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*European Standard (Telecommunications series)*

**Electromagnetic compatibility  
and Radio spectrum Matters (ERM);  
Ultra-High Frequency (UHF) on-board vessels  
communications systems and equipment;  
Part 1: Technical characteristics and  
methods of measurement**

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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 Ultra-High Frequency (UHF) on-board vessels communications systems and equipment, as identified below:

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

Part 2: "Harmonized EN under article 3.2 of the R&TTE Directive".

<b>National transposition dates</b>	
Date of adoption of this EN:	28 September 2007
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Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 June 2008
Date of withdrawal of any conflicting National Standard (dow):	30 June 2008

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# 1 Scope

The present document specifies the minimum technical characteristics required for UHF on board vessels radio equipment and systems operating on frequencies allocated to the maritime mobile services by the ITU Radio Regulations [6].

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# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version 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.

- [1] ITU-R Recommendation M.1174-2: "Technical characteristics of equipment used for on-board vessel communications in the bands between 450 and 470 MHz".
- [2] ITU-T Recommendation O.41 (1994): "Psophometer for use on telephone-type circuits".
- [3] ISO 694: "Ships and marine technology - Positioning of magnetic compasses in ships".
- [4] ANSI C63.5 (2006): "American National Standard for Electromagnetic Compatibility - Radiated Emission Measurements in Electromagnetic Interference (EMI) Control - Calibration of Antennas (9 kHz to 40 GHz)".
- [5] ITU-R Recommendation SM.332-4: "Selectivity of receivers".
- [6] ITU Radio Regulations (2004).

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# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

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

**integral antenna:** antenna designed as a fixed part of the equipment, without the use of an external connector and as such which can not be disconnected from the equipment by the user

**modulation index:** ratio between the frequency deviation and the modulation frequency

## 3.2 Symbols

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

dBA                      acoustic level in dB relative to  $2 \times 10^{-5}$  Pa



### 3.3 Abbreviations

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

ad	amplitude difference
CSP	Channel Spacing Parameters
emf	electro-motive force
EUT	Equipment Under Test
fd	frequency difference
OATS	Open Area Test Site
PEP	Peak Envelope Power
RF	Radio Frequency
rms	root mean square
SINAD	signal + noise + distortion / noise + distortion
UHF	Ultra High Frequency
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 for use on board vessels.

For portable equipment the colour shall be neither orange nor yellow.

### 4.2 Frequencies

The equipment shall operate either on single-frequency or two-frequency simplex channels on those frequencies specified in ITU-R Recommendation M.1174-2 [1].

Single frequency simplex channels shall be in accordance with table 1.

Additional channels for 12,5 kHz equipment shall be in accordance with table 2.

Two frequency simplex channels for use with a repeater shall be in accordance with table 3.

**Table 1: Single frequency simplex channels (25 kHz or 12,5 kHz use)**

Channel designator	CSP	Frequency
Channel A	25 kHz	467,525 MHz
Channel A*	12,5 kHz	
Channel B	25 kHz	467,550 MHz
Channel B*	12,5 kHz	
Channel C	25 kHz	467,575 MHz
Channel C*	12,5 kHz	
Channel D	25 kHz	457,525 MHz
Channel D*	12,5 kHz	
Channel E	25 kHz	457,550 MHz
Channel E*	12,5 kHz	
Channel F	25 kHz	457,575 MHz
Channel F*	12,5 kHz	

**Table 2: Additional channels for 12,5 kHz equipment**

Channel designator	CSP	Frequency
Channel M*	12,5 kHz	467,5375 MHz
Channel N*	12,5 kHz	467,5625 MHz
Channel O*	12,5 kHz	457,5375 MHz
Channel P*	12,5 kHz	457,5625 MHz

**Table 3: Two-frequency simplex channels for use with repeater only**

Channel designator	CSP	Repeater Rx frequency	Repeater Tx frequency
Channel G	25 kHz	467,525 MHz	457,525 MHz
Channel G*	12,5 kHz		
Channel H	25 kHz	467,550 MHz	457,550 MHz
Channel H*	12,5 kHz		
Channel J	25 kHz	467,575 MHz	457,575 MHz
Channel J*	12,5 kHz		
Channel K*	12,5 kHz	467,5375 MHz	457,5375 MHz
Channel L*	12,5 kHz	467,5625 MHz	457,5625 MHz

Designators for 12,5 kHz channels (with the \*) means that the equipment shall show that the operation is 12,5 kHz by visual or other means.

Independent selection of transmitting and receiving frequencies shall not be possible.

The equipment shall be fitted with at least one single-frequency simplex channel, the frequency of which shall be 457,525 MHz.

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

## 4.3 Controls

The equipment shall have the following controls:

- a channel selector which shall indicate the designator of the channel to which the equipment is set;
- on/off switch for the equipment with visual indication that the equipment is switched on;
- a manual non-locking, push-to-talk switch to operate the transmitter (except for repeater equipment);
- an audio-frequency power volume control (except for repeater equipment).

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

## 4.4 Switching time

The channel switching arrangements shall be such that the time necessary to change over from using one of the channels to using any other channel does not exceed 5 seconds.

The time necessary to change over from transmission to reception and vice versa, shall not exceed 0,3 seconds.

## 4.5 Safety precautions

Provision shall be made for protecting equipment from the effects of excessive current or voltage. Means shall be incorporated to prevent reversal of polarity of the battery power supply.

Equipment with an antenna socket shall not be damaged by the effect of open-circuit or short-circuit of the antenna socket for a period of at least 5 minutes.

The manufacturer shall declare the compass safe distance according to ISO 694 [3], Method B.

## 4.6 Class of emission and modulation characteristics

The equipment shall use phase modulation, G3E (frequency modulation with a pre-emphasis of 6 dB/octave).

The equipment shall be designed to operate with a channel spacing of 25 kHz or 12,5 kHz or both.

## 4.7 Batteries for portable equipment

The battery may be an integral part of the equipment.

Primary and/or secondary batteries may be used.

Provisions shall be made for replacing the battery easily.

If the equipment is fitted with secondary batteries, a suitable battery charger shall be recommended by the manufacturer.

## 4.8 Loudspeaker and microphone

The equipment shall be provided with a microphone and a loudspeaker which may be combined (except for repeater equipment).

In the transmit condition the output of the receiver shall be muted (except for repeater equipment).

## 4.9 Labelling

All controls shall be clearly labelled. The labelling shall include:

- the name of the manufacturer and his trademark;
- the type number and serial number of the equipment; and
- the compass safe distance.

## 4.10 Equipment documentation

For the purpose of conformance testing in accordance with the present document, adequate technical and operational documentation shall be supplied with the equipment.

---

# 5 Test conditions, power sources and ambient temperatures

## 5.1 Normal and extreme test conditions

Tests shall be made under normal test conditions and also, where stated, under extreme test conditions.

## 5.2 Test power source

Unless otherwise stated, the battery of the equipment shall be replaced by a test power source capable of producing normal and extreme test voltages as specified in clauses 5.3.2 and 5.4.2.

The voltage of the power source shall be measured at the input terminal of the equipment.

During testing, the power source voltage shall be maintained within a tolerance of  $\pm 3$  % 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 limits:

- temperature: +15°C to +35°C;
- relative humidity: 20 % to 75 %.

### 5.3.2 Normal test voltage

#### 5.3.2.1 Battery power source

Where the equipment is designed to operate from a battery, the normal test voltage shall be the nominal voltage of the battery.

#### 5.3.2.2 Other power sources

For operation from other power sources the normal test voltage shall be that declared by the manufacturer.

## 5.4 Extreme test conditions

### 5.4.1 Extreme temperatures

#### 5.4.1.1 Upper extreme temperature

Tests at the upper extreme temperature shall be made at +55°C.

#### 5.4.1.2 Lower extreme temperature

Tests at the lower extreme temperature shall be made at -20°C.

### 5.4.2 Extreme test power supply values

#### 5.4.2.1 Upper extreme test voltage - Portable equipment

The upper extreme test voltage shall be declared by the manufacturer and shall not be lower than the following:

- when using primary batteries, the voltage corresponding to the voltage that a fresh battery gives at the upper extreme temperature when loaded with a load equal to that of the equipment in the muted receive condition;
- when using secondary batteries, the voltage corresponding to the voltage that a fully charged battery gives at the upper extreme temperature when loaded with a load equal to that of the equipment in the muted receive condition.

#### 5.4.2.2 Lower extreme test voltage - Portable equipment

The lower extreme test voltage shall be declared by the manufacturer and shall not be higher than the following:

- when using primary batteries, 0,85 times the voltage that a fresh battery gives at the lower extreme temperature when loaded with a load equal to that of the equipment in the muted receive condition;

- when using secondary batteries, 0,85 times the voltage that a fully charged battery gives at the lower extreme temperature when loaded with a load equal to that of the equipment in the muted receive condition.

#### 5.4.2.3 Extreme test voltages - Other equipment

For operation from other sources the extreme test voltages shall be those declared by the manufacturer.

### 5.5 Procedure for tests at extreme temperatures

The equipment shall be placed in the test chamber at normal temperature. The maximum rate of rising or reducing the temperature of the chamber shall be 1°C/minute. The equipment shall be switched off during the temperature-stabilizing periods.

Before conducting tests at extreme temperatures, the equipment in the test chamber shall have reached thermal equilibrium and be subjected to the extreme temperature for a period of 10 hours to 16 hours.

For tests at the lower extreme temperature, the equipment shall then be switched on to the standby or receive condition for one minute, after which the relevant tests shall be performed.

For tests at the higher extreme temperature, the equipment shall then be switched on in the high power transmit condition for 5 minutes followed by 5 minutes in the receive condition, after which the relevant tests shall be performed.

The temperature of the chamber shall be maintained at the extreme temperatures for the whole duration of the performance tests.

