the receiver input is less than a given value.

8.11.2 Method of measurement

A signal generator shall be connected to the receiver input:

a) the signal generator shall be set to produce a normal test signal (subclause 6.1.4) at the nominal frequency of the receiver at a level + 20 dB above the limit of the maximum usable sensitivity (subclause 8.1). The squelch facility shall be switched off. The audio output of the receiver shall be measured by an rms voltmeter connected to the receiver through a psophometric filter and shall be adjusted to approximately half the rated power (subclause 6.1.6). With the squelch switched on, the squelch operating point shall be raised to such a value that the audio output is muted, and the audio output shall be measured;

b) the output of the signal generator shall be reduced to a level of + 20 dBμV emf, and the squelch operating point decreased to the minimum possible value while not enabling the AF output on the receiver noise alone. The output of the signal generator shall now be increased to the level at which the audio output is enabled by the squelch circuit and the corresponding RF input level shall be noted.

8.11.3 Limits

Under the conditions specified in subclause 8.11.2 a), the difference in audio output between squelch operative and inoperative shall be at least 40 dB.

Under the conditions specified in subclause 8.11.2 b), the squelch threshold setting range shall be from:

- below the maximum usable sensitivity level;

- to the level declared by the manufacturer within a range of - 3 dB and + 10 dB.

8.12 Cross modulation rejection

8.12.1 Definition

Cross modulation is the transposition of the AM component from a strong unwanted signal to the wanted signal.

Cross modulation rejection is the level difference between an unwanted signal and the wanted signal at the point where the audio component due to crossmodulation is - 5 dB of the audio response due to the wanted signal.

8.12.2 Method of measurement

The two inputs signals shall be connected to the receiver via a combining network. An rms voltmeter shall be connected to the receiver output terminals via a psophometric filter.

The wanted signal, a normal test signal (subclause 6.1.4) at the nominal frequency of the receiver, at a level of + 20 dBµV emf, the value of the limit of the maximum usable sensitivity (subclause 8.1), shall be applied to the receiver input connector via one of the inputs of the combining network.

Where possible, the receiver volume control shall be adjusted to give at least 50 % of the rated output power (subclause 6.1.6).

The modulation of the wanted signal shall be switched off.

The unwanted signal at a frequency offset of 100 kHz with respect to the nominal frequency of the receiver and amplitude modulated with 400 Hz at a depth of modulation of 30 % shall be applied to the second input of the combining network.

The RF output level of the unwanted signal shall be increased to obtain an audio output 5 dB less than the nominal audio output level.

Then the RF output level of the wanted signal shall be increased continuously to + 106 dBµv emf

(- 7 dBm) and the audio level shall be checked. At the output level (if any) where the audio level increases to a maximum the RF level of the unwanted signal shall be reduced to obtain again a - 5 dB audio output.

The ratio between this RF level of the unwanted signal and the maximum usable sensitivity is the cross modulation rejection.

8.12.3 Limits

The cross modulation rejection ratio shall be at least 80 dB.

8.13 RF automatic gain control

8.13.1 Definition

The RF automatic gain control expresses the capability of the receiver to limit the resulting audio output as a function of varying input signal levels.

8.13.2 Method of measurement

The AF automatic gain control shall be disabled. A normal test signal (subclause 6.1.4) with carrier frequency equal to the nominal frequency of the receiver and level equal to the limit of the maximum usable sensitivity (subclause 8.1) shall be applied to the receiver under normal test conditions (subclause 5.3). The resulting audio output shall be measured by an AF power meter connected to the receiver and the value noted. The RF input level shall then be increased by 80 dB and the AF output level shall again be noted.

8.13.3 Limit

The RF automatic gain control shall compress an input level change of 80 dB with respect to the limit of the maximum usable sensitivity level to less than 6 dB resulting audio output power changes.

9 Measurement uncertainty and interpretation of the measured results

The results of the measurement shall be recorded in the test report.

The measurement uncertainties shall be calculated by the test laboratory performing the measurements and shall also be recorded in the test report.

