TCN 68-242: 2006

RADIO EQUIPMENTS OPERATING IN THE 2.4 GHZ BAND AND USING SPREAD SPECTRUM MODULATION TECHNIQUES

Technical Requirements

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FOREWORD

The Technical Standard TCN 68-242: 2006 **"Radio equipments operating in the 2.4 GHz band and using spread spectrum modulation techniques - Technical Requirements"** is based on the standards ETS 300 328 (11 - 1996) of the European Telecommunications Standards Institute (ETSI).

The Technical Standard TCN 68-242: 2006 is drafted by Posts and Telematics Quality Control Directorate (PTQC) at the proposal of Department of Science & Technology and issued following the Decision No. 27/2006/QD-BBCVT dated 25/7/2006 of the Minister of Posts and Telematics.

The Technical Standard TCN 68-242: 2006 is issued in a bilingual document (Vietnamese version and English version). In cases of interpretation disputes, Vietnamese version is applied.

DEPARTMENT OF SCIENCE & TECHNOLOGY

RADIO EQUIPMENTS OPERATING IN THE 2.4 GHz BAND AND USING SPREAD SPECTRUM MODULATION TECHNIQUES

TECHNICAL REQUIREMENTS

(Issued together with the Decision No. 27/2006/QD-BBCVT dated 25/7/2006 of the Minister of Posts and Telematics)

1. SCOPE

This standard specifies the minimum technical requirements to be provided radio equipments operating in the 2.4 GHz band and using spread spectrum modulation techniques with output power up to 100 mW e.i.r.p.

This standard does not cover the requirements to the designing, manufacturing or operating procedure for Radio equipments operating in the 2.4 GHz band and using spread spectrum modulation techniques.

This standard does not apply to the radio equipment using for fixed radio service point - to – point.

This standard is used as the basic to type approval for Radio equipments operating in the 2.4 GHz band and using spread spectrum modulation techniques with output power up to 100 mW e.i.r.p.

2. NORMATIVE REFERENCES

[1] ETS 300 328 Second Edittion (11/1996) Radio Equipment and Systems (RES); Wideband Transmission systems; Data transmission equipment operating in the 2.4 GHz ISM band and using spread spectrum modulation techniques.

[2] ETSI EN 300 328 V1.4.1 (2003-04) Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband Transmission systems; Data transmission equipment operating in the 2.4 GHz ISM band and using spread spectrum modulation techniques; Harmonized EN covering essential requirements under article 3.2 of the R & TTE Directives.

[3] EN 300 328-1 V1.3.1 (2001-12) Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband Transmission systems; Data transmission equipment operating in the 2.4 GHz ISM band and using spread spectrum modulation techniques; Part 1: Technocal characteristics and test conditions

3. DEFINITIONS AND ABBREVIATIONS

3.1. Definitions

Chip: A unit of modulation used in direct sequence spread spectrum modulation.

Chip rate: The number of chips per second.

Chip sequence: A sequence of chips with defined length and defined chip polarities.

Combined equipment: any combination of non-radio equipment that requires a plug-in radio device to offer full functionality

Direct sequence spread spectrum modulation: A form of modulation where a combination of data to be transmitted and a known code sequence (chip sequence) is used to directly modulate a carrier.

Fixed station: Equipment intended for use in a fixed location and fitted with one or more antennae.

Frequency hopping spread spectrum modulation: A spread spectrum technique in which the transmitter signal occupies a number of frequencies in time, each for some period of time, referred to as the dwell time. Transmitter and receiver follow the same frequency hop pattern. The frequency range is determined by the lowest and highest hop positions and the bandwidth per hop position.

Frequency range: The range of operating frequencies over which the equipment can be adjusted.

Host: Host equipment is any equipment which has complete user functionality when not connected to the radio equipment part and to which the radio equipment part provides additional functionality and to which connection is necessary for the radio equipment part to offer functionality.

Integral antenna: An antenna designed to be connected to the equipment without the use of a standard connector and considered to be part of the equipment.

Mobile station: Equipment normally used in a vehicle or as a transportable station.