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, whichever is the longer, before the next test is carried out. Alternatively, observing the same precautions, the equipment may be returned directly to the conditions required for the start of the next tests.

---

## 6 General conditions of measurement

### 6.1 Test connections

For the purpose of testing, suitable connections to the following test points shall be made available:

- the antenna terminal for 50 Ω connection (for equipment without an external antenna connector a permanent internal or a temporary internal 50 Ω RF connector which allows access to the transmitter output and the receiver input shall be available);
- the transmitter audio input(s);
- the receiver audio output(s);
- the push-to-talk switch;
- the battery terminals for test power source connections.

### 6.2 Arrangements for test signals

#### 6.2.1 Test signals applied to the transmitter input

For the purpose of tests, the transmitter internal microphone shall be disconnected and an audio frequency signal generator shall be applied to the transmitter audio input terminals.

## 6.2.2 Test signals applied to the antenna terminal

Test signal generators shall be connected to the antenna terminal in such a way that the impedance presented to the receiver input is 50  $\Omega$ , irrespective of whether one or more test signals are applied simultaneously.

The levels of the test signals shall be expressed in terms of the electro-motive force (emf).

The effects of any intermodulation product and noise product in the test signal generators should be negligible.

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

## 6.3 Receiver mute or squelch facility

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

## 6.4 Normal test modulation

For normal test modulation, the modulation frequency shall be 1 kHz and the frequency deviation shall be:

- $\pm 3$  kHz for 25 kHz channels;
- $\pm 1,5$  kHz for 12,5 kHz channels.

## 6.5 Artificial antenna

When tests are conducted with an artificial antenna, this shall be a 50  $\Omega$  non-reactive, non-radiating load.

## 6.6 Test channels

For equipment operating in both the 457 MHz and 467 MHz bands, tests shall be carried out at the highest and lowest channels within the frequency range of the equipment, unless otherwise stated.

Where only one single channel is required for the test, then any channel available in the equipment may be used.

## 6.7 Measurement uncertainty and interpretation of the measuring results

### 6.7.1 Measurement uncertainty

**Table 4: Absolute measurement uncertainties: maximum values**

Parameter	Maximum uncertainty
RF frequency	1 x 10 <sup>-7</sup>
RF power	0,75 dB
Maximum frequency deviation:	
- within 300 Hz to 6 kHz of modulation frequency	5 %
- within 6 kHz to 25 kHz of modulation frequency	3 dB
Deviation limitation	5 %
Adjacent channel power	5 dB
Audio output power	0,5 dB
Amplitude characteristics of receiver limiter	1,5 dB
Sensitivity at 20 dB SINAD	3 dB
Two-signal measurement	4 dB
Three-signal measurement	3 dB
Conducted spurious emission of transmitter	4 dB
Conducted emission of receiver	3 dB
Radiated emission of transmitter	6 dB
Radiated emission of receiver	6 dB
Transmitter transient time	20 %
Transmitter transient frequency	250 Hz

### 6.7.2 Interpretation of the measurement results

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

- the measured value related to the corresponding limit 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 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 table 4.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with TR 100 028 (see bibliography) and shall correspond to an expansion factor (coverage factor)  $k = 1,96$  or  $k = 2$  (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Table 4 is based on such expansion factors.

---

## 7 Environmental tests

### 7.1 Procedure

Environmental tests shall be carried out before any other tests of the same equipment in respect to the other requirements of the present document are performed. The tests shall be carried out in the order they appear in the present document.

Unless otherwise stated, the equipment shall be connected to an electrical power source during the periods for which it is specified that electrical tests shall be carried out. These tests shall be performed using normal test voltage and on one channel only.

### 7.2 Performance check

For the purpose of the present document, the term "performance check" shall be taken to mean:

- for the transmitter:
  - carrier frequency:
    - with the transmitter connected to an artificial antenna (see clause 6.5), the transmitter shall be keyed without modulation. The carrier frequency shall be within  $\pm 2,3$  kHz of the nominal carrier frequency (for equipment operating with 25 kHz channel separations) or  $\pm 1,15$  kHz of the nominal carrier frequency (for equipment operating with 12,5 kHz channel separations);
  - output power:
    - with the transmitter connected to an artificial antenna (see clause 6.5), the transmitter shall be keyed without modulation. With the output power switch set at maximum, the output power shall be measured and this value recorded (Pt). For the purposes of the performance check, the output power shall be within the range of Pt  $\pm 3$  dB when measured into an artificial antenna.
- for the receiver:
  - maximum usable sensitivity:
    - a test signal at the nominal frequency of the receiver modulated with normal test modulation (see clause 6.4) shall be applied to the receiver input. The level of the input signal shall be adjusted until the SINAD at the output of the receiver is 20 dB and the output power is at least the rated output power (see clause 9.1.3). The level of the input signal shall be less than +12 dB $\mu$ V.

### 7.3 Drop test on to a hard surface - Portable equipment

#### 7.3.1 Definition

The immunity against the effects of dropping is the ability of the equipment to maintain the specified mechanical and electrical performance after being subjected to a series of drops on a hard wooden test surface.



## 7.3.2 Method of measurement

The hard wooden test surface shall consist of a piece of solid hard wood with a minimum thickness of 15 cm and a mass of 30 kg or more.

The test shall consist of a series of 6 drops, one on each surface of the equipment.

During the test the equipment shall be fitted with a suitable set of batteries and antenna but it shall be switched off. The test shall be carried out under normal temperature and humidity conditions.

The height of the lowest part of the equipment under test relative to the test surface at the moment of release shall be 1 m.

If the equipment is to be used with, for example, a separate microphone and/or loudspeaker, the test shall be carried out for those accessories separately.

Following the test, the equipment shall be subjected to a performance check.

## 7.3.3 Requirement

The requirement for the performance check shall be met.

## 7.4 Temperature tests

### 7.4.1 General

The maximum rate of raising or reducing the temperature of the chamber in which the equipment is being tested shall be 1°C/minute.

### 7.4.2 Dry heat

#### 7.4.2.1 Method of measurement

The equipment shall be placed in a chamber of normal temperature. The temperature shall then be raised to and maintained at +70°C ( $\pm 3^\circ\text{C}$ ) for a period of at least 10 hours. After this period any climatic control device provided in the equipment may be switched on and the chamber cooled to +55°C ( $\pm 3^\circ\text{C}$ ). The cooling of the chamber shall be completed within 30 minutes.

The equipment shall then be switched on and shall be kept working continuously for a period of two hours. The transmitter shall be keyed with a duty cycle of one minute transmission and four minutes reception. The equipment shall be subjected to a performance check during the two-hour period.

The temperature of the chamber shall be maintained at +55°C ( $\pm 3^\circ\text{C}$ ) during the two-hour period.

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 before the next test is carried out.

#### 7.4.2.2 Requirement

The requirement for the performance check shall be met.

## 7.4.3 Damp heat

### 7.4.3.1 Method of measurement

The equipment shall be placed in a chamber at normal room temperature and humidity which, steadily, over a period three hours ( $\pm 30$  minutes), shall be heated from room temperature to  $+40^{\circ}\text{C}$  ( $\pm 3^{\circ}\text{C}$ ) and shall during this period be brought to a relative humidity of 93 % ( $\pm 2$  %) so that excessive condensation is avoided.

30 minutes later the equipment shall be switched on, and shall then be kept working continuously for a period of two hours. The transmitter shall be keyed with a duty cycle of one minute transmission and four minutes reception.

The equipment shall be subjected to a performance check during the two-hour period.

The chamber shall be maintained at a temperature of  $+40^{\circ}\text{C} \pm 3^{\circ}\text{C}$  and a relative humidity of 93 %  $\pm 2$  % during the two-hour, 30 minutes period.

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, whichever is longer, before the next test is carried out.

### 7.4.3.2 Requirement

The requirement for the performance check shall be met.

---

## 8 Transmitter

### 8.1 Frequency error

#### 8.1.1 Definition

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

#### 8.1.2 Method of measurement

The carrier frequency shall be measured in the absence of modulation, with the transmitter connected to an artificial antenna (see clause 6.5). Measurements shall be made under normal test conditions (see clause 5.3) and under extreme test conditions (clauses 5.4.1 and 5.4.2 applied simultaneously).

#### 8.1.3 Limits

The frequency error shall not exceed:

- 2,3 kHz for 25 kHz channels;
- 1,15 kHz for 12,5 kHz channels.

### 8.2 Maximum effective radiated power

#### 8.2.1 Definition

The maximum effective radiated power of the transmitter is the maximum value of the output PEP for any condition of modulation radiated in the direction of the maximum field strength by the equipment with its antenna fitted.

## 8.2.2 Method of measurement

On a test site, selected from annex B, the equipment, with the antenna connected, shall be placed at the specified height on a non-conducting support, in the position closest to normal use as declared by the manufacturer.

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

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

The transmitter shall be switched on and the measuring receiver shall be tuned to the centre frequency of the channel on which the transmitter is intended to operate.

The test antenna shall be raised and lowered through the specified range of height until a maximum signal level is detected on the measuring receiver.

When a test site according to clause B.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 maximum signal level detected by the measuring receiver shall be noted.

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

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

The sensitivity of the measuring receiver shall be increased in accordance with the new input level (change in attenuator setting).

The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received. When a test site according to clause B.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 a level that produces the level detected by the measuring receiver, that is equal to the level noted while using the transmitter under test, corrected for the change in the attenuator setting in the measuring receiver.

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

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

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

If an output power switch is fitted it shall be placed in the maximum position.

## 8.2.3 Limit

The maximum effective radiated power shall not exceed 2 Watts.

## 8.3 Frequency deviation

### 8.3.1 Definition

The frequency deviation is the difference between the instantaneous frequency of the modulated radio frequency signal and the carrier frequency in the absence of modulation.

