Recommendation T/R 20-03 (Puerto de la Cruz 1974, revised at Malaga-Torremolinos 1975, Stockholm 1976 and 1977, and Montpellier 1984)

LOW-POWER TELECOMMAND AND TELEMETRY EQUIPMENT OPERATING ON COLLECTIVE FREQUENCIES IN ISM BANDS

Recommendation proposed by the "Radiocommunications" Working Group T/WG 3 (R)

Revised text of Recommendation adopted by "Telecommunications" Committee:

"The European Conference of Posts and Telecommunications Administrations,

considering

(a) that technical progress has made available to the public:
- telecommand and telemetry equipment for commercial applications;
- telecommand equipment for use with toys and scale models, the various items of equipment being low-powered and suitable for use on collective frequencies in ISM bands (frequency bands to be utilised, according to the Radio Regulations, for industrial, scientific and medical applications),

(b) that utilisation of such equipment is expanding, bringing technical and regulatory problems for Administrations,

(c) that it would be desirable for Administrations to have common regulations to simplify these problems,

(d) that it would be of benefit to Administrations, users and manufacturers of this telecommand and telemetry equipment to exchange approval test reports between Administrations where the latter so desired,

(e) that mutual acceptance by the CEPT members of test reports and approval certificates should be the goal to be aimed for,

recommends

1. that, insofar as their national, regulations permit, CEPT members should make provision to adopt measures authorising telecommand and telemetry equipment for commercial applications, and telecommand equipment for toys and scale models, in accordance with the conditions given in Annex I to this Recommendation,
2. that the technical specifications of this equipment and the methods of measurement utilised for approval tests should be those contained in Annex II,
3. that the test report should include what is necessary for precise identification of the equipment and for the conduct of the tests. To this end, applicants should supply at least the information given in Annex III to this Recommendation, this information to be passed on when test reports are exchanged,
4. that, in drafting test reports Administrations should, where possible, follow the order of tests and paragraph numbering given in Annex II and adopt the terminology of the said annex in this Recommendation."

Annex I

SPECIFICATIONS FOR UTILISATION OF LOW-POWER TELECOMMAND AND TELEMETRY EQUIPMENT OPERATING ON COLLECTIVE FREQUENCIES IN THE ISM BANDS

1. It should be possible to utilise telecommand and telemetry equipment for commercial-type applications, and telecommand equipment for toys and scale models, as of right (general authorisation). Where this is contrary to legislation and national regulations, individual licences should be issued under the least restrictive conditions possible.
2. Administrations may set a minimum age requirement, in accordance with their national regulations, for utilisation of telemetry equipment and the three categories of telecommand equipment.
3. Where a licence is required, this licence should be issued irrespective of the nationality of the applicant.
4. This telecommand and telemetry equipment should comply with the respective approved types.
5. All equipment delivered in parts and assembled by the purchaser should be subject to individual approval.
6. Equipment should bear an approval number and, where physically possible, the following indications:
   (a) Manufacturer
   (b) Type
   (c) Serial number
   (d) Frequency(ies)
7. Approval tests shall be carried out using the antenna or antennae supplied by the manufacturer with the equipment. Only antennae of this type shall be authorised.

Annex II

TECHNICAL SPECIFICATIONS AND METHODS OF MEASUREMENT USED FOR APPROVAL TESTS OF LOW-POWER TELECOMMAND AND TELEMETRY EQUIPMENT OPERATING ON COLLECTIVE FREQUENCIES IN THE ISM BAND

1. SCOPE OF SPECIFICATIONS

These technical specifications cover the minimum characteristics considered necessary in order to make the best use of the available frequencies. They do not necessarily include all the characteristics which may be required by a user, nor do they necessarily represent the optimum performance achievable.

They apply to equipment with an antenna connection as well as to equipment with integral antennae. In these specifications, an integral antenna is defined as one which is designed to be connected permanently to the transmitter or receiver without the use of a connector and/or cable.

1.1. General

In the case of equipment which is intended for use with an integral antenna as well as for use with an external antenna linked using a connector, the equipment shall be tested as equipment intended for use with a detachable external antenna and shall meet the appropriate limits. In addition to this, the transmitter characteristics: transmitter carrier power and spurious emissions of the transmitter, and the receiver characteristic: spurious emissions of the receiver, shall be measured as for equipment with integral antenna and the appropriate limits shall be confirmed.

1.2. Frequency aspects

1.2.1. *Frequencies available*

13.560 MHz	27.145 MHz	40.675 MHz
26.995 MHz	27.195 MHz	40.685 MHz
27.045 MHz	27.255 MHz	40.695 MHz
27.095 MHz	40.665 MHz	

and the 433.05-434.79 MHz band (centre frequency: 433.92 MHz)*.

* "According to the Radio Regulations (RR 662), this band is an ISM band in Germany (Federal Republic of), Austria, Liechtenstein, Portugal, Switzerland and Yugoslavia.
As far as the other CEPT countries are concerned, according to the provisions of RR 661, this band may be designated an ISM band subject to special authorisation by the Administration concerned and in agreement with other administrations whose radiocommunication services might be affected."

1.2.2. *Channel spacing*

On frequencies below 50 MHz the channel spacing is 10 kHz. On frequencies above 50 MHz, the channel spacings of 12.5, 20 and 25 kHz can be used.

1.2.3. *Synthesisers and phase-locked loops (PLL)*

If, for generating the transmitter frequency, use is made of a synthesiser and/or a phase-locked loop system, the transmitter shall be inhibited when synchronisation is absent. Administrations wishing to verify the transient behaviour of transmitters may do so with the method of measurement given in Appendix B.

1.2.4. *Types of modulation*

Amplitude, frequency and phase-modulation are allowed.

1.3. Mechanical construction and electrical design

Controls allowing to regulate the modulation level shall not be accessible to the user of the equipment.

2. TEST CONDITIONS, POWER SOURCES AND AMBIENT TEMPERATURES

2.1. Normal and extreme test conditions

Type-approval tests 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 2.2. and 2.4.3. below.

2.2. **Test power source**

During type-approval tests 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 2.3.2. and 2.4.2. 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.

In equipment with incorporated batteries 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 of ±3% relative to the voltage at the beginning of each test.

2.3. **Normal test conditions**

2.3.1. *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%

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

2.3.2. *Normal test power source*

2.3.2.1. Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of these specifications, 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.

2.3.2.2. Regulated lead-acid battery power sources on vehicles

When the radio equipment is intended for operation from the usual types of regulated lead-acid battery power source of vehicles, the normal test voltage shall be 1.1 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

2.3.2.3. 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.

2.4. **Extreme test conditions**

2.4.1. *Extreme temperatures*

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in Clause 2.4.3., at the upper and lower temperatures of:
−25° C to +55° C
−10° C to +55° C

The test reports shall specify the range chosen.

2.4.2. *Extreme test voltages*

2.4.2.1. Mains voltage

The extreme test voltage for equipment to be connected to an AC mains source shall be the nominal mains voltage ±10%. The frequency of the test power source corresponding to the AC mains shall be between 49 and 51 Hz.