Operating frequency: The nominal frequency at which the equipment can be operated; this is also referred to as the operating centre frequency.

Plug-in radio device: Equipment intended to be used with or within variety of host systems, using their control functions and power supply.

Power envelope: The frequency/power contour within which the useful RF power is generated.

Spread spectrum modulation: A modulation technique in which the energy of a transmitted signal is spread throughout a relatively large portion of the frequency spectrum.

Stand-alone radio equipment: Equipment that is intended primarily as communications equipment and that is normally used on a stand-alone basis.

3.2 Abbreviations

DSSS	Direct Sequence Spread Spectrum
e.i.r.p.	equivalent isotropically radiated power
FHSS	Frequency Hopping Spread Spectrum
ISM	Industrial, Scientific and Medical
R&TTE	Radio and Telecommunications Terminal Equipment
RF	Radio Frequency
Rx	Receiver
Tx	Transmitter

3.3. Symbols

dBm	dB relative to 1 milliwatt power
dBW	dB relative to 1 watt power

4. TECHNICAL CHARACTERISTICS

4.1 Modulation

The manufacturer shall declare the modulation characteristics of the equipment to be tested. For the purpose of deciding which level of power density applies to equipment offered for testing, this standard defines two categories of equipment: equipment conforming to the stated characteristics of FHSS and equipment not conforming to these characteristics. The latter category includes equipment using DSSS modulation.

4.1.1 FHSS modulation

FHSS modulation shall make use of at least 20 well defined, non-overlapping channels or hopping positions separated by the channel bandwidth as measured at 20 dB below peak power. The dwell time per channel shall not exceed 0.4 seconds. While the equipment is operating (transmitting and/or receiving) each channel of the hopping sequence shall be occupied at least once during a period not exceeding four times the product of the dwell time per hop and the number of channels.

4.1.2 DSSS and other forms of modulation

For the purposes of this standard, other forms of spread spectrum modulation which do not satisfy the constraints of the specification given in subclause 4.1.1, shall be considered equivalent to DSSS modulation. Systems using these other forms of modulation shall be considered equivalent to DSSS systems and shall be tested according to the requirements for DSSS modulation.

4.2 Transmitter parameter limits

4.2.1 Effective radiated power

The effective radiated power is defined as the total power of the transmitter. The effective radiated power shall be equal to or less than -10 dBW (100 mW) e.i.r.p. This limit shall apply for any combination of power level and intended antenna assembly.

4.2.2 Peak power density

The peak power density is defined as the highest instantaneous level of power in Watts per Hertz generated by the transmitter within the power envelope. For equipment using FHSS modulation, the power density shall be limited to -10 dBW (100 mW) per 100 kHz e.i.r.p. For equipment using other types of modulation, the peak power shall be limited to -20 dBW (10 mW) per MHz e.i.r.p.

4.2.3 Frequency range

The frequency range of the equipment is determined by the lowest and highest frequencies occupied by the power envelope.

f_H is the highest frequency of the power envelope: it is the frequency furthest above the frequency of maximum power where the output power drops below the level of -80 dBm/Hz e.i.r.p. spectral power density (-30 dBm if measured in a 100 kHz bandwidth).

f_L is the lowest frequency of the power envelope; it is the frequency furthest below the frequency of maximum power where the output power drops below the level equivalent to -80 dBm/Hz e.i.r.p. spectral power density (or -30 dBm if measured in a 100 kHz bandwidth).

For a given operating frequency, the width of the power envelope is (f_H – f_L). In equipment that allows adjustment or selection of different operating frequencies, the power envelope takes up different positions in the allocated band. The frequency range is determined by the lowest value of f_L and the highest value of

F_H resulting from the adjustment of the equipment to the lowest and highest operating frequencies.

For all equipment the frequency range shall lie within the band 2.4 GHz to 2.4835 GHz ($f_L > 2.4$ GHz and $f_H < 2.483\ 5$ GHz).

4.2.4 Spurious emissions

Spurious emissions are emissions outside the frequency range(s) of the equipment as defined in subclause 4.2.3.

