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Radio Equipment and Systems (RES); Land mobile service Technical characteristics and test conditions for non - speech and combined analogue speech/non-speech equipment with an internal or external antenna connector intended for the transmission of data

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New presentation - see History box

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Foreword

This Interim European Telecommunication Standard (I-ETS) has been prepared by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI). This I-ETS has been adopted having undergone the ETSI standards approvals procedure.

This I-ETS will in future be likely to be superseded or complemented by a corresponding ETS.

This standard is based upon CEPT Recommendation T/R 24-01 [1], and is complementary to ETS 300 086 [2], which covers radio equipment for use in the land mobile service and intended primarily for analogue speech.

This is a general standard which may be superseded or complemented by specific standards addressing specific applications. It applies to equipment designed to operate within the private mobile radio service and to the associated frequency planning.

This standard is voluntary in application, however, it may be made mandatory by national administrations as a part of the conditions attached to the issue of licenses for the use or sale of radio apparatus.

Additional standards or specifications may also be required for equipment such as that intended for connection to the public switched telephone network (PSTN), or data networks.

Constant envelope modulation should be used. The particular type of modulation will be chosen by the manufacturer, although it is recognized that in some countries national legislation may limit the use of certain code structures/data formats.

Channel separations, temperature range, maximum transmitter output power/effective radiated power, class of transmitter intermodulation attenuation and channel access timings may be conditions to the issue of a licence by the appropriate administration.

This standard does not cover requirements for radiated emissions below 30 MHz. It is anticipated that methods of measurements and minimum standards for such emissions will be covered by standards supporting EMC Directive 89/336/EEC.

All transmissions according to this standard should include at specified moments, an information establishing the identity of the transmitter.

The means of system identification should be approved by the appropriate national regulatory authority.

Annex A: provides additional information concerning radiated measurements.

Annex B: is normative and gives the requirements for equipment to be used for the measurement of adjacent channel power.

Annex C: is normative and gives a graphic representation of subclause 4.1.2, referring to the presentation of equipment for testing purpose.

Annex D: is informative and presents the technical characteristics to be fulfilled, when required by the appropriate national regulatory authority, for the identification of stations type approved for private mobile radio systems, that do not comply with other system protocols (e.g. trunking protocols); it is the responsibility of the manufacturer to ensure that the modulation that he has chosen for the identification, in accordance with the tables of this annex fulfils the requirements corresponding to the channels where the equipment is designed to operate, as specified in the main body of this standard. The tables of this annex are expected to be updated regularly in order to reflect the progress accomplished in the field of mobile data transmissions. It is envisaged that this annex could be normative in the future when I-ETS 300 113 will be turned, when mature, into an ETS.

Annex E: is informative and provides guidance concerning the technical characteristics of the modulation, coding and format.

Annex F: is normative, it applies to equipment to be operated in shared channels (for further details, see Clause F.1); it also contains two methods of measurement used for the assessment of receiver timing parameters. No other access protocol and occupation rules shall be made mandatory for cases where this annex is applicable.

Introduction

This standard is intended to specify the minimum performance and the methods of measurement of radio equipment for use in the land mobile service as specified in the scope.

Clause 5 provides the corresponding limits. These limits have been chosen to ensure an acceptable grade of service and to minimise harmful interference to other equipment and services. They are based on the interpretation of the measurement results in subclause 4.3.

This standard will 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 of the performance of the corresponding production model. In order to avoid any ambiguity in that assessment, this standard contains instructions for the presentation of equipment for type testing purposes, Clause 4, measurement methods, Clauses 8, 9 and 10, and conditions, Clauses 6 and 7.

This standard may also be used by monitoring services in particular for the identification of stations (see Annex D).

This standard was drafted on the assumption that:

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

- if equipment available on the market is required to be checked it should be tested in accordance with the methods specified in this standard.

This standard covers base stations, mobile stations and two categories of handportable stations. One category is fitted with an antenna socket or connector. The other category has no external antenna socket, but either:

- it is fitted with a permanent internal 50 Ω Radio Frequency (RF) connector;

- or, it can be fitted with a temporary internal 50 Ω RF connector, so that conducted measurements can be performed.

The means to access and/or implement the internal connector should be provided by the manufacturer.

Details of the means actually used during the type testing should be recorded by the accredited test laboratory in the test report (see subclause 4.2.4).

1 Scope

This Interim European Telecommunication Standard (I-ETS) covers the minimum characteristics considered necessary in order to make the best use of the available frequencies. It does not necessarily include all the characteristics which may be required by a user, nor does it necessarily represent the optimum performance achievable. It applies to constant envelope angle modulation systems for use in the land mobile service, using the available bandwidth, operating on radio frequencies between 30 MHz and 1000 MHz, with channel separations of 12,5 kHz, 20 kHz and 25 kHz intended for data transmissions. It applies to non-speech and combined analogue speech/non-speech radio equipment for the transmission of data.

It is also recognised that mobile data systems using high bit rates may have an occupied bandwidth which is excessive for the existing channel separation. Equipment for such systems operating with modulation bit rates higher than 2400 bits/s may be the subject of another standard, with different limits, although the methods of measurement may be the same.

In this standard different requirements are given for the different radio frequency bands, channel separations, etc., where appropriate.

In this standard, data transmission systems are defined as systems which transmit and/or receive data. The equipment shall comprise of a transmitter and associated encoder and modulator and/or a receiver and associated demodulator and decoder.

The types of equipment covered by this standard are as follows:

- Base Station (equipment fitted with an antenna socket, intended for use in a fixed location);
- Mobile Station (equipment fitted with an antenna socket, normally used in a vehicle or as a transportable);
- and those Handportable Stations:

  a) fitted with an antenna socket;

  or,

  b) without an external antenna socket (integral antenna equipment), but fitted with a permanent internal or a temporary internal 50 Ω RF connector which allows access to the transmitter output and the receiver input.

For the type of equipment defined in b) the following additional measurements shall be made with the equipment antenna connected (and not through any connector):

- transmitter effective radiated power;
- transmitter radiated spurious emissions;
- receiver maximum usable sensitivity (data, field strength);
- receiver radiated spurious radiations.

Handportable equipment without an external or internal R.F. connector and without the possibility of having a temporary internal 50 Ω RF connector is not covered by this standard.

In the case of combined full bandwidth analogue speech/full bandwidth non-speech equipment, if the speech part of the equipment has already been type approved according to ETS 300 086 [2], only some additional measurements have to be performed. They shall ensure that the equipment fulfils the requirements of the following subclauses:

5.1.4 (Adjacent channel power);
5.1.5 (Spurious emission);
5.1.7 (Transmitter attack time);
5.1.8 (Transmitter release time);
5.1.9 (Transient behaviour of the transmitter);
5.2.1 (Maximum usable sensitivity (data, conducted));
5.2.2 (Maximum usable sensitivity (data, field strength));
5.2.3 (Bit error rate in normal operation);
5.2.4 (Co-channel rejection);
5.2.5 (Adjacent channel selectivity);
5.2.10 (Carrier sense delay); and,
5.2.11 (Receiver opening delay).

The measurement in subclause 8.6 (Spurious emissions) shall be performed when testing an add-on data unit to an equipment previously type approved to ETS 300 086 [2]. In the case of equipment originally combined for speech and data, the measurement does not need to be performed when the data-part is operational while making the test corresponding to ETS 300 086 [2].

In the case where an equipment has already been type approved according to this standard, and is resubmitted with an add-on device, using another type of modulation, only some additional measurements have to be performed. They shall ensure that the equipment fulfils the requirements of the following subclauses:

5.1.4 (Adjacent channel power);
5.1.5 (Spurious emission);
5.2.1 (Maximum usable sensitivity (data, conducted));
5.2.2 (Maximum usable sensitivity (data, field strength));
5.2.3 (Bit error rate in normal operation);
5.2.4 (Co-channel rejection);
5.2.5 (Adjacent channel selectivity);
5.2.11 (Receiver opening delay).

In the case where low bit rate data is transmitted together with speech, the speech part of the equipment is tested according to ETS 300 086 [2], and it will also be checked that the low bit rate data does not make the adjacent channel power and spurious emissions fall outside the appropriate limits.

2 Normative references

This I-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 amendments to, or revisions of any of these publications apply to this I-ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1] CEPT Recommendation T/R 24-01: "Specifications of equipments for use in the Land Mobile Service".

[2] ETS 300 086: "Radio Equipment and Systems; Land mobile group; Technical characteristics and test conditions for radio equipment with an internal or external RF connector intended primarily for analogue speech".

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

[4] CCITT Recommendation O.153: "Basic parameters for the measurement of error performance at bit rates below the primary rate".

3 Definitions, abbreviations and symbols

3.1 Definitions

For the purpose of this standard the following definitions apply.

Base station: Equipment fitted with an antenna socket, for use with an external antenna, and intended for use in a fixed location.

Mobile station: Mobile equipment fitted with an antenna socket, for use with an external antenna, normally used in a vehicle or as a transportable station.

Handportable station: Equipment either fitted with an antenna socket or integral antenna, or both, normally used on a stand-alone basis, to be carried on a person or held in the hand.

Integral antenna: An antenna designed to be connected to the equipment without the use of a 50 Ω external connector and considered to be part of the equipment. An integral antenna may be fitted internally or externally to the equipment.

Angle modulation: Either phase modulation or frequency modulation.

Full tests: In all cases except where qualified as "limited", tests shall be performed according to this standard.

Limited tests: Receiver maximum usable sensitivity (conducted): subclause 9.1.
Receiver maximum usable sensitivity (field strength), subclause 9.2 integral antenna equipment only.
Receiver adjacent channel selectivity, subclause 9.6.
Transmitter frequency error, subclause 8.1.
Transmitter carrier power (conducted), subclause 8.2.
Transmitter effective radiated power, subclause 8.3, integral antenna equipment only.
Transmitter adjacent channel power, subclause 8.5.

Conducted measurements: Measurements which are made using direct 50 Ω connection to the equipment under test.

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

Bit: Binary digit.

Block: The smallest quantity of information that shall be sent over the radio channel. A constant number of useful bits shall always be sent together with the corresponding redundancy bits.

Packet: One block or a contiguous stream of blocks sent by one (logical) transmitter to one particular receiver or one particular group of receivers.

Burst (physical): Transmission of a small number of packets in a "stealing mode" for the access protocol (see Annex F).

Transmission (physical): One or several packets transmitted between power on and power off of a particular transmitter.

Window: A set of inter-related transmissions resulting from the action of the "initiating transmitter", and limited in time by the access protocol and corresponding occupation rules to a duration of $t_t + dt_t$.

Session: A set of inter-related exchange of packets occupying one or several windows or part thereof (if applicable). It corresponds to a complete interactive procedure for interchanging data between users, comprising initiator, data transmission and termination procedures. The session can be short (e.g. 2 packets) or long (e.g. one full page of text).

Message: User data to be transferred in one or more packets in a session.

Initiating transmitter: The initiating transmitter is the station that has completed the "observation time" (see subclause F.3.5) and therefore starts a transmission. This initiates a window and triggers the timer t_t (applicable for Annex F).

Reply: A transmission of a station as an answer to the "initiating transmitter" (applicable for Annex F). This reply can be an ACK or a NACK or a longer packet of useful information.

3.2 Abbreviations

The following abbreviations are used in this document.

SND/ND: (Signal+Noise+Distortion)/(Noise+Distortion)
IF: Intermediate Frequency
RF: Radio Frequency
Tx: Transmitter
Rx: Receiver
dBc: decibels relative to the carrier power
MSB: Most Significant Bit
emf: electro-motive force
FSK: Frequency Shift Keying
FFSK: Fast Frequency Shift Keying

3.3 Symbols

The following symbols are used in this document.

Eo: reference field strength (see Annex A)
Ro: Reference distance (see Annex A)

4 General

4.1 Presentation of equipment for testing purposes

Each equipment submitted for type testing shall fulfil the requirements of this standard on all channels over which it is intended to operate.

To simplify and harmonise the type testing procedures between the different test laboratories, measurements shall be performed, according to this standard, on samples of equipment defined in subclauses 4.1.1 to 4.1.12.

These subclauses are intended to give confidence that the requirements set out in this standard have been met without the necessity of performing measurements on all channels.

4.1.1 Choice of model for type testing

The manufacturer shall provide one or more production model(s) of the equipment, as appropriate, for type testing.

If type approval is given on the basis of tests on a preliminary model, then the corresponding production models shall be identical in all respects with the preliminary model tested.

In the case of hand portable equipment without a 50 Ω external antenna connector, see subclause 4.1.12.

4.1.2 Definitions of alignment range and switching range

The manufacturer shall, when submitting equipment for type testing, state the alignment ranges for the receiver and the transmitter.

The alignment range is defined as the frequency range over which the receiver and the transmitter can be programmed and/or realigned to operate, without any physical change of components other than programmable read only memories or crystals (for the receiver and the transmitter).

The manufacturer shall also state the switching range of the receiver and the transmitter (which may differ).

The switching range is the maximum frequency range over which the receiver or the transmitter can be operated without reprogramming or realignment.

For the purpose of all measurements, the receiver and transmitter shall be considered separately.

4.1.3 Definition of the categories of the alignment range (AR1 and AR2)

The alignment range falls into one of two categories. The first category corresponds to a limit of the alignment range, of the receiver and the transmitter, which is less than 10 % of the highest frequency of the alignment range for equipment operating on frequencies up to 500 MHz, or less than 5 % for equipment operating above 500 MHz. This category is defined as AR1.

The second category corresponds to an alignment range of the receiver and transmitter which is greater than 10 % of the highest frequency of the alignment range for equipment on frequencies up to 500 MHz, or greater than 5 % for equipment operating above 500 MHz. This category is defined as AR2.

4.1.4 Choice of frequencies

The frequencies for testing shall be chosen by the manufacturer in consultation with the appropriate authority, in accordance with subclauses 4.1.5 to 4.1.11 (see also Annex C). The manufacturer, when selecting the frequencies for testing, will ensure that the frequencies chosen are within one or more of the national bands for which type approval is required.

4.1.5 Testing of single channel equipment of category AR1

In the case of equipment of the category AR1, one sample of the equipment shall be tested.

Full tests shall be carried out on a channel within 100 kHz of the centre frequency of the alignment range.

4.1.6 Testing of single channel equipment of category AR2

In the case of equipment of the category AR2, three samples of the equipment shall be tested. Tests shall be carried out on a total of three channels.

The frequency of the channel of the first sample shall be within 100 kHz of the highest frequency of the alignment range.

The frequency of the channel of the second sample shall be within 100 kHz of the lowest frequency of the alignment range.

The frequency of the channel of the third sample shall be within 100 kHz of the centre frequency of the alignment range.

Full tests shall be carried out on all three channels.

4.1.7 Testing of two channel equipment of category AR1

In the case of equipment of category AR1, one sample of the equipment shall be tested. Tests shall be carried out on the two channels.

The frequency of the upper channel shall be within 100 kHz of the highest frequency of the switching range.

The frequency of the lower channel shall be within 100 kHz of the lowest frequency of the switching range. In addition the average of the frequencies of the two channels shall be within 100 kHz of the centre frequency of the alignment range.

Full tests shall be carried out on the upper channel and limited tests on the lower channel.

4.1.8 Testing of two channel equipment of category AR2

In the case of equipment of the category AR2, three samples of the equipment shall be tested. Tests shall be carried out on a total of four channels.

The highest frequency of the switching range of one sample shall be within 100 kHz of the centre frequency of the alignment range. The frequency of the upper channel shall be within 100 kHz of the highest frequency of the switching range and the frequency of the lower channel shall be within 100 kHz of the lowest frequency of the switching range.

Full tests shall be carried out on the upper channel and limited tests on the lower channel.

The frequency of one of the channels of the second sample shall be within 100 kHz of the highest frequency of the alignment range.

Full tests shall be carried out on this channel.

The frequency of one of the channels of the third sample shall be within 100 kHz of the lowest frequency of the alignment range.

Full tests shall be carried out on this channel.

4.1.9 Testing of multi channel equipment (more than two channels) of category AR1

In the case of equipment of the category AR1, one sample of the equipment shall be tested.

The centre frequency of the switching range of the sample shall correspond to the centre frequency of the alignment range.

Full tests shall be carried out on a frequency within 100 kHz of the centre frequency of the switching range. Limited tests shall be carried out within 100 kHz of the lowest and also within 100 kHz of the highest frequency of the switching range.

4.1.10 Testing of multi channel equipment (more than two channels) of category AR2 (switching range less than the alignment range)

In the case of equipment of the category AR2, three samples of the equipment shall be tested. Tests shall be carried out on a total of five channels.

The centre frequency of the switching range of one sample shall be within 100 kHz of the centre frequency of the alignment range. The frequency of the upper channel shall be within 100 kHz of the highest frequency of the switching range and the frequency of the lower channel shall be within 100 kHz of the lowest frequency of the switching range.

Full tests shall be carried out on the centre channel and limited tests on the upper and lower channel.

The frequency of one of the channels of the second sample shall be within 100 kHz of the highest frequency of the alignment range.

Full tests shall be carried out on this channel.

The frequency of one of the channels of the third sample shall be within 100 kHz of the lowest frequency of the alignment range.

Full tests shall be carried out on this channel.

4.1.11 Testing of multi channel equipment (more than two channels) of category AR2 (switching range equals the alignment range)

In the case of equipment of the category AR2, one sample of the equipment shall be tested.

The centre frequency of the switching range of the sample shall correspond to the centre frequency of the alignment range.

Full tests shall be carried out on a frequency within 100 kHz of the centre frequency of the switching range and within 100 kHz of the lowest and also within 100 kHz of the highest frequency of the switching range.

4.1.12 Testing of equipment without an external 50 Ω RF connector

4.1.12.1 Equipment with an internal permanent or temporary antenna connector

The means to access and/or implement the internal permanent or temporary antenna connector shall be stated by the manufacturer with the aid of a diagram. The fact that use has been made of the internal antenna connection to facilitate measurements shall be recorded in the test report.

4.1.12.2 Equipment with a temporary antenna connector

The manufacturer, or his representative, may submit one set of equipment with the normal antenna connected, to enable the radiated measurements to be made. He shall attend the test laboratory at conclusion of the radiated measurements, to disconnect the antenna and fit the temporary connector.

The test laboratory staff shall not connect or disconnect any temporary antenna connector.

Alternatively the manufacturer, or his representative, may submit two sets of equipment to the test laboratory, one fitted with a temporary antenna connector with the antenna disconnected and the other with the antenna connected. Each equipment shall be used for the appropriate tests.

4.2 Mechanical and electrical design

4.2.1 General

The equipment submitted for type testing by the manufacturer or his representative, shall be designed, constructed and manufactured in accordance with sound engineering practice, and with the aim to minimise harmful interference to other equipment and services.

4.2.2 Controls

Those controls which if maladjusted might increase the interfering potentialities of the equipment shall not be accessible to the user.

4.2.3 Marking

The equipment shall be marked in a visible place. This marking shall be legible, tamperproof and durable.

The marking shall include:

- the name of the manufacturer or his trade mark;
- type number of designation and serial number;
- type approval number (when allocated by the appropriate authorities).

4.2.4 Interpretation of the measurement results

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

a) the measured value related to the corresponding limit will be used to decide whether an equipment meets the minimum requirements of this standard;

b) the actual measurement uncertainty of the test laboratory carrying out the measurement, for each particular measurement, shall be included in the test report;

c) the values of the actual measurement uncertainty shall be, for each measurement, equal to or lower than the figures given in Clause 11 (absolute measurement uncertainties).

NOTE: This procedure for using maximum acceptable uncertainty values is valid until superseded by other appropriate ETSI publications covering this subject.

The use of the measured value has been chosen because there is no definitive standard allowing for the measurement uncertainty agreed at the time of publication of this standard. Therefore the measurement uncertainty shall be used to assess the quality of the actual measurement. The measurement uncertainty values can also be used by accreditation authorities during their accreditation procedures to ensure compliance/conformity with the requirements of type testing to ETSI standards.