9.1 Maximum measurement uncertainties

The measurement uncertainties shall be better than or equal to those given in tables 2 and 3.

Table 2: Transmitter measurement uncertainty: maximum values

Measurement uncertainties	Maximum values
Frequency error	$\pm 1 \times 10^{-7}$
Carrier power (normal and extreme test conditions)	$\pm 0,75$ dB
Modulation depth	± 5 %
Modulation compression	± 3 %
Amplitude modulation distortion	± 3 %
Audio frequency response	± 2 dB
Unwanted carrier frequency modulation	± 50 Hz
Adjacent channel power	± 5 dB
Conducted spurious emissions valid 1 GHz to 4 GHz	± 3 dB ± 6 dB
Cabinet radiation valid 1 GHz to 4 GHz	± 3 dB ± 6 dB
Transient frequency behaviour	± 250 Hz
Intermodulation	± 3 dB
RF power attack and release times	± 20 % of the limits values

Table 3: Receiver measurement uncertainty: maximum values

Measurement uncertainties	Maximum values
Maximum usable sensitivity	± 3 dB
Harmonic distortion	± 0,5 dB
Audio frequency response	± 3 dB
Audio noise level	± 3 dB
Adjacent channel selectivity	± 4 dB
Spurious response rejection	± 4 dB
Intermodulation response rejection	± 3 dB
Blocking and desensitisation	± 4 dB
Conducted spurious radiations valid 1 GHz to 4 GHz	± 3 dB ± 6 dB
Cabinet radiations valid 1 GHz to 4 GHz	± 3 dB ± 6 dB
Squelch operation	± 2 dB
Cross modulation rejection	± 4 dB
RF automatic gain control	± 2 dB

For the test methods according to this ETS the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in ETR 028 [2].

9.2 Interpretation of the measurement results

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

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of this ETS;

- the measurement uncertainty value 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 lower than the figures in tables 2 and 3 (tables of measurement uncertainties).

Annex A (normative):   Radiated measurements

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

A.1.1   Outdoor test site

The outdoor test site shall be on a reasonably level surface or ground. At one point on the site, a ground plane of at least 5 m diameter shall be provided. In the middle of this ground plane, a non-conducting support, capable of rotation through 360° in the horizontal plane, shall be used to support the test sample at 1,5 m above the ground plane. The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of $\lambda/2$ or 3 m whichever is the greater. The distance actually used shall be recorded with the results of the tests carried out on the site.

Sufficient precautions shall be taken to ensure that reflections from extraneous objects adjacent to the site and ground reflections do not degrade the measurements results.
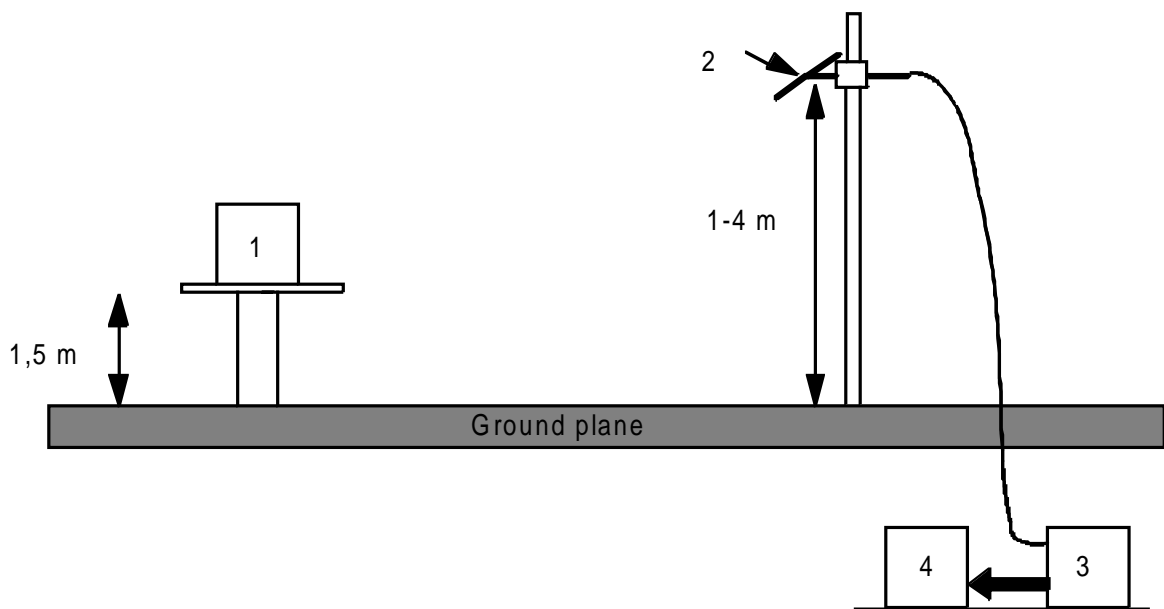