2.4.2.2. Regulated lead-acid battery power source on vehicles

When the equipment is intended for operation from the usual types of regulated lead-acid battery power sources of vehicles the extreme test voltages shall be 1.3 and 0.9 times the nominal voltage of the battery (6 volts, 12 volts, etc.).

2.4.2.3. Other power sources

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

1. For the Leclanché type of battery:
   0.85 times the nominal voltage of the battery;
2. For the mercury type of battery:
   0.9 times the nominal voltage of the battery;
3. For lithium type of battery:
   0.85 times the nominal voltage of the battery;
4. For other types of primary batteries:
   end point voltage declared by the equipment manufacturer.

For equipment using other sources, the extreme test voltages shall be those agreed between the equipment manufacturer and the testing authority and shall be recorded with the results.

For equipment capable of being operated from a variety of power sources, the extreme test voltages shall be determined for each one of the sources and the lower and upper values obtained adopted as the extreme test voltages and recorded with the results.

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

Before tests at the upper temperatures, the equipment shall be placed in the test chamber and shall be left there 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. For tests at the lower temperatures 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.

3. GENERAL CONDITIONS

3.1. Definitions

3.1.1. *Response indicator*

Any suitable means of indicating that the receiver has responded to a correctly coded input signal may be used.

3.1.2. *Reset*

The reset may if necessary be a manual or automatic method of cancelling the response indication and resetting the decoder enabling it to respond to the next correctly coded input signal.

3.1.3. *Reset time*

The reset time of the receiver is the minimum elapsed time between two messages in order that they may both be successfully registered. The reset time shall be declared by the manufacturer in order that the formation of a normal coded test signal may be derived.

3.1.4. *Normal coded test signal*

The normal coded test signal shall be a continuously modulated signal or trains of correctly coded signals, separated from each other by a time of not less than the reset time of the receiver. This signal shall be that, as agreed between the manufacturer and testing authority, which requires the greatest radio frequency occupied bandwidth. Details of the test signal shall be included in the test report.

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

3.1.5. *Sufficient response*

Sufficient response is:

- in case of a specific response:
  the situation where 80% of the transmitted messages result in the expected response;
- in the case of proportional telecommand:
  a good correspondence between the transmitted signal and the resulting response, as agreed between the manufacturer and the testing authority.

Details of the applied criterion shall be recorded in the test report.

3.2. Artificial antenna

Tests on the transmitter shall be carried out with a non-reactive non-radiating load of 50 ohms connected to the antenna terminals, or in the case of equipments with integral antenna, to the test fixture terminal.

3.3. Encoder for receiver measurements

To facilitate measurements on the receiver of those equipments of which the adjacent channel selectivity shall be measured, an encoder for the signalling system should accompany the model submitted, complete with details of the normal modulation process. The encode will be used to modulate a signal generator for use as a test signal source.

The encoder should be operating in the continuous mode or else be capable of operation in a repetitive mode with intervals between each code that are not less than the reset time of the receiver.

Details of the code and code format(s) shall be given.

3.4. Test signals applied to the receiver

3.4.1. *Direct connection with antenna socket*

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 ohms.

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

The levels of the test signals shall be expressed in terms of e.m.f. at the receiver input terminals.

The effects of any intermodulation products and noise produced in the signal generators should be negligible.

The test generators shall be substantially free from amplitude modulation.

3.4.2. *Test fixture for integral antenna*

In the case of equipment intended for use with an integral antenna, the manufacturer may be required to supply a test fixture suitable to allow relative measurements to be made on the submitted sample.

This test fixture shall provide a 50 ohms radio frequency terminal at the working frequencies of the equipment.

The test fixture shall provide means of making external connection at least to radio frequency output and of replacing the power source by external power supplies.

The performance characteristics of this test fixture under normal and extreme conditions are subject to the approval of the testing authority.

The characteristics of interest to the testing authority will be that

(a) the coupling loss shall not be excessive, that is not greater than 30 dB;
(b) the variation of coupling loss with frequency shall not cause errors exceeding 2 dB in measurements using the test fixture;
(c) the coupling device shall not include any non-linear elements.

The testing autority may provide its own test fixture.

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

(For general guidance, see also Appendix A.)

3.5.1. *Outdoor site*

3.5.1.1. Test site

The test site shall be on a reasonable level surface or ground.

At one point on the site, a ground plane of at least 5 metres diameter shall be provided. In the centre of this ground plane, a support, capable of rotation through 360° in the horizontal plane, shall be used to support the test sample at 1.5 metres above the ground plane. For equipment operating on radio frequencies above 50 MHz this shall be a non-conducting support.

For equipment operating on radio frequencies up to 50 MHz a support consisting of a salt-water-filled (9 g NaCl per litre) plastic tube with a length of 1.5 metres and 10 ±0.5 centimetres inner diameter shall be used. The top end is closed by a metal plate, diameter 15 cm, in contact with the water.

The sample shall be placed with its side of largest area on the metal plate. To meet the requirement that the antenna is vertical while maintaining contact with the metal plate, it may be necessary to use a second metal plate, attached to the first. This metal plate shall be 10 × 15 cm in size and shall be hinged to the first plate by its 10 cm edge in such a way that the angle between the plates can be adjusted between 0° and 90°. The hinge point shall be adjustable so that the centre of the sample can be placed above the centre of the circular plate. In the case of samples whose length along the antenna axis is less than 15 cm, the sample shall be arranged so that the base of the antenna is at the edge of the hinged plate.

The test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of at least the higher of the two values $\lambda/2$ or 3 m. The distance actually used shall be recorded with the results of the test 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 measurement results.

3.5.1.2. 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 polarization and for the height of its centre above ground to be varied over the range 1-4 metres. Preferably test antennae 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 radiation measurements, the test antenna is connected to a test receiver, capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input. When necessary (for receiver measurements) the test receiver is replaced by a signal source.

3.5.1.3. Substitution antenna

The substitution antenna shall be a $\lambda/2$ dipole, reasonant at the frequency under consideration, or a shortened dipole, calibrated to the $\lambda/2$ dipole or a horn radiator calibrated to the half-wave dipole. The centre of this antenna shall coincide with the reference point of the test sample it has replaced. This reference point shall be the wolume centre of the sample when its antenna is mounted inside the cabinet, or the point where an outside antenna is connected to the cabinet.

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

The substitution antenna shall be connected to a calibrated signal generator when the site is used for radiation measurements and to a calibrated measuring receiver when the site is used for measurement of receiver characteristics. The signal generator and the receiver shall be operating at the frequencies under investigation and shall be connected to the antenna through suitable matching and balancing networks.

3.5.2. *Alternative indoor site*

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

The measurement site may be a laboratory room with a minimum area of 6 metres by 7 metres and at least 2.7 metres 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 site arrangement is in principle shown in Figure 1 (T/R 20-03).