5 Technical characteristics

The definitions of the parameters specified in this clause can be found in Clauses 8, 9 and 10.

5.1 Transmitter parameter limits

5.1.1 Frequency error

For the definition and the measuring method see subclause 8.1.

The frequency error shall not exceed the values given in table 1, under normal and extreme test conditions, or in any intermediate set of conditions. However, for practical reasons the measurement will be performed only at nominal and extreme test conditions as defined in subclause 8.1.

Table 1

Channel separation (kHz)	Frequency error limits (kHz)				
	Below 47 MHz	47 to 137 MHz	above 137 to 300 MHz	above 300 to 500 MHz	above 500 to 1000 MHz
20 and 25	±0,60	±1,35	±2,00	±2,00	±2,50(a)
12,5	±0,60	±1,00	±1,00(B) ±1,50(M)	±1,00(B) ±1,50(a,M)	no value specified

Note: B = base station

M = mobile or handportable station

(a) = For handportable equipments having integral power supplies, the frequency error given shall not be exceeded over a temperature range of 0 °C to +30 °C. Under extreme temperature conditions (see subclause 6.4.1) the frequency error shall not exceed:

±2,50 kHz for a channel separation of 12,5 kHz between 300 and 500 MHz;

±3,00 kHz for a channel separation of 20 and 25 kHz between 500 and 1000 MHz.

5.1.2 Carrier power (conducted)

For the definition and the measuring method see subclause 8.2.

The carrier power (conducted) under the specified conditions of measurement (see subclause 8.2.2) and at normal test conditions, shall be within ±1,5 dB of the rated carrier power (conducted).

Furthermore, the carrier output power (conducted) shall not exceed the maximum value allowed by the appropriate regulatory authority.

The carrier power (conducted) under extreme test conditions shall be within +2,0 dB and -3,0 dB of the rated output power.

5.1.3 Effective radiated power

This measurement applies only to equipment without a 50 Ω external antenna connector. For the definition and the measuring method see subclause 8.3.

The effective radiated power under normal test conditions shall be within ±7,5 dB of the rated effective radiated power.

Furthermore, the effective radiated power shall not exceed the maximum value allowed by the appropriate regulatory authority.

The measurement shall be carried out under normal test conditions only.

5.1.4 Adjacent channel power

For the definition and the measuring method see subclause 8.5.

For channel separations of 20 kHz and 25 kHz, the adjacent channel power shall not exceed a value of 70,0 dB below the carrier power (conducted) of the transmitter without any need to be below 0,2 µW. For a channel separation of 12,5 kHz, the adjacent channel power shall not exceed a value of 60,0 dB below the transmitter carrier power (conducted) without the need to be below 0,2 µW.

5.1.5 Spurious emissions

For the definition and the measuring method see subclause 8.6.

The power of any spurious emission shall not exceed the values given in tables 2 and 3.

Table 2: Conducted emissions

Frequency range	9 kHz to 1 GHz	above 1 GHz to 4 GHz, or above 1 GHz to 12,75 GHz (see subclause 8.6.2)
Tx operating	0,25 µW	1,00 µW
Tx standby	2,00 nW	20,0 nW

Table 3: Radiated emissions

Frequency range	30 MHz to 1 GHz	above 1 GHz to 4 GHz
Tx operating	0,25 µW	1,00 µW
Tx standby	2,0 nW	20,0 nW

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

- for equipment with an internal integral antenna, the normal antenna shall remain connected;
- for equipment with an external antenna socket, an artificial load shall be connected to the socket for the test.

5.1.6 Intermodulation attenuation

This requirement applies only to transmitters to be used in base stations. For the definition and the measuring method see subclause 8.7.

Two classes of transmitter intermodulation attenuation are defined, the equipment shall fulfil one of the requirements:

- in general the intermodulation attenuation ratio shall be at least 40,0 dB for any intermodulation component;

- for base station equipment to be used in special service conditions (e.g. at sites where more than one transmitter will be in service) or when the regulatory authority makes it a condition of the licence, the intermodulation attenuation ratio shall be at least 70,0 dB for any intermodulation component. In the case where the performance is achieved by additional internal or external isolating devices (such as circulators) they shall be supplied at the time of type testing and shall be used for the measurements.

5.1.7 Transmitter attack time

For the definition and the measuring method see subclause 8.8 and figures 2 and 3.

The transmitter attack time shall not exceed 25 ms ($t_{am} \leq t_{al}$).

5.1.8 Transmitter release time

For the definition and the measuring method see subclause 8.9 and figure 4.

The transmitter release time shall not exceed 20 ms ($t_{rm} \leq t_{rl}$).

5.1.9 Transient behaviour of the transmitter

For the definition and the measuring method see subclause 8.10 and figures 2, 3 and 4.

The plots of carrier power (conducted) and carrier frequency as a function of time, covering in an appropriate way the transients, shall be included in the test report.

At any time when the carrier power is above P_c - 30 dB, the carrier frequency shall remain within half a channel separation (df_c) from the steady carrier frequency (F_c).

The slopes of the plots "power as a function of frequency" corresponding to both attack and release times, shall be such that:

- $t_p \geq$ 0,20 ms and $t_d \geq$ 0,20 ms, for attack and release time;

- between the P_c- 30 dB point and the P_c- 6 dB point, both in the case of attack and release time, the sign of the slope shall not change. The transient power, in the adjacent channels shall not exceed:

  - 60,0 dB below the carrier power (conducted) of the transmitter in decibels relative to the carrier power (dBc), for channel separations of 20 and 25 kHz;

  - 50,0 dB below the carrier power (conducted) of the transmitter (in dBc), for a channel separation of 12,5 kHz.

5.2 Receiver parameter limits

5.2.1 Maximum usable sensitivity (data, conducted)

For the definition and the measuring method see subclause 9.1.

The maximum usable sensitivity shall not exceed an electro-motive force (emf) of + 3,0 dB µV under normal test conditions, and an emf of + 9,0 dB µV under extreme test conditions.

5.2.2 Maximum usable sensitivity (data, field strength)

This measurement applies only to equipment without a 50 Ω external antenna connector.

For the definition and the measurement method see subclause 9.2.

The maximum usable sensitivity shall not exceed the field strength values shown in table 4.

Table 4

Frequency band MHz	Field strength in dB relative to 1µV/m (Normal test conditions)
30 to 100	11,0
100 to 230	17,0
230 to 470	23,0
470 to 1000	29,0

5.2.3 Bit error rate in normal operation

Performance without the presence of noise.

For the definition and the measuring method see subclause 9.4

The number of errors within a period of 3 minutes shall be 0 or 1.

5.2.4 Co-channel rejection

For the definition and the measuring method see subclause 9.5.

The value of the co-channel rejection ratio, expressed in dB, at the signal displacements given in the method of measurement, shall be:

- between - 8,0 dB and 0 dB, for channel separations of 20 kHz and 25 kHz;
- between -12,0 dB and 0 dB, for channel separations of 12,5 kHz.

Any positive value is also acceptable.

5.2.5 Adjacent channel selectivity

For the definition and the measuring method see subclause 9.6.

The adjacent channel selectivity for different channel separations shall not be less than the values given in table 5.

Table 5

	Channel separations 12,5 kHz	20/25 kHz
normal test conditions	60,0 dB	70,0 dB
extreme test conditions	50,0 dB	60,0 dB

5.2.6 Spurious response rejection

For the definition and the measuring method see subclause 9.7.

At any frequency separated from the nominal frequency of the receiver by more than one channel separation, the spurious response rejection shall not be less than 70,0 dB.

5.2.7 Intermodulation response

For the definition and the measuring method see subclause 9.8.

The intermodulation response ratio shall not be less than 70,0 dB for base station equipment and 65 dB for mobile and handportable equipment.

5.2.8 Blocking or desensitisation

For the definition and the measuring method see subclause 9.9.

The blocking ratio for any frequency within the specified ranges shall not be less than 84,0 dB, except at frequencies on which spurious responses are found (see subclause 9.7).

5.2.9 Spurious radiations

For the definition and the measuring method see subclause 9.10.

The power of any spurious radiation shall not exceed the values given in tables 6 and 7.

Table 6: Conducted components

Frequency range	9 kHz to 1 GHz	above 1 GHz to 4 GHz, or above 1 GHz to 12,75 GHz (see subclause 9.10.2)
Limit	2,0 nW	20,0 nW

Table 7: Radiated components

Frequency range	30 MHz to 1 GHz	above 1 GHz to 4 GHz
Limit	2,0 nW	20,0 nW

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

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

5.2.10 Carrier sense delay

The measurement of the carrier sense delay is only required for equipment using the access protocol and occupation rules described in Annex F.

For the definition and the measuring method see subclause F.5.1.

The carrier sense delay shall be less than or equal to 10 ms.

5.2.11 Receiver opening delay

The measurement of the receiver opening delay is only required for equipment using the access protocol and occupation rules described in Annex F.

For the definition and the measuring method see subclause F.5.2.

The delay between the application of the test signal and the start of the modulation shall have a nominal value of 10 ms and shall not exceed 15 ms.

The resulting number of bit errors shall be 0 or 1 in the case of the pseudorandom bit sequence.

All three transmissions shall be correctly received in the case of the coded messages.

5.3 Duplex operation - receiver limits

5.3.1 Receiver desensitisation and maximum usable sensitivity (with simultaneous transmission and reception)

For the definition and the measuring method see subclause 10.1.

The desensitisation shall not exceed 3,0 dB and the limit of maximum usable sensitivity under normal test conditions shall be met (see subclause 5.2.1).

5.3.2 Receiver spurious response rejection

For the definition and the measuring method see subclause 10.2.

At any frequency separated from the nominal frequency of the receiver by more than two channels, the spurious response rejection ratio shall be greater than 67,0 dB.

6 Test conditions, power sources and ambient temperatures

6.1 Normal and extreme test conditions

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

The test conditions and procedures shall be as specified in subclauses 6.2 to 6.5.

6.2 Test power source

During type testing the power source of the equipment shall be replaced by a test power source, capable of producing normal and extreme test voltages as specified in subclauses 6.3.2 and 6.4.2. 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 tests, the voltage of the power source shall be measured at the input terminals of the equipment.

If the equipment is provided with a permanently connected power cable, the test voltage shall be that measured at the point of connection of the power cable to the equipment.

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

During tests the power source voltages shall be maintained within a tolerance ±1 % relative to the voltage at the beginning of each test. The value of this tolerance is critical for power measurements. Using a smaller tolerance will provide a better uncertainty value for these measurements.

6.3 Normal test conditions

6.3.1 Normal temperature and humidity

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

- temperature +15 °C to +35 °C;

- relative humidity 20 % to 75 %.

When it is impracticable to carry out the tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

6.3.2 Normal test power source

6.3.2.1 Mains voltage

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

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

6.3.2.2 Regulated lead-acid battery power sources used on vehicles

When the radio equipment is intended for operation from the usual types of regulated lead-acid battery power source used on vehicles, the normal test voltage shall be 1,1 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

6.3.2.3 Other power sources

For operation from other power sources or types of battery (primary or secondary), the normal test voltage shall be that declared by the equipment manufacturer.

6.4 Extreme test conditions

6.4.1 Extreme temperatures

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in subclause 6.5, at the upper and lower temperatures of one of the following ranges:

- - 25°C to +55°C;

- - 15°C to +55°C;

- - 10°C to +55°C.

For the purpose of (a) in the note attached to table 1 in subclause 5.1.1 an additional extreme temperature range of 0 °C to +30 °C shall be used.

Type-approval test reports shall state which range is used.

6.4.2 Extreme test source voltages

6.4.2.1 Mains voltage

The extreme test voltage for equipment to be connected to an AC mains source shall be the nominal mains voltage ±10 %.

6.4.2.2 Regulated lead-acid battery power sources on vehicles

When the radio equipment is intended for operation from the usual type of regulated lead-acid battery power sources used on vehicles, the extreme test voltages shall be 1,3 and 0,9 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

6.4.2.3 Power sources using other types of batteries

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

- for the Leclanché or the lithium type of battery: 0,85 times the nominal voltage of the battery;

- for the mercury type or nickel-cadmium type of battery: 0,9 times the nominal voltage of the battery.

No upper extreme test voltages apply.

6.4.2.4 Other power sources

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

6.5 Procedure for tests at extreme temperatures

Before measurements are made the equipment shall have reached thermal balance in the test chamber. The equipment shall be switched off during the temperature stabilising period.

In the case of equipment containing temperature stabilisation circuits designed to operate continuously, the temperature stabilisation circuits may be switched on for 15 minutes after thermal balance has been obtained, and the equipment shall then meet the specified requirements. For such equipment the manufacturer shall provide for the power source circuit feeding the crystal oven, to be independent of the power source for the rest of the equipment.

If the thermal balance is not checked by measurements, a temperature stabilising period of at least one hour, or such period as may be decided by the testing authority, shall be allowed. The sequence of measurements shall be chosen, and the humidity content in the test chamber shall be controlled so that excessive condensation does not occur.

6.5.1 Procedure for equipment designed for continuous operation

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

Before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on in the transmit condition for a period of half an hour after which the equipment shall meet the specified requirements.

Before tests at the lower extreme temperature the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for a period of one minute after which the equipment shall meet the specified requirements.

6.5.2 Procedure for equipment designed for intermittent operation

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

Before tests at the upper extreme temperature the equipment shall be placed in the test chamber and left until thermal balance is attained. The equipment shall then be switched on for one minute in the transmit condition, followed by four minutes in the receive condition, after which the equipment shall meet the specified requirements.

Before tests at the lower extreme temperature the equipment shall be left in the test chamber until thermal balance is attained, then switched to the standby or receive condition for one minute after which the equipment shall meet the specified requirements.

7 General conditions

7.1 Arrangements for test signals applied to the receiver input

Sources of test signals for application to the receiver input shall be connected in such a way that the impedance presented to the receiver input is 50 Ω (non-reactive, see subclause 7.6).

This requirement shall be met irrespective of whether one or more signals using a combining network are applied to the receiver simultaneously.

The levels of the test signals shall be expressed in terms of emf at the receiver input terminals (RF socket).

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

7.2 Receiver mute or squelch facility

If the receiver is equipped with a mute or squelch circuit, this shall be made inoperative for the duration of the type testing.

7.3 Normal test signal and normal test modulation

When the equipment is designed to transmit continuous bit streams (e.g. data, facsimile, image transmission, digital speech) the normal test signal shall be as follows:

- Signal M0, consisting of an infinite series of 0-bits;
- Signal M1, consisting of an infinite series of 1-bits;
- Signal M2, consisting of a pseudorandom bit sequence of at least 511 bits according to CCITT Recommendation O.153 [4];
- Signal M2', this is the same type as M2, but the pseudorandom bit sequence is independent of M2 (perhaps identical with M2 but started at another point of time);
- Signal M3, consisting of an RF signal, modulated by an audio frequency signal of 1 kHz with a deviation of 12 % of the channel separation. This signal is used as an unwanted signal.

Applying an infinite series of 0 bits or 1 bits does not normally produce the typical bandwidth. Signal M2 is designed to produce a good approximation of the typical bandwidth.

Guidance concerning technical characteristics of modulation, coding and format are given in Annex E.

If the transmission of a continuous bit stream is not possible, the normal test signal shall be trains of correctly coded bits or messages. This signal shall be that, as agreed between the manufacturer and testing authority, which produces the greatest radio frequency occupied bandwidth. Details of this test signal shall be included in the test report.

In this case, the encoder, which is associated with the transmitter, shall be capable of supplying the normal test signal. The resulting modulation is called the normal test modulation. If possible this should be continuous modulation for the duration of the measurements.

7.4 Encoder for receiver measurements

Whenever needed and in order to facilitate measurements on the receiver, an encoder for the data system shall accompany the model submitted, together with details of the normal modulation process. The encoder will be used to modulate a signal generator for use as a test signal source.

In the case of equipment unable to operate with continuous bit streams, the encoder shall be capable of operation in a repetitive mode, with intervals between each message that are not less than the reset time of the receiver.

Complete details of all codes and code format(s) used shall be given.

7.5 Transceiver data interface

Equipment that does not integrate the keyboard and display used for normal operation shall provide a V.24/V.28 interface (preferably) or other suitable interfaces.

Variation in the level of the input signals, within the specified limits for that interface, shall have no measurable influence on the characteristics of the signals on the radio path.

7.6 Impedance

In this standard the term "50 Ω" is used for a 50 Ω non-reactive impedance.

7.7 Artificial antenna

Tests shall be carried out using an artificial antenna which shall be a substantially non-reactive non-radiating load of 50 Ω connected to the antenna connector.

7.8 Tests of equipment with a duplex filter

If the equipment is provided with a built-in duplex filter or a separate associated filter, the requirements of this standard shall be met when the measurements are carried out using the antenna connector of this filter.

7.9 Facilities for access

7.9.1 Analogue access

In order to simplify the measurements in subclauses 9.2 and 9.7, temporary access to a point where the amplitude of the analogue output of the RF part can be measured should be provided, e.g. Intermediate Frequency (IF) output or the demodulated subcarrier point may be provided for the equipment to be tested. This access can be used to determine the frequency where a spurious response is expected.

7.9.2 Raw bit stream access

The raw bit stream is the stream of bits at the modulator input or the demodulator output respectively. In order to make the measurements according to Clauses 8, 9 and 10 an access to the raw bit stream (physical layer) shall be provided for the equipment to be tested.

7.9.3 Coupling arrangements

If the equipment does not have an external antenna connection, arrangements shall be made by the manufacturer to couple the unit to be tested to the test equipment by a method which does not affect the radiated field (e.g. acoustic, ultra sonic or optic) and according to subclauses 7.9.3.1 and 7.9.3.2.

7.9.3.1 Arrangements for measurements with continuous bit streams

For the measurements of the receiver on a test site, arrangements to couple the unit to be tested to the bit error ratio measuring device shall be available (see subclause 7.9.2).

Furthermore, the manufacturer can also provide another facility to give access to the analogue information (see subclause 7.9.1).

7.9.3.2 Arrangements for measurements with messages

For the measurement of the receiver on a test site, arrangements to couple the unit to be tested to the error observation device (or to an operator) shall be available.

Furthermore, the manufacturer shall also provide another facility to give access to the analogue information (see subclause 7.9.1).

7.10 Test site and general arrangements for measurements involving the use of radiated fields

For guidance see Annex A: descriptions of the radiated measurement arrangements are included in this annex.

7.11 Modes of operation of the transmitter

For the purpose of the measurements according to this standard, there should preferably be a facility to operate the transmitter unmodulated. The method of obtaining an unmodulated carrier or special types of modulation patterns may also be decided by agreement between the manufacturer and the test laboratory. It shall be described in the test report. It may involve suitable temporary internal modifications of the equipment under test. For instance in the case of direct Frequency Shift Keying (FSK), a means to continuously transmit a sequence M0 containing only "zeros" and a sequence M1 containing only "ones" is desirable.

8 Methods of measurement for transmitter parameters

8.1 Frequency error

This measurement is made if the equipment is capable of producing an unmodulated carrier. Otherwise the adjacent channel power shall also be measured under extreme test conditions and the limits given in subclause 5.1.4 shall be met.

8.1.1 Definition

The frequency error of the transmitter is the difference between the measured carrier frequency and its nominal value, selected for the test.

8.1.2 Method of measurement

The equipment shall be connected to the artificial antenna (see subclause 7.7).

The carrier frequency shall be measured in the absence of modulation. The measurement shall be made under normal test conditions (see subclause 6.3) and extreme test conditions (subclauses 6.4.1 and 6.4.2 applied simultaneously).

8.2 Carrier power (conducted)

It is assumed that the appropriate regulatory authority will state the maximum transmitter output power/effective radiated power.

If the equipment is designed to operate with different carrier powers, the rated power for each level, or range of levels, shall be declared by the manufacturer. The power adjustment control shall not be accessible to the user.

The requirements of this standard shall be met for all power levels at which the transmitter is intended to operate. For practical reasons measurements shall be performed only at the lowest and highest power level at which the transmitter is intended to operate.