Figure A.1: Outdoor test site

Key:

1   Equipment under test
2   Test antenna
3   High pass filter (necessary for strong fundamental Tx radiation)
4   Spectrum analyser or measuring receiver

A.1.2   Test antenna

The test antenna is used to detect the radiation from both the test sample and the substitution antenna, when the site is used for radiation measurements; where necessary, it is used as a transmitting antenna, when the site is used for the measurement of receiver characteristics.

This antenna is mounted on a support such as to allow the antenna to be used in either horizontal or vertical polarisation and for the height of its centre above ground to be varied over the range 1 to 4 m. Preferably a test antenna with pronounced directivity should be used. The size of the test antenna along the measurement axis shall not exceed 20 % of the measuring distance.

For receiver and transmitter radiation measurements, the test antenna is connected to a measuring receiver, capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input. For receiver radiated sensitivity measurements the test antenna is connected to a signal generator.

A.1.3   Substitution antenna

When measuring in the frequency range up to 1 GHz the substitution antenna shall be a $\lambda/2$ dipole, resonant at the frequency under consideration, or a shortened dipole, calibrated to the $\lambda/2$ dipole. When measuring in the frequency range above 4 GHz a horn radiator shall be used. For measurements between 1 and 4 GHz either a $\lambda/2$ dipole or a horn radiator may be used. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the volume centre of the sample when its antenna is mounted inside the cabinet, or the point where an external antenna is connected to the cabinet.

The distance between the lower extremity of the dipole and the ground shall be at least 0,3 m.

The substitution antenna shall be connected to a calibrated signal generator when the site is used for spurious radiation measurements and transmitter effective radiated power measurements. The substitution antenna shall be connected to a calibrated measuring receiver when the site is used for the measurement of receiver sensitivity.

The signal generator and the receiver shall be operating at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

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

A.1.4   Optional additional indoor site

When the frequency of the signals being measured is greater than 80 MHz, use may be made of an indoor site. If this alternative site is used, this shall be recorded in the test report.

The measurement site may be a laboratory room with a minimum area of 6 m by 7 m and at least 2,7 m in height.

Apart from the measuring apparatus and the operator, the room shall be as free as possible from reflecting objects other than the walls, floor and ceiling.

The potential reflections from the wall behind the equipment under test are reduced by placing a barrier of absorbent material in front of it. The corner reflector around the test antenna is used to reduce the effect of reflections from the opposite wall and from the floor and ceiling in the case of horizontally polarised measurements. Similarly, the corner reflector reduces the effects of reflections from the side walls for vertically polarised measurements. For the lower part of the frequency range (below approximately 175 MHz) no corner reflector or absorbent barrier is needed. For practical reasons, the $\lambda/2$ antenna in figure A.2 may be replaced by an antenna of constant length, provided that this length is between $\lambda/4$ and l at the frequency of measurement and the sensitivity of the measuring system is sufficient. In the same way the distance of $\lambda/2$ to the apex may be varied.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method.

To ensure that errors are not caused by the propagation path approaching the point at which phase cancellation between direct and the remaining reflected signals occurs, the substitution antenna shall be moved through a distance of ± 0,1 m in the direction of the test antenna as well as in the two directions perpendicular to this first direction.