The level of spurious emissions shall be measured as:

either:

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

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

or:

c) their effective radiated power when radiated by cabinet and antenna.

The spurious emissions of the transmitter shall not exceed the values in tables 1 and 2 in the indicated bands.

Table 1: Transmitter limits for narrowband spurious emissions

Frequency Range	Limit when operating	Limit when in standby
30 MHz – 1 GHz	-36 dBm	-57 dBm
above 1 GHz - 12.75 GHz	-30 dBm	-47 dBm
1.8 GHz – 1.9 GHz 5.15 GHz – 5.3 GHz	-47 dBm	-47 dBm

The above limit values apply to narrowband emissions, e.g. as caused by local oscillator leakage. The measurement bandwidth for such emissions may be as small as necessary to achieve a reliable measurement result.

Wideband emissions shall not exceed the values given in table 2.

Table 2: Transmitter limits for wideband spurious emissions

Frequency Range	Limit when operating	Limit when in standby
30 MHz – 1 GHz	-86 dBm/Hz	-107 dBm/Hz
above 1 GHz - 12.75 GHz	-80 dBm/Hz	-97 dBm/Hz
1.8 GHz – 1.9 GHz 5.15 GHz – 5.3 GHz	-97 dBm/Hz	-97 dBm/Hz

4.3 Receiver parameter limits

4.3.1 General

This standard does not impose limits on the receiver of the equipment other than spurious emission limits.

4.3.2 Spurious emissions

The spurious emissions of the receiver shall not exceed the values in tables 3 and 4 in the indicated bands.

Table 3: Narrowband spurious emission limits for receivers

Frequency Range	Limit
30 MHz – 1 GHz	-57 dBm
above 1 GHz - 12.75 GHz	-47 dBm

The above limit values apply to narrowband emissions, e.g. as caused by local oscillator leakage. The measurement bandwidth for such emissions may be as small as necessary to get a reliable measurement result.

Wideband emissions shall be not exceed the values given in table 4.

Table 4: Wideband spurious emission limits for receivers

Frequency Range	Limit
30 MHz – 1 GHz	-107 dBm/Hz
above 1 GHz - 12.75 GHz	-97 dBm/Hz

5. TEST CONDITIONS

5.1 Normal and extreme test conditions

Type tests shall be made under normal and extreme test conditions, unless otherwise stated.

5.2 Power sources

5.2.1 Power sources for stand-alone equipment

During type tests, the power source of the equipment shall be replaced by a test power source capable of producing normal and extreme test voltages. 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.

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

5.2.2 Power sources for plug-in radio devices

The power source for testing plug-in radio devices shall be provided by a test jig or host equipment.

Where the host equipment and/or the plug-in radio device is battery powered, the battery may be removed and the test power source applied as close to the battery terminals as practicable.

5.3 Normal test conditions

5.3.1 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 recorded in the test report.

The actual values during the tests shall be recorded in the test report.

5.3.2 Normal power source

5.3.2.1 Mains voltage

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage.

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

5.3.2.2 Lead-acid battery power sources used on vehicles

When radio equipment is intended for operation from the usual, alternator fed lead-acid battery power source used on vehicles, then the normal test voltage shall be 1.1 times the nominal voltage of the battery (6V, 12V, etc.).

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

5.4 Extreme test conditions

5.4.1 Extreme temperatures

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in subclause 5.4.3, at the upper and lower temperatures of the range as follows:

- Temperature: -20°C to +55°C;

5.4.2 Extreme power source voltages

Tests at extreme power source voltages specified below are not required when the equipment under test is designed for operation as part of and powered by another system or piece of equipment.

5.4.2.1 Mains voltage

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

5.4.2.2 Lead-acid battery power sources used on vehicles

When radio equipment is intended for operation from the usual type of alternator fed lead-acid battery power source used on vehicles, then extreme test voltage shall be 1.3 and 0.9 times the nominal voltage of the battery (6V, 12V etc.).