8.2.1 Definitions

The transmitter carrier power (conducted) is the mean power delivered to the artificial antenna during a radio frequency cycle.

The rated output power is the carrier power (conducted) of the equipment declared by the manufacturer.

8.2.2 Method of measurement

The measurement shall be performed preferably in the absence of modulation.

When it is not possible to measure it in the absence of modulation, this fact shall be stated in the test report (see subclause 7.11).

The transmitter shall be connected to an artificial antenna (see subclause 7.7), and the power delivered to this artificial antenna shall be measured.

The measurement shall be made under normal test conditions (see subclause 6.3) and extreme test conditions (subclauses 6.4.1 and 6.4.2 applied simultaneously).

8.3 Effective radiated power (field strength)

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

8.3.1 Definition

The effective radiated power is the power radiated in the direction of the maximum field strength under specified conditions of measurements, in the absence of modulation.

The rated effective radiated power is the effective radiated power of the equipment as declared by the manufacturer.

8.3.2 Method of measurement

The measurement will be performed preferably in the absence of modulation.

When it is not possible to measure it in the absence of modulation this fact shall be stated in the test report (see subclause 7.11).

On a test site, selected from Annex A, the equipment shall be placed at the specified height on a non-conducting support, in the position closest to normal use as declared by the manufacturer. This position shall be recorded in the test report.

The test antenna shall be orientated for vertical polarisation 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 without modulation, and the measuring receiver shall be tuned to the frequency of the transmitter under test.

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 Annex A, Clause A.3 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.

This 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 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 Annex A, Clause A.3 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 polarisation.

The measure of the 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.

8.4 Maximum permissible frequency deviation

This measurement is only performed with equipment using subcarrier FSK-modulation.

It is more particularly suitable for use in the case of field measurements. No limits are given for this parameter.

8.4.1 Definition

The maximum permissible frequency deviation is the maximum value of frequency deviation stipulated in this standard for the separation between adjacent channels.

8.4.2 Method of measurement

The frequency deviation shall be measured at the output of the transmitter connected to an artificial antenna (see subclause 7.7), 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.

Two types of measurement shall be carried out:

- one with the test signal M0, producing a frequency deviation of F0;
- the other with the test signal M1, producing a frequency deviation of F1.

8.5 Adjacent channel power

8.5.1 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.

8.5.2 Method of measurement

The adjacent channel power may be measured with a power measuring receiver which conforms to Annex B (referred to in this subclause as the "receiver").

a) the transmitter shall be operated at the carrier power determined in subclause 8.2 under normal test conditions (see subclause 6.3)[1)]. 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. If an unmodulated carrier cannot be obtained, then the measurement shall be made with the transmitter modulated with the normal test signal M2, according to subclause 7.3, in which case this fact shall be recorded in the test report;

c) the frequency of the "receiver" shall be adjusted above 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 as given in table 8;

Table 8: Frequency displacement

Channel separation (kHz)	Specified necessary bandwidth (kHz)	Displacement from the -6 dB point (kHz)
12,5	8,5	8,25
20	14	13
25	16	17

d) the transmitter shall be modulated by a normal test signal M2 according to subclause 7.3;

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 the adjacent channel power to the carrier power is the difference between the attenuator settings in steps b) and e), corrected for any differences in the reading of the meter. The measurement shall be repeated with the frequency of the "receiver" adjusted below 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 as given in table 9.

1) The measurement may be made under extreme conditions (see subclause 7.1).

8.6 Spurious emissions

8.6.1 Definition

Spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with normal modulation.

The level of spurious emissions shall be measured as:

either

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

and,

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

or,

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

8.6.2 Method of measuring the power level

This method applies only to equipment having an external connector.

Spurious emissions shall be measured as the power level of any discrete signal delivered into a 50 Ω load. This may be done by connecting the transmitter output through an attenuator to a spectrum analyser[1)] or selective voltmeter, or by monitoring the relative levels of the spurious signals delivered to an artificial antenna (see subclause 7.7).

If possible, the transmitter shall be unmodulated. The measurements shall be made, for equipment operating on frequencies not exceeding 470 MHz, in the frequency range 9 kHz - 4 GHz, and for equipment operating on frequencies above 470 MHz, additionally in the frequency range 4 GHz - 12,75 GHz, except for the channel on which the transmitter is intended to operate, and its adjacent channels.

The measurement shall be repeated with the transmitter modulated by the normal test signal M2 (see subclause 7.3) [2)] . If possible the modulation should be continuous for the duration of the measurement.

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

8.6.3 Method of measuring the effective radiated power

On a test site, fulfilling the requirements of Clause A.2, the sample shall be placed at the specified height on the support. The transmitter shall be operated at the carrier power as specified under subclause 8.2, delivered to:

- an artificial antenna (see subclause 7.7) for equipment having an external antenna connector (see subclause 8.6.1, b));

- or to the integral antenna (see subclause 8.6.1, c)).

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1 See also Clause B.2.

2 The bandwidth used in this measurement for each spurious emission shall be sufficiently wide to accept all significant components of the spurious emission concerned. The conditions used in the relevant measurements shall be reported in the test report.

If possible the transmitter shall be unmodulated and the radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 30 MHz - 4 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

At each frequency at which a component is detected, the sample shall be rotated to obtain maximum response and the effective radiated power of that component determined by a substitution measurement.

The measurement shall be repeated with the transmitter modulated by the normal test signal M2 (see subclause 7.3)[1] if the measured power level of the conducted spurious emission increases by more than 6 dB when the transmitter is modulated. If possible the modulation should be continuous for the duration of the measurement.

The measurements shall be repeated with the test antenna in the orthogonal polarisation plane.

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

8.7 Intermodulation attenuation

This requirement applies only to transmitters to be used in base stations.

8.7.1 Definition

For the purpose of this standard the intermodulation attenuation is a measure of the capability of a transmitter to inhibit the generation of signals in its non-linear elements caused by the presence of the carrier and an interfering signal entering the transmitter via its antenna.

8.7.2 Method of measurement

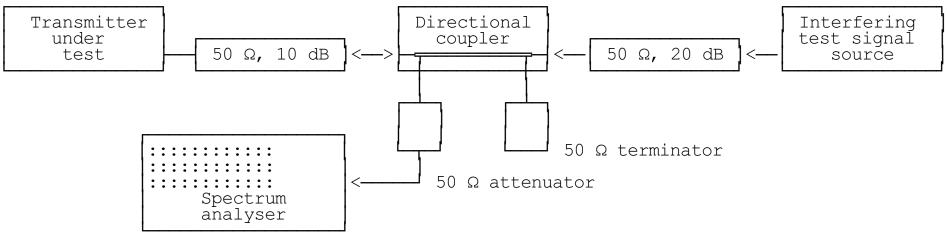

Figure 1: Measurement arrangement

The measurement arrangement shown in figure 1 shall be used.

The transmitter shall be connected to a 50 Ω 10 dB power attenuator and via a directional coupler to a spectrum analyser. An additional attenuator may be required between the directional coupler and the spectrum analyser to avoid overloading.

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 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.

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1) The bandwidth used in this measurement for each spurious emission shall be sufficiently wide to accept all significant components of the spurious emission concerned. The conditions used in the relevant measurements shall be reported in the test report.

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 50 kHz to 100 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 of the ratio of the largest third order intermodulation component with respect to the carrier.

This measurement shall be repeated with the interfering test signal source at a frequency within 50 kHz to 100 kHz **below** the frequency of the transmitter under test.

8.8 Transmitter attack time

This measurement does not apply to transmitter intended for continuous transmission only.

8.8.1 Definition

The transmitter attack time (t_a) is the time which elapses between the initiation of the "transmitter on" function (T_{xon}) and:

a) the moment when the transmitter output power has reached a level 1 dB below or 1,5 dB above the steady state power (P_c) and maintains a level within +1,5 dB / -1 dB from P_c thereafter as seen on the measuring equipment or in the power plot as a function of time;

   or,

b) the moment after which the frequency of the carrier always remains within ±1 kHz of its steady state frequency, F_c, as seen on the measuring equipment or the frequency plot as a function of time;

whichever occurs later (see subclause 8.10, figures 2 and 3).

The measured value of t_a is t_{am}; its limit is t_{al}.

The choice of conditions for b), above, is made in order to make the method of measurement easier to perform and to have good repeatability. It is expected that under these conditions, in the worse case, the frequency of the carrier will be within the frequency tolerance of the steady state, df_e, a few ms after the end of the attack time as defined in b) above.

8.8.2 Method of measurement

a) The transmitter is connected to a RF detector and to a test discriminator via a matched test load. The attenuation of the test load shall be chosen in such a way that the input of the test discriminator is protected against overload and the limiter amplifier of the test discriminator operates correctly in the limiting range as soon as the transmitter carrier power (before attenuation) exceeds 1mW. A dual trace storage oscilloscope (or a transient recorder) records the amplitude transient from the detector on a logarithmic scale and the frequency transient from the discriminator.

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 on" function is initiated. The measuring arrangement is shown in figure 5 of subclause 8.10.

A spectrum analyser and a test discriminator/storage oscilloscope can also be used.

b) The traces of the oscilloscope shall be calibrated in power and frequency (Y axes) 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 preferably unmodulated.

8.9 Transmitter release time

This measurement does not apply to transmitter intended for continuous transmission only.

8.9.1 Definition

The transmitter release time (t_r) is the time which elapses between the initiation of the "transmitter off" function (T_{xoff}) and the moment when the transmitter output power has reduced to a level 50 dB below the steady state power (P_c) and remains below this level thereafter as seen on the measuring equipment or in the power plot as a function of time (see subclause 8.10, figure 4).

The measured value of t_r is t_{rm}; its limit is t_{rl}.

8.9.2 Method of measurement

a) The transmitter is connected to a RF detector and to a test discriminator via a matched test load. The attenuation of the test load shall be chosen in such a way that the input of the test discriminator is protected against overload and the limiter amplifier of the test discriminator operates correctly in the limiting range as long as the transmitter carrier power (before attenuation) exceeds 1mW. A dual trace storage oscilloscope (or a transient recorder) records the amplitude transient from the detector on a logarithmic scale and the frequency transient from the discriminator. 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 off" function is initiated. If the transmitter possesses an automatic powering down facility (e.g. in the case of fixed length message transmission), it may replace the trigger device for starting the sweep of the oscilloscope. The measuring arrangement is shown in figure 5 of subclause 8.10.

A spectrum analyser and a test discriminator/storage oscilloscope can also be used.

b) The traces of the oscilloscope shall be calibrated in power (Y axes) and in time (X axis) by replacing the transmitter and test load by the signal generator.

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

8.10 Transient behaviour of the transmitter

Limitations of the transmitter attack and release times (see subclauses 8.8 and 8.9) are intended to improve the spectrum efficiency. The attack and release times can also be used to allow the definition of the timings in the protocols.

The measurements of transient behaviour are intended to ensure that the transmitter will not cause harmful interference in the other channels when the operating frequency is outside the tolerance of the steady state df_e.

The method of measurement includes:

- the drawing of plots of "carrier power as a function of time" and "carrier frequency as a function of time";
- the evaluation of the slopes of those plots between predetermined points;
- the measurement of the transient power in the adjacent channels.

8.10.1 Definitions

The transient behaviour of the transmitter is defined as the time-dependency of transmitter frequency, power and spectrum when the RF output power is switched on and off.

The following powers, frequencies, frequency tolerances and transient times are specified;

P_o : rated power,

P_c : steady state power,

P_a : adjacent transient channel power, is the ratio in dB of the highest peak envelope power in the adjacent channels to the steady state power,

F_o : nominal carrier frequency,

F_c : steady state carrier frequency,

df : frequency difference (relative to F_c) or frequency error (absolute) (see subclause 8.1.1), of the transmitter,

df_e : limit of the frequency error (df) in the steady state (see subclause 5.1.1),

df_0 : limit of the frequency difference (df) equal to 1 kHz. If it is impossible to switch off the transmitter modulation one half channel separation is added,

df_c : limit of the frequency difference (df) during the transient, equal to one half channel separation; while the frequency difference is less than df_c, the carrier frequency remains within the boundaries of the allocated channel. If it is impossible to switch off the transmitter modulation another half channel separation is added,

T_{xon} : time at which the final irrevocable logic decision to power on the transmitter is taken.

The power starts to rise somewhere between T_{xon} and t_{on} (RF-power on);

t_{on} : time when the carrier power, measured at the transmitter output, exceeds P_c - 30dB,

t_p : period of time starting at t_{on} and finishing when the power reaches P_c - 6dB,

t_{am} : transmitter attack time as defined in subclause 8.8,

t_{al} : limit of t_{am} as given in subclause 5.1.7,

T_{xoff} : time at which the final irrevocable logic decision to power off the transmitter is taken.

The power starts to decrease somewhere between T_{xoff} and the moment when P_c - 6dB is reached (RF-power off);

t_{off} : time when the carrier power falls below P_c - 30dB,

t_d : period of time starting when the power falls below P_c - 6dB and finishing at t_{off},

t_{rm} : transmitter release time as defined in subclause 8.9, after which the power remains below P_c - 50dB,

t_{rl} : limit of t_{rm} as given in subclause 5.1.8.

If use is made of a synthesizer and/or a PLL system, for determining the transmitter frequency, then the transmitter shall be inhibited when synchronisation is absent or in the case of PLL, when the loop system is not locked.

8.10.2 Timings, frequencies and powers

Figures 2, 3 and 4 represent the timings, frequencies and powers as defined in subclauses 8.8.1, 8.9.1 and 8.10.1.

The corresponding limits are given in subclauses 5.1.7, 5.1.8 and 5.1.9.

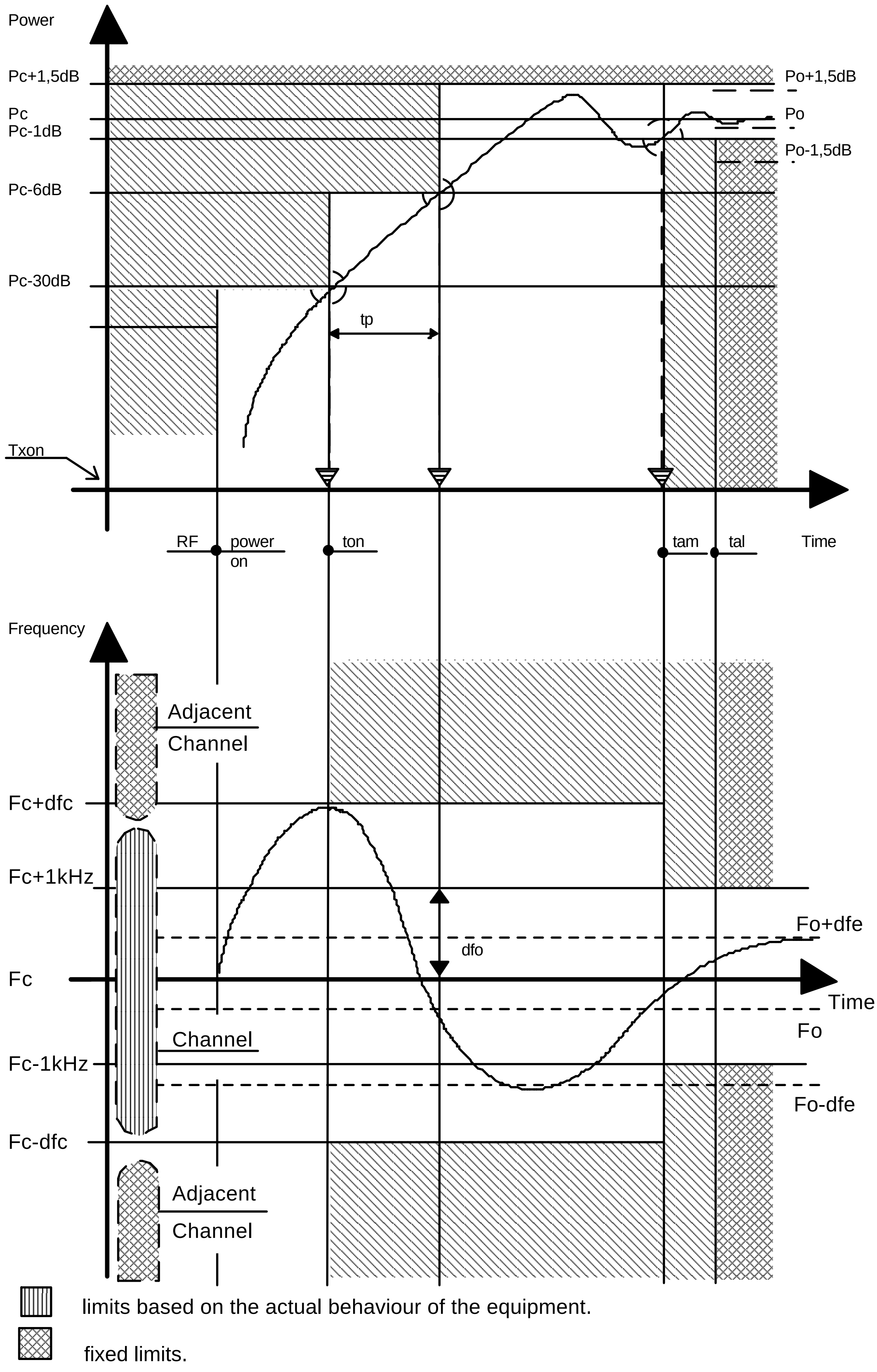


Figure 2: Transmitter attack time according to subclause 8.8 and transient behaviour during switch-on. ase where the attack time is defined by subclause 8.8.1 a), (given by the behaviour of the power rise).

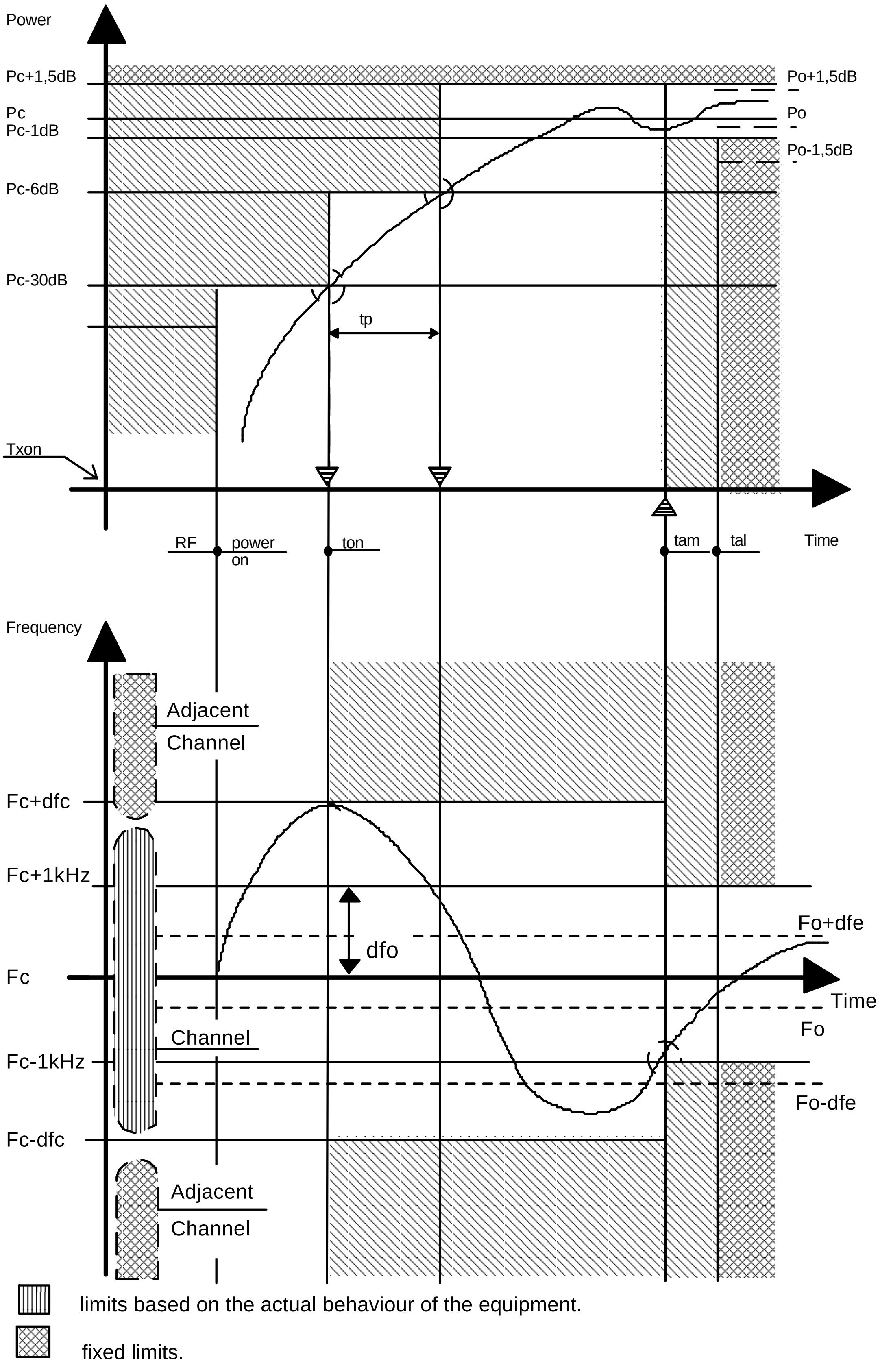


Figure 3: Transmitter attack time according to subclause 8.8 and transient behaviour during switch-on. Case where the attack time is defined by subclause 8.8.1 b) (given by the behaviour of the frequency).