If these changes of distance cause a signal change of greater than 2 dB, the test sample should be re-sited until a change of less than 2 dB is obtained.
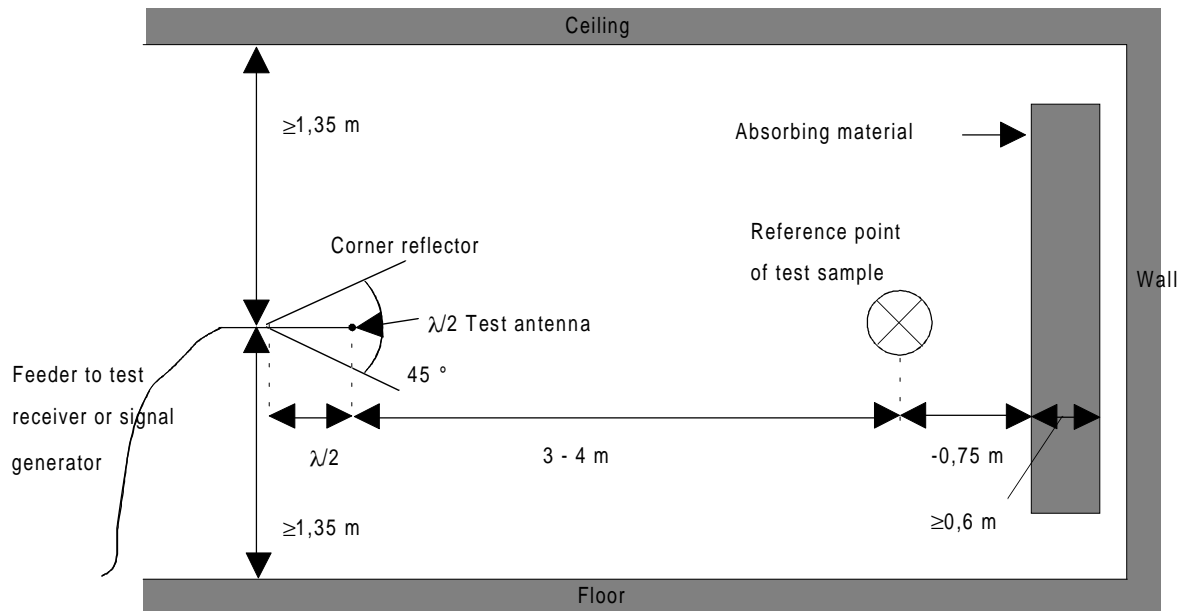

Figure A.2: Indoor site arrangement (shown for horizontal polarisation)

A.2   Guidance on the use of radiation test sites

For measurements involving the use of radiated fields, use may be made of a test site in conformity with the requirements of subclause A.1 of this annex. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

A.2.1   Measuring distance

Evidence indicates that the measuring distance is not critical and does not significantly affect the measuring results, provided that the distance is not less than $\lambda/2$ at the frequency of measurement, and the precautions described in this annex are observed. Measuring distances of 3, 5, 10 and 30 m are in common use in European test laboratories.

A.2.2   Test antenna

Different types of test antenna may be used, since performing substitution measurements reduces the effect of the errors on the measuring results.

Height variation of the test antenna over a range of 1 to 4 m is essential in order to find the point at which the radiation is a maximum.

Height variation of the test antenna may not be necessary at the lower frequencies below about 100 MHz.

A.2.3 Substitution antenna

Variations in the measuring results may occur with the use of different types of substitution antenna at the lower frequencies below about 80 MHz.

Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used should be included with the results of the tests carried out on the site. Correction factors shall be taken into account when shortened dipole antennas are used.

A.2.4 Artificial antenna

The dimensions of the artificial antenna used during radiated measurements should be small in relation to the sample under test.

Where possible, a direct connection should be used between the artificial antenna and the test sample.

In cases where it is necessary to use a connecting cable, precautions should be taken to reduce the radiation from this cable by, for example, the use of ferrite cores or double screened cables.

A.2.5 Auxiliary cables

The position of auxiliary cables (power supply and microphone cables etc.) which are not adequately decoupled may cause variations in the measuring results. In order to get reproducible results, cables and wires of auxiliaries should be arranged vertically downwards (through a hole in the non-conducting support).