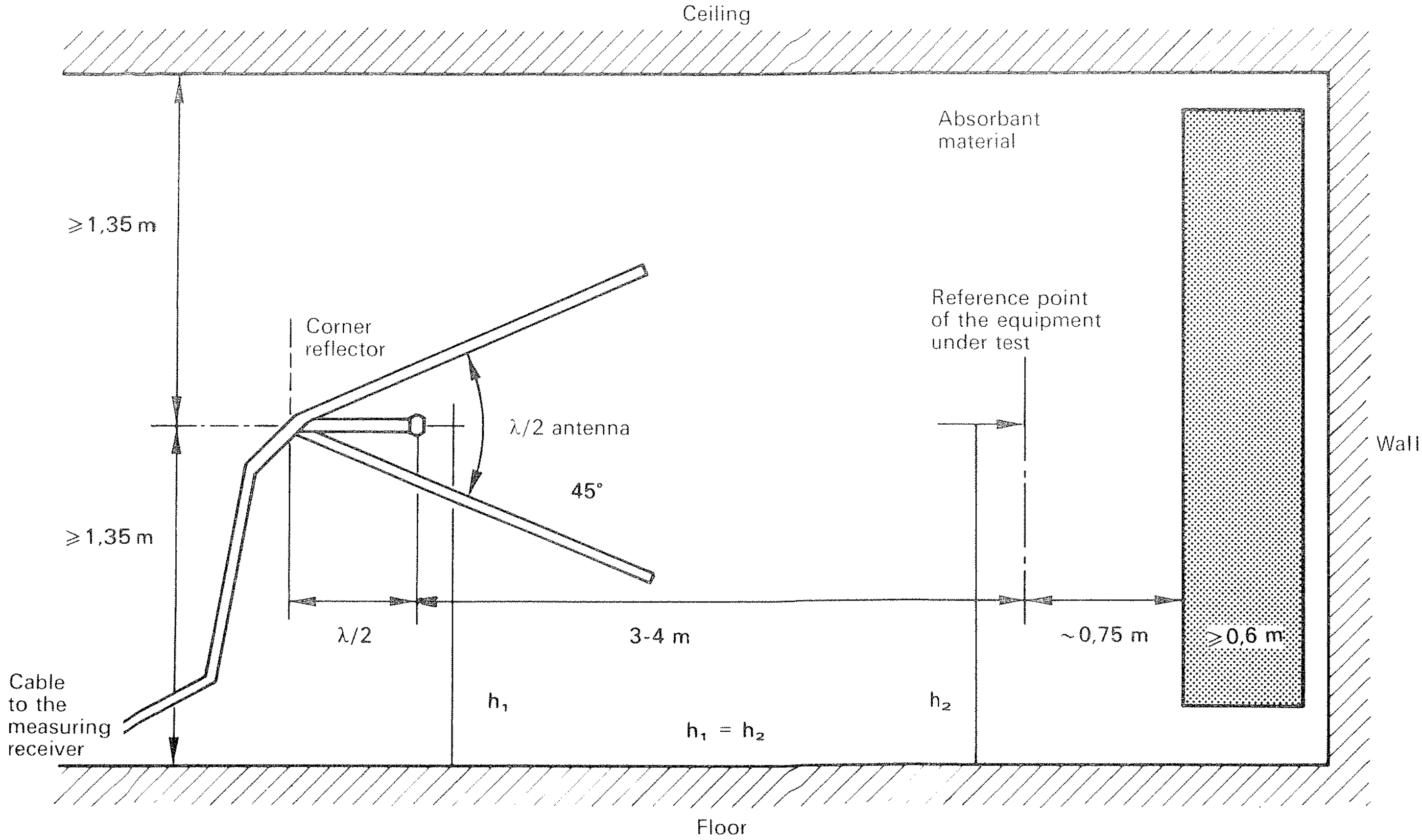

Figure 1 (T/R 20-03). Indoor Site arrangement (shown for horizontal polarization).

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 polarized measurements. Similarly, the corner reflector reduces the effects of reflections from the side walls for vertically polarized measurements.

For measurements in the lower part of the frequency range (below approx. 175 MHz) no corner reflector or absorbent barrier is needed. For measurements in the higher part of the frequency range, no corner reflector is needed if use is made of a horn radiator or a parabolic antenna. For practical reasons, the λ/2 antenna in Figure 1 (T/R 20-03) may be replaced by an antenna of constant length, allowing it to be used at frequencies corresponding to a length between λ/4 and λ, as long as the sensitivity is sufficient. In the same way the distance of λ/2 to the apex may be varied.

The test antenna, test receiver, substitution antenna and calibrated signal generator are used in a way similar to 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 ± 10 cm in the direction of the test antenna as well as in the two directions perpendicular to this first direction. If these changes of distance cause a signal change of greater than 2 dB, the test sample should be resited until a change of less than 2 dB is obtained.

4. TRANSMITTER

4.1. Frequency error

4.1.1. *Definition*

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

4.1.2. *Method of measurement*

The carrier frequency shall be measured in the absence of modulation (if possible) with the transmitter connected to an artificial antenna (Clause 3.2.). Equipment with integral antennae shall be placed in a test fixture (Clause 3.4.2.) connected to the artificial antenna (Clause 3.2.). The measurement shall be made under normal test conditions (Clause 2.3.) and extreme test conditions (Clause 2.4.), (Clauses 2.4.1. and 2.4.2. applied simultaneously).

4.1.3. *Limit*

The frequency error shall not exceed the values given in Table I in both normal and extreme test conditions or in any intermediate set of conditions.

Frequency	Below 50 MHz	Above 50 MHz		
Channel spacing (kHz)	10	12.5	20	25
Frequency error	1.5	1.5	2.5	2.5

Table I (T/R 20-03).

4.2. **Transmitter carrier power**

4.2.1. *Definition*

The transmitter carrier power is the mean power delivered to the artificial antenna during a radio frequency cycle or, in the case of equipment with integral antennae: the effective radiated power in the direction of maximum field strength under specified conditions of measurement (Clause 3.5.), if possible in the absence of modulation.

The rated output power is the carrier power declared by the manufacturer.

4.2.2. *Method of measurement for equipment with provision for external antennae*

The transmitter shall be connected to an artificial antenna (Clause 3.2.), and the power delivered to this artificial antenna shall be measured.

The measurements shall be made under normal test conditions (Clause 2.3.) and extreme test conditions (Clause 2.4.), (Clauses 2.4.1. and 2.4.2. applied simultaneously).

4.2.3. *Method of measurement of equipment with integral antennae*

4.2.3.1. Method of measurement under normal test conditions

On a test site fulfilling the requirements of Clause 3.5. the sample shall be placed on the support in the following position:

(a) for equipment with internal antennae, it shall stand vertically, with that axis vertical which is closest to vertical in normal use;
(b) for equipment with rigid external antennae, the antenna shall be vertical;
(c) for equipment with non-rigid external antennae, with the antenna extended vertically upwards by a non-conducting support.