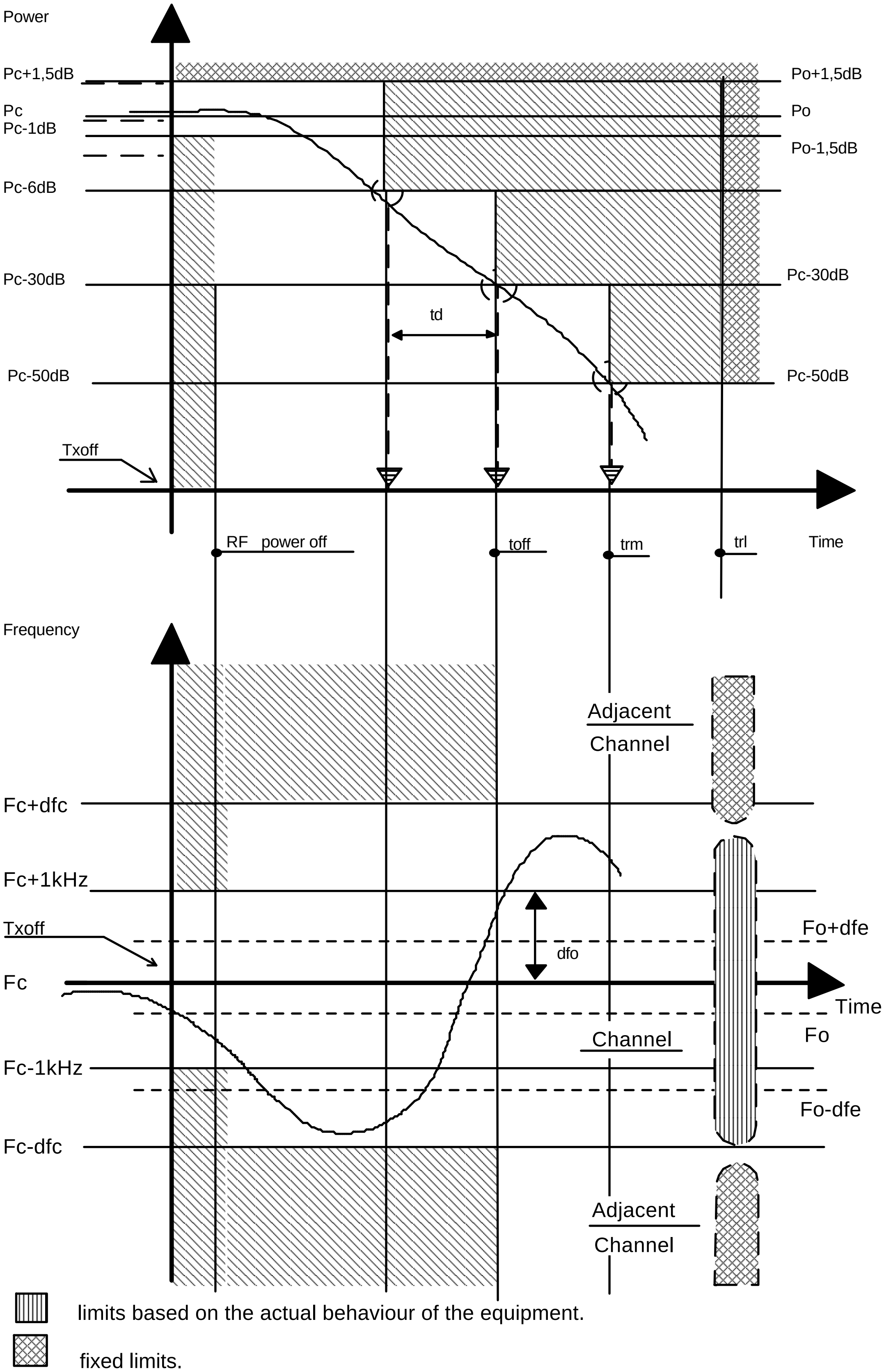


Figure 4: Transmitter release time according to subclause 8.9 and transient behaviour, during switch-off.

8.10.3 Methods of measurement

The transient timings (switch on/switch off cases) and the frequency differences occurring during these periods of time can be measured by means of a spectrum analyser and a test discriminator which meets the requirements indicated in subclause 8.10.3.2. The corresponding limits are given in subclause 5.1.9.

The power, impairing the operation on the adjacent channels, can be measured using an appropriate transient power measuring device which meets the requirements of subclause 8.10.3.4 .

8.10.3.1 Time and frequency domain analysis measurements

The measurement will be performed in the absence of modulation.

The transmitter is connected to the test set-up as shown in figure 5.

The calibration of the test set-up shall be checked. The transmitter output is connected to the input of the spectrum analyser and test discriminator via power attenuators and a power splitter.

The attenuation of the power attenuators shall be chosen in such a way that the input of the test equipment is protected against overload and that the limiter amplifier of the test discriminator operates correctly in the limiting range when the power conditions of subclause 8.10.1 are reached.

The spectrum analyser is set to measure and display power as a function of time ("zero span mode").

The test discriminator shall be calibrated. This can be done by feeding RF voltages from a signal generator with defined frequency differences from the nominal frequency of the transmitter.

By appropriate means, a triggering pulse is generated for the test equipment when the T_{xon} function or the T_{xoff} function are activated.

The "RF power on" and the "RF power off" can be monitored.

The voltage occurring at the test discriminator output shall be recorded as a function of time in correspondence with the power level on a storage device or a transient recorder. This voltage is a measure of the frequency difference. The elapsed periods of time during the frequency transient can be measured using the time base of the storage device. The output of the test discriminator is valid only after t_{on} and before t_{off}.

8.10.3.2 Test arrangement and characteristics of the test discriminator

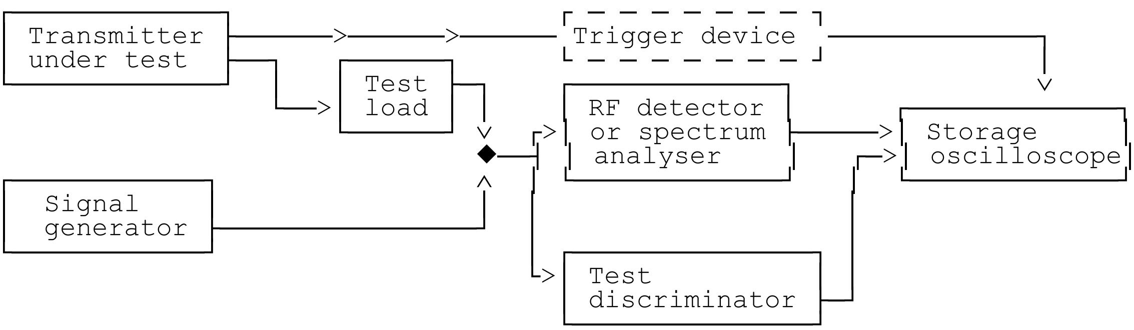


Figure 5: Test arrangement for transient behaviour of transmitter power and frequency, including ransmitter attack and release time.

The test discriminator may consist of a mixer and a local oscillator (providing the auxiliary frequency) used to convert the transmitter frequency to be measured into the frequency fed to the (broadband) limiter amplifier and the associated broadband discriminator:

- the test discriminator shall be sensitive enough to cope with input signals down to P_c - 30 dB;

- the test discriminator shall be fast enough to display the frequency deviations (approx. 100 kHz/100 µs);

- the test discriminator output shall be d.c. coupled.

8.10.3.3 Adjacent channel power transient measurements

The transmitter under test shall be connected via the power attenuator to the "adjacent channel transient power measuring device" as described in subclause 8.10.3.4. So that the level at its input shall be between zero and -10 dBm when the transmitter power is P_c.

a) The transmitter shall be unmodulated and operated at the maximum carrier power level under normal test conditions.

b) The tuning of the "transient power measuring device" shall be adjusted so that a maximum response is obtained. This is the 0 dBc reference level.

c) The tuning of the "transient power measuring device" shall be adjusted away from the carrier so that its -6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency as given in table 9.

Table 9: Frequency displacement

Channel separation (kHz)	Displacement (kHz)
12,5	8,25
20	13
25	17

d) The transmitter shall be switched on.

e) The spectrum analyser shall be used to record the first 35 ms of the envelope of the transient power as a function of time. The peak envelope transient power shall be noted in dBc.

f) The transmitter shall be switched off.

g) The spectrum analyser shall be used to record the first 35 ms of the envelope of the transient power as a function of time. The peak envelope transient power shall be noted in dBc.

h) The steps c) to g) shall be repeated with the "transient power measuring device" tuned to the other side of the carrier.

i) The transient power in the adjacent channel during the attack and release times is the dBc value corresponding to the highest of the four powers noted for the adjacent channels in steps e) and g).

8.10.3.4 Characteristics of the adjacent channel transient power measuring device

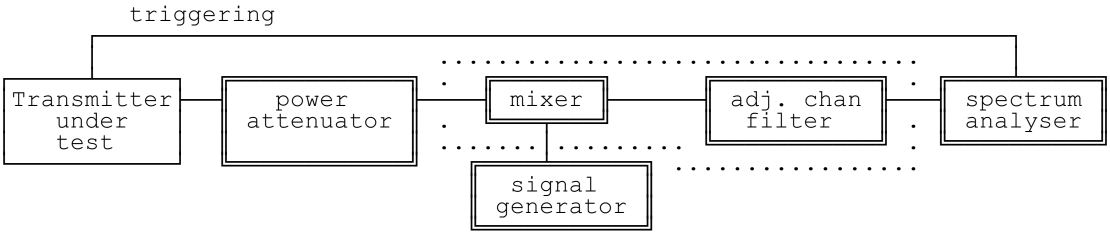


Figure 6: Adjacent channel transient power measuring device measurement arrangement

The adjacent channel transient power measuring device may be as follows:

mixer	:	50 Ω balanced diode mixer; with an appropriate local oscillator level, for example +7 dBm;
adjacent channel filter	:	50 Ω;
spectrum analyser	:	100 kHz bandwidth, peak detection, or power/time measurement provision.

9 Methods of measurement for receiver parameters

9.1 Maximum usable sensitivity (data, conducted)

9.1.1 Definition

The maximum usable sensitivity (data) of the receiver is the minimum level of signal (emf) at the receiver input, at the nominal frequency of the receiver, with normal test signal (see subclause 7.3), which without interference will produce after demodulation a data signal with a specified bit error ratio or a specified successful message ratio. The specified bit error ratio is 10^{-2}. The specified successful message ratio is 0,8.

9.1.2 Method of measurement with continuous bit streams

a) An input signal with a frequency equal to the nominal frequency of the receiver, modulated by the normal test signal M2 (see subclause 7.3), shall be applied to the receiver input terminals.

b) The bit pattern of the modulating signal shall be compared to the bit pattern obtained from the receiver after demodulation.

c) The emf of the input signal to the receiver is adjusted until the bit error ratio is 10^{-2}.

d) The maximum usable sensitivity is the emf of the input signal to the receiver.

e) The measurement shall be repeated under extreme test conditions (subclauses 6.4.1 and 6.4.2 applied simultaneously).

9.1.3 Method of measurement with messages

In the case where operation using a continuous bit stream is not possible, the following method of measurement shall be applied.

a) A signal of carrier frequency equal to the nominal frequency of the receiver and modulated with the normal test signal (see subclause 7.4) in accordance with the instructions of the manufacturer (and approved by the type testing authority) shall be applied to the receiver input terminals.

b) The level of this signal shall be such that a successful message rate of less than 10 % is obtained.

c) The normal test signal shall be transmitted repeatedly whilst observing in each case whether or not a successful response is obtained. The input level shall be increased by 2 dB for each occasion that a successful response **is not** obtained. The procedure shall be continued until three consecutive successful responses are observed. The level of the input signal shall be recorded.

d) The input signal level shall be reduced by 1 dB and the new value recorded. The normal test signal shall then be transmitted 20 times. In each case, if a response **is not** obtained the input level shall be increased by 1 dB and the new value recorded. If a successful response **is** obtained, the input level shall not be changed until three consecutive successful responses have been obtained. In this case, the input level shall be reduced by 1 dB and the new value recorded.

NOTE: No input signal levels shall be recorded unless **preceded** by a change in level.

e) The maximum usable sensitivity is the average of the values recorded in steps c) and d).

f) The measurement shall be repeated under extreme test conditions (subclauses 6.4.1 and 6.4.2 applied simultaneously).

9.2 Maximum usable sensitivity (data, field strength)

This measurement applies only to equipment without an external antenna connection.

9.2.1 Definition

The maximum usable sensitivity of the receiver is the minimum fieldstrength present at the location of the receiver created by a signal, at the nominal frequency of the receiver, with the normal test signal (see subclause 7.3), which will allow the receiver to fulfil the requirements of subclause 9.1.

9.2.2 Method of measurement with continuous bit streams

The manufacturer shall specify the polarisation of the RF field for which the equipment has been designed.

Arrangements shall be made by the manufacturer to couple the unit under test to the bit error rate measuring device by a method which does not affect the radiated field (see also subclause 7.9.3.1).

9.2.2.1 Test conditions

Three test conditions are specified:

a) The manufacturer declares the direction corresponding to the maximum usable sensitivity in this case this position is used to perform the measurement in subclause 9.2.2.2;

b) If the manufacturer does not declare the position corresponding to the maximum usable sensitivity but provides an analogue output according to subclause 7.9.1, then this output will be used to determine the direction of the maximum usable sensitivity. This will be the position used for the measurement in subclause 9.2.2.2;

c) If the direction corresponding to the maximum usable sensitivity cannot be determined as specified in a) or b) above, then an initial position will be used and the measurement in subclause 9.2.2.2 will be repeated with eight positions, 45° apart. The maximum usable sensitivity will be determined from the minimum field strength recorded.

9.2.2.2 Test procedure

On a test site, selected from Annex A, the equipment shall be placed at the specified height on a non-conducting support, in the position determined in subclause 9.2.2.1. The position shall be recorded in the test report.

The test antenna shall be orientated for the polarisation specified by the manufacturer and the length of the test antenna shall be chosen to correspond to the frequency of the receiver. The input of the test antenna shall be connected to a signal generator.

The signal generator shall be tuned to the frequency of the receiver under test and its output level shall be adjusted to 100 dBµV.

The signal generator shall be modulated by the normal test signal M2 (see subclause 7.3).

The raw bit stream produced by the receiver will be monitored.

The test signal output level shall be reduced until a bit error ratio of 10^{-2} is obtained.

The test antenna shall be raised and lowered through the specified range of height to find the lowest level of the test signal, that still produces a bit error ratio of 10^{-2}. The test antenna need not be raised or lowered if the measurement is carried out on a test site according to Annex A, Clause A.3.

The input signal level to the test antenna shall be noted and maintained.
The receiver shall then be replaced by a substitution antenna as defined in subclause A.2.3.
The substitution antenna shall be orientated for the polarisation of the test antenna and the length of the substitution antenna shall be adjusted to correspond to the frequency of the receiver.
The substitution antenna shall be connected to a calibrated measuring receiver.
The test antenna shall be raised and lowered through the specified range of height to ensure that the maximum signal is received.

The test antenna need not be raised or lowered if the measurement is carried out on a test site according to Annex A, Clause A.3.

The measured signal level shall be recorded as a field strength in dBμV/m and is the maximum usable sensitivity, corresponding to the direction used.

9.2.3 Method of measurement with messages

In the case where operation, using a continuous bit stream is not possible, the following method of measurement shall be applied.

The manufacturer shall specify the polarisation of the RF field for which the equipment has been designed.

Arrangements shall be made by the manufacturer to couple the unit under test to the observation device by a method which does not affect the radiated field, (see also subclause 7.9.3.2).

9.2.3.1 Test conditions

Three test conditions are specified:

a) The manufacturer declares the direction corresponding to the maximum usable sensitivity, in this case this position is used to perform the measurement in subclause 9.2.3.2;

b) If the manufacturer does not declare the position corresponding to the maximum usable sensitivity but provides an analogue output according to subclause 7.9.1, then this output will be used to determine the direction of the maximum usable sensitivity. This will be the position used for the measurement in subclause 9.2.3.2;

c) If the direction corresponding to the maximum usable sensitivity cannot be determined as specified in a) or b) above, then an initial position will be used and the measurement in subclause 9.2.3.2 will be repeated with eight positions, 45° apart. The maximum usable sensitivity will be determined from the minimum field strength recorded.

9.2.3.2 Test procedure

On a test site, selected from Annex A, the equipment shall be placed at the specified height on a non-conducting support, in the position determined in subclause 9.2.3.1. This position shall be recorded in the test report.

The test antenna shall be orientated for the polarisation specified by the manufacturer and the length of the test antenna shall be chosen to correspond to the frequency of the receiver.

The input of the test antenna shall be connected to a signal generator.

The signal generator shall be tuned to the frequency of the receiver under test and its output level shall be adjusted to 100 dBμV.

The signal generator shall be modulated by the normal test signal in accordance with subclause 9.1.3, a).

The test antenna shall be raised and lowered through the specified range of height to find the lowest level of the test signal necessary.

The test antenna need not be raised or lowered if the measurement is carried out on a test site according to Annex A, Clause A.3.

Under these test conditions and positions, the actual sensitivity will be measured using the "up down method" described in subclause 9.1.3, b) to d), using the test antenna and the signal generator connected to it.

The input signal level to the test antenna shall be set to the average of the values noted (see subclause 9.1.3, e)).

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

The substitution antenna shall be orientated for the polarisation specified and the length of the substitution antenna shall be adjusted to correspond to the frequency of the receiver.

The substitution antenna shall be connected to a calibrated measuring receiver.

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

The test antenna need not be raised or lowered if the measurement is carried out on a test site according to Annex A, Clause A.3.

The measured signal level shall be recorded as a field strength in dBμV/m and is the maximum usable sensitivity, corresponding to the direction used.

9.3 Level of the wanted signal for the degradation measurements (data)

9.3.1 Definition

The level of the wanted signal for the degradation measurements of the receiver corresponds to the minimum level of signal (emf) at the receiver input, at the nominal frequency of the receiver, with normal test signal (see subclause 7.3), which will produce, after demodulation, a data signal with a specified bit error ratio or a specified successful message ratio, in the case of degradation due to interference conditions.

9.3.2 Defined level

The level of the wanted signal for the degradation measurements (data) is an emf of + 6 dB μV. It is 3 dB above the limit of the maximum usable sensitivity (data).