## 8.3.2 Maximum frequency deviation

### 8.3.2.1 Method of measurement

The frequency deviation shall be measured at the output with the transmitter connected to an artificial antenna (see clause 6.5), by means of a deviation meter capable of measuring the maximum deviation, including that due to any harmonics and intermodulation products which may be generated in the transmitter.

The modulation frequency shall be varied between 100 Hz and 3 kHz. The level of this test signal shall be 20 dB above the level which produces normal test modulation (see clause 6.4). This test shall be carried out with the output power switch set at maximum and then at minimum.

### 8.3.2.2 Limit

The maximum frequency deviation shall not exceed:

- $\pm 5$  kHz for 25 kHz channels;
- $\pm 2,5$  kHz for 12,5 kHz channels.

## 8.3.3 Frequency deviation at modulation frequencies above 3 kHz

### 8.3.3.1 Method of measurement

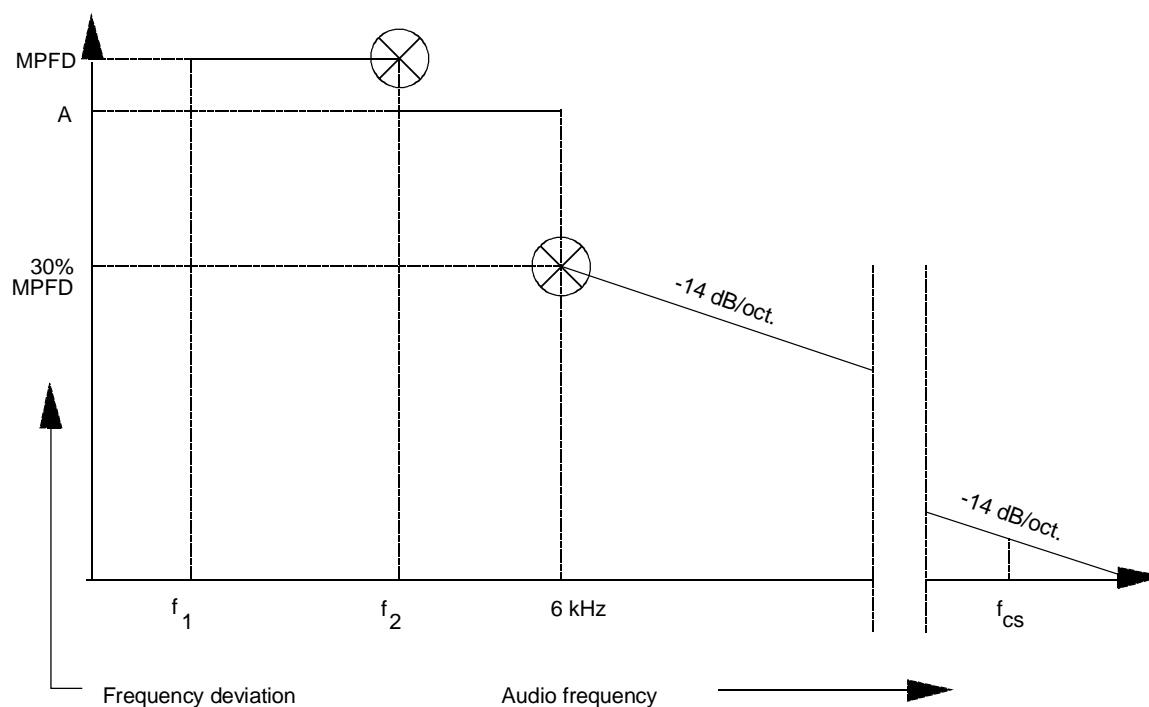
The transmitter shall operate under normal test conditions (see clause 5.3) connected to a load as specified in clause 6.5. The transmitter shall be modulated by the normal test modulation (see clause 6.4). With the input level of the modulating signal being kept constant, the modulation frequency shall be varied between 3 kHz (see note) and 25 kHz and the frequency deviation shall be measured.

NOTE: 2,55 kHz for transmitters intended for 12,5 kHz channel separation.

### 8.3.3.2 Limits

The frequency deviation at modulation frequencies between 3,0 kHz (for equipment operating with 25 kHz channel separations) or 2,55 kHz (for equipment operating with 12,5 kHz channel separation) and 6,0 kHz shall not exceed the frequency deviation at a modulation frequency of 3,0 kHz/2,55 kHz. At 6,0 kHz the deviation shall be not more than 30,0 % of the maximum permissible frequency deviation.

The frequency deviation at modulation frequencies between 6,0 kHz and a frequency equal to the channel separation for which the equipment is intended shall not exceed that given by a linear representation of the frequency deviation (dB) relative to the modulation frequency, starting at the 6,0 kHz limit and having a slope of -14,0 dB per octave. These limits are illustrated in figure 1.



## NOTE:

## Abbreviations:

- f<sub>1</sub> lowest appropriate frequency.  
 f<sub>2</sub> 3,0 kHz (for 25 kHz channel separation); or  
 2,55 kHz (for 12,5 kHz channel separation).  
 MPFD Maximum Permissible Frequency Deviation, clause 8.3.2.1.  
 A measured frequency deviation at f<sub>2</sub>.  
 f<sub>cs</sub> frequency equal to channel separation.

Figure 1: Frequency deviation

## 8.4 Limitation characteristics of the modulator

### 8.4.1 Definition

This characteristic expresses the capability of the transmitter of being modulated with a deviation approaching the maximum deviation specified in clause 8.3.2.

### 8.4.2 Method of measurement

A modulating signal at a frequency of 1 kHz shall be applied to the transmitter, and its level adjusted so that the frequency deviation is  $\pm 1$  kHz. The level of the modulating signal shall then be increased by 20 dB and the deviation shall again be measured.

### 8.4.3 Limit

The frequency deviation shall be contained between:

- $\pm 3,5$  kHz and  $\pm 5$  kHz for 25 kHz channels;
- $\pm 1,75$  kHz and  $\pm 2,5$  kHz for 12,5 kHz channels.

## 8.5 Sensitivity of the modulator, including microphone (except for repeater equipment)

### 8.5.1 Definition

This sensitivity expresses the capability of the transmitter to produce sufficient modulation when an audio frequency signal corresponding to the normal mean speech level is applied to the microphone.

### 8.5.2 Method of measurement

An acoustic signal with a frequency of 1 kHz and a sound level of 94 dBA shall be applied to the microphone. The resulting frequency deviation shall be measured.

This test shall be carried out on any one channel only (see clause 6.6).

### 8.5.3 Limit

The resulting frequency deviation shall be between:

- $\pm 1,5$  kHz and  $\pm 3$  kHz for 25 kHz channels;
- $\pm 0,75$  kHz and  $\pm 1,5$  kHz for 12,5 kHz channels.

## 8.6 Audio frequency response

### 8.6.1 Definition

The audio frequency response is the frequency deviation of the transmitter as a function of the modulating frequency.

### 8.6.2 Method of measurement

A modulating signal at a frequency of 1 kHz shall be applied to the transmitter and the deviation shall be measured at the output. The audio input level shall be adjusted so that the frequency deviation is  $\pm 1$  kHz. This is the reference point in figure 2 (1 kHz corresponds to 0 dB).

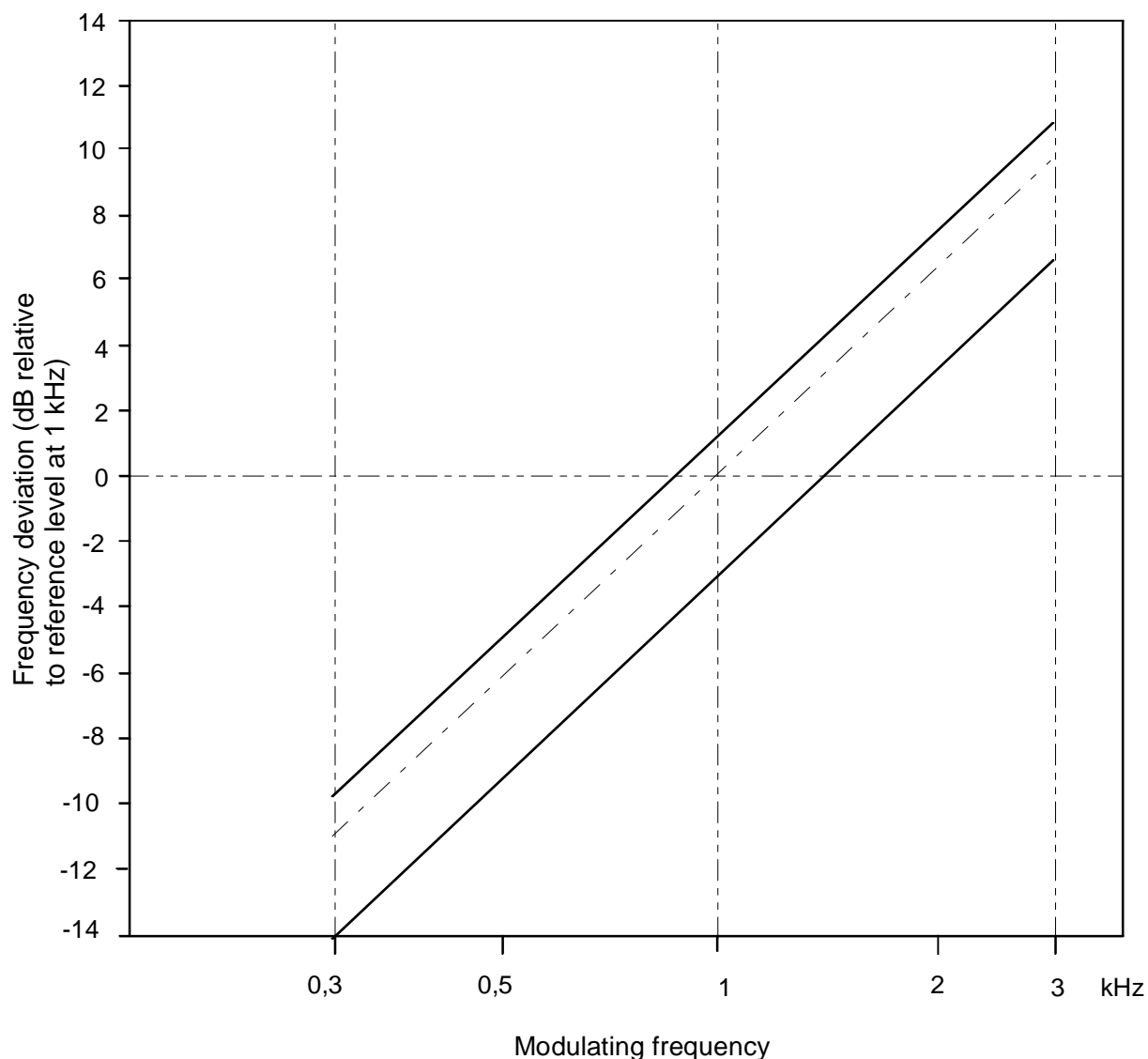
The modulation frequency shall then be varied between 300 Hz and 3 kHz (see note), with the level of the audio frequency signal being kept constant and equal to the value specified above.