A.2.6 Acoustic measuring arrangement

When carrying out measurements of the maximum usable sensitivity (radiated) of the receiver, the audio output shall be monitored by acoustically coupling the audio signal from the receiver loudspeaker/transducer to the test microphone. On the radiation test site all conducting materials shall be placed below the ground surface and the acoustic signal is conveyed from the receiver to the test microphone in a non-conducting acoustic pipe.

The acoustic pipe shall have an appropriate length. The acoustic pipe shall have an inner diameter of 6 mm and a wall thickness of 1,5 mm. A plastic funnel of a diameter corresponding to the receiver loudspeaker/transducer shall be attached to the receiver surface centred in front of the receiver loudspeaker/transducer. The plastic funnel shall be very soft at the attachment point to the receiver in order to avoid mechanical resonance. The narrow end of the plastic funnel shall be connected to the one end of the acoustic pipe and the test microphone to the other.

A.3 Further optional alternative indoor test site using an anechoic chamber

For radiation measurements when the frequency of the signals being measured is greater than 30 MHz, use may be made of an indoor site being a well-shielded anechoic chamber simulating free space environment. If such a chamber is used, this shall be recorded in the test report.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method, subclause A.1. In the range between 30 MHz and 100 MHz some additional calibration may be necessary.

An example of a typical measurement site may be an electrically shielded anechoic chamber being 10 m long, 5 m broad and 5 m high.

Walls and ceiling should be coated with RF absorbers of 1 m height.

The base should be covered with absorbing material 1 m thick, and a wooden floor, able to carry test equipment and operators.

A measuring distance of 3 to 5 m in the long middle axis of the chamber can be used for measurements up to 12,75 GHz.

The construction of the anechoic chamber is described in the following subclauses.

A.3.1   Example of the construction of a shielded anechoic chamber

Free-field measurements can be simulated in a shielded measuring chamber where the walls are coated with RF absorbers.

Figure A.3 shows the requirements for shielding loss and wall return loss of such a room.

As dimensions and characteristics of usual absorber materials are critical below 100 MHz (height of absorbers < 1 m, reflection attenuation < 20 dB) such a room is preferably suitable for measurements above 100 MHz.

Figure A.4 shows the construction of a shielded measuring chamber having a base area of 5 m by 10 m and a height of 5 m.

Ceilings and walls are coated with pyramidal formed absorbers approximately 1 m high. The base is covered with absorbers which are able to carry and which forms a sort of floor.

The available internal dimensions of the room are 3 m x 8 m x 3 m, so that a measuring distance of maximum 5 m length in the middle axis of this room is available.

At 100 MHz the measuring distance can be extended up to a maximum of 2 lambda.

The floor absorbers reject floor reflections so that the antenna height need not be changed and floor reflection influences need not be considered.

All measuring results can therefore be checked with simple calculations and the measuring tolerances have the smallest possible values due to the simple measuring configuration.

For special measurements it can be necessary to re-introduce floor reflections. Taking away the floor absorbers would mean a removal of approximately 24 m3 absorber material. Therefore the floor absorbers are covered with metal plates of metallic nets instead.

A.3.2   Influence of parasitic reflections in anechoic chambers

For free-space propagation in the far field condition the correlation E=Eo(Ro/R) is valid for the dependence of the field strength E on the distance R, whereby Eo is the reference field strength in the reference distance Ro.

It is useful to use just this correlation for comparison measurements, as all constants are eliminated with the ratio and neither cable attenuation nor antenna mismatch or antenna dimensions are of importance.

Deviations from the ideal curve can be seen easily if the logarithm of the above equation is used, because the ideal correlation of field strength and distance can then be shown as a straight line and the deviations occurring in practice are clearly visible. This indirect method shows the disturbances due to reflections more readily and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in subclause A.3 at low frequencies up to 100 MHz there are no far field conditions, and therefore reflections are stronger so that careful calibration is necessary.