The transmitter shall be switched on, without modulation (if possible), and the test receiver shall be tuned to the frequency of the signal being measured. The test antenna shall be orientated for vertical polarization and shall be raised or lowered through the specified height range until a maximum signal level is detected on the test receiver.

The transmitter shall be rotated through 360° until a higher maximum signal is received.

Note. This maximum may be a lower value than the value obtainable at heights outside the specified limits.

The transmitter shall be replaced by the substitution antenna as defined in Clause 3.5., and the test antenna raised or lowered as necessary to ensure that the maximum signal is still received. The input signal to the substitution antenna shall be adjusted in level until an equal or a known related level to that detected from the transmitter is obtained in the test receiver.

The carrier power is equal to the power supplied to the substitution antenna, increased by the known relationship if necessary.

The measurement shall be repeated for any alternative antenna supplied by the manufacturer.

A check should be made at other planes of polarization to ensure that the value obtained above is the maximum. If larger values are obtained, this fact should be recorded in the test report.

4.2.3.2. Method of measurement under extreme test conditions

The equipment shall be placed in the test fixture (Clause 3.4.2.), and the power delivered to the artificial antenna shall be measured. The measurements shall be made under normal test conditions (Clause 2.3.) and extreme test conditions (Clause 2.4.). (Clauses 2.4.1. and 2.4.2. applied simultaneously).

4.2.4. *Limits*

The carrier output power under normal test conditions and under extreme test conditions shall not exceed the value given in Table II (T/R 20-03).

Carrier frequencies	Below 50 MHz	Above 50 MHz
Effective radiated power	0.1 W	0.5 W
Output power	0.5 W	0.5 W

Table II (T/R 20-03).

4.3. Adjacent channel power

4.3.1. *Definition*

The adjacent channel power is that part of the total output power of a transmitter modulated under defined condition of modulation which falls within a specified passband centered 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.

4.3.2. *Methods of measurement*

4.3.2.1. General

Two methods are proposed, the results of which are equivalent. The member Administrations of CEPT are requested to use one or both of these methods. The method applied shall be stated in the test reports.

Note. When using the test fixture for this measurement, it is important to ensure that direct radiation from the transmitter to the power measuring receiver or spectrum analyser does not affect the result.

4.3.2.2. Method of measuring using a power measuring receiver

The adjacent channel power shall be mesured with a power measuring receiver which conforms to Clause 4.3.2.2.2. (also referred to in Clause 4.3. as the "receiver").

4.3.2.2.1. Operations

(a) The transmitter shall be operated at the carrier power determined in Clause 4.2. under normal test conditions (Clause 2.3.). 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 ohms and the level at the "receiver" input is appropriate.

In the case of equipment with integral antennae the equipment shall be placed in the test fixture (Clause 3.4.2.) and operated at the carrier power (Clause 4.2.) under normal test conditions (Clause 2.3.). The radio frequency output of the test fixture shall be applied to the input of the receiver, at a level that is appropriate.

(b) With the transmitter unmodulated[1]), the tuning of the "receiver" shall be adjusted so that the maximum response is obtained. This is the 0 dB response point. The "receiver" attenuator setting and the reading of the meter shall be recorded.

[1]) The measurement may be made with the transmitter modulated with the normal code test signal (Clause 3.1.4.), in which case this fact shall be recorded along with the mesurement results.

(c) The tuning of the power measuring receiver shall be adjusted away from the carrier so that the "receiver's" 6 dB response nearest to the transmitter carrier frequency is located at a displacement from the nominal carrier frequency as given in Table III (T/R 20-03).

Channel spacing in kHz	Specified necessary bandwidth in kHz	Displacement of the 6 dB point
25	16	17
20	14	13
12.5	8.5	8.25
10	8.5	5.75

Table III (T/R 20-03).

(d) The transmitter shall be modulated with the normal coded test signal (Clause 3.1.4.). If possible this should be continuous modulation for duration of the measurement.

(e) The receiver variable attenuator shall be adjusted to obtain the same meter reading as in step (b), or a known relation to it.

(f) The ratio of adjacent channel power to carrier power is the difference between the attenuator settings in step (b) and (e) corrected for any differences in the reading of the meter.

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

4.3.2.2.2. Power measuring receiver specification

The power measuring receiver consists of a mixer, an IF-filter, an oscillator, an amplifier, a variable attenuator and an rms value indicator.

Instead of the variable attenuator with the rms value indicator it is also possible to use a dB-calibrated rms voltmeter.

The technical characteristics of the power measuring receiver are given below.

4.3.2.2.2.1. IF-filter

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

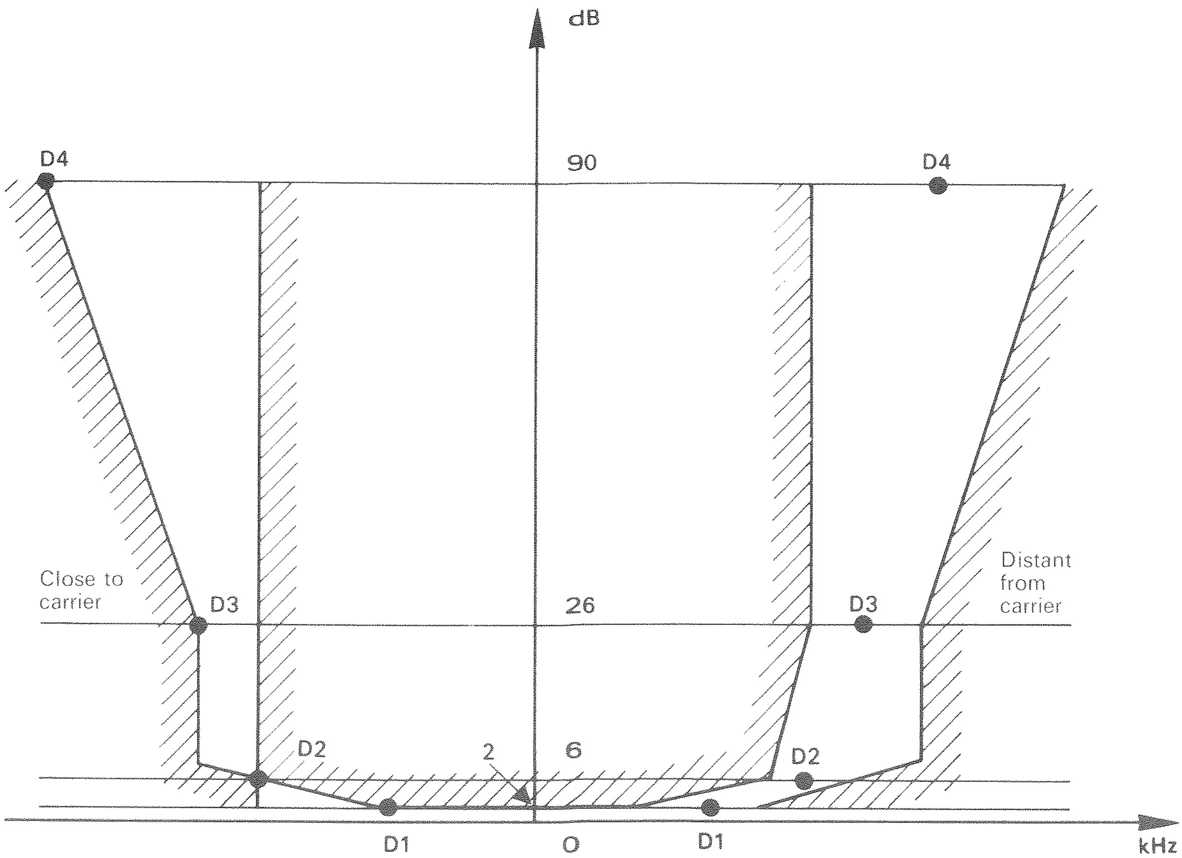

Figure 2 (T/R 20-03). Selectivity characteristic of the "receiver".