The test shall be carried out on any one channel only (see clause 6.6).

NOTE: 2,55 kHz for transmitters intended for 12,5 kHz channel separation.

### 8.6.3 Limit

The audio frequency response shall be within +1 dB and -3 dB of a 6 dB/octave line passing through the reference point (see figure 2). The upper limit frequency shall be 2,55 kHz for 12,5 kHz channels.



**Figure 2: Audio frequency response**

## 8.7 Audio frequency harmonic distortion of the emission

### 8.7.1 Definition

The harmonic distortion of the emission modulated by an audio frequency signal is defined as the ratio, expressed as a percentage, of the root mean square (rms) voltage of all the harmonic components of the fundamental frequency to the total rms voltage of the signal, measured after linear demodulation.

## 8.7.2 Method of measurement

The RF signal produced by the transmitter shall be applied via an appropriate coupling device to a linear demodulator with a de-emphasis network of 6 dB per octave.

The radio frequency signal shall be modulated successively at frequencies of 300 Hz and 1 000 Hz with a constant modulation index of 3 for 25 kHz channel equipment or a constant modulation index of 1,5 for 12,5 kHz channel equipment.

The distortion of the audio frequency signal shall be measured at the frequencies specified above.

The test shall be carried out on one channel only (see clause 6.6).

## 8.7.3 Limit

The harmonic distortion shall not exceed 10 %.

## 8.8 Adjacent channel power

### 8.8.1 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.

### 8.8.2 Method of measurement

The adjacent channel power can be measured with a power measuring receiver which conforms to annex B (referred to in this clause and annex A as the "receiver") ITU-R Recommendation SM.332-4 [5]:

- a) The transmitter shall be activated under normal test conditions. If an output power switch is fitted it shall be placed in the maximum position.

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  $\Omega$  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 normal test modulation, 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 17 kHz for 25 kHz channels or 8,25 kHz for 12,5 kHz channels.
- d) The transmitter shall be modulated with 1,25 kHz at a level which is 20 dB higher than that required to produce  $\pm 3$  kHz deviation for 25 kHz channels or  $\pm 1,5$  kHz deviation for 12,5 kHz channels.
- 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.

The measurement may be made with the transmitter modulated with normal test modulation, in which case this fact shall be recorded with the test results.



### 8.8.3 Limit

The adjacent channel power shall not exceed a value of:

- 25 kHz channel: 70 dB below the carrier power of the transmitter without any need to be below 0,2  $\mu$ W.
- 12,5 kHz channel: 60 dB below the carrier power of the transmitter without any need to be below 0,2  $\mu$ W.

## 8.9 Residual modulation of the transmitter

### 8.9.1 Definition

The residual modulation of the transmitter is the ratio, in dB, of the demodulated RF signal in the absence of wanted modulation, to the demodulated RF signal produced when the normal test modulation is applied.

### 8.9.2 Method of measurement

The normal test modulation defined in clause 6.4 shall be applied to the transmitter. The high frequency signal produced by the transmitter shall be applied, via an appropriate coupling device, to a linear demodulator with a de-emphasis network of 6 dB per octave. The time constant of this de-emphasis network shall be at least 750  $\mu$ s.

Precautions shall be taken to avoid the effects of emphasizing the low audio frequencies produced by internal noise.

The signal shall be measured at the demodulator output using a rms voltmeter.

The modulation shall then be switched off and the level of the residual audio frequency signal at the output shall be measured again.

The test shall be carried out on any one channel only (see clause 6.6).

### 8.9.3 Limit

The residual modulation shall not exceed -40 dB.

## 8.10 Transient frequency behaviour of the transmitter

### 8.10.1 Definition

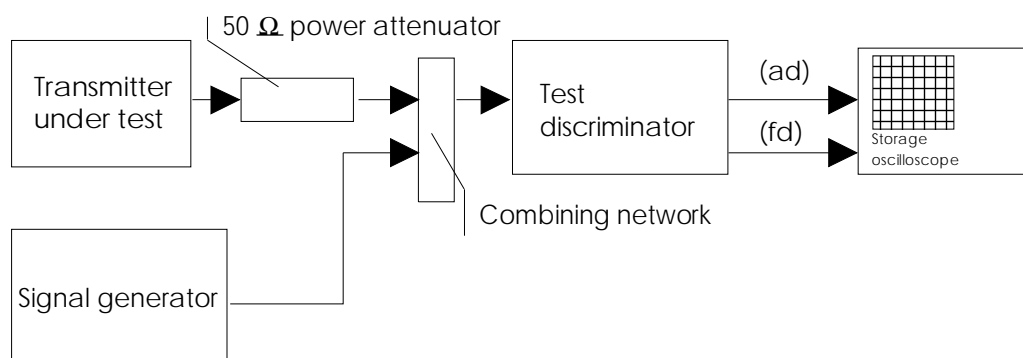
The transient frequency behaviour of the transmitter is the variation in time of the transmitter frequency difference from the nominal frequency of the transmitter when the RF output power is switched on and off.

- $t_{on}$ : according to the method of measurement described in clause 8.10.2 the switch-on instant  $t_{on}$  of a transmitter is defined by the condition when the output power, measured at the antenna port, exceeds 0,1 % of the nominal power;
- $t_1$ : period of time starting at  $t_{on}$  and finishing according to table 5;
- $t_2$ : period of time starting at the end of  $t_1$  and finishing according to table 5;
- $t_{off}$ : switch-off instant defined by the condition when the nominal power falls below 0,1 % of the nominal power;
- $t_3$ : period of time that finishing at  $t_{off}$  and starting according to table 5.

Table 5

$t_1$ (ms)	5,0
$t_2$ (ms)	20,0
$t_3$ (ms)	5,0

### 8.10.2 Method of measurement



**Figure 3: Measurement arrangement**

Two signals shall be connected to the test discriminator via a combining network (see clause 6.2.2), figure 3.

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 deviation equal to the channel spacing of the transmitter.

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 plus or minus one 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 will show the 1 kHz test signal continuously.

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

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 5 shall be used to define the appropriate template (see figure 4).

The transmitter shall remain switched on.

The storage oscilloscope shall be set to trigger on the channel corresponding to the amplitude difference (ad) input at a high input level, decaying 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  $t_{\text{off}}$ .

The period of time  $t_3$  as defined in the table shall be used to define the appropriate template (see figure 4).

The test shall be carried out on one channel only (see clause 6.6).

### 8.10.3 Limits

The results shall be recorded as frequency difference versus time.

During the periods of time  $t_1$  and  $t_2$  the frequency difference shall not exceed the values given in clause 8.10.1.

The frequency difference, after the end of  $t_2$ , shall be within the limit of the frequency error, see clause 8.1.

During the period of time  $t_3$  the frequency difference shall not exceed the values given in clause 8.10.1.

Before the start of  $t_3$  the frequency difference shall be within the limit of the frequency error, see clause 8.1.