In the medium frequency range from 100 MHz to 1 GHz the dependence of the field strength on the distance meets the expectations very well.

In the frequency range of 1 to 12,75 GHz, because more reflections will occur, the dependence of the field strength on the distance will not correlate so closely.

A.3.3 Calibration of the shielded anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 12,75 GHz.
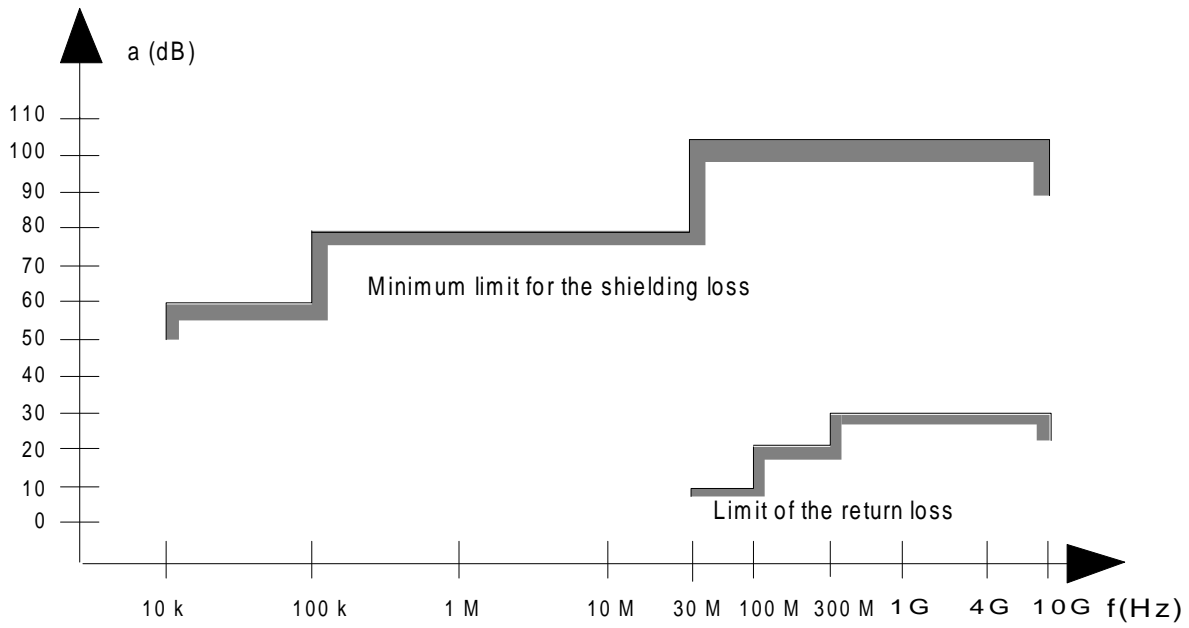