Depending on the channel spacing, the selectivity characteristic shall keep the following frequency separations from the nominal centre frequency of the adjacent channel:

Channel spacing kHz	Frequency separation of filter curve from nominal centre frequency of adjacent channel (kHz)			
	D1	D2	D3	D4
10/12.5	3	4.25	5.5	9.5
20	4	7.0	8.25	12.25
25	5	8.0	9.25	13.25

Table IV (T/R 20-03).

Depending on the channel spacing, the attenuation points shall not exceed the following tolerances:

Channel spacing kHz	Tolerances range (kHz)			
	D1	D2	D3	D4
10/12.5	+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 V (T/R 20-03). Attenuation points close to carrier.

Channel spacing kHz	Tolerances range (kHz)			
	D1	D2	D3	D4
10/12.5	±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

Table VI (T/R 20-03). Attenuation points distant from the carrier.

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

4.3.2.2.2.2. 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.

4.3.2.2.2.3. 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.

4.3.2.2.2.4. Oscillator and amplifier

The oscillator and the amplifier shall be designed in such a way that the measurement of the adjacent channel power of an unmodulated transmitter, whose self-noise has a negligible influence on the measurement result, yields a measured value of ≤ −90 dB for channel spacing of 20 and 25 kHz and ≤ −80 dB for spacing of 10 and 12.5 kHz referred to the transmitter carrier power.

4.3.2.3. Method of measurement using a spectrum analyser

4.3.2.3.1. The adjacent channel power may be measured with a spectrum analyser which conforms to Clause 4.3.2.5.

The transmitter shall be operated at the carrier power determined in Clause 4.2. under normal test conditions (Clause 2.3.). The output of the transmitter shall be linked to the input of a spectrum analyser by a connecting device such that the impedance presented to the transmitter is 50 ohms and the level at the spectrum analyser input is appropriate. The transmitter shall be modulated by the normal coded test signal. If possible this should be continuous modulation for the duration of the measurement. The spectrum analyser shall be so adjusted that the spectrum of the transmitter output, including that part which lies within the adjacent channel, is displayed.

For the purpose of this test, the bandwidth of a receiver of the type normally used in the system shall be taken from among the following values:
(a) 16 kHz for adjacent channel separation of 25 kHz;
(b) 14 kHz for adjacent channel separation of 20 kHz;
(c) 8.5 kHz for adjacent channel separation of 10/12.5 kHz, with a tolerance of ± 10%.

The centre frequency of the bandwidth within which measurements are to be made shall have a separation from the nominal carrier frequency of the transmitter equal to the channel separation for which the equipment is intended. The adjacent channel power is the sum of the power level relative to the wanted signal and of the noise in the appropriate bandwidth.

This sum may be calculated or an automatic power level integrating device may be used to obtain it (see Clause 4.3.2.3.3.).

In the latter case, the relative power level of the carrier and its sidebands is initially measured by integration in the appropriate bandwidth, centred on the nominal frequency. The integration is repeated at this bandwidth centred on the nominal frequency of the adjacent channel and the input level of the carrier signal increased until the same power level at the output of the device is obtained.

The difference in the input levels, in dB, is the ratio of the adjacent channel power to the carrier output power.

The adjacent channel power is determined by applying this ratio to the carrier output power as measured in Clause 4.2. or by a direct substitution measurement using a calibrated source.

The measurement shall be repeated for the other adjacent channel.

4.3.2.3.2. 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 of 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 a signal separated in frequency by:
(a) 10 kHz, at a level 90 dB above that of the signal to be measured for 25 and 20 kHz channel separations, and
(b) 6.25 kHz, at a level 80 dB above that of the signal to be measured for a 12.5 kHz channel separation, and
(c) 5 kHz at a level 80 dB above that of the signal to be measured for a 10 kHz spacing.

The reading accuracy of the frequency marker shall be within ± 2% of the channel separation.

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

It shall be possible to adjust the spectrum analyser to allow the separation on its screen of two components with a frequency difference of 1 kHz.

4.3.2.3.3. Integrating and power summing device

The integrating and power summing device is connected to the video output of the spectrum analyser, described in Clause 4.3.2.3.2.

It shall be possible to summate the effective power of all wanted signal components and the noise power in the selected bandwidth and to measure this as a ratio 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.

When power levels as low as 50 nanowatts are measured, the output of the device should exceed the internal noise level by 10 dB. The dynamic range shall permit measurement of the values required under Clause 4.3.3. with a margin of at least 10 dB.

4.3.3. *Limits*

The power in the adjacent channel shall not exceed a value given in Table VII (T/R 20-03).

Channel spacing (kHz)	Power in the adjacent channel (μW)
10/12.5	10
20/25	0,2

Table VII (T/R 20-03).

4.4. Spurious emissions of the transmitter

4.4.1. *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:
(a) their power level in a transmission line or antenna and
(b) their effective radiated power when radiated by the cabinet and structure of the equipment
(b) is also known as "cabinet radiation".

For equipment which can only be used with an integral antenna, only the measurements mentioned under (b) apply.

4.4.2. *Method of measuring the power level (a)*

Spurious emissions shall be measured as the power level of any discrete signal delivered into a 50 ohms load. This may be done by connecting the transmitter output through an attenuator to a spectrum analyser or selective voltmeter, or by monitoring the relative levels of the spurious signals delivered to an artificial antenna (Clause 3.2.).

The transmitter shall be unmodulated if possible and the measurements made over the frequency range 100 kHz to 4 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

The measurements shall be repeated with the transmitter modulated with normal coded test signal (Clause 3.1.4.).

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

4.4.3. *Method of measuring the effective radiated power (b)*

On a test site, fulfilling the requirements of Clause 3.5., the sample shall be placed at the specified height on a conducting support (Clause 3.5.1.1.). The transmitter shall be operated with the carrier power delivered to an artificial antenna (Clause 3.2.) without modulation (if possible).