9.3.3 Relations between the results of measurements using continuous bit streams and messages

The methods of measurement using messages are sensitive to the length of the coded messages. It can be demonstrated that a random distributed bit error ratio of 10^{-2} will give a probability of error free reception of 80 % for a 22 bit long message.

9.4 Bit error rate in normal operation

9.4.1 Definition

The bit error rate in normal operation is the residual bit error rate found at levels significantly above the maximum usable sensitivity. This bit error rate shall be as low as possible.

9.4.2 Method of measurement

The input signal of the receiver is adjusted to a level of 30 dB above the level of the wanted signal for the degradation measurements (see subclause 9.3). The number of errors that occur at the data output terminal or at a special measuring terminal of the receiver, during a period of 3 minutes, is counted.

The measurement is repeated with the input signal of the receiver at a level of 100 dB above the level of the wanted signal for the degradation measurements (see subclause 9.3).

9.5 Co-channel rejection

9.5.1 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 the presence of an unwanted modulated signal, both signals being at the nominal frequency of the receiver.

9.5.2 Method of measurement with continuous bit streams

a) The two input signals shall be connected to the receiver via a combining network (see also subclause 7.1).

   The wanted signal shall be modulated by the normal test signal M2. The unwanted signal shall be the signal M3 (see subclause 7.3).

   Both signals shall be at the nominal frequency of the receiver.

b) Initially the unwanted signal shall be switched off and the amplitude of the wanted signal shall be adjusted to establish the level of the wanted signal specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

c) The unwanted signal shall then be switched on, and the input level adjusted until a bit error ratio of about 10^{-1} is obtained.

d) The normal test signal M2 shall be transmitted whilst observing the bit error ratio. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. The level of the unwanted signal shall then be recorded.

e) The co-channel rejection ratio shall be expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal, at the receiver input. This ratio shall be noted.

f) The measurement shall be repeated for displacements of ±1500 Hz and ±3000 Hz of the unwanted signal.

The lowest of the five values expressed in dB, noted in step e) shall be recorded as the co-channel rejection.

The value of the co-channel rejection ratio, expressed in dB, is generally negative (therefore, for example, -12 dB is lower than -8 dB).

9.5.3 Method of measurement with messages

In the case where operation using a continuous bit stream is not possible, the following method of measurement shall be applied.

a) The two input signals shall be connected to the receiver via a combining network (see also subclause 7.1).

   The wanted signal shall be modulated by the normal test signal M2 (see subclause 7.3).

The unwanted signal shall be the signal M3 (see subclause 7.3).

Both signals shall be at the nominal frequency of the receiver.

b) Initially the unwanted signal shall be switched off and the amplitude of the wanted signal shall be adjusted to establish the level of the wanted signal (specified in subclause 9.3) (data) at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

c) The unwanted signal shall then be switched on, and the input level adjusted until a successful message rate of less than 10 % is obtained.

d) The normal test signal shall be transmitted repeatedly whilst observing in each case whether or not a successful response is obtained. The level of the unwanted signal shall be reduced by 2 dB for each occasion that a successful response is not obtained. The procedure shall be continued until three consecutive successful responses are observed. The level of the input signal shall then be recorded.

e) The unwanted input signal level shall be increased by 1 dB and the new value recorded. The normal test signal shall then be transmitted 20 times. In each case, if a response **is not** obtained the level of the unwanted signal shall be reduced by 1 dB and the new value recorded. If a successful response **is** obtained the level of the unwanted signal shall not be changed until three consecutive successful responses have been obtained. In this case the unwanted signal shall be increased by 1 dB and the new value recorded.

NOTE: No levels of the unwanted input signal level shall be recorded unless **preceded** by a change in level.

f) The co-channel rejection ratio shall be expressed as the ratio in dB of the average of the levels of the unwanted signal recorded in steps d) and e) to the level of the wanted signal, at the receiver input. This ratio shall be noted.

g) The measurement shall be repeated for displacements of ±1500 Hz and ±3000 Hz of the unwanted signal.

The lowest of the five values expressed in dB, noted in step e) shall be recorded as the co-channel rejection.

The value of the co-channel rejection ratio, expressed in dB, is generally negative (therefore, for example, -12 dB is lower than -8 dB).

9.6 Adjacent channel selectivity

9.6.1 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 signal which differs in frequency from the wanted signal by an amount equal to the adjacent channel separation for which the equipment is intended.

9.6.2 Method of measurement with continuous bit streams

a) Two signal generators, A and B, shall be applied to the receiver via a combining network (see also subclause 7.1).

Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3).

Signal generator B shall be modulated with the signal M3 and shall be adjusted to the frequency of the channel immediately above that of the wanted signal.

b) Initially signal generator B shall be switched off. Signal generator A will be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

c) The unwanted signal (generator B) shall then be switched on, and the input level adjusted until a bit error ratio of 10^{-1} is obtained.

d) The normal test signal M2 shall be transmitted whilst observing the bit error ratio. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. The level of the unwanted signal shall then be recorded.

e) The adjacent channel selectivity 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 input.

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

g) The adjacent channel selectivity shall be expressed as the lower value of the ratios for the upper and lower adjacent channel of the levels of the unwanted signal to the level of the wanted input signal (generator A).

h) The measurement shall be repeated under extreme test conditions (subclauses 6.4.1 and 6.4.2 applied simultaneously), using the level of the wanted signal, specified in subclause 9.3 (data), increased by 6 dB, unless analogue measurements were made, in which case the adjacent channel selectivity shall be measured at normal test conditions only.

NOTE: This is a valid procedure, because the degradation of adjacent channel selectivity at extreme test conditions is known by the analogue measurement results.

9.6.3 Method of measurement with messages

In the case where operation using a continuous bit stream is not possible, the following method of measurement shall be applied.

a) Two signal generators A and B shall be applied to the receiver via a combining network (see also subclause 7.1).

Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3).

Signal generator B shall be modulated with the signal M 3 and shall be adjusted to the frequency of the channel immediately above that of the wanted signal.

b) Initially signal generator B shall be switched off. Signal generator A shall be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

c) The unwanted signal (generator B) shall then be switched on, and the input level adjusted until a successful message rate of less than 10 % is obtained.

d) The normal test signal M2 shall be transmitted repeatedly whilst observing in each case whether or not a successful response is obtained. The level of the unwanted signal shall be reduced by 2 dB for each occasion that a successful response **is not** obtained. The procedure shall be continued until three consecutive successful responses are observed. The level of the input signal shall then be recorded.

e) The unwanted input signal level shall be increased by 1 dB and the new value recorded. The normal test signal shall then be transmitted 20 times. In each case, if a response **is not** obtained the level of the unwanted signal shall be reduced by 1 dB and the new value recorded. If a successful response **is** obtained, the level of the unwanted signal shall not be changed until three consecutive successful responses have been obtained. In this case the unwanted signal shall be increased by 1 dB and the new value recorded.

NOTE: No levels of the unwanted input signal shall be recorded unless **preceded** by a change in level.

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

g) The adjacent channel selectivity shall be expressed as the lower value of the ratios for the upper and lower adjacent channel of the average of the levels of the unwanted signal recorded in steps d) and e), to the level of the wanted input signal (generator A).

h) The measurement shall be repeated under extreme test conditions (subclauses 6.4.1 and 6.4.2 applied simultaneously), using the level of the wanted signal, specified in subclause 9.3 (data), increased by 6 dB, unless analogue measurements were made, in which case the adjacent channel selectivity shall be measured only at normal test conditions.

NOTE: This is a valid procedure, because the degradation of adjacent channel selectivity at extreme test conditions is known by the analogue measurement results.

9.7 Spurious response rejection

9.7.1 Definition

The spurious response rejection is a measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted modulated signal at any other frequency, at which a response is obtained.

9.7.2 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 equal to:

The frequency of the local oscillator signal (f_{lo}) applied to the 1st mixer of the receiver ± the sum of the intermediate frequencies (if_1, ..., if_n) and half the switching range (sr) of the receiver (see Clause 4).

Hence:

the "limited frequency range" = $f_{lo} \pm (if_1 + if_2 + ... + if_n + sr/2)$.

b) The calculation of the frequencies at which spurious response can occur outside the range determined in a) above is made for the remainder of the frequency range of interest, as given in subclauses 9.7.4 and 9.7.5.

The frequencies outside the "limited frequency range" are equal to:

The harmonics of the frequency of the local oscillator signal (f_{lo}) applied to the 1st mixer of the receiver or the harmonics of any other oscillator used to generate reference frequencies in the receiver (f_r) present at the first mixer of the receiver ± the numeric value of the 1st intermediate frequency (if_1) of the receiver.

Hence:

the frequencies of these spurious responses = $nf_{lo} + if_1$ and $pf_r \pm if_1$

where n is an integer greater than or equal to 2,
where p is an integer greater than or equal to 1.

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

For the calculations a) and b) above, the manufacturer shall state the frequency of the receiver, the frequency of the local oscillator signal (f_{lo}) applied to the 1st mixer of the receiver, the intermediate frequencies (if_1, if_2, etc.) and the switching range (sr) of the receiver.

9.7.3 Method of search over the "limited frequency range"

a) Two signal generators A and B shall be connected to the receiver via a combining network (see also subclause 7.1).

Signal generator A (wanted signal) shall be at the nominal frequency of the receiver and shall be modulated with the signal M2 (see subclause 7.3).

Signal generator B (unwanted signal) shall be modulated with the signal M3.

b) Initially signal generator B shall be switched off. Signal generator A shall be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf) under normal test conditions.
The bit error rate of the receiver after demodulation shall be noted.

c) The unwanted signal (generator B), shall then be switched on and its amplitude shall be adjusted to a level of 86 dBµV at the receiver input terminals. The frequency of the unwanted signal generator shall be varied incrementally over the "limited frequency range" to search for frequencies at which spurious responses occur. The incremental steps of the frequency of the unwanted signal shall be 5 kHz.

d) The frequency of any spurious response detected (by an increase in the previously noted bit error rate) during the search shall be recorded for use in the measurements in accordance with subclauses 9.7.4 and 9.7.5.

e) In the case where operation using a continuous bit stream is not possible a similar method shall be used. However, instead of identifying a spurious response by noting an increase in the bit error rate, the identification shall be by the observed degradation of the message ratio to less than 10%.

9.7.4 Method of measurement with continuous bit streams

a) Two signals generators A and B shall be connected to the receiver via a combining network (see also subclause 7.1).

Signal generator A (wanted signal) shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3).

Signal generator B (unwanted signal) shall be modulated with the signal M3 and shall be adjusted to a frequency at which it a spurious response occurs as identified by the procedure given in subclause 9.7.2 and 9.7.3.

b) Initially signal generator B shall be switched off. Signal generator A shall be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

c) The unwanted signal (generator B) shall then be switched on and the input level adjusted until a bit error ratio of 10^{-1} is obtained.

d) The normal test signal M2 shall be transmitted whilst observing the bit error ratio. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. The level of the unwanted signal shall then be recorded.

e) The spurious response rejection shall be expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal (generator A) at the receiver input.

The measurement shall be performed at all spurious response frequencies found during the search over the "limited frequency range", (see subclause 9.7.2, a)) and at frequencies calculated for the remainder of the spurious response frequencies (see subclause 9.7.2, b)) in the frequency range 100 kHz to 2 GHz for equipment operating on frequencies below 470 MHz, or in the frequency range of 100 kHz to 4 GHz for equipment operating on frequencies above 470 MHz.

9.7.5 Method of measurement with messages

In the case where operation using a continuous bit stream is not possible, the following method of measurement shall be applied.

a) Two signal generators A and B shall be connected to the receiver via a combining network (see also subclause 7.1).

Signal generator A (wanted signal) shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3).

Signal generator B (unwanted signal) shall be modulated with the signal M3 and shall be adjusted to a frequency at which it a spurious response occurs as identified by the procedure given in subclauses 9.7.2 and 9.7.3.

b) Initially, signal generator B shall be switched off. Signal generator A shall be used for the wanted signal whose amplitude shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

c) The unwanted signal shall then be switched on and the input level adjusted until a successful message ratio of less than 10 % is obtained.

d) The normal test signal M2 shall be transmitted repeatedly whilst observing in each case whether or not a successful response is obtained. The level of the unwanted signal shall be reduced by 2 dB for each occasion that a successful response is not obtained. The procedure shall be continued until three consecutive successful responses are observed.

The level of the input signal shall then be recorded.

e) The unwanted input signal level shall be increased by 1 dB and the new value recorded; the normal test signal shall then be transmitted 20 times. In each case, if a response **is not** obtained the level of the unwanted signal shall be reduced by 1 dB and the new value recorded. If a successful response **is** obtained, the level of the unwanted signal shall be changed until three consecutive successful responses have been obtained. In this case the unwanted signal shall be increased by 1 dB and the new value recorded.

NOTE: No levels of the unwanted input signal shall be recorded unless **preceded** by a change in level.

f) The spurious response rejection shall be expressed as the ratio in dB of the average of the levels of the unwanted signal, recorded in steps d) and e), to the level of the wanted signal (generator A) at the receiver input.

The measurement shall be performed at all spurious response frequencies found during the search over the "limited frequency range", (see subclause 9.7.2, a)) and at frequencies calculated for the remainder of the spurious response frequencies (see subclause 9.7.2, b)) in the frequency range 100 kHz to 2 GHz for equipment operating on frequencies below 470 MHz, or in the frequency range of 100 kHz to 4 GHz for equipment operating on frequencies above 470 MHz.

9.8 Intermodulation response

9.8.1 Definition

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

9.8.2 Method of measurement with continuous bit streams

a) Three signal generators A, B and C shall be connected to the receiver via a combining network (see also subclause 7.1).

   Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3).

   Signal generator B shall be unmodulated and shall be adjusted to a frequency 50kHz **above** the nominal frequency.

   Signal generator C shall be modulated with the signal M3 and shall be adjusted to a frequency 100 kHz **above** the nominal frequency.

b) Initially signal generators B and C will be switched off. Signal generator A shall be used for the wanted signal, the amplitude of which shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions). This level shall be noted.

c) Signal generators B and C (providing the unwanted signals) shall then be switched on. The output levels of the two signal generators shall be kept equal and adjusted to a value such that a bit error ratio of 10^{-1} is obtained.

d) The normal test signal M2 shall be transmitted whilst observing the bit error ratio. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. The level of the input signals shall then be recorded.

e) The intermodulation response is expressed as the value in dB of the input levels of the two signal generators to the level of the wanted signal (generator A).

f) The measurements in a) above shall be repeated with the frequencies of the unwanted signals **below** the wanted input signal.

9.8.3 Method of measurement with messages

In the case where operation using a continuous bit stream is not possible, the following method of measurement shall be applied.

a) Three signal generators A, B and C shall be applied to the receiver via a combining network (see also subclause 7.1).

Signal generator A shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3).

Signal generator B shall be unmodulated and shall be adjusted to a frequency 50 kHz **above** the nominal frequency.

Signal generator C shall be modulated with the signal M3 and shall be adjusted to a frequency 100 kHz **above** the nominal frequency.

b) Initially signal generators B and C shall be switched off. Signal generator A shall be used for the wanted signal, the amplitude of which shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions). This level shall be noted.

c) Signal generators B and C (providing the unwanted signals) shall then be switched on. The output levels of the two signal generators shall be kept equal and adjusted to a value such that a successful message rate of less than 10 % is obtained.

d) The normal test signal M2 shall be transmitted repeatedly whilst observing in each case whether or not a successful response is obtained. The levels of the unwanted signals shall be reduced by 2 dB for each occasion that a successful response **is not** obtained. The procedure shall be continued until three consecutive successful responses are observed.

The level of the input signals shall then be recorded.

e) The unwanted input signal level shall be increased by 1 dB and the new value recorded; the normal test signal M2 shall then be transmitted 20 times. In each case, if a response **is not** obtained the level of the unwanted signal shall be reduced by 1 dB and the new value recorded. If a successful response **is** obtained, the input level of the unwanted signal shall not be changed until three consecutive successful responses have been obtained. In this case the unwanted signal shall be increased by 1 dB and the new value recorded.

NOTE: No input signal level shall be recorded unless **preceded** by a change in input level.

f) The intermodulation response is expressed as the value in dB of the average of the input levels of the two signal generators recorded in steps d) and e) to the level which is noted is step b).

g) The measurements in a) above shall be repeated with the frequencies of the unwanted signals **below** the wanted input signal.

9.9 Blocking or desensitisation

9.9.1 Definition

Blocking is a measure of the capability of the receiver to receive a modulated wanted input signal in the presence of an unwanted input signal on frequencies other than those of the spurious responses or the adjacent channels, without these unwanted input signals causing a degradation of the performance of the receiver beyond a specified limit.

9.9.2 Method of measurement with continuous bit streams

a) Two input signals shall be applied to the receiver via a combining network (see also subclause 7.1). The wanted signal shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3). The amplitude (emf) of the wanted signal shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

b) The unwanted signal shall be unmodulated and the frequency shall be varied between +1 MHz and +10 MHz and also between -1 MHz and -10 MHz relative to the nominal frequency of the receiver. However for practical reasons measurements will be carried out at certain frequencies of the unwanted signal at approximately ± 1 MHz, ± 2 MHz, ± 5 MHz and ± 10 MHz. At any frequency in the specified range, other than those at which a spurious response could occur (see subclause 9.7), the level of the unwanted signal shall be adjusted until a bit error ratio of less then 10^{-1} is obtained.

c) The normal test signal shall then be transmitted whilst observing the bit error ratio. The level of the unwanted signal shall be reduced in steps of 1 dB until a bit error ratio of 10^{-2} or better is obtained. The level of the unwanted signal shall then be recorded.

d) The blocking level is expressed as the ratio in dB of the levels of the unwanted signal to the level of the wanted signal, at the receiver input.

9.9.3 Method of measurement with messages

In the case where operation, using a continuous bit stream is not possible, the following method of measurement shall be applied.

a) Two input signals shall be applied to the receiver via a combining network (see also subclause 7.1). The wanted signal shall be at the nominal frequency of the receiver and shall be modulated by the normal test signal M2 (see subclause 7.3). The amplitude (emf) of the wanted signal shall be adjusted to the level of the wanted signal, specified in subclause 9.3 (data), at the receiver input terminals (i.e. 6 dB above 1 µV emf under normal test conditions).

b) The unwanted signal shall be unmodulated and the frequency shall be varied between +1 MHz and +10 MHz and also between -1 MHz and -10 MHz relative to the nominal frequency of the receiver.

   However for practical reasons measurements shall be carried out at certain frequencies of the unwanted signal at approximately ± 1 MHz, ± 2 MHz, ± 5 MHz and ± 10 MHz. At any frequency in the specified range, other than those at which a spurious response could occur (see subclause 9.6), the level of the unwanted signal shall be adjusted until a successful message rate of less than 10 % is obtained.

c) The normal test signal M2 shall then be transmitted repeatedly whilst observing in each case whether or not a successful response is obtained. The level of the unwanted signal shall be reduced by 2 dB for each occasion that a successful response **is not** obtained. The procedure shall be continued until three consecutive successful responses are observed. The level of the input signal shall then be recorded.

d) The unwanted input signal shall then be increased by 1 dB and the new value recorded. The normal test signal shall then be transmitted 20 times. In each case if a response **is not** obtained the level of the unwanted signal shall be reduced by 1 dB and the new value recorded. If a successful response **is** obtained, the level of the unwanted signal shall not be changed until three consecutive successful responses have been obtained. In this case the unwanted signal shall be increased by 1 dB and the new value recorded.

   NOTE: No levels of the unwanted signal shall be recorded unless **preceded** by a change in level.

e) The blocking level is expressed as the ratio in dB of the average of the levels of the unwanted signal recorded in steps c) and d) to the level of the wanted signal, at the receiver input.