5.4.2.3 Power sources using other types of batteries

The lower extreme test voltages for equipment with power sources using the following types of battery, shall be:

- For the Leclanché or lithium type battery: 0.85 times the nominal voltage of the battery;

- For the mercury or nickel-cadmium type of battery: 0.9 times the nominal voltage of the battery.

In both cases, the upper extreme test voltage shall be 1.15 times the nominal voltage of the battery.

For equipment using other power sources, or capable of being operated from a variety of power sources (primary or secondary), the extreme test voltages shall be those declared by the manufacturer.

5.4.3 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 stabilizing period. In the case of equipment containing temperature stabilizing circuits designed to operate continuously, these circuits shall be switched on for 15 minutes after thermal balance has been reached. After this time the equipment shall meet the specified requirements. For this type of equipment the manufacturer shall provide for the power source circuit feeding these circuits to be independent of the power source of the rest of the equipment.

If thermal balance is not checked by measurements, a temperature stabilizing period of at least one hour, or such period as may be decided by the testing laboratory, 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.

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 than be made to transmit the test data sequence for at least one minute, followed by four minutes in the receive condition, after which the equipment shall meet the specified requirements.

For 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.

5.5 Choice of equipment for test suites

5.5.1 Choice of model

The tests shall be carried out on one or more production models or equivalent preliminary models, as appropriate. If testing is performed on (a) preliminary model(s), then the corresponding production models shall be identical to the tested models in all respects relevant for the purposes of the present document, to the preliminary model(s) tested.

Radiated RF power measurements are imprecise and therefore conducted measurements are recommended. Equipment used for testing may be provided with a suitable connector for conducted RF power measurements. Where this is not possible, a suitable test fixture shall be used to convert the radiated signal into a conducted signal. Alternatively, radiated measurements shall be performed.

5.5.2 Presentation

Stand-alone equipment shall be tested complete with any ancillary equipment.

Plug-in radio devices may be tested together with a suitable test jig and/or typical host equipment.

Where multiple combinations of radio equipment and antennae are intended, the configuration to be used for testing shall be chosen as follows:

- For each combination, determine the highest user selectable power level and the antenna assembly with the highest gain;
- From the resulting combinations, choose the one with the highest e.i.r.p.

5.5.3 Choice of operating frequencies

Where equipment can be adjusted to or operated at different operating frequencies, a minimum of two operating frequencies shall be chosen such that the lower and higher limits of the operating range(s) of the equipment are covered

5.6 Testing of host connected equipment and plug-in radio devices

For combined equipment and for radio parts for which connection to or integration with host equipment is required to offer functionality to the radio, different alternative test approaches are permitted. Where more than one such combination is intended, testing shall not be repeated for combinations of the radio part and various host equipment where the latter are substantially similar.

Where more than one such combination is intended and the combinations are not substantially similar, one combination shall be tested against all requirements of the present document and all other combinations shall be tested separately for radiated spurious emissions only.

5.6.1 Alternative A: combined equipment

Combined equipment or a combination of a plug-in radio device and a specific type of host equipment may be used for testing according to the full requirements of the present document.

5.6.2 Alternative B: use of a host or test jig

Where the radio part is a plug-in radio device which is intended to be used within a variety of combinations, a suitable test configuration consisting of either a test jig or a typical host equipment shall be used. This shall be representative for the range of combinations in which the device may be used. The test jig shall allow the radio equipment part to be powered and stimulated as if connected to or inserted into host or combined equipment. Measurements shall be made to all requirements of the present document.

5.6.3 Test data sequence

The manufacturer shall describe and provide a test data sequence with which the transmitter is modulated during the measurements described in this standard. The test data sequence shall spread the transmitted power throughout the power envelope. Where the equipment is not capable of continuous RF transmission, the test data sequence shall be such that:

- The generated RF signal is the same for each transmission;

- Transmissions occur regularly in time;

- Sequences of transmissions can be repeated accurately.

The same test data sequence shall be used for all measurements on the same equipment.