Radiation of any spurious components shall be detected by the test antenna and receiver, over the frequency range 25 MHz to 4 GHz, except for the channel on which the transmitter is intended to operate and its adjacent channels.

At each frequency at which a component is detected, the sample shall be rotated to obtain the 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 polarization plane.

The measurements shall be repeated with the transmitter modulated by normal coded test signal (Clause 3.1.4.).

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

4.4.4. *Limit*

The power of any spurious emission in the specified range of frequencies shall not exceed the value of 4 nW in the frequency bands:
41-68 MHz
87.5-118 MHz
162-230 MHz
470-862 MHz
and shall not exceed a value of 250 nW on other frequencies below 1 GHz.

On frequencies above 1 GHz the power of any spurious emission shall not exceed a value of 1 μW.

In the case of measurements in the standby mode, the limit is 2 nW for frequencies up to 1 GHz and 20 nW for frequencies above 1 GHz.

5. RECEIVER

5.1. Adjacent channel selectivity

5.1.1. *Definition*

The adjacent channel selectivity is a measure of the capability of the receiver to operate satisfactorily in 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.

5.1.2. *Method of measurement*

(a) Two signal generators A and B shall be applied to the receiver via a combining network or the test antenna. Signal generator A shall be at the nominal frequency of the channel and shall be modulated by the normal coded test signal (Clause 3.1.4.).

Signal generator B shall be unmodulated and shall be adjusted to the frequency of the channel immediately above that of the wanted signal (see Clause 1.2.2.).

(b) Initially signal generator B shall be switched off and using signal generator A the level which still gives sufficient response shall be established in this test set up. The output level of generator A shall then be increased by 3 dB.

(c) Generator B shall then be switched on the input level adjusted until the highest level which still allows sufficient response.

(d) The output level difference in dB of generator B and A shall be recorded.

(e) The measurement shall be repeated with the unwanted signal at the frequency of the channel below that of the wanted signal (see Clause 1.2.2.).

(f) The adjacent channel selectivity shall be expressed as the lower value for the upper and lower adjacent channels obtained in steps (d) and (e).

5.1.3. *Limits*

The adjacent channel selectivity shall be at least 50 dB for equipment intended for 10 kHz and 12.5 kHz channel spacing, and 60 dB for equipment intended to 20 and 25 kHz channel spacing.

5.3. **Spurious emissions of the receiver**

5.2.1. *Definition*

Spurious emissions are any emissions from the receiver. The level of spurious emissions shall be measured by:

(a) their power level in a transmission line or antenna and
(b) their effective radiated power when radiated by the cabinet and structure of the equipment;
(c) is also known as "cabinet radiation".

For equipment using only an integral antenna, point (b) only shall apply.

5.2.2. *Method of measuring the power level (a)*

Spurious emissions 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 ohms 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 substitution method using a signal generator.

The measurements shall extend over a frequency range of 100 kHz to 4,000 MHz.

5.2.3. *Method of measuring the effective radiated power (b)*

On a test site fulfilling the requirements of Clause 3.5.1., the sample shall be placed at the specified height on a 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 with a non-reactive, non-radiating load of 50 ohms (measurements to be repeated with receiver connected to real antenna).

Radiation of any spurious components shall be detected by the test antenna and receiver over the frequency range 25-4,000 MHz.

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

5.2.4. *Limit*

The power of any spurious emission in the specified range of frequencies shall not exceed 2 nanowatts in the range 100 kHz to 1,000 MHz and shall not exceed 20 nanowatts in the range 1,000 MHz to 4,000 MHz.

6. PRESENTATION OF SINGLE AND MULTICHANNEL EQUIPMENT FOR TYPE APPROVAL

6.1. Choice of model for type approval

The manufacturer shall provide a production model of the equipment, for type approval testing.

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

6.2. Single-channel equipment

Anny channel within the specified frequency range may be selected for type approval testing. The choice shall be approved by the testing authority.

6.3. Multichannel equipment

Type approval tests need to be carried out only on the highest and lowest channels within the switching range of the equipment and on a channel near to the middle of the switching range, except in special circumstances. The switching range shall be declared by the manufacturer. The choice of channels for type approval testing shall be approved by the testing authority.

7. ACCURACY OF MEASUREMENTS

The tolerance for the measurement of the following parameters shall be as given below:

7.1.1.	DC voltage	± 3%
7.1.2.	AC mains voltage	± 3%
7.1.3.	AC mains frequency	± 0.5%
7.2.1.	Radio frequency	± 50 Hz
7.2.2.	Radio frequency voltage	± 2 dB
7.2.3.	Radio frequency field strength	± 3 dB
7.2.4.	Radio frequency carrier power	± 10%
7.2.5.	Radio frequency adjacent channel power	± 3 dB
7.3.1.	Impedance of artificial loads, combing units, cables, plugs, attenuators, etc.	± 5%
7.3.2.	Source impedance of generators and input impedance of measuring receivers	± 10%
7.3.3.	Attenuation by attenuators	± 0.5 dB
7.4.1	Temperature	± 1° C
7.4.2.	Humidity	± 5%

Appendix A to Annex II

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 paragraph 3.5. of the Annex. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

A.1. Measuring distance

Evidence indicates that the measuring distance is not critical and does not significantly affect the measuring results, provided that the distance is not less than $\lambda/2$ at the frequency of measurement, and the precautions described in this Annex are observed.

Measuring distances of 3 m, 5 m, 10 m and 30 m are in common use in the CEPT countries.

A.2. Test antenna

Different types of test antennae may be used, since in performing substitution measurements, calibration errors of the test antenna do not affect the measuring results.

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

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

A.3. Substitution antenna

Variations in the measuring results may occur with the use of different types of substitution antennae at the lower frequencies below about 80 MHz. Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used should be included with the results of the tests carried out on the site.

A.4. Artificial antenna

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

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

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

A.5. Auxiliary cables

The position of auxiliary cables which are not adequately decoupled may cause variations in the measuring results. In order to get reproducible results, cables and wires of auxiliaries are mounted vertically downwards (through a hole in the isolating table or in the base plate of the salt water column) and shall be fitted at the upper part with a radio frequency stop filter (for instance using ferrite cores).

Appendix B to Annex II

GUIDANCE FOR MEASUREMENT OF TRANSMITTER TRANSIENT STATE

B.1. **Definitions**

The transient state of a transmitter is characterised by the relationships between time, frequency and transmitter power, where the latter is switched (on, off, etc.). This specification covers only transmitter frequency characteristics during transient phases.

Frequency tolerances and the different transient phases are defined as follows:

Δf_0: Steady-state frequency tolerance.

Δf_1: Frequency error which may be greater than half the adjacent channel spacing.

Δf_2: Frequency error which may not be greater than half the adjacent channel spacing.

t_1, t_3: Time interval during which frequency tolerance Δf_1 applies.

t_2: Time interval during which frequency tolerance Δf_2 applies.