9.10 Spurious radiations

9.10.1 Definition

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

The level of spurious radiations shall be measured by:

either,

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

and,

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

or,

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

9.10.2 Method of measuring the power level

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

Spurious radiations shall be measured as the power level of any discrete signal at the input terminals of the receiver. The receiver input terminals are connected to a spectrum analyser or selective voltmeter having an input impedance of 50 Ω and the receiver 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, for equipment operating on frequencies not exceeding 470 MHz, over the frequency range of 9 kHz to 4 GHz, and in addition shall be repeated over the frequency range 4 GHz to 12,75 GHz for equipment operating on frequencies above 470 MHz.

9.10.3 Method of measuring the effective radiated power

On a test site, fulfilling the requirements of Clause A.2, the sample shall be placed at the specified height on the non-conducting support. The receiver shall be operated from a power source via a radio frequency filter to avoid radiation from the power leads.

The receiver shall be connected to:

- an artificial antenna (see subclause 7.7) for equipment having an external antenna connector (see subclause 9.10.1, b));

- or to the integral antenna (see subclause 9.10.1 ,c)).

Radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 30 MHz to 4 GHz.

At each frequency at which a component is detected, the sample shall be rotated to obtain maximum response and the effective radiated power of that component determined by a substitution measurement.

The measurement shall be repeated with the test antenna in the orthogonal polarisation plane.

10 Duplex operation

If the equipment is designed for duplex operation, when submitted for type testing it shall be fitted with a duplex filter and the following additional measurements shall be carried out to ensure satisfactory duplex operation.

10.1 Receiver desensitisation with simultaneous transmission and reception

10.1.1 Definition

The desensitisation is the degradation of the sensitivity of the receiver resulting from the transfer of power from the transmitter to the receiver due to coupling effects. It is expressed as the difference in dB of the maximum usable sensitivity (data) levels, with and without simultaneous transmission.

10.1.2 Method of measurement when the equipment has a duplex filter

The antenna terminal of the equipment comprising of the receiver, transmitter and duplex filter, shall be connected through a coupling device to the artificial antenna specified in subclause 7.7. A signal generator modulated by a normal test signal M2 (see subclause 7.3), shall be connected to the coupling device so that it does not affect the impedance matching. The transmitter shall be brought into operation at the carrier output power as defined in subclause 8.2, modulated by a normal test signal M2' (see subclause 7.3). The receiver sensitivity (data) shall then be measured in accordance with subclause 9.1.

The output level of the signal generator shall be recorded as C in dB relative to an emf of 1 µV.

The transmitter shall be switched off and the receiver sensitivity (data) is measured again.

The output level of the signal generator shall be recorded as D in dB relative to an emf of 1 µV.

The desensitisation is the difference between the values of C and D in dB.

10.1.3 Measuring method when the equipment has to operate with two antennae

The transmitter shall be connected to an attenuator to dissipate the nominal RF output power of the transmitter the rating of which shall be declared by the manufacturer. The attenuator output shall be connected to the receiver input by means of a coupling device and a filter, if the latter is part of the standard equipment. The total attenuation between transmitter and receiver shall be 30 dB. A signal generator modulated by normal test signal M2 (see subclause 7.3) shall be connected to the coupling device in such a way as not to affect the impedance matching. The transmitter shall be brought into operation with an output power as defined in subclause 8.2; modulated by a normal test signal M2' (see subclause 7.3). The receiver sensitivity (data) is then measured in accordance with subclause 9.1.

The output level of the signal generator shall be recorded as C in dB relative to an emf of 1 µV.

The transmitter shall be switched off and the receiver sensitivity measured again.

The output level of the signal generator shall be recorded as D in dB relative to an emf of 1 µV.

The desensitisation is the difference between the values of C and D in dB.

10.2 Receiver spurious response rejection

The receiver spurious response rejection is measured as specified in subclause 9.7 with the equipment arrangement described in subclause 10.1.2 or 10.1.3, except that the transmitter shall be unmodulated. The transmitter shall be operated at the carrier output power as defined in subclause 8.2.

The measurement shall be performed around frequencies fm derived from the expressions:

pft + qfm = fr and fm = nft ± fif1 where ft is the transmitter frequency, fr is the receiver frequency and fif1 is the first IF of the receiver.

Particular attention shall be given to the following values: p = -1, q = 2 and p = 2, q = -1

It should be noted that the method of measurement described, may cause errors at certain frequencies due to the effect of signal generator intermodulation. To overcome such errors due to intermodulation products generated by the signal generators, a band stop filter at the transmitting frequency may be inserted between the output of the signal generator combining network and the equipment under test.

11 Measurement uncertainty

Absolute measurement uncertainties: maximum values

Valid up to 1 GHz for the RF parameters unless otherwise stated.

Radio Frequency	$\pm 1 \times 10^{-7}$
RF Power (up to 160W)	± 0,75 dB
Adjacent channel power	± 5 dB
Conducted emission of transmitter, valid up to 12,75 Ghz	± 4 dB
Conducted emission of receiver, valid up to 12,75 GHz	± 3 dB
Two-signal measurement, valid up to 4 GHz	± 4 dB
Three-signal measurement	± 3 dB
Radiated emission of the transmitter, valid up to 4 GHz	± 6 dB
Radiated emission of receiver, valid up to 4 GHz	± 6 dB
Transmitter transient time	± 20 %
Transmitter transient frequency	± 250 Hz
Transmitter intermodulation	± 3 dB
Receiver desensitisation (duplex operation)	± 0,5 dB

For the test methods according to this standard, the uncertainty figures are valid to a confidence level of 95 % calculated according to the methods described in ETR 028 [3].

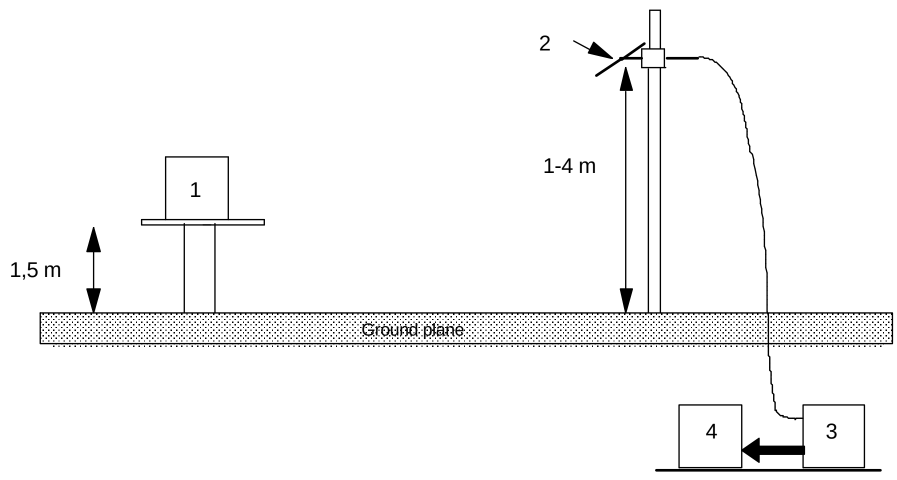
Annex A (normative): Radiated measurements

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

A.1.1 Test site

The 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 λ/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.



Legend:

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

Figure A.1

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 a $\lambda/2$ 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 operated 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 signal 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 λ 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 ±0,10 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 shall be re-sited until a change of less than 2 dB is obtained.

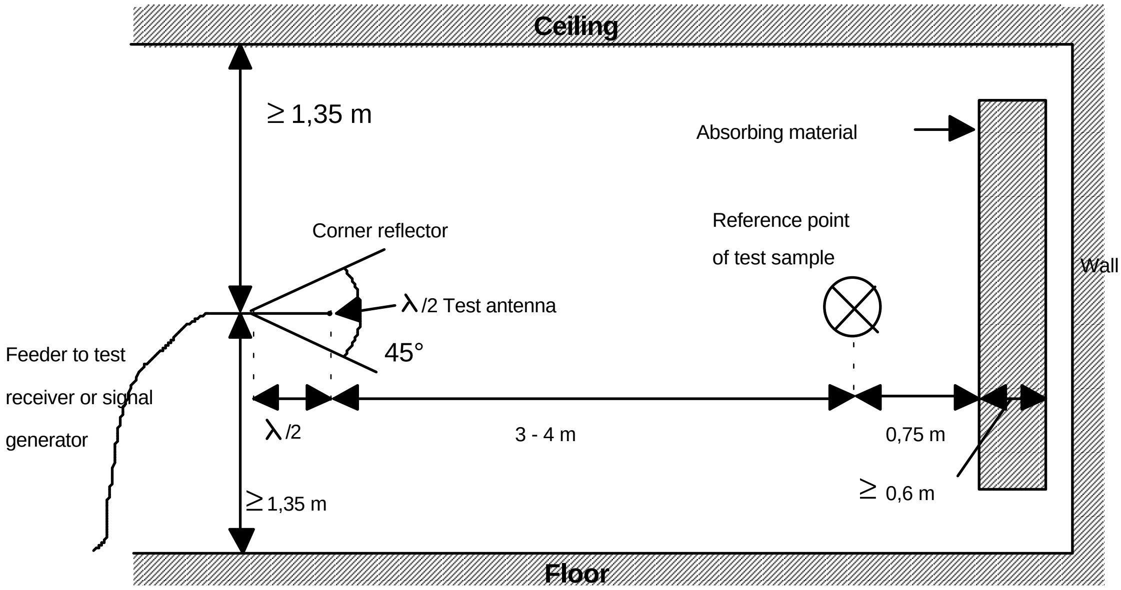


Figure A.2: Indoor site arrangement (shown for horizontal polarisation).

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 Clause A.1. 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 λ/2 at the frequency of measurement and the precautions described in this annex are observed. Measuring distances of 3m, 5m, 10m 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 approximately 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 approximately 80 MHz.

Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used shall 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 shall be used between the artificial antenna and the test sample.

In cases where it is necessary to use a connecting cable, precautions shall 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 shall 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 conveyed from the receiver to the test microphone via a non-conducting acoustic pipe.

The acoustic pipe shall have an appropriate length, 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 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 consisting of a well-shielded anechoic chamber simulating a free space environment. If such a chamber is used, this shall be recorded in the test report.

The test antenna, test receiver, substitution antenna and calibrated signal generator shall be used in a way similar to that of the general method, given in Clause A.1. In the range between 30 MHz to 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 are coated with RF absorbers of 1 m height.

The base is 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 RF absorbers approximately 1 m high. The base is covered with absorbers above which is constructed a non-conducting sub-floor, or with special ground floor absorbers.

The available internal dimensions of the room are 3 m by 8 m by 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 wavelengths.

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 would be necessary to re-introduce floor reflections. Therefore the floor absorbers are covered with metal plates or metallic nets instead.

A.3.2 Influence of parasitic reflections in anechoic chambers

For free-space propagation in the far field 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 at 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, nor 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.

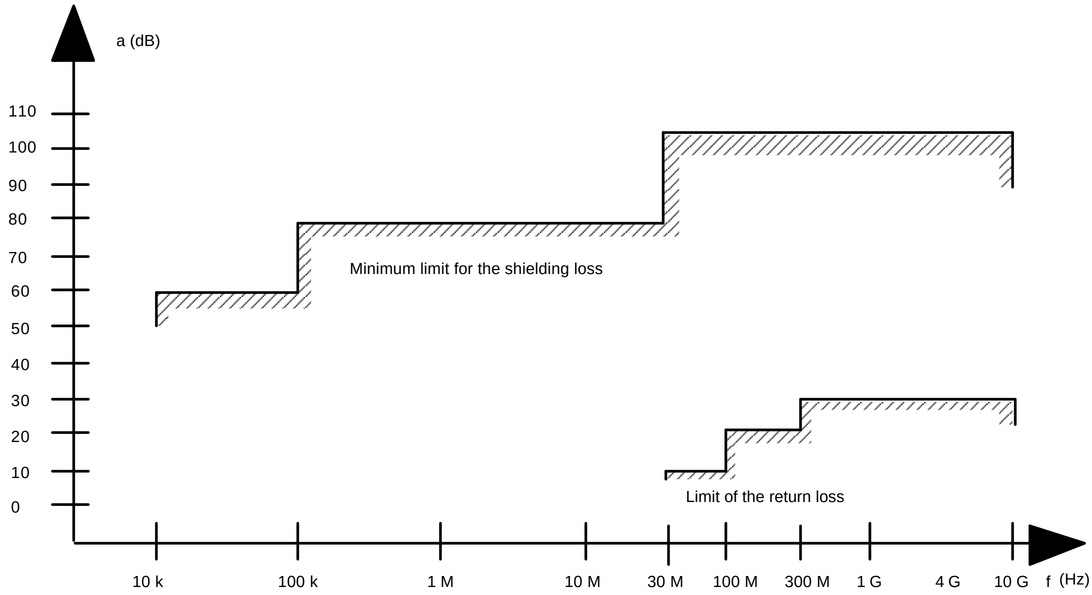
With an anechoic chamber of the dimensions suggested in Clause A.3 at low frequencies up to 100 MHz there are no far field conditions, and therefore reflections are stronger so that careful calibration is necessary.

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.



a = attenuation, f = frequency

Figure A.3: Specifications for shielding and reflections

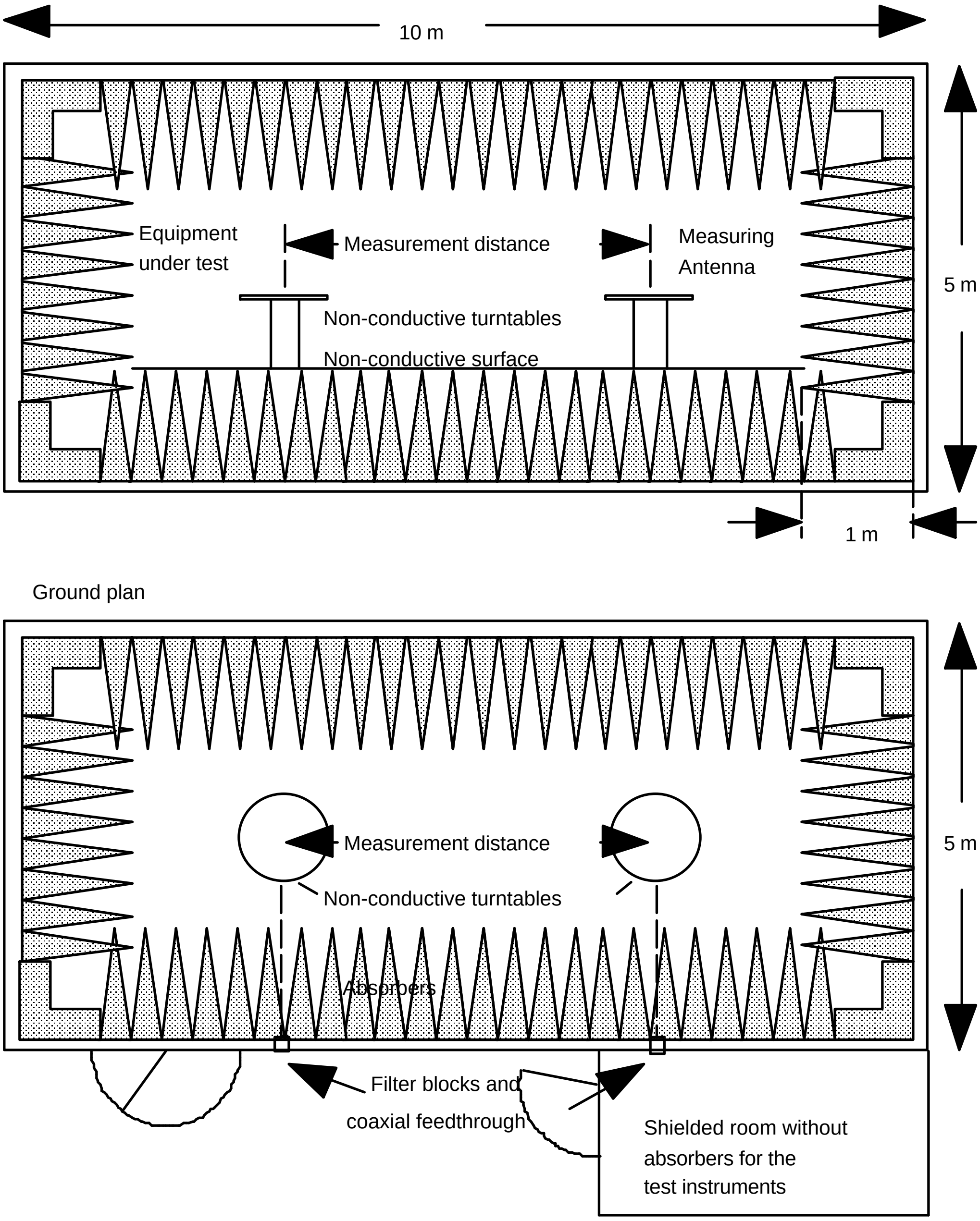


Figure A.4: Example of the construction of an anechoic shielded chamber

Annex B (normative): Specification for some particular measurement arrangements

B.1 Power measuring receiver specification

The power measuring receiver consists of a mixer, an IF filter, an oscillator, an amplifier, a variable attenuator and a root mean squared (rms) value indicator.

Instead of the variable attenuator with the rms value indicator it is also possible to use a 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 selectivity characteristic of figure B.1.

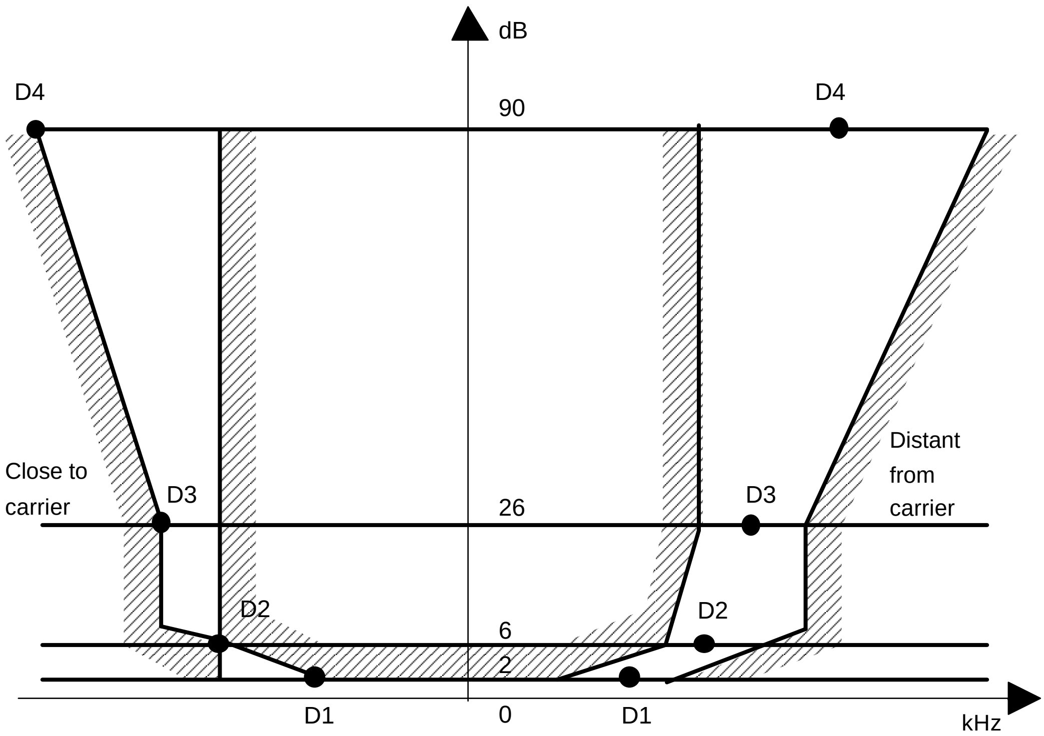


Figure B.1

Depending on the channel separation, the selectivity characteristic shall keep the frequency separations from the nominal centre frequency of the adjacent channel as stated in table B.1.

Table B.1: Selectivity characteristics

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
20	4	7,0	8,25	12.25
25	5	8,0	9,25	13.25

Depending on the channel separation, the attenuation points shall not exceed the tolerances as stated in tables B.2 and B.3.