5.7 Product information

The following information is necessary in order to carry out the test suites:

a) The type of modulation used: FHSS modulation, DSSS modulation or any other type of modulation;

b) Where FHSS modulation is used: the number of hopping channels, the dwell time per channel and the maximum time between two instances of use of the same channel;

c) The operating frequency range(s) of the equipment and, where applicable, band(s) of operation;

d) The type of the equipment, for example: stand-alone equipment, plug-in radio device, combined equipment, etc. ;

e) The extreme operating conditions that apply to the equipment;

f) The intended combination(s) of the radio equipment power settings and one or more antenna assemblies and their corresponding e.i.r.p levels;

g) The nominal voltages of the stand-alone radio equipment or the nominal voltages of the host equipment or combined equipment in case of plug-in devices;

h) The test modulation used.

6. METHODS OF MEASUREMENT

6.1 General

This subclause describes methods of measurement for the following transmitter and receiver parameters:

- The effective radiated power;
- The peak power density;
- The frequency range(s);
- The transmitter spurious emissions.
- The receiver spurious emissions.

The following methods of measurement shall apply to the testing of stand-alone units and to the equipment configurations identified in subclause 5.5.

6.2 Measurements of transmitter parameters

6.2.1 Effective radiated power (e.r.p)

See clause 5 for the test conditions.

The effective radiated power shall be determined and recorded in the test report.

The following shall be applied to the combination(s) of the radio device and its intended antenna(e). In the case that the RF power level is user adjustable, all measurements shall be made with the highest power level available to the user for that combination.

The following method of measurement shall apply to both conducted and radiated measurements.

In the case of radiated measurements, using a test site as described in annex A and applicable measurement procedures as described in annex B, the effective radiated power as defined in subclause 4.2.1 shall be measured and recorded in the test report.

In case of conducted measurements, the transmitter shall be connected to the measuring equipment via a suitable attenuator and the RF power as defined in subclause 4.2.1 shall be measured and recorded in the test report.

The measurement shall be performed using normal operation of the equipment with modulation, using the test data sequence, applied.

The test procedure shall be as follows:

Step 1:

- Using a suitable means, the output of the transmitter shall be coupled to a diode detector;

- The output of the diode detector shall be connected to the vertical channel of an oscilloscope;

- The combination of the diode detector and the oscilloscope shall be capable of faithfully reproducing the envelope peaks and the duty cycle of the transmitter output signal;

- The observed duty cycle of the transmitter (Tx on/(Tx on +Tx off)) shall be noted as x, $(0 < x < 1)$ and recorded in the test report. For the purpose of testing, the equipment shall be operated with a duty cycle that is equal to or more than 0.1;

Step 2:

- The average output power of the transmitter shall be determined using a wideband, calibrated RF power meter with a thermocouple detector or an equivalent thereof and, where applicable, with an integration period that exceeds the repetition period of the transmitter by a factor 5 or more. The observed value shall be recorded as "A" (in dBm);

- The e.i.r.p. shall be calculated from the above measured power output A, the observed duty cycle x, and the applicable antenna assembly gain "G" in dBi, according to the formula:

$$P = A + G + 10 \log (1/x);$$

P shall not exceed the value specified in subclause 4.2.1.

Step 3:

- The measurement set up as given under step 1 shall be used to determine on the oscilloscope the peak of the envelope of the output signal of the transmitter;

- The maximum deviation of the Y-trace of the oscilloscope shall be recorded as "B";

Step 4:

- The transmitter shall be replaced by a signal generator. The output frequency of the signal shall be made equal to the centre of the frequency range occupied by the transmitter;

- The signal generator shall be unmodulated. The output power of the signal generator shall be raised to a level such that the deviation of the Y-trace of the oscilloscope reaches level B, as indicated in step 3;

- This output power level "C" (in dBm) of the signal generator shall be determined using a wideband, calibrated RF power meter with a thermocouple detector or an equivalent thereof;

- Level C shall not exceed by more than 3 dB the value specified in subclause 4.2.1 minus the applicable antenna assembly gain G in dBi;

These measurements shall be performed at normal and extreme test conditions, see clause 5.

6.2.2 Peak power density

The peak power density shall be measured and recorded in the test report.