The following definitions are also given, for the purposes of the method of measurement described in Clause B.2.:

t_{on}: Moment of transmitter start-up: point when the output power, measured at the antenna pick-up, exceeds the lower of the two values: 10% of the nominal power of 100 mW".

t_{off}: Moment of shut-down: point when power falls below the afore-mentioned limit.

The following cases should be considered:

B.1.1. *Criteria to be used on start-up*

The duration of the various transient phases and the frequency tolerances are given in Figure A (T/R 20-03).

B.1.2. *Criteria to be used on shut-down*

The transient period is not subdivided: the frequency tolerance is given in Figure B (T/R 20-03).

B.1.3. *Other cases*

These include all complex switching cases, as, for example, the connection/disconnection of radio equipment with the "send" button depressed.

Switching procedures of this type can always be related to the procedures in Clauses B.1.1. and B.1.2.

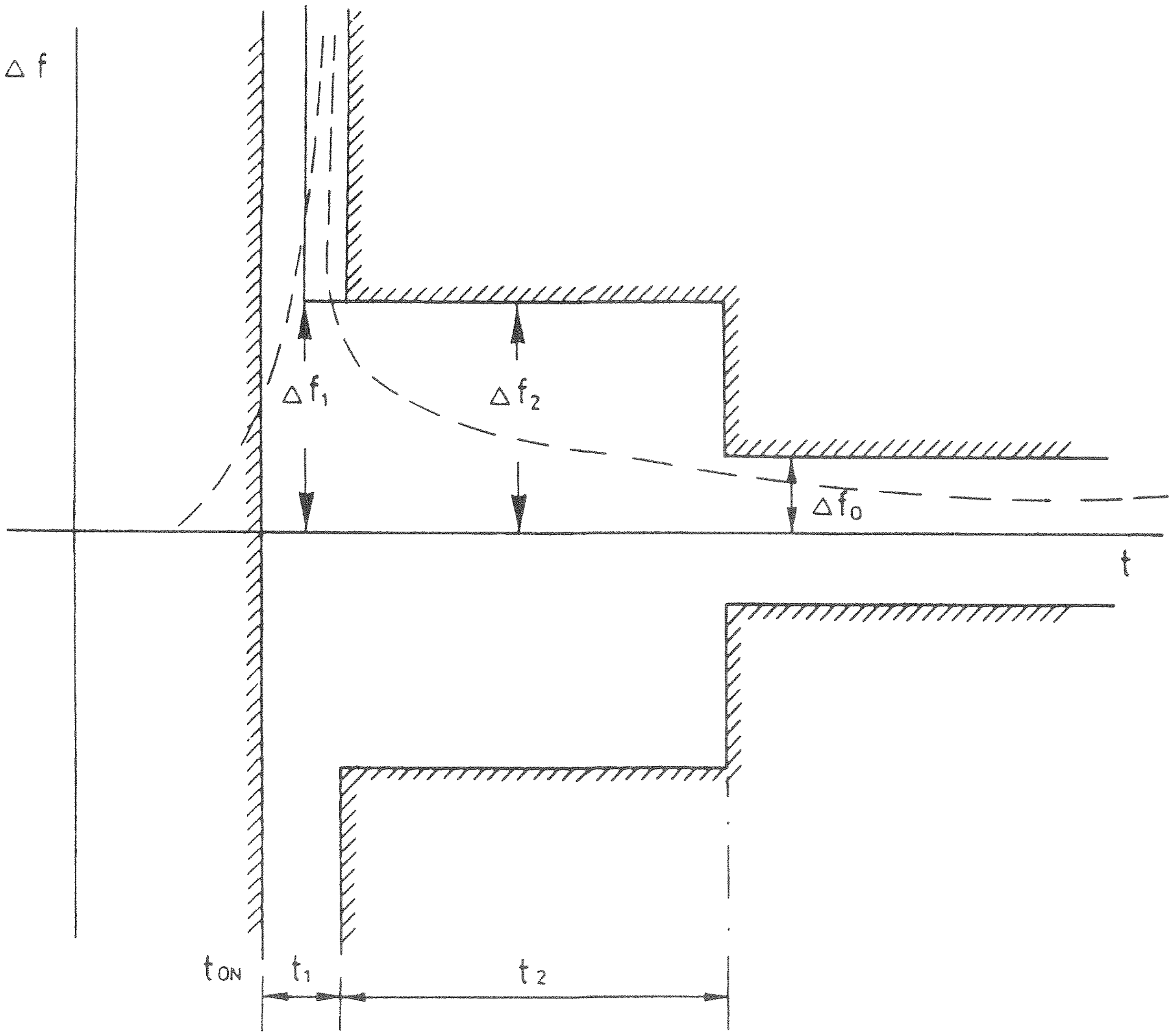

Figure A (T/R 20-03). Transient state on start-up (Clauses B.1.1. and B.1.3.).