Table B.2: Attenuation points close to the carrier

Channel separation (kHz)	Tolerances range (kHz)			
	D1	D2	D3	D4
12,5	+1,35	±0,1	-1,35	-5,35
20	+3,1	±0,1	-1,35	-5,35
25	+3,1	±0,1	-1.35	-5,35

Table B.3: Attenuation points distant from the carrier

Channel separation (kHz)	Tolerances range (kHz)			
	D1	D2	D3	D4
12,5	±2,0	±2,0	±2,0	+2,0 -6,0
20	±3,0	±3,0	±3,0	+3,0 -7,0
25	±3,5	±3,5	±3,5	+3,5 -7,5

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

B.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.

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 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 ≤ -90 dB for channel separations of 20 and 25 kHz and of ≤ -80 dB for a channel separation of 12,5 kHz, referred to the carrier of the oscillator.

B.2 Spectrum analyser specification

The specification shall include the following requirements:

It shall be possible, using a resolution bandwidth of 1 kHz, to measure the amplitude of a signal, or noise at a level 3 dB or more above the noise level of the spectrum analyser, as displayed on the screen, to an accuracy of ±2 dB in the presence of the wanted signal.

The accuracy of relative amplitude measurements shall be within ±1 dB.

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

NOTE: This point shall be considered very carefully.

B.3 Integrating and power summing device

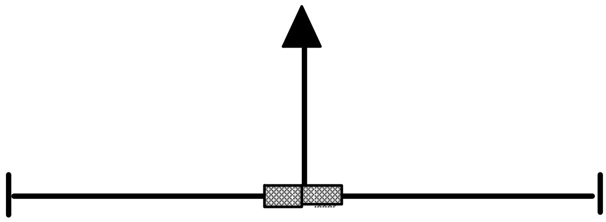
The integrating and power summing device is connected to the video output of the spectrum analyser, referred to in Clause B.2.

It shall be possible to sum the effective power of all discrete components, the spectral power density and the noise power in the selected bandwidth and to measure this as a ratio relative to the carrier power.

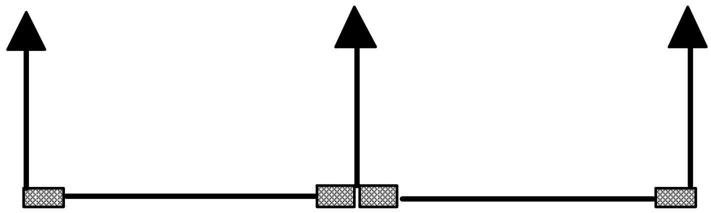
The position and the width of the integration range selected can be indicated on the spectrum analyser by brightening the trace.

Annex C (informative): Graphic representation of the selection of equipment and frequencies for testing

SINGLE CHANNEL EQUIPMENT

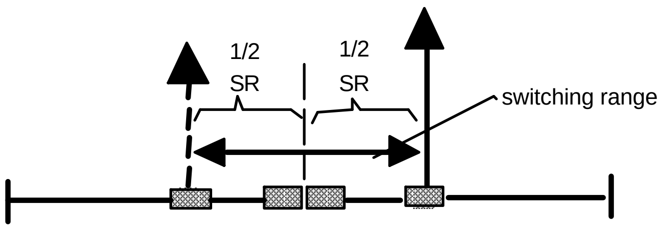


Equipment of category AR1 see subclause 4.1.5

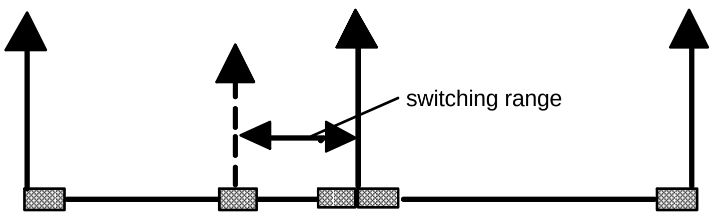


Equipment of category AR2 see subclause 4.1.6

TWO CHANNEL EQUIPMENT



Equipment of category AR1 see subclause 4.1.7

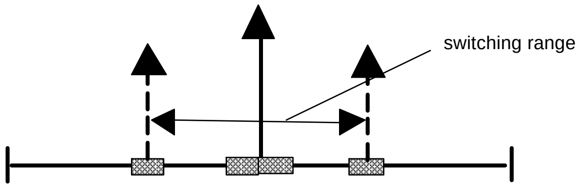


Equipment of category AR2 see subclause 4.1.8

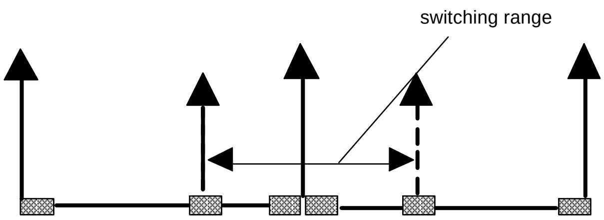
Note: for legend see figure C.2

Figure C.1: Single channel/two channel equipment

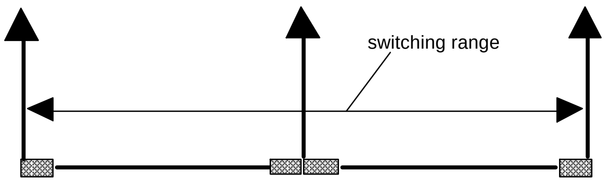
MULTI CHANNEL EQUIPMENT



Equipment of category AR1 see subclause 4.1.9



Equipment of category AR2 see subclause 4.1.10



Equipment of category AR2 see subclause 4.1.11

AR = SR

Legend:

AR1 - First category of alignment range, see subclause 4.1.3.

AR2 - Second category of alignment range, see subclause 4.1.3.

Limited test, see subclause 3.1.

Full test, see subclause 3.1.

100 kHz range in which the test shall be carried out.

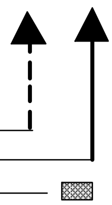


Figure C.2: Multichannel equipment

Annex D (informative): Identification

D.1 Scope

The identification code shall fulfil the specifications given in this annex unless identification is included in a system protocol approved by the appropriate national regulatory authority. It shall also be used by combined speech/non speech equipment in the case of speech transmissions.

D.2 General

The design of a mobile system depends upon the requirements of that system, the evolution of technology and the specific needs and/or requirements of each country. When possible, the identification code would use the same techniques as the transmission of the user information itself. Therefore, a variety of possibilities have been presented in this annex. They are presented using several item tables and/or cross-tables:

- modulation, (indicating speed, channel separation and modulation): table D.1;
- bitsync (if needed) and synchronisation word: table D.2;
- redundancy code and length of the useful bits protected by that code (CRC): table D.3;
- header of the ID (length and contents shall be unique to avoid ambiguous situations): table D.4;
- country code and length of national information: table D.5;
- national information subdivided in fields: table D.6 (table D.7 and figures D.2 to D.6);
- combinations of the previous items that could be used: table D.8;
- combinations that will in fact be used in the various countries: table D.9;
- organisation of the fields that will in fact be used in the various countries: table D.10.

These tables can be used by manufacturers for the design of the equipment, for the type approval of the equipment and by the monitoring stations for the analysis of the identification of the transmissions.

D.3 Position of the identification code

Considering that a receiver in the monitoring service is often operated in scanning mode and stops on a detected carrier, the identification code will be transmitted as described below.

D.3.1 Base stations

For base stations the identification ID shall be transmitted at the beginning and end of each session, at the end of the corresponding packets. If the session lasts for more than 3 minutes, an ID will also be transmitted at the end of the first transmitted packet after the 3 minutes has elapsed since the last transmission of the ID ("the 3 minutes rule"). There is no need for more than one ID per packet, unless 3 minutes have elapsed since the last transmission of the ID.

D.3.1.1 System without windows

In the case of continuous transmissions, the 3 minutes rule shall apply (not more than 3 minutes between transmissions of the ID).

D.3.1.2 Systems with windows

In the case of windows of less than 3 minutes, the ID shall also be sent at the end of the first packet of each window.

In the case of windows of more than 3 minutes, the ID shall, in addition, be sent according to the "3 minutes rule".

D.3.2 Mobile stations

The same rule as for the base stations applies except that a mobile only transmitting to a BS with a transmission shorter than 300 ms (e.g. the duration of a databurst according to Annex F), does not have to transmit its ID systematically in each session. Instead, the 3 minute rule applies, as follows:

- the ID shall be sent at the end of the first packet to be sent after 3 minutes have elapsed since the last transmission of the ID.

D.4 Bit rates and modulations

Using the following table, demodulation can be performed, producing a "raw" bit stream. In the case of sub-carrier modulation (indirect modulation), the carrier can be modulated in phase (/ph.) or frequency (/frq.).

Table D.1

name	speed	channel separation	modulation (or reference)	details (or reference)
MM12n /ph. /frq.	1 200 b/s	12,5 kHz	MSK (FFSK)	0=1800Hz,1=1200Hz
MM12w /ph. /frq.	1 200 b/s	20/25 kHz	MSK (FFSK)	0=1800 Hz,1=1200Hz
MV22w	1 200 b/s	20/25 kHz	CCITT V 22	4 phase state
MV23w	1 200 b/s	20/25 kHz	CCITT V 23	FSK 0=2100 Hz,1=1300Hz
MM24n	2 400 b/s	12,5 kHz	MSK (FFSK)	0=2400 Hz,1=1200Hz
MM24w	2 400 b/s	20/25 kHz	MSK (FFSK)	0=2400 Hz,1=1200Hz
MD24n	2 400 b/s	12,5 kHz	Direct	
MD24w	2 400 b/s	20/25 kHz	Direct	
MM36n	3 600 b/s	12,5 kHz	MSK (FFSK)	0=3600 Hz,1=1800Hz
MM36w	3 600 b/s	20/25 kHz	MSK (FFSK)	0=3600 Hz,1=1800Hz
MD36n	3 600 b/s	12,5 kHz	Direct	
MD36w	3 600 b/s	20/25 kHz	Direct	
MM48n	4 800 b/s	12,5 kHz	MSK (FFSK)	0=4800 Hz,1=2400Hz
MM48w	4 800 b/s	20/25 kHz	MSK (FFSK)	0=4800 Hz,1=2400Hz
MD48n	4 800 b/s	12,5 kHz	Direct	
MD48w	4 800 b/s	20/25 kHz	Direct	
MD80n	8 000 b/s	12,5 kHz	Direct	
MD80w	8 000 b/s	20/25 kHz	Direct	
MD96n	9 600 b/s	12,5 kHz	Direct	
MD96w	9 600 b/s	20/25 kHz	Direct	
MD160	16 000 b/s	(20)/25 kHz	Direct	
MD192	19 200 b/s	25 kHz	Direct	

Notes to Table D.1:

NOTE 1: the direct modulation concerns only constant envelope modulation methods and includes: GMSK, generalised tamed FM, multilevel state FM, PLL-4-PSK, 8 PSK.

NOTE 2: other modulation systems are under consideration and may be added later to this table if proven to provide better performance.

NOTE 3: the frequency shift used with the direct FSK modulation shall be chosen to meet subclause 8.5 (adjacent channel transmitter power).

NOTE 4: some modulation methods presented in this table have not yet been proven to meet subclause 8.5 (adjacent channel transmitter power).

D.5 Format of the identification

The identification (ID) shall be transmitted in one block (see definitions in subclause 3.1).

If bit rate/modulation of the users information and of the "ID" block are not the same, the block shall be preceded by "bit sync". If bit rate and modulation are the same, the "bit sync" is optional. However, it is well known that the autocorrelation properties of the "sync word" are calculated with respect to their corresponding "bit sync" (see table D.2).

		<-------- ID Block ----------->				
bit sync.	sync. word	header	Ntl infor.	C.Code	CRC	

Figure D.1: ID block organisation

D.6 Synchronisation

Using the following table, the monitoring station receiver/decoder can be synchronised (detection of the beginning of each block) and bits can be extracted from the "raw" bit stream. Bits shall be transmitted in the order of Most Significant Bit (MSB) first.

Table D.2

bit sync (if needed)	Sync. word		Notes
	name	value	
1010 1010 1010 1010	S1	1011 0100 0011 0011	(NOTE 1)
1010 1010 1010 1010	S2	0011 1011 0010 1000	
10 10 10 10	S3	1100 1110 00	(NOTE 2)
01 01 01 01	S3'	0011 0001 11	(NOTE 2)
1010 1010 1010 1010	S4	1100 0100 1101 0111	
1010 1010 1010 1010	S5	(1)010 0010 1111 0111	
	S6	(1)101 1101 0000 1000	
1010 1010 1010 1010	S7	1010 1111 0001 0010	

NOTE 1: This sync word has optimal autocorrelation properties.

NOTE 2: Frame synchronisation comprises 10 bits with the structure:

S3 = transmissions Base to Mobile;
S3' = transmissions Mobile to Base.

Only these 10 bits are used for frame synchronisation when mobile evaluates base radio stations.
These 10 bits plus base identity (10 bits) in the scheme apply to all other communication with the current base as synchronisation word for frame synchronisation. Furthermore, four control flags are included in the synchronisation word, i.e. the total length of the frame head is: 24 bits + bit sync.

D.7 Code and block length

Using the table D.3 following, the "useful" bits of each block can be counted and checked (error detection can be performed). Corrections could also be performed: a trade-off between detection and correction performance and notes concerning the code are proposed in column Det/Corr.

Table D.3

Name	Sizes	Notes	Details	Det/Corr
C1	(64,48)		$X^{15}+X^{14}+X^{13}+X^{11}+X^4+X^2+1$ cyclic (63,48), LSB inv. +1 parity (even) bit appended	Det =< 5 errors
C2	(n+8,n)		$X^8+X^7+X^4+1$ all bits	
C3	(69,48)		Shortened cyclic	Det/Corr
C4	(16,8)	NOTE 1	Block code: Corr 2 er.	
OC1	16*(8,4)	NOTE 2	for "overcoding" the block in certain frequency bands parity check matrix: (01 -- -- --) (10 01 -- --) (10 10 01 --) (00 10 10 01)	Corr 2 er.

NOTE 1: Code C4 may be used in systems which need high protection and with a small amount of data to be transferred in a normal transmission. (6 blocks are needed to transmit the ID).

NOTE 2: Code OC1, in some frequency bands, may be used to protect all the bits of the block (in order to allow the correction of errors due to ignition noise, etc.). In the case where the code OC1 is used, the code C1 should only be used for error detection.

D.8 Contents of the identification block

D.8.1 Header

Using table D.4, the nature of the information contained in the block can be determined: ID or users/system information. Many of the combinations in this header are free for other use. Using such an organisation could allow countries using only one block for the ID to use only first bit as ID (users/system) information flag, while leaving it open for other countries to use more bits. These bits could also be considered as part of the sync word for hunting purposes.

Table D.4

Name	Length	Binary	Interpretation
H1	4 bits	Hn2 = 0 0 x x	ID word to be used during the session (monitored on F1 or F2)
		Hn1 = 0 1 x x	ID word transmitting on F1; it can be used to activate the corresponding repeater
		Hd = 1 y x x	user/system information bloc; bits y and x are free for future use or for transmitting user/system information

NOTE: When a repeater is used, "F1" is the frequency used for the mobiles to transmit, "F2" is the output frequency of the repeater.

D.8.2 Country code

Table D.5 allows for the transcoding of the 5 bit OC field into the actual country where the ID has been allocated.

Table D.5

Country code	Country	Length of Ntl info (if deviating from 39 bits) (see D.8.3)
00 000	Nil	
01 111	Germany (Fed. Rep.)	41 bits
01 110	Andorra	
11 001	Austria	
01 100	Belgium	
00 100	Cyprus	
00 011	Czechoslovakia	
01 000	Denmark	
10 111	Spain	
01 011	Finland	
10 000	France	
00 111	Greece	
11 110	Ireland	
11 000	Iceland	
11 011	Luxembourg	
11 101	Malta	
11 111	Monaco	
01 101	Norway	
10 001	Netherlands	
10 101	Poland	
00 010	Portugal	
01 001	United Kingdom	
10 110	San Marino	
10 010	Sweden	
00 101	Switzerland	41 bits
11 100	Turkey	
00 001	Vatican (City)	
10 100	Yugoslavia	

D.8.3 National Information

The following options for the fields containing the "National" (Ntl) information are based on the assumption that the ID blocks contain 48 useful bits and provide 39 bits for the "National" information field (field F).

D.8.3.1 Field description

The following fields can either be used for the purpose of identification and/or used for transmitting information corresponding to user data or system needs:

Table D.6

Category	No of bits
Licensee number	- Lnb: 0 - 14
Individual transmitter identification	- TID: 0 - 20
Network identification	- NID:14 - 20
Regional licensing office	- LOF: 0 - 8
Relay station number	- Rnb: 0 - 12
National Additional information	- NAI: 0 - 20
User group	- UG : 0 - 7
Field free for system or user data	- FF :

The maximum total number of bits available in field F is 39 bits (however national information can go up to 41 bits by overflow of 2 bits into the header Hxx bits).

All categories are expected to be coded in binary (and will be presented in 4 bit nibbles).

D.8.3.2 Field size options

Table D.7

Name of the scheme	Field description		
	Size	Name	Usage
FZ1	7 bits 7 bits 14 bits 13 bits	LOF UG NID TID	regional licensing office ID user group network identification individual transmitter ID
FZ2	5 bits 18 bits 12 bits	Rnb NID TID	relay number network ID individual mobile number
FZ3	27 bits 14 bits	Lnb NID	licensee number network ID

D.8.3.3 Options for the organisation of the fields

* bit	0	2	9	13	16	30	43
sync word	H Oy	UG 7 bits	LOFM 4 bit	LOFL 3 bit	NID 14 bits	TID 13 bits	CC 5 bit

Figure D.2: FO1

* bit	0	4	9	13	31	43
sync word	H Oyxx	Rnb 5 bits	FF 4 bit	NID 18 bits	TID 12 bits	CC 5 bit

Figure D.3: FO2

* bit	0	2	29	43
sync word	H Oy	Lnb 27 bits	NID 14 bits	CC 5 bit

Figure D.4: FO3

* bit	0	4	9	36	43
sync word	H Obxx	FF 5 bits	Lnb 27 bits	NID 7 bits	CC 5 bits

Figure D.5: FO3b

* bit	0	4	9	13	17	31	43
sync word	H Obxx	Rnb 5 bits	FF 4 bit	Ext 4 bits	NID 14 bits	TID 12 bits	CC 5 bit

Figure D.6: FO4

Option

F04, given in figure D.6 above, is a common representation where the extension (4 bits) could be either FF or LOFL or an extension for NID

NOTE : "bit", in these tables, means the first bit of the corresponding field.

D.8.3.4 Examples of user/system information usage

The bits of the ID block that have not been allocated in table D.6 (free fields "FF") can be:

- used for numbering the blocks in the packets (e.g. 3 bits);
- used as a function code (e.g. 2 bits);
- used for the transmission of status;
- used to transmit an acknowledge;
- used to transmit a no-acknowledge;
- used to clear down the repeater (deactivation of the repeater after an activation using, for instance, Header code Hn1).

D.9 Combinations

Tables D.8 and D.9 indicate which of the combinations given in the "Items Tables" will in fact be used.

D.9.1 List of possible combinations

Table D.8 indicates the "lower layer" combinations that have been explicitly supported by the regulatory authorities and that could be accepted in some countries. Knowing these formats and codes, NTL information can be easily accessed.

Table D.8: Combinations table

modulation	sync. word	code length	Header	Freq.Band	comb.name +notes
MM12w	S1	C1	H1(w/2bit)		ACx
MM12n	S1	C1	H1	< 500 MHz	ACy
MM12n,w	S3 + S3'	C3	H1	< 1000 MHz	ACzn,ACzw
MM12n,w	S7	C4	H1	< 500 MHz	ACtn,ACtw

NOTE: To be completed in the future

D.9.2 Relations between country code and allowed combinations

The following table indicates, among the combinations included in table D.8, those which are, or will soon be, effectively allowed in the different countries.