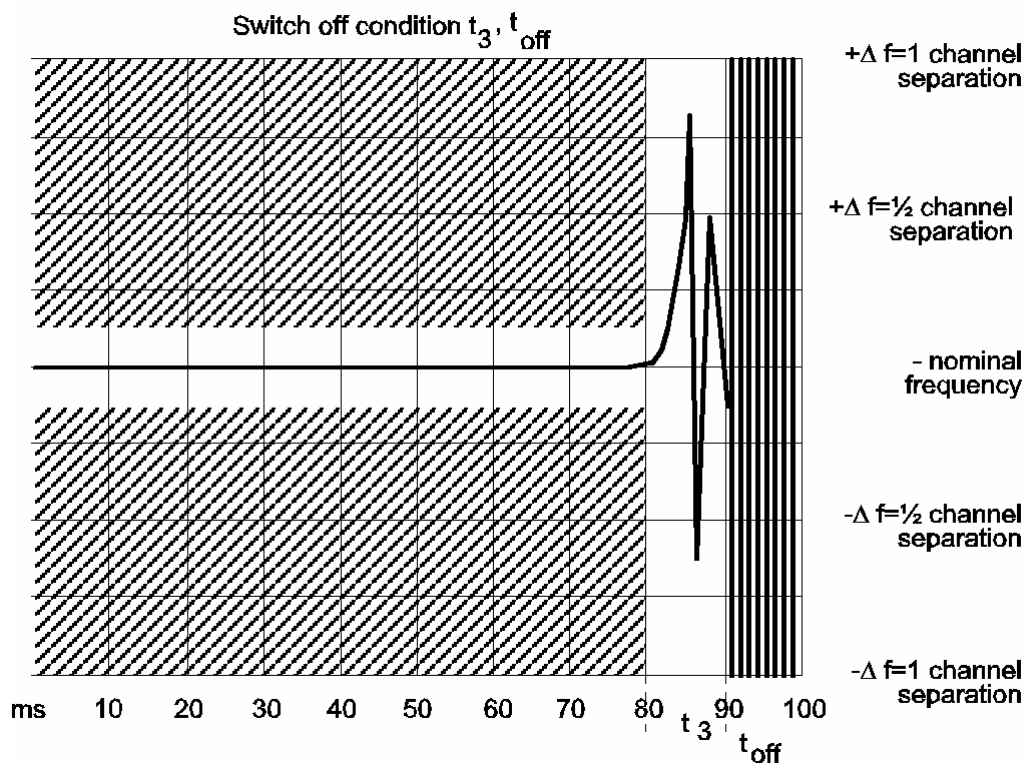
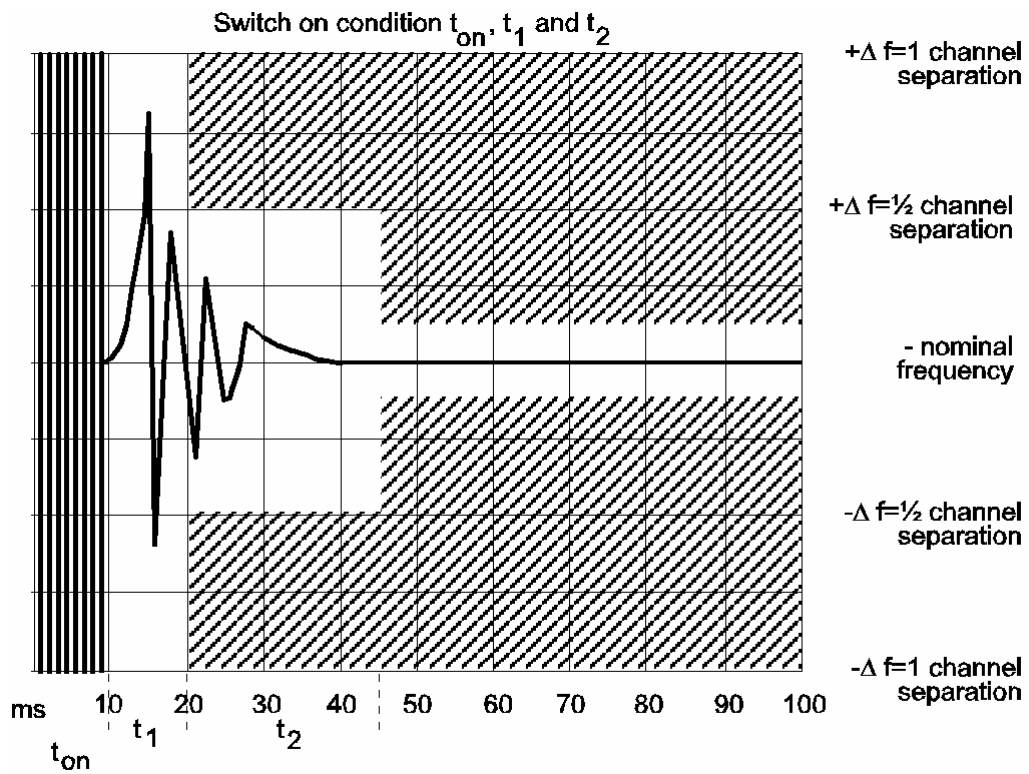


Figure 4

## 8.11 Conducted spurious emissions conveyed to the antenna

### 8.11.1 Definition

Conducted 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.

### 8.11.2 Method of measurement

Conducted spurious emissions shall be measured with the unmodulated transmitter connected to the artificial antenna (see clause 6.5).

The measurements shall be made over a range from 9 kHz to 2 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.

### 8.11.3 Limit

The power of any spurious emission on any discrete frequency shall not exceed 0,25  $\mu$ W.

## 8.12 Cabinet radiation and conducted spurious emissions other than those conveyed to the antenna

### 8.12.1 Definitions

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.

Conducted spurious emissions other than those conveyed to the antenna are emissions at frequencies, other than those of the carrier and the sideband components resulting from the wanted modulation process, which are produced by conduction in the wiring and accessories used with the equipment.

### 8.12.2 Method of measurement

On a test site, selected from annex B, the equipment shall be placed at the specified height on a non-conducting support and in a position which is closest to normal use as declared by the manufacturer.

The transmitter antenna connector shall be connected to an artificial antenna, clause 6.5.

Integral antenna equipment shall be tested with the normal antenna fitted and the carrier frequency emission shall be filtered as described in the method of measurement. 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, or a suitable broadband antenna may be used.

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

For integral antenna equipment testing, a filter shall be inserted between the test antenna and the measuring receiver. For the measurement of spurious emissions below the second harmonic of the carrier frequency the filter used shall be a high Q (notch) filter centred on the transmitter carrier frequency and attenuating this signal by at least 30 dB. For the measurement of spurious emissions at and above the second harmonic of the carrier frequency the filter used shall be a high pass filter with a stop band rejection exceeding 40 dB and the cut off frequency of this high pass filter shall be approximately 1,5 times the transmitter carrier frequency.

The transmitter shall be switched on without modulation, and the measuring receiver shall be tuned over the frequency range 30 MHz to 2 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:

- a) 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 B.1.1 is used there is no need to vary the height of the antenna);
- b) the transmitter shall be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver;
- c) the maximum signal level detected by the measuring receiver shall be noted;
- d) the transmitter shall be replaced by a substitution antenna;
- e) 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;
- f) the substitution antenna shall be connected to a calibrated signal generator;
- g) 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 heights to ensure that the maximum signal is received. (When a test site according to clause B.1.1 is used there is no need to vary the height of the antenna);
- j) 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;
- k) 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;
- l) the measurement shall also be taken with the test antenna and the substitution antenna orientated for horizontal polarization;
- m) the effective radiated power of the spurious component is the larger of the two power levels recorded for that spurious component at the input to the substitution antenna, corrected to compensate for the gain of the antenna if necessary;
- n) the measurements shall be repeated with the transmitter in stand-by mode.

### 8.12.3 Limits

With the transmitter in stand-by mode the cabinet radiation and spurious emissions shall not exceed 2 nW.

With the transmitter in operation the cabinet radiation and spurious emissions shall not exceed 0,25 µW.

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## 9 Receiver

### 9.1 Harmonic distortion and rated audio frequency output power

#### 9.1.1 Definition

The harmonic distortion at the receiver output port 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.

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

#### 9.1.2 Methods of measurement

Test signals at levels of +60 dB $\mu$ V and +100 dB $\mu$ V, at a carrier frequency equal to the nominal frequency of the receiver and modulated by the normal test modulation (see clause 6.4) shall be applied in succession to the receiver antenna port under the conditions specified in clause 6.2.2.

For each measurement, the receiver's audio frequency volume control shall be set so as to obtain, in a resistive load which simulates the receiver's operating load, the rated audio frequency output power (see clause 9.1.1). The value of this load shall be stated by the manufacturer.

Under normal test conditions (see clause 5.3) the test signal shall be modulated successively at 300 Hz, 500 Hz and 1 kHz with a constant modulation index of 3 for 25 kHz channel equipment or a constant modulation index of 1,5 for 12,5 kHz channel equipment. The harmonic distortion and audio frequency output power shall be measured at all the frequencies specified above.

Under extreme test conditions (clauses 5.4.1 and 5.4.2 applied simultaneously), the tests shall be made at the receiver's nominal frequency and at the nominal frequency  $\pm 1,5$  kHz for 25 kHz channel equipment or  $\pm 0,75$  kHz for 12,5 kHz channel equipment. For these tests, the modulation frequency shall be 1 kHz and the frequency deviation shall be  $\pm 3$  kHz for 25 kHz channel equipment or  $\pm 1,5$  kHz for 12,5 kHz channel equipment.

The test shall be carried out on one channel only (see clause 6.6).

#### 9.1.3 Limits

The rated audio frequency output power shall be at least:

- 200 mW in a loudspeaker (except for repeater equipment);
- 1 mW in the handset earphone if provided.

The harmonic distortion shall not exceed 10 %.

### 9.2 Audio frequency response

#### 9.2.1 Definition

The audio frequency response is the variation in the receiver's audio frequency output level as a function of the modulating frequency of the radio frequency signal with constant deviation applied to its input.

## 9.2.2 Method of measurement

A test signal of +60 dB $\mu$ V, at a carrier frequency equal to the nominal frequency of the receiver and modulated with normal test modulation (see clause 6.4), shall be applied to the receiver antenna port under the conditions specified in clause 6.2.2.

The receiver's audio frequency power control shall be set so as to produce a power level equal to 50 % of the rated output power (see clause 9.1). This setting shall remain unchanged during the test.

The frequency deviation shall then be reduced to 1 kHz for 25 kHz channel equipment or 500 Hz for 12,5 kHz channel equipment and the audio output is the reference point in figure 5 (1 kHz corresponds to 0 dB).

The frequency deviation shall remain constant while the modulation frequency is varied between 300 Hz and 3 kHz for 25 kHz channel equipment or 300 Hz and 2,55 kHz for 12,5 kHz channel equipment and the output level shall then be measured.