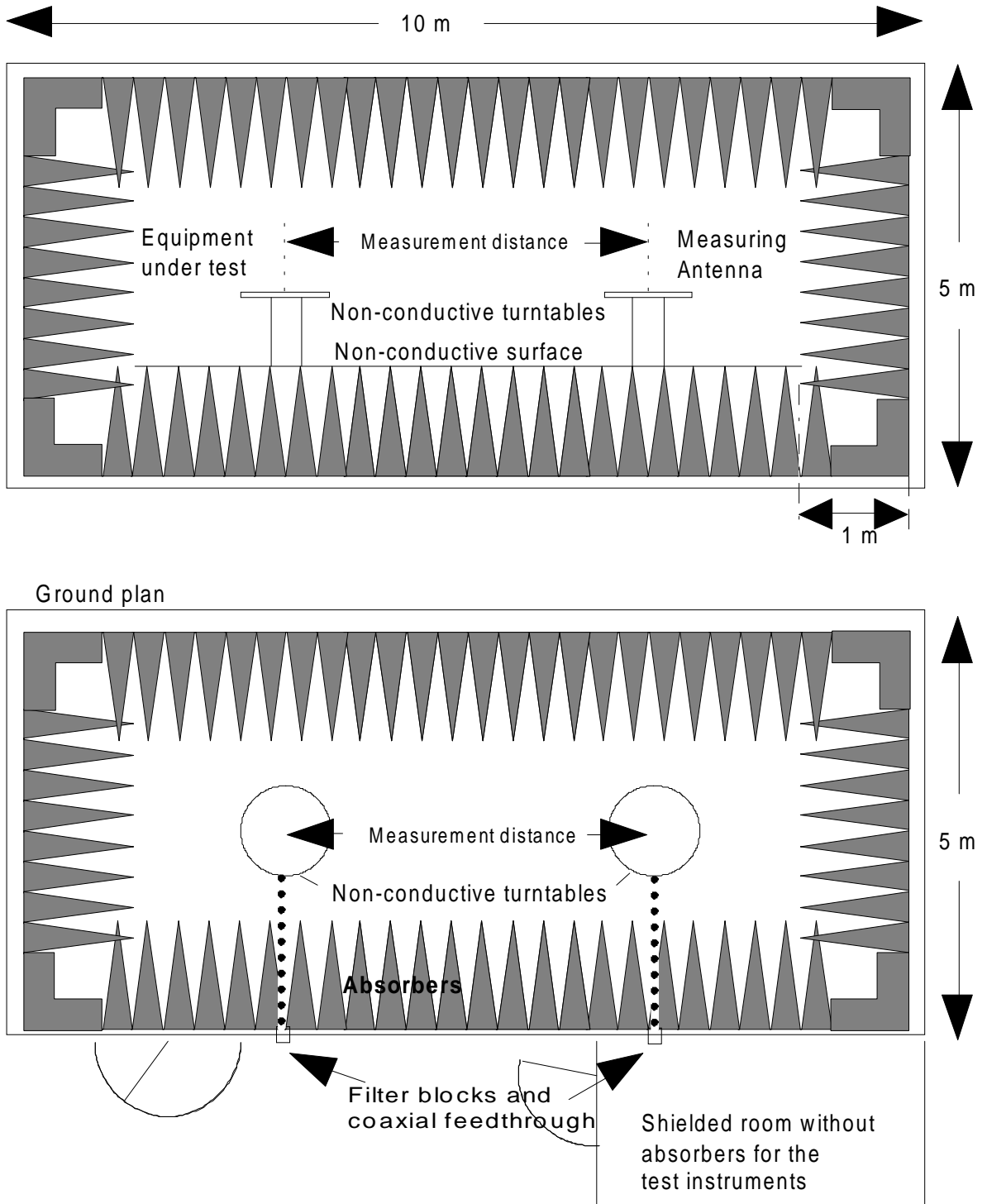**Figure A.3: Specifications for shielding and reflections**

10 m

Equipment under test

Measurement distance

Measuring Antenna

Non-conductive turntables

Non-conductive surface

5 m

1 m

Ground plan

Measurement distance

Non-conductive turntables

Absorbers

5 m

Filter blocks and coaxial feedthrough

Shielded room without absorbers for the test instruments

Figure A.4: Example of construction of an anechoic shielded chamber

Annex B (normative): Specification for adjacent channel power measurement arrangements

B.1 Power measuring receiver specification

The power measuring receiver consists of a mixer, an Intermediate Frequency (IF) filter, and oscillator, an amplifier, a variable attenuator and an rms value indicator. Instead of the variable attenuator with the rms value indicator it is also possible to use an rms voltmeter calibrated in dB. The technical characteristics of the power measuring receiver are given below.