Table D.9: Combinations in a country

Country code	Allowed combinations	Notes
D 01 111	ACx, Fs	Not all combinations will be allowed
And 01 110		
A 11 001		
B 01 100		
CY 00 100		
DK 01 000	Fs	
E 10 111	Fs	
SF 01 011	Fs	
F 10 000	ACy	Until further notice, only one is allowed
GR 00 111		
IRL 11 110		
IS 11 000		
I 01 010	Fs	
FL 11 010		
L 11 011		
M 11 101		
MC 11 111		
N 01 101	Fs	
NL 10 001	Fs	In the future only a few comb. will be allowed
P 00 010	Fs	
GB 01 001	ACy	Other comb. could be allowed
SMR 10 110		
S 10 010	ACzw, ACtw	Other comb. could be allowed
CH 00 101	Fs	
TR 11 100		
SCV 00 001		
YU 10 100		

NOTE: Fs: further study is needed
comb: combinations.

D.9.3 Interpretation of the fields of the ID block

Using table D.10, interpretation of the various fields could be performed.

Table D.10: Interpretation table

Country code		Scheme for organisation of NTL info (NOTE 2)
D	01 111	FZ1 / F01
And	01 110	
A	11 001	
B	01 100	
CY	00 100	
DK	01 000	Fs (NOTE 1)
E	10 111	Fs
SF	01 011	Fs
F	10 000	FZ2 / F02, equivalent to F04 with EXT used for extension of NID
GR	00 111	
IRL	11 110	
IS	11 000	
I	01 010	Fs
FL	11 010	FZ3 / FO3
L	11 011	
M	11 101	
MC	11 111	
N	01 101	
NL	10 001	
P	00 010	
GB	01 001	
SMR	10 110	
S	10 010	Fs
CH	00 101	FZ3 / F03
TR	11 100	
SCV	00 001	
YU	10 100	

NOTE 1: Fs: further study is needed.

NOTE 2: For NTL information see subclause D.8.3, including tables D.6 and D.7 and figures D.2 to D.6

Annex E (informative): Information on modulation, coding and format

It is pointed out that this ETS addresses only the minimum performance of the hardware/lower layers of the data equipment and that it does not cover measurements that confirm the error ratio performance of the radio data systems in real or simulated mobile environment conditions (multipath fading, burst interference, ignition noise, etc).

Attention is drawn to the fact that CCITT standards do not address the mobile system error ratio issue. And therefore equipment designed to meet such standards is not necessarily suitable for use in mobile radio systems. Specifically external modems, protocols and also ancillary units used in conjunction with mobile radio equipment should be capable of operating with the mobile radio system in such a manner as to minimise the system error ratio in real conditions, and to provide good spectrum efficiency.

Attention is also drawn to the availability of CCIR recommendations and reports on the subject (see CCIR volume VIII).

Furthermore it is recommended to obtain the approval of the mobile radio manufacturer of any equipment to be incorporated in a mobile radio data system (eg. in "OEM" basis).

Bibliography: COST 207 final report, Brussels 1989.

Annex F (normative): Access protocol and occupation rules for the transmission of data on shared channels

F.1 Scope

This annex is not mandatory. However administrations are requested not to consider the mandatory use of any other access protocol and occupation rules if this annex is applicable.

F.1.1 General

This access protocol applies to single frequency simplex operation (and two frequency, repeater operations with the repeater in the duplex mode and the mobile units in the simplex mode). This access protocol is applicable for:

- multiple, independent from each other, private data only users which do not share a common central control facility, but may share a common single or two frequency radio channel;

- multiple, independent from each other, private mixed analogue speech and data users which do not share a common central control facility, but may share a common single, or two frequency, radio channel and where speech is to have priority over data transmissions.

This access protocol is not applicable for data users with common central control facilities or for trunked systems operating on dedicated non shared channels.

In the case of analogue transmissions, the corresponding access protocol is known as the "radio-discipline" of the users.

Within the limits set out in this annex, each group of users may use its own communication protocol.

F.1.2 Priority

This access protocol gives speech priority over data, on mixed speech/data channels. In order to limit annoyance to the speech user, data transmissions shall be very short (see subclause F.3.7.1).

F.1.3 Sharing data/data

On frequencies assigned only to data communication users (without common central control facilities), the access protocol provides access to independent users with equal priority.

F.1.4 Traffic load

With (existing) speech users having priority over their data counterparts, the waiting time for data users will increase rapidly with increasing speech traffic load.

Therefore, this access protocol shall not be used for channels with a speech traffic of more than 0.2 erlang in the busy hour. The extra traffic generated by data transmissions shall not exceed an additional traffic of 0,05 erlang.

F.2 Technical characteristics of the equipment

The timing requirements that the equipment shall fulfil in order to operate correctly and efficiently can be found in subclauses 5.1.7, 5.1.8, 5.2.10 and 5.2.11.

The corresponding methods of measurement can be found in subclauses 8.8, 8.9 (in main body) and in subclauses F.5.1 and F.5.2, of this annex.

F.3 Procedure of the access protocol

F.3.1 General

The access protocol shall be used for each occupation of the RF channel for sharing data/data and for sharing speech/data with automatic channel access.

F.3.2 Considerations

The transceiver shall determine whether or not the channel is and has been idle for a certain period (the observation time) by means of carrier sensing.

The observation time consists of a fixed part and a randomly selected part. When the channel still appears to be idle at the end of the observation time, the transmitter is initiated and shall be powered up within a specified time (attack time; see subclause 8.8).

The duration of the emission is limited (see subclause F.3.7).

F.3.3 Procedure

The transceiver shall determine whether or not the channel is and has been idle for a certain period, the observation time t_o, by means of carrier sensing (see subclause F.3.4). The observation time t_o consists of a fixed part t_f and a randomly selected part t_r.

If the channel is occupied during part of the observation time, the process shall be repeated.

If the channel still appears to be idle during the observation time, the transmitter shall be initiated and powered up within a specified time. The channel can then be seized for the duration of one time interval. The maximum length t_t of this interval depends on the frequency category (data/speech, data/data).

If no response is received (owing, for example, to simultaneous channel access by several users), the channel shall be detected as free during the observation time t_o prior to a repetition of a transmission.

Within one time interval, radio traffic may take place:

a) from a base station to one or several mobiles;

b) from a mobile to a base station;

c) between mobiles.

To ensure that no other user can access the channel during a time interval, the reversion time t_c between transmission of a message and corresponding acknowledgement and reply, shall not exceed 50 ms. The reversion time t_c, is the time between the switch off of one transmitter and the switch on of the other, as measured at 50 % of the rated carrier power.

F.3.4 Carrier sensing

The carrier sense shall be able to detect RF signals with different types of modulation (e.g. F3E, G3E, F1D, F2D, G1D). The threshold level for the carrier sense during the observation time (subclause F.3.5) shall not exceed 2 µV emf. The carrier sense delay (see subclauses 5.2.10 and F.5) shall be less than or equal to 10 ms.

F.3.5 Observation time

F.3.5.1 Start of the observation time

The observation time shall start within 10 ms after each time that the RF channel has become idle. It will also start at power on.

F.3.5.2 Observation time

The observation time t_o is the sum of the fixed part t_f and the random part $t_r = nt_i$

$$t_o = t_f + nt_i.$$

The fixed part , t_f, of the observation time shall be:

- on pure data channels : 60 ms;
- on combined speech/data channels : 2000 ms.

The increment time t_i shall be 50 ms ± 0,1 ms.

The number n is a random number between 1,2,..., m; this means that 1,2,...,m is the event field of the random number n. The random number n shall be determined by use of a random generator with a uniform distribution. To achieve short delays during low traffic, the observation time should be short, i.e. m should be a small integer.

A short random part of the observation time however, increases the probability of several users simultaneously accessing the channel for a time interval. In the event of an unsuccessful transmission attempt, the channel shall be detected as free during a new t_o before a repetition of the transmission takes place. The event field (1,2,...,m) is doubled with each trial. In this way, channel congestion can be reduced even with short initial observation times.

For the first trial, m is set to 4.

For the second trial, m is set to 8, etc. until m = 64.

F.3.6 Initiation of the transmitter

If the channel has not been occupied since the start of the observation time, then the transmitter can be initiated. The time, which elapses between the end of the observation time and the moment that the carrier power from the transmitter has reached a level of 1 dB below the steady state power, shall not exceed 25 ms (equivalent to the transmitter attack time (see subclause 8.8).

F.3.7 Duration of the RF channel occupation (time interval)

F.3.7.1 Transmissions of data packets exceeding 300 ms

The time interval during which packets of data can be sent by the initiating transmitter to the addressed parties is called t_t. To ensure that only the initiating transmitter monitors the time interval, acknowledgements and replies may exceed the time interval t_t by the time dt_t. This determines the duration of the windows (see definitions in subclause 3.1). Equipment designed to comply with this protocol shall provide for the following ranges and step sizes:

t_t = 1, ...,10s step size 100ms;

dt_t = 0,1,..,10s step size 100ms.

F.3.7.2 Emissions of data packets not exceeding 300 ms

On mixed speech/data channels additional short data bursts of a duration not exceeding 300 ms can be transmitted. The start of the observation time is regulated by subclause F.3.5.1. The observation time (with carrier sense) before such emissions shall be equal to the random part stated in subclause F.3.5.2 (the fixed part of the observation time shall be zero).

If a re-transmission or another burst is to be transmitted, this procedure may only be repeated after two seconds (fixed part of the observation time).

F.4 Examples

Figures F.1 to F.4 illustrate the protocol as described.

F.5 Methods of measurement (receiver)

F.5.1 Carrier sense delay

F.5.1.1 Definition

The carrier sense delay is the time which elapses between the application of a carrier to the receiver and the detection of the carrier by that receiver.

F.5.1.2 Method of measurement

The receiver shall be connected to a signal generator with the frequency equal to the nominal frequency of the receiver. The level is set to 6 dB above the maximum usable sensitivity (data).

The test signal ("test carrier") shall be switched on and off by means of a (logical) input signal. The rise and decay time of this signal shall be less than 1 ms. The receiver under test shall provide a measurement point where the "carrier detect signal" can be observed. The delay between the application of the test carrier and the detection by the receiver shall be noted.

The measurement shall be carried out with:

a) an unmodulated carrier;

b) a carrier modulated with 400 Hz, with a deviation corresponding to 12 % of the channel separation;

c) a carrier modulated with data similar to the data format/modulation used by the equipment.

F.5.2 Receiver opening delay

F.5.2.1 Definition

The receiver opening delay is the time which elapses between the application of a test signal ("carrier") to the receiver and the establishment of the receiving condition.

F.5.2.2 Method of measurement

The receiver shall be connected to a signal generator with the frequency equal to the nominal frequency of the receiver.

A test signal with a level of 20 dB above the maximum usable sensitivity (data) is applied at a known instant to the receiver.

After the specified delay (see subclause 5.2.11), the test signal shall then be modulated by a data signal, consisting of a relevant synchronising sequence and a pseudorandom bit sequence of 511 bits or a correctly coded message.

When a coded message has to be used, the measurement shall be repeated three times. The number of errors shall be noted.

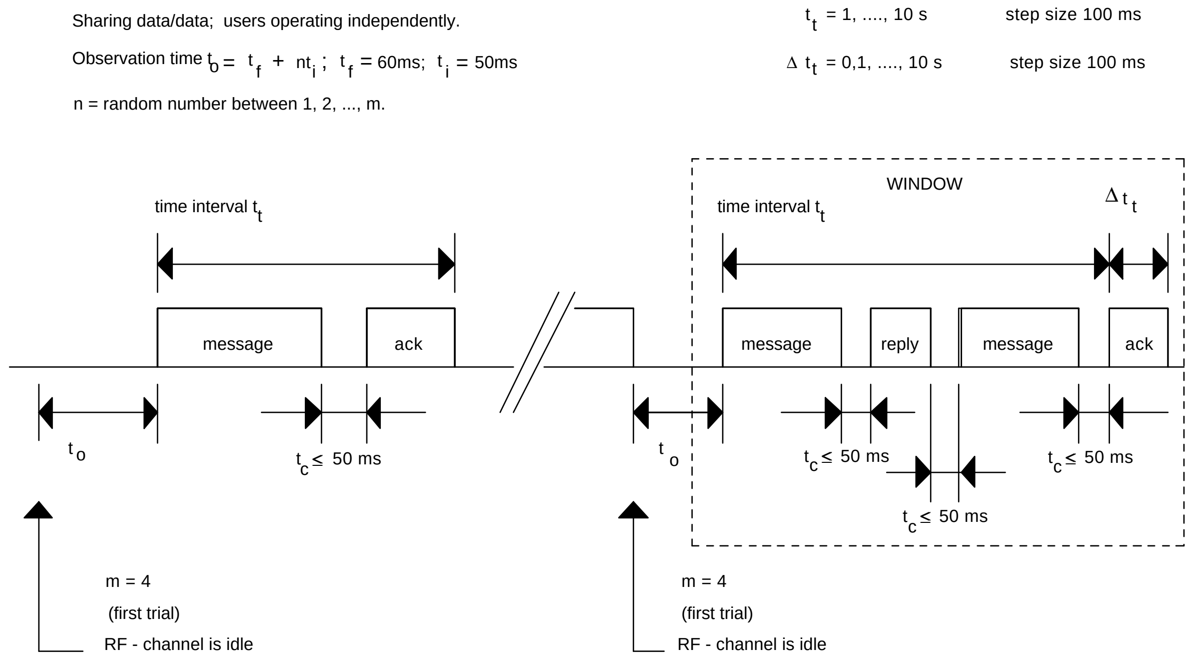


Figure F.1

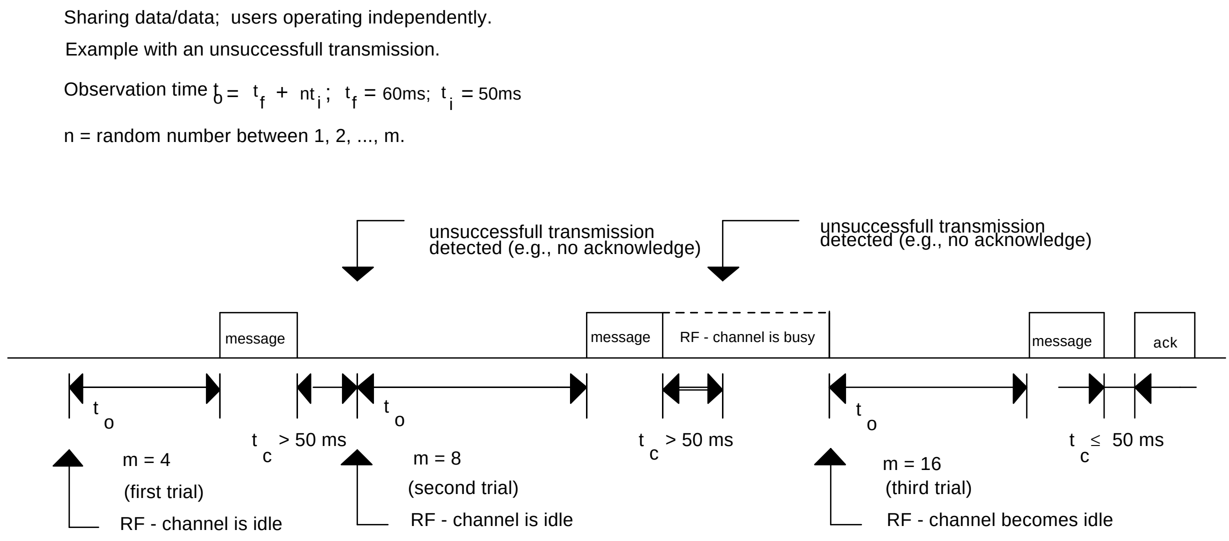


Figure F.2

Sharing data/data; users operating independently.

Observation time $t_o = t_f + nt_i$; t_f = 60ms; t_i = 50ms

n = random number between 1, 2, ..., m.

t_t = 1, ... 10 s step size 100 ms

Δt_t = 0,1.... 10 s step size 100 ms

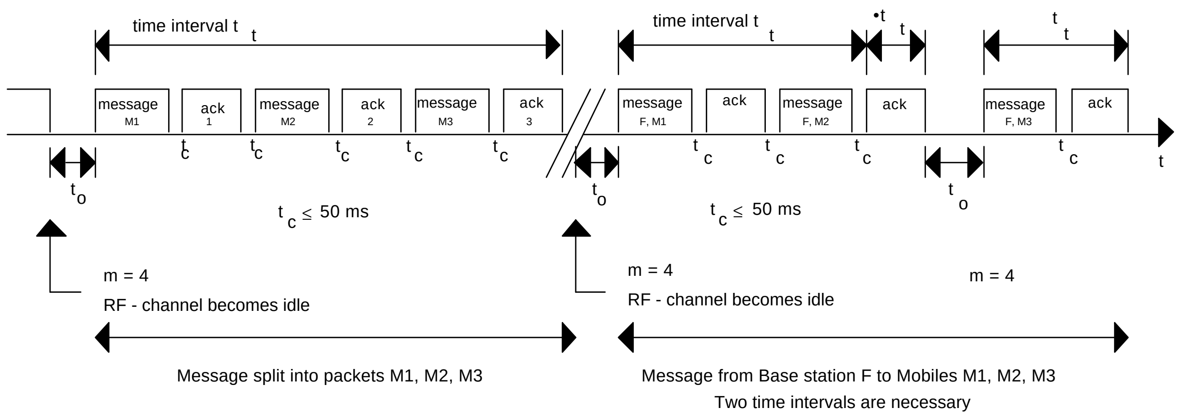


Figure F.3

Sharing speech/data; users operating independently.

Observation time $t_o = t_f + nt_i$; t_f = 60ms; t_i = 50ms

n = random number between 1, 2, ..., m.

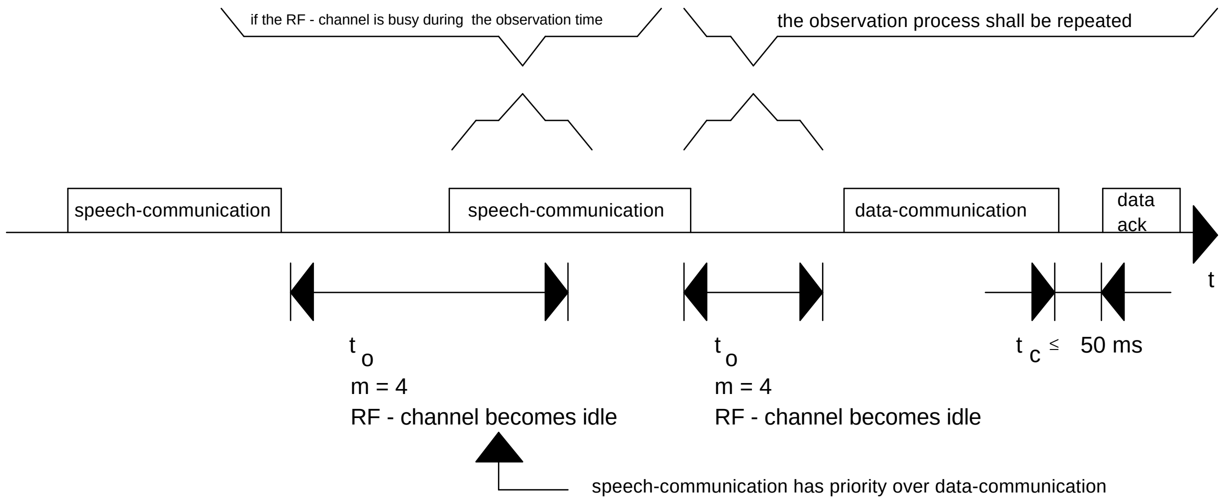


Figure F.4

History

Document history	
January 1992	First Edition
March 1996	Converted into Adobe Acrobat Portable Document Format (PDF)