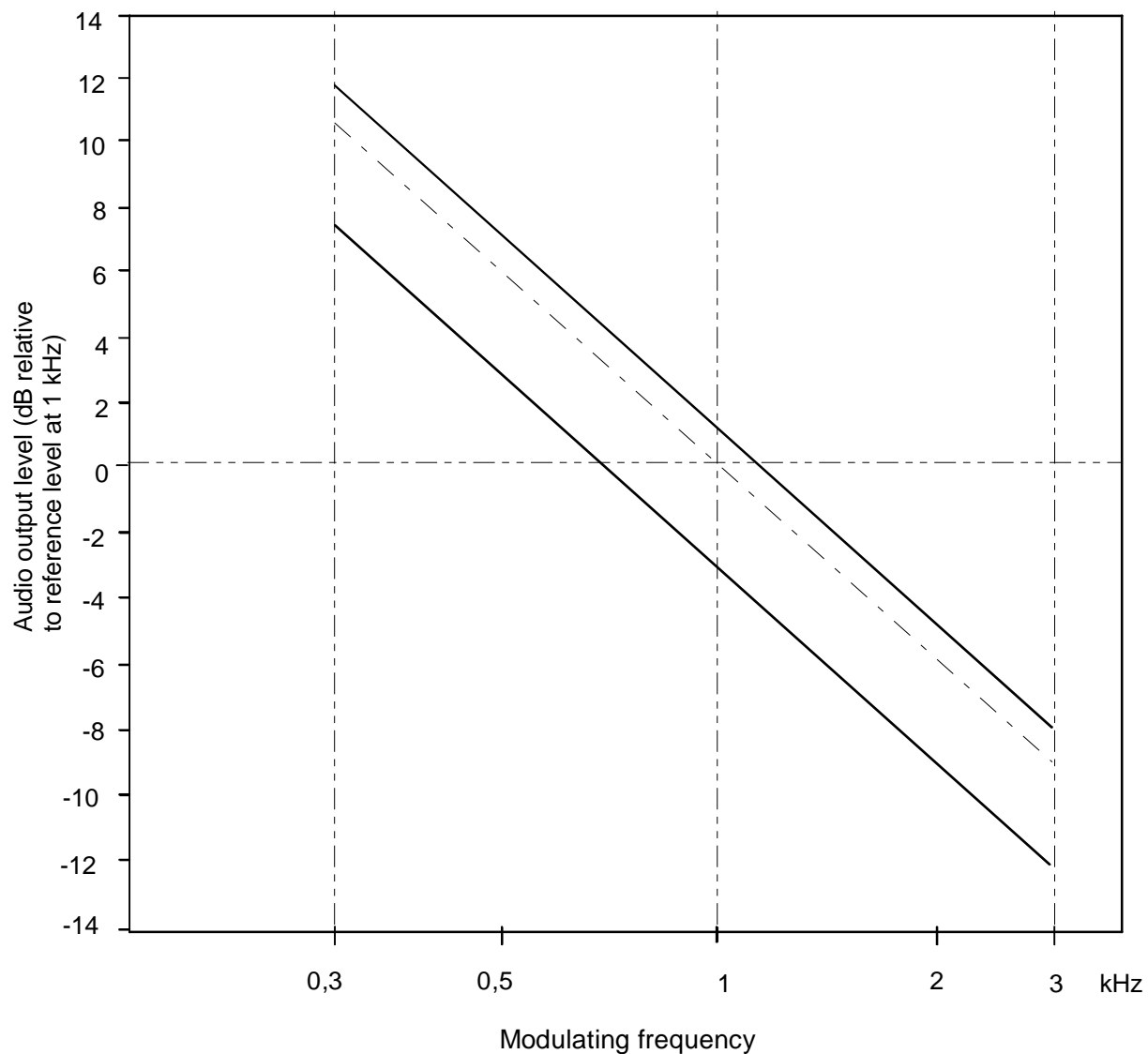
The measurement shall be repeated with a test signal at frequencies 1,5 kHz above and below the nominal frequency of the receiver for 25 kHz channel equipment or 750 Hz above and below the nominal frequency of the receiver for 12,5 kHz channel equipment.

The test shall be carried out on any one channel only (see clause 6.6).

## 9.2.3 Limits

The audio frequency response shall not deviate by more than +1 dB or -3 dB from a characteristic giving the output level as a function of the audio frequency, decreasing by 6 dB per octave and passing through the measured point at 1 kHz (see figure 5). For 12,5 kHz channels the upper frequency limit shall be 2,55 kHz.





**Figure 5: Audio frequency response**

## 9.3 Maximum usable sensitivity

### 9.3.1 Definition

The maximum usable sensitivity of the receiver is the minimum level of the signal at the nominal frequency of the receiver which, when applied to the receiver antenna port with normal test modulation (see clause 6.4), will produce:

- in all cases, an audio frequency output power equal to 50 % of the rated output power (see clause 9.1); and
- a SINAD ratio of 20 dB, measured at the receiver output port through a psophometric telephone filtering network such as described in ITU-T Recommendation O.41 [2].

## 9.3.2 Method of measurement

A test signal at a carrier frequency equal to the nominal frequency of the receiver, modulated by the normal test modulation (see clause 6.4) shall be applied to the receiver antenna port. An audio frequency load and a measuring instrument for measuring the SINAD ratio (through a psophometric network as specified in clause 9.3.1) shall be connected to the receiver output port.

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. The level of the test signal at the antenna port is the value of the maximum usable sensitivity.

The measurements shall be made under normal test conditions (see clause 5.3) and under extreme test conditions (clauses 5.4.1 and 5.4.2 applied simultaneously).

A receiver output power variation of  $\pm 3$  dB relative to 50 % of the rated output power may be allowed for sensitivity measurements under extreme test conditions.

## 9.3.3 Limits

The maximum usable sensitivity shall not exceed +6 dB $\mu$ V under normal test conditions and +12 dB $\mu$ V under extreme test conditions.

## 9.4 Co-channel rejection

### 9.4.1 Definition

The co-channel rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal, both signals being at the nominal frequency of the receiver.

### 9.4.2 Method of measurement

The two input signals shall be connected to the receiver antenna port via a combining network (see clause 6.2.2). The wanted signal shall have normal test modulation (see clause 6.4). The unwanted signal shall be modulated by 400 Hz with a deviation of 3 kHz. Both input signals shall be at the nominal frequency of the receiver under test. The measurement shall be repeated for displacements of the unwanted signal of  $\pm 3$  kHz.

For 12,5 kHz channels the frequency deviation and the displacement of the unwanted signal shall be  $\pm 1,5$  kHz.

The wanted input signal level shall be set to the value corresponding to the maximum usable sensitivity as measured in clause 9.3. The amplitude of the unwanted input signal shall then be adjusted until the SINAD ratio (psophometrically weighted) at the output port of the receiver is reduced to 14 dB.

The co-channel rejection ratio shall be expressed as the ratio in dB of the level of the unwanted signal to the level of the wanted signal at the receiver antenna port for which the specified reduction in SINAD ratio occurs.

The test shall be carried out on one channel only (see clause 6.6).

### 9.4.3 Limit

The co-channel rejection ratio, at any frequency of the unwanted signal within the specified range, shall be between:

- -10 dB and 0 dB for 25 kHz channels;
- -12 dB and 0 dB for 12,5 kHz channels.

## 9.5 Adjacent channel selectivity

### 9.5.1 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 the nominal channel spacing.

### 9.5.2 Method of measurement

The two input signals shall be applied to the receiver input via a combining network (see clause 6.2.2). The wanted signal shall be at the nominal frequency of the receiver and shall have normal test modulation (see clause 6.4). The unwanted signal shall be modulated by 400 Hz with a deviation of  $\pm 3$  kHz for 25 kHz channels or  $\pm 1,5$  kHz for 12,5 kHz channels, and shall be at the frequency of the channel immediately above that of the wanted signal.

The wanted input signal level shall be set to the value corresponding to the maximum usable sensitivity as measured in clause 9.3. The amplitude of the unwanted input signal shall then be adjusted until the SINAD ratio at the receiver output port, psophometrically weighted, is reduced to 14 dB. The measurement shall be repeated with an unwanted signal at the frequency of the channel immediately 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.

### 9.5.3 Limits

25 kHz channels: The adjacent channel selectivity shall be not less than 70 dB under normal test conditions and not less than 60 dB under extreme test conditions.

12,5 kHz channels: The adjacent channel selectivity shall be not less than 60 dB under normal test conditions and not less than 50 dB under extreme test conditions.

## 9.6 Spurious response rejection

### 9.6.1 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.

### 9.6.2 Method of measurement

Two input signals shall be applied to the receiver antenna port via a combining network (see clause 6.2.2). The wanted signal shall be at the nominal frequency of the receiver and shall be modulated with normal test modulation (see clause 6.4).

The unwanted signal shall be modulated by 400 Hz with a deviation of 3 kHz for 25 kHz channel equipment or 1,5 kHz for 12,5 kHz channel equipment.

The wanted input signal level shall be set to the value corresponding to the maximum usable sensitivity as measured in clause 9.3. The amplitude of the unwanted input signal shall be adjusted to +86 dB $\mu$ V. The frequency shall then be stepped over the frequency range from 100 kHz to 2 000 MHz in steps not larger than 5 kHz.

At any frequency at which a response is obtained, the input level shall be adjusted until the SINAD ratio, psophometrically weighted, is reduced to 14 dB.

The spurious response rejection ratio shall be expressed as the ratio in dB between the unwanted signal and the wanted signal at the receiver antenna port when the specified reduction in the SINAD ratio is obtained.

The test shall be carried out on one channel only (see clause 6.6).

### 9.6.3 Limit

At any frequency separated from the nominal frequency of the receiver by more than the nominal channel spacing, the spurious response rejection ratio shall be not less than 70 dB.