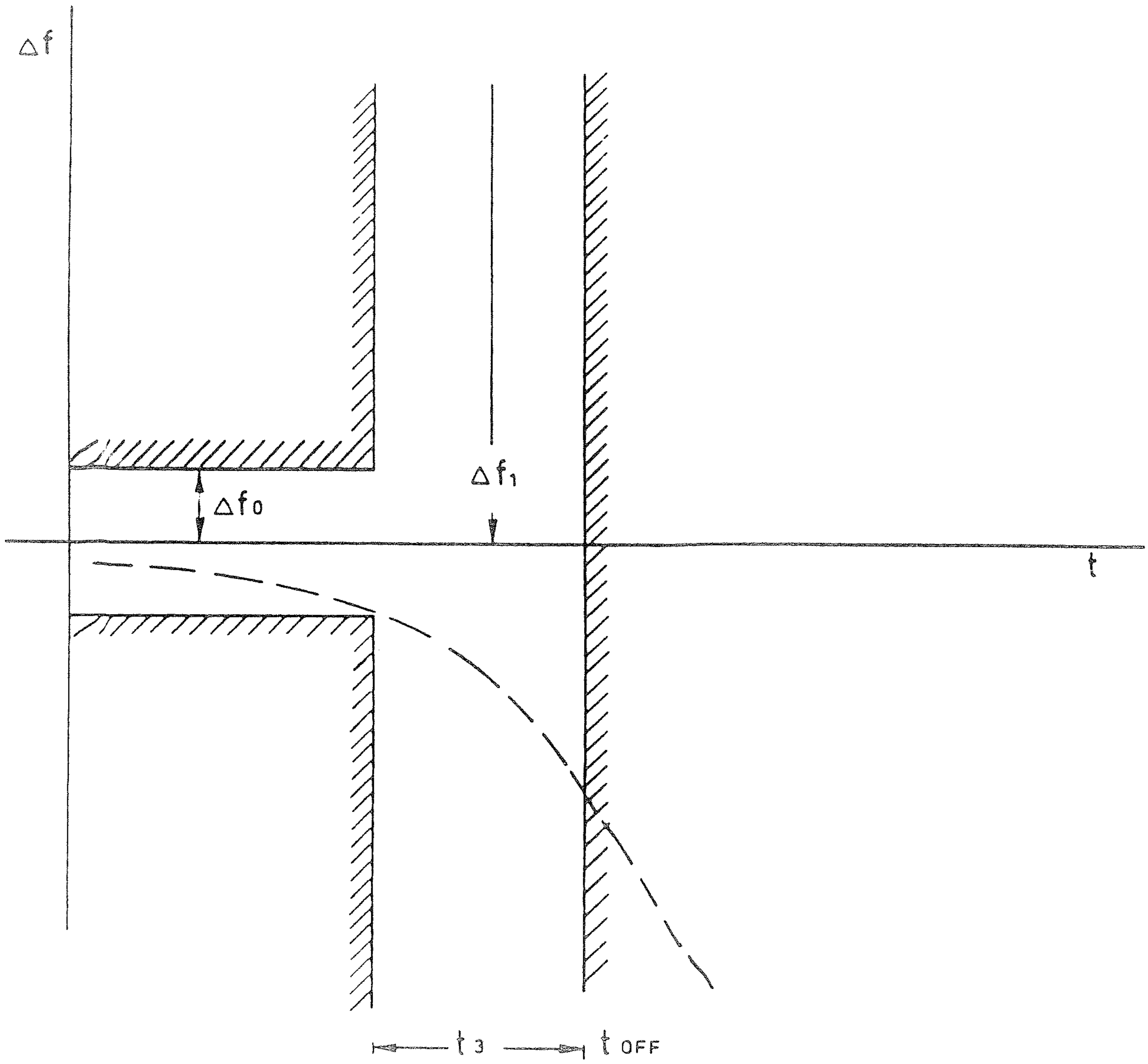

Figure B (T/R 20-03). Transient state on shut-down (Clauses B.1.2. and B.1.3.).

B.2. **Method of measurement**

The duration of the different transient phases and the frequency differences arising during these phases can be measured using a frequency measuring discriminator which satisfies the conditions in Clause B.2.1.

The transmitter is connected to the circuit depicted in Figure C (T/R 20-03). Its output is connected to the input of the measuring discriminator by way of an adjusted attenuator which constitutes the transmitter load. Attenuation of the transmitter must be such that, on the one hand, the discriminator input is protected against any overload, and, on the other, the discriminator limiting amplifier operates correctly, as a limiter, when a power level corresponding to point t_{on} is achieved.

This circuit should then be calibrated, and the transmitter activated, without modulation where possible, as indicated in Clauses B.1.1. to B.1.3.

The calibration of the measuring discriminator is verified by injecting it with signals at radio frequencies presenting known frequency errors, following correct tuning at the nominal transmitter frequency.

It is also necessary, using appropriate means, to generate a trigger pulse, either at the moment when the transmitter is switched on or off, or when the electrical power supply to the equipment is connected or disconnected with the transmitter "send" button remaining depressed. The discriminator output voltage should be recorded as a time function, using a storage oscilloscope or a transient state recorder. The voltage deviation is a measure of the frequency error. The duration of the different frequency errors can be measured using the oscilloscope time base.

B.2.1. *Characteristics of frequency measuring discriminator*

The measuring discriminator is composed of a local oscillator and a mixer serving to convert the measured transmitter frequency into a frequency signal suitable for the limiting amplifier (wideband) and for the wideband discriminator which follows it.

— The effective bandwidth of measuring equipment shall be sufficiently broad to permit exact measurement of frequency errors of the order of 5 times the channel spacing.

The frequency measuring discriminator should be capable of displaying frequency errors sufficiently rapidly (around 100 kHz/100 μs).

— It should be possible to connect the discriminator output using direct current.

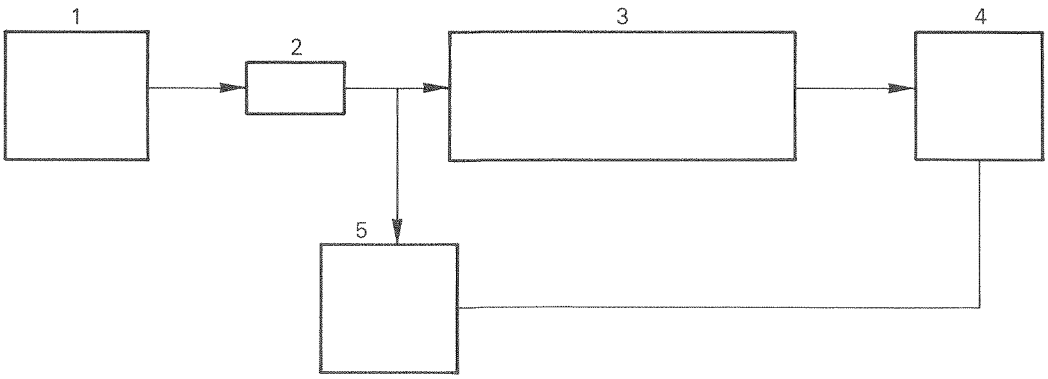

Figure C (T/R 20-03). Circuit for frequency measurement of transient state transmitters.

Key:

1 Transmitter under test.
2 Attenuator.
3 Wideband measuring discrimination.
4 Storage oscilloscope or transient recorder.
5 Trigger device.

B.3. **Limits**

The duration of the different phases of the transient state shall not exceed the value given below:

	Below 50 MHz	50-100 MHz	100-300 MHz	300-500 MHz	500-1,000 MHz
t_1 (ms)	5	5	5	10	20
t_2 (ms)	20	20	20	25	50
t_3 (ms)	5	5	5	10	10

Annex III

INFORMATION TO BE PROVIDED BY AN APPLICANT FOR THE TYPE APPROVAL OF LOW-POWER TELECOMMAND AND TELEMETRY EQUIPMENT OPERATING ON COLLECTIVE FREQUENCIES IN ISM BANDS

General

- Applicant: name, address, telephone number and telex.
- Responsible person supporting the application: name and telephone number.
- Manufacturer: name and address.
- Type designation and commercial designation (if shown on the equipment).
- Countries in which the equipment or a component from which it has been assembled have already been submitted for type approval and results obtained.
- Type of equipment: transmitter, receiver or transmitter/receiver.
- Possible applications: fixed, mobile or portable.
- Connectors and/or additional devices.
- Power supply: integral or externally supplied to the equipment; using cells, accumulator, or mains supply.
- Antennae: nature of antenna terminals;
  impedance at antenna terminals;
  integral antenna: type, length.
- Class off emission: type of modulation.
- Operational frequency band of the equipment.
- Maximum number of radio channels for which the equipment is designed.
- List of carrier frequencies available to the equipment at the time of testing.

Transmitter

- Nominal effective radiated power.
- Nominal output power.
- Total nominal direct current power supply.
- Relationship of transmitting frequency to oscillator frequency.

Receiver

- Frequency changing formula(e).
- Number and value of intermediate frequencies.

Test conditions

- Extreme low temperature.
- Extreme high temperature.
- Nominal supply voltage(s).