In the case of radiated measurements, using a test site as described in annex A and applicable measurement procedures as described in annex B, the peak power density as defined in subclause 4.2.2 shall be measured and recorded in the test report.

In case of conducted measurements, the transmitter shall be connected to the measuring equipment via a suitable attenuator and the peak power density as defined in subclause 4.2.2 shall be measured and recorded in the test report.

The peak power density shall be determined using a spectrum analyser of adequate bandwidth for the type of modulation being used in combination with an RF power meter.

Equipment where the transmitter is on for 10 μs or more shall be measured as follows:

Connect an RF power meter to the IF output of the spectrum analyser and correct its reading using a known reference source, e.g. a signal generator.

NOTE: The IF output of the spectrum analyser may be 20 dB or more below the input level of the spectrum analyser. Unless the power meter has adequate sensitivity, a wideband amplifier may be required.

The test procedure shall be as follows:

Step 1:

- The measurement set-up shall be calibrated with a CW signal from a calibrated source; the reference signal should have a strength of 10 dBm;

- The settings of the spectrum analyser shall be:

+ Centre Frequency: equal to the signal source;

+ Resolution BW: 100 kHz for FHSS, 1 MHz for DSSS;

+ Video BW: same;

+ Detector mode: positive peak;

+ Averaging: off;

+ Span: zero Hz;

+ Amplitude: adjust for middle of the instrument's range;

Step 2:

- The calibrating signal power shall be reduced to 0 dBm and it shall be verified that the power meter reading also reduces by 10 dB;

Step 3:

- Connect the equipment to be measured. Using the following settings of the spectrum analyser in combination with "max hold" function, find the frequency of highest power output in the power envelope:

+ Centre Frequency: equal to operating frequency;

+ Resolution BW: 100 kHz for FHSS , 1 MHz for DSSS;

+ Video BW: same;

+ etector mode: positive peak;

+ Averaging: off;

+ Span: 3 times the spectrum width;

+ Amplitude: adjust for middle of the instrument's range;

- The frequency found shall be recorded in the test report;

Step 4:

Set the centre frequency of the spectrum analyser to the found frequency and switch to zero span. The power meter indicates the measured power density. The power density e.i.r.p. is calculated from the measured power density and the declared antenna assembly gain(s).

The above procedure shall be repeated for each of the two frequencies identified by the procedure given in subclause 5.2.1.

Where the spectrum analyser bandwidth is non-Gaussian, a suitable correction factor shall be determined and applied.

Where a spectrum analyser is equipped with a facility to measure power density, this facility may be used instead of the above procedure.

6.2.3 Frequency range of equipment using FHSS modulation

Using applicable measurement procedures as described in annex B the frequency range of the equipment shall be measured and recorded in the test report.

During these measurements the test data sequence as specified in subclause 5.6.3 shall be used.

These measurements shall be performed under both normal and extreme test conditions.

The measurement procedure shall be as follows:

a) Place the spectrum analyser in video averaging mode with a minimum of 50 sweeps selected and activate the transmitter with modulation applied. The display will form an image like that shown in figure 2;

b) Select lowest operating frequency of the equipment under test;

c) Find lowest frequency below the operating frequency at which spectral power density drops below the level given in subclause 4.2.3. See A in figure 2. This frequency shall be recorded in the test report;

d) Select the highest operating frequency of the equipment under test;

e) Find the highest frequency at which the spectral power density drops below the level given in subclause 4.2.3, see B in figure 2. This frequency shall be recorded in the test report;

f) The difference between the frequencies measured in steps c) and e) is the frequency range; it shall be recorded in the test report.

NOTE: For equipment with a single, fixed operating frequency, steps b) and d) are omitted.

This measurement shall be repeated for each operating frequency range declared by the manufacturer.