## 9.7 Intermodulation response

### 9.7.1 Definition

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

### 9.7.2 Method of measurement

Three signal generators, A, B and C shall be connected to the receiver antenna port via a combining network (see clause 6.2.2). The wanted signal, represented by signal generator A shall be at the nominal frequency of the receiver and shall have normal test modulation (see clause 6.4). The unwanted signal from signal generator B shall be unmodulated and adjusted to the frequency 50 kHz above the nominal frequency of the receiver. The second unwanted signal from signal generator C shall be modulated by 400 Hz with a deviation of 3 kHz for 25 kHz channel equipment or 1,5 kHz for 12,5 kHz channel equipment, and adjusted to a frequency 100 kHz above the nominal frequency of the receiver.

The wanted input signal shall be set to a value corresponding to the maximum usable sensitivity as measured in clause 9.3. The amplitude of the two unwanted signals shall be maintained equal and shall be adjusted until the SINAD ratio at the receiver output port, psophometrically weighted, is reduced to 14 dB. The frequency of signal generator B shall be adjusted to produce the maximum degradation of the SINAD ratio. The level of the two unwanted test signals shall be readjusted to restore the SINAD ratio of 14 dB. The intermodulation response ratio shall be expressed as the ratio in dB between the two unwanted signals and the wanted signal at the receiver antenna port, when the specified reduction in the SINAD ratio is obtained.

The measurement shall be repeated with the unwanted signal from signal generator (B) at a frequency 25 kHz above the wanted signal and with the unwanted signal from signal generator (C) at a frequency 50 kHz above the wanted signal.

The set measurements described above shall be repeated with the unwanted signals below the nominal frequency by the specified amounts.

### 9.7.3 Limit

The intermodulation response ratio shall be greater than 68 dB.

## 9.8 Blocking or desensitization

### 9.8.1 Definition

Blocking is a change (generally a reduction) in the wanted audio frequency output power of the receiver or a reduction of the SINAD ratio due to an unwanted signal on another frequency.

## 9.8.2 Method of measurement

Two input signals shall be applied to the receiver via a combining network (see clause 6.2). The modulated wanted signal shall be at the nominal frequency of the receiver and shall have normal test modulation (see clause 6.4). Initially the unwanted signal shall be switched off and the wanted signal set to the value corresponding to the measured maximum usable sensitivity (see clause 9.3).

The audio frequency output power of the wanted signal shall be adjusted, where possible, to 50 % of the rated audio frequency output power and in the case of stepped volume controls, to the first step that provides an audio frequency output power of at least 50 % of the rated audio frequency output power. The unwanted signal shall be un-modulated at frequencies of  $\pm 1$  MHz,  $\pm 2$  MHz,  $\pm 5$  MHz and  $\pm 10$  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 adjusted so that the unwanted signal causes:

- a reduction of 3 dB in the audio frequency output level of the wanted signal; or
- a reduction to 14 dB of the SINAD ratio (psophometrically weighted) at the receiver audio frequency output, whichever occurs first.

This level shall be noted.

## 9.8.3 Limit

The blocking level for any frequency within the specified ranges, shall be not less than 90 dB $\mu$ V, except at frequencies on which spurious responses are found (see clause 9.6).

## 9.9 Conducted spurious emissions conveyed to the antenna

### 9.9.1 Definition

Conducted spurious emissions are components at any frequency generated in the receiver and radiated by its antenna.

### 9.9.2 Method of measurement

Spurious radiations shall be measured as the power level of any discrete signal at the antenna port of the receiver. The receiver antenna port is connected to a spectrum analyzer or selective voltmeter having an input impedance of 50  $\Omega$  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 2 GHz.

### 9.9.3 Limit

The power of any spurious component between 9 kHz and 2 GHz shall not exceed 2 nW.

## 9.10 Radiated spurious emissions

### 9.10.1 Definition

Radiated spurious emissions from the receiver are components at any frequency radiated by the equipment cabinet and the structure.

## 9.10.2 Method of measurements

On a test site selected from annex B, the equipment shall be placed at the specified height on a non-conducting support and in a position which is closest to normal use as declared by the manufacturer.

Equipment with an antenna connector shall be connected to an artificial antenna, clause 6.5.

Integral antenna equipment shall be tested with the normal antenna fitted.

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, or a suitable broadband antenna may be used.

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

The receiver shall be switched on without modulation, and measuring receiver shall be tuned over the frequency range 30 MHz to 2 GHz.

At each frequency at which a spurious component is detected:

- a) 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 B.1.1 is used there is no need to vary the height of the antenna);
- b) the receiver shall be rotated through 360° in the horizontal plane, until the maximum signal level is detected by the measuring receiver;
- c) the maximum signal level detected by the measuring receiver shall be noted;
- d) the receiver shall be replaced by a substitution antenna;
- e) 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;
- f) the substitution antenna shall be connected to a calibrated signal generator;
- g) 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 heights to ensure that the maximum signal is received. (When a test site according to clause B.1.1 is used there is no need to vary the height of the antenna);
- j) 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;
- k) 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;
- l) the measurement shall also be taken with the test antenna and the substitution antenna orientated for horizontal polarization;
- m) the effective radiated power of the spurious component is the larger of the two power levels recorded for that spurious component at the input to the substitution antenna, corrected to compensate for the gain of the antenna if necessary.

## 9.10.3 Limit

The power of any spurious radiation shall not exceed 2 nW at any frequency in the range between 30 MHz and 2 GHz.

## Annex A (normative): Measuring receiver for adjacent channel power measurement

### A.1 Power measuring receiver specification

The power measuring receiver consists of a mixer, an IF filter, an 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 (see also ITU-R Recommendation SM.332-4 [5]).

#### A.1.1 IF filter

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

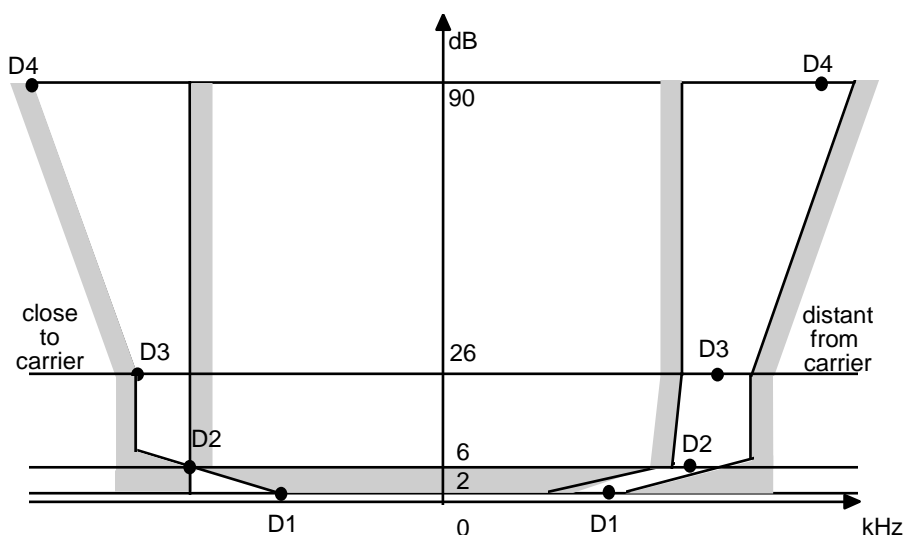


Figure A.1: IF filter characteristics

The selectivity characteristics shall keep the frequency separations shown in table A.1 from the nominal centre frequency of the adjacent channel.

Table A.1: Selectivity characteristic

Channel separation (kHz)	Frequency separation of filter curve from nominal centre frequency of adjacent channel (kHz)			
	D1	D2	D3	D4
12,5	3	4,25	5,5	9,5
25	5	8,0	9,25	13,25

The attenuation points shall not exceed following tolerances shown in table A.2.

Table A.2: Tolerance of attenuation points close to carrier

Channel separation (kHz)	Tolerance range (kHz)			
	D1	D2	D3	D4
12,5	+1,35	±0,1	-1,35	-5,35
25	+3,1	±0,1	-1,35	-5,35

**Table A.3: Tolerance of attenuation points distant from the carrier**

Channel separation (kHz)	Tolerance range (kHz)			
	D1	D2	D3	D4
12,5	±2,0	±2,0	±2,0	+2,0 -6,0
25	±3,5	±3,5	±3,5	+3,5 -7,5

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

## A.1.2 Attenuation indicator

The attenuation indicator shall have a minimum range of 80 dB and a reading accuracy of 1 dB. With a view to future regulations an attenuation of 90 dB or more is recommended.

## A.1.3 RMS value indicator

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

## A.1.4 Oscillator and amplifier

The 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 less than -90 dB.



## Annex B (normative): Radiated measurement

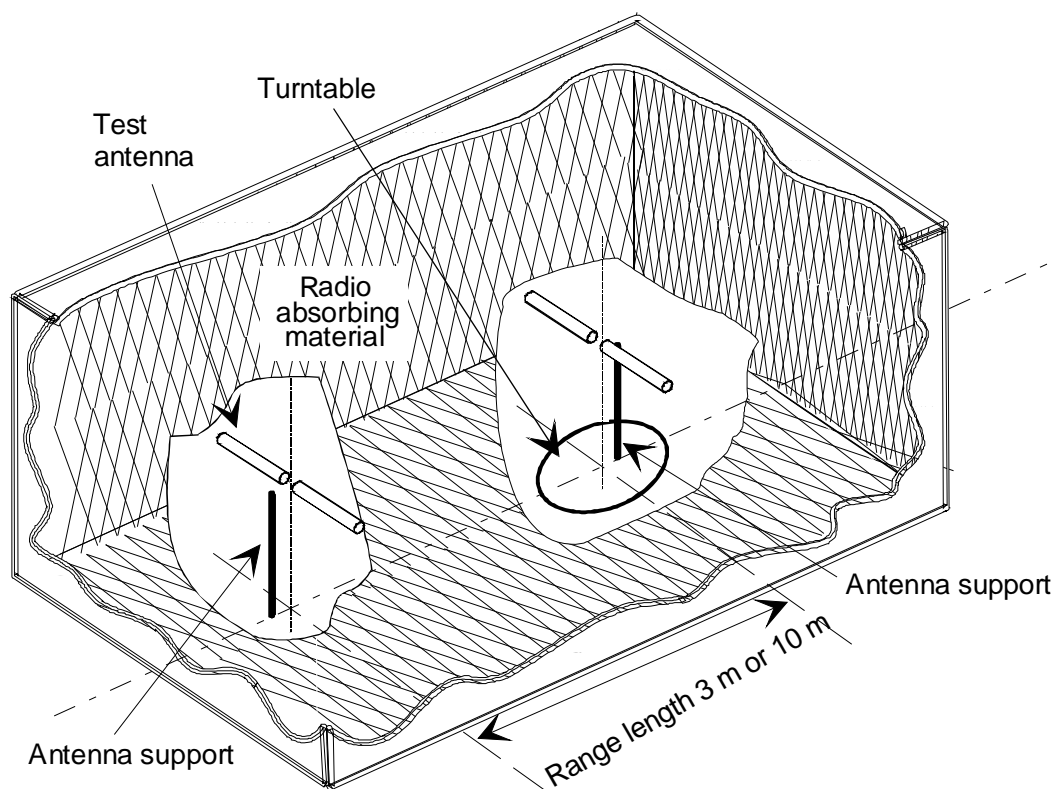
### B.1 Test sites and general arrangements for measurements involving the use of radiated fields

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 relevant parts 2, 3 and 4 (see bibliography).