B.1.1 IF filter

The IF filter shall be within the limits of the following selectivity characteristics.
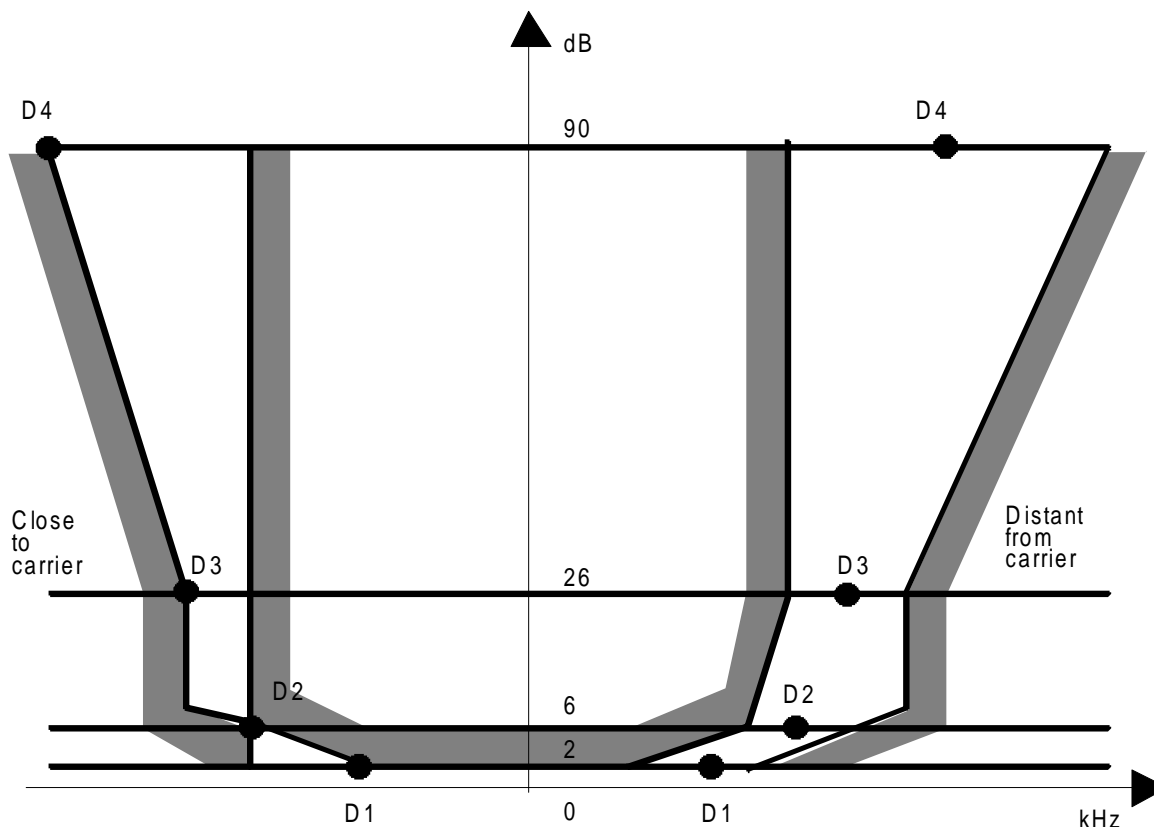

Figure B.1: Limits of the selectivity characteristic

The selectivity characteristic shall keep the following frequency separations from the nominal centre frequency of the adjacent channel:

Table B.1: Selectivity characteristic

Frequency separation of filter curve from nominal centre frequency of adjacent channel (kHz)			
D1	D2	D3	D4
2,5	3,5	4	5,8

The attenuation points shall not exceed the following tolerances:

Table B.2: Attenuation points close to carrier

Tolerance range (kHz)			
D1	D2	D3	D4
+ 1,35	± 0,1	- 1,35	- 5.35

Table B.3: Attenuation points distant from the carrier

Tolerance range (kHz)			
D1	D2	D3	D4
± 2	± 2	± 2	+ 2, - 6

The minimum attenuation of the filter outside the 90 dB attenuation points shall be equal to or greater than 90 dB.

B.1.2   Attenuation indicator

The attenuation indicator shall have a minimum range of 70 dB and a reading accuracy of 1 dB.

B.1.3   RMS value indicator

The instrument shall accurately indicate non-sinusoidal signals in a ratio of up to 10:1 between peak value and rms value.

B.1.4   Oscillator and amplifier

The crystal oscillator and the amplifier shall be designed in such a way that the measurement of the adjacent channel power of a low-noise unmodulated transmitter, whose self-noise has a negligible influence on the measurement result, yields a measured value of < - 80 dB.

History

Document history		
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