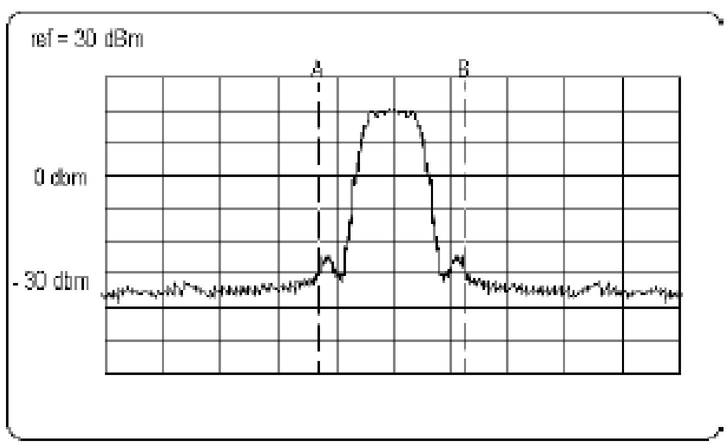


Figure 2: Measuring the extreme frequencies of the power envelope

This example assumes a 100 kHz resolution bandwidth.

6.2.4 Frequency range of equipment using other forms of modulation

Using applicable measurement procedures as described in annex B the frequency range(s) shall be measured and recorded in the test report.

During these measurements the test data sequence as specified in subclause 5.6.3 shall be used.

These measurements shall be performed under both normal and extreme test conditions.

The measurement procedure shall be as follows:

a) Place the spectrum analyser in video averaging mode with a minimum of 50 sweeps selected and activate the transmitter with modulation applied. The RF emission of the equipment shall be displayed on the spectrum analyser. The display will form an image like that shown in figure 2;

b) Select lowest operating frequency of the equipment under test;

c) Using the marker of the spectrum analyser, find lowest frequency below the operating frequency at which spectral power density drops below the level given in subclause 4.2.3. See line A in figure 2.

This frequency is recorded in the test report;

d) Select the highest operating frequency of the equipment under test;

e) Find the highest frequency at which the spectral power density drops below the value given in subclause 4.2.3. See line B in figure 2. This frequency shall be recorded in the test report;

f) The difference between the frequencies measured in steps c) and e) is the frequency range; it shall be recorded in the test report.

NOTE: For equipment with a single, fixed operating frequency, steps b) and d) are omitted.

This measurement shall be repeated for each frequency range declared by the manufacturer.

6.2.5 Spurious emissions

The following method of measurement shall apply to both conducted and radiated measurements.

In the case of radiated measurements, using a test site as described in annex A and applicable measurement procedures as described in annex B, the spurious emissions as defined in subclause 4.2.4 shall be measured and recorded in the test report.

In case of conducted measurements, the radio device shall be connected to the measuring equipment via a suitable attenuator.

Tests of FHSS equipment shall be carried out while the equipment is hopping on the following operating frequencies:

- The lowest operating frequency; and
- The highest operating frequency.

During this test modulation shall be applied using the test data sequence.

Where the transmitter ceases transmission between hops, during this test, the transmitter shall cease transmitting for a minimum period of time equal to or greater than that for which it ceases transmission during normal operation.

If the equipment is fitted with an automatic shut-off facility it shall be made inoperative for the duration of this test unless it has to be left operative to protect the equipment. If the shut-off facility is left operative, the status of the equipment shall be indicated. The measurement equipment shall be set for peak hold mode of operation.

The measurement procedure shall be as follows:

- The transmitter shall be operated at the highest output power, or , in the case of equipment able to operate at more than one power level, at the lowest and highest output powers;

- The spectrum outside the declared frequency range(s) shall be searched for emissions that exceed the limit values given in subclause 4.2.4 or that come to within 6 dB below the limit values given in subclause 4.2.4. Each occurrence shall be noted in the test report;

- This measurement shall be made with the transmitter set to the lowest operating frequency and with the transmitter set to the highest operating frequency.

This measurement shall be repeated with the transmitter in standby mode where applicable.

Where these measurements are made with a spectrum analyser, the following settings and procedures shall be used.

For finding spurious emissions the spectrum analyser shall be set as follows:

- Resolution BW: 100 kHz;

- Video BW: same;

- Detector mode: positive peak;

- Averaging: off;

- Span: 100 MHz;

- Amplitude: adjust for middle of the instrument's range;

- Sweep time