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

#### B.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 B.1.



**Figure B.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 B.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.

## B.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 B.2.

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

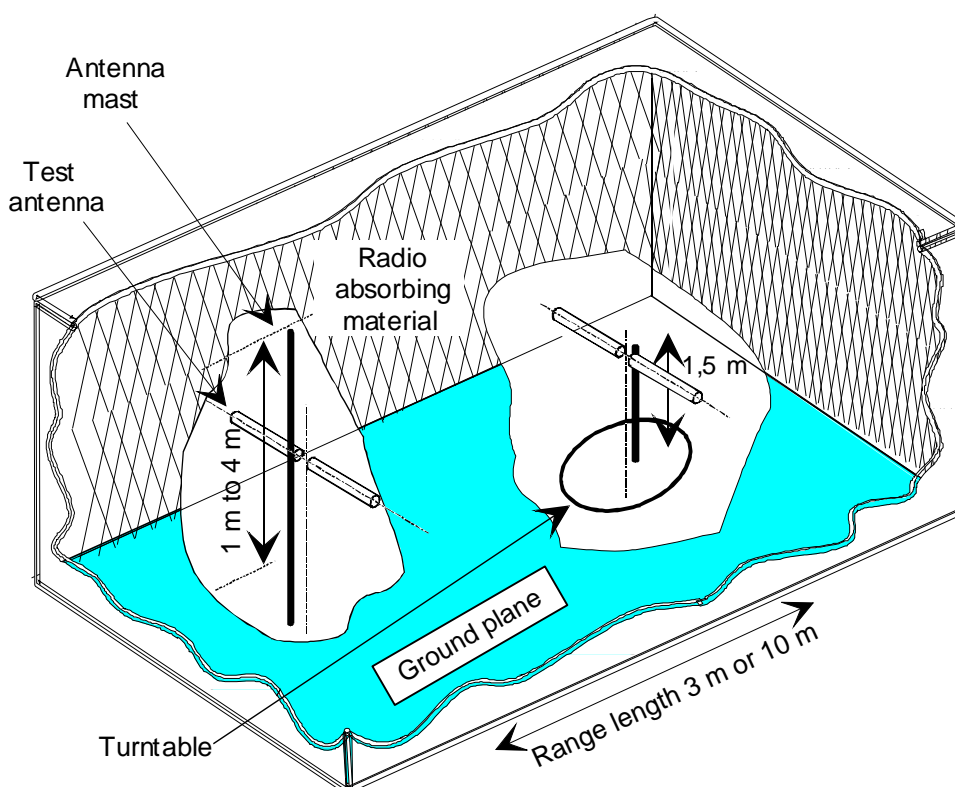


Figure B.2: A typical anechoic chamber with a ground plane

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.

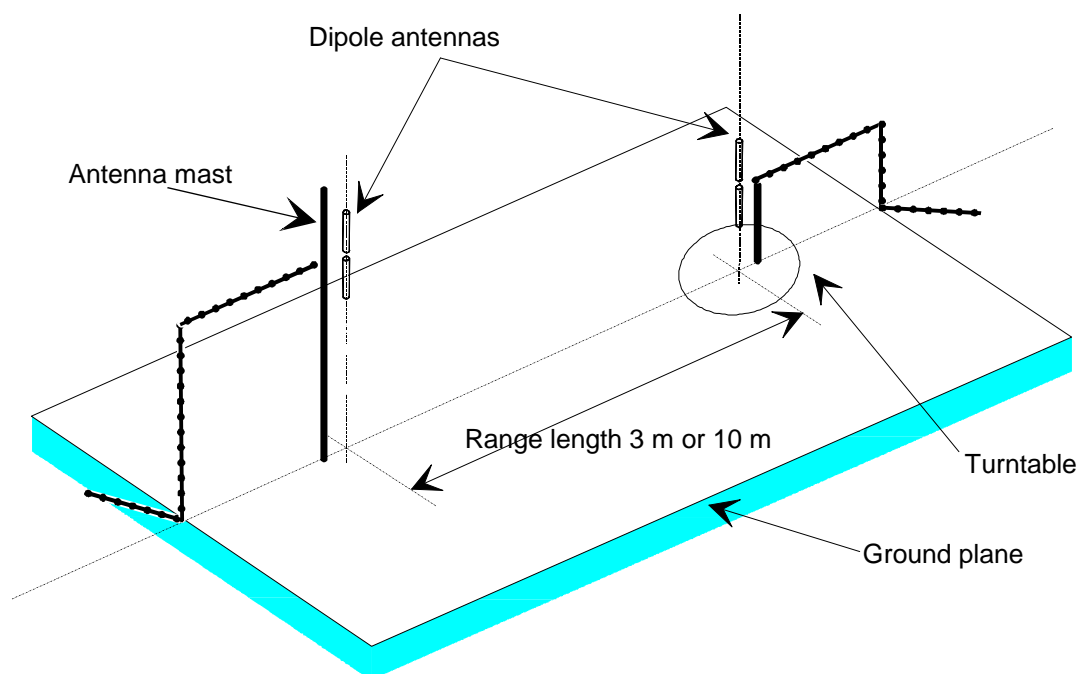
A turntable is capable of rotation through 360° in the horizontal plane and it is used to support the test sample (EUT) at a specified height, usually 1,5 m above the ground plane. The chamber shall be large enough to allow the measuring distance of at least 3 m or  $2(d_1+d_2)^2/\lambda$  (m), whichever is greater (see clause B.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.

### B.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 B.3.

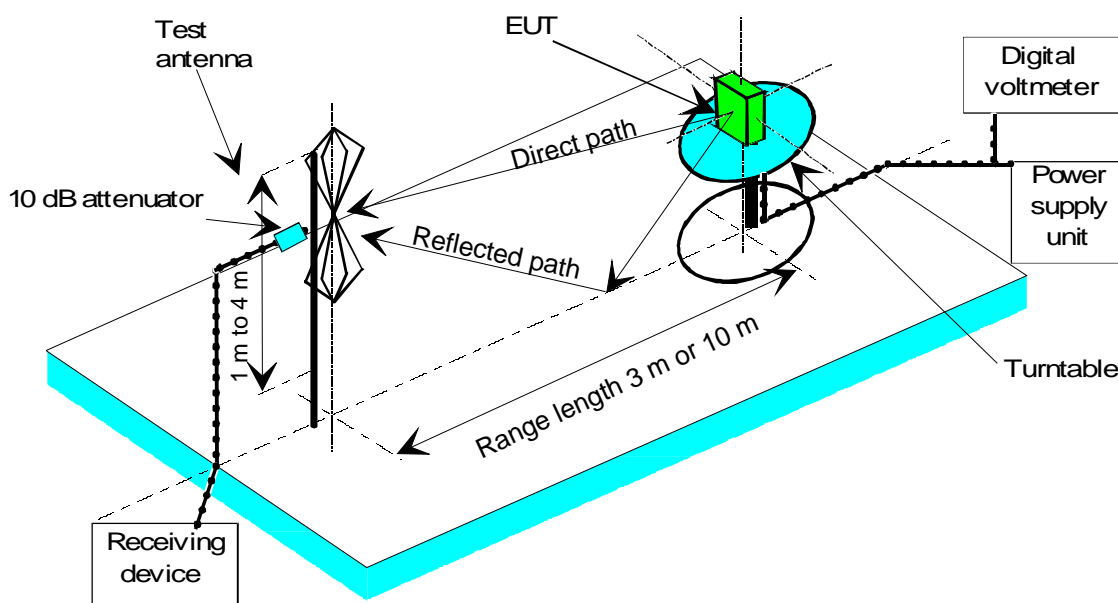


**Figure B.3: A typical OATS**

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 B.4.



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

## B.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 [4]) 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.

## B.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 [4]). 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.

## B.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 field 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 [4]). 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.

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## B.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.

### B.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 parts 2, 3 and 4, respectively (see bibliography).

### B.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, channel spacing, 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, balsa wood, etc.

### B.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.

### B.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.

## B.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);
- $\lambda$  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.

## B.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:  $\pm 0,5$  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.

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## Annex C (informative): Bibliography

- ETSI TR 100 028: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics".
- ETSI TR 102 273 (all parts) (2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Improvement on Radiated Methods of Measurement (using test site) and evaluation of the corresponding measurement uncertainties".



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## History

<b>Document history</b>		
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V1.3.2	October 2007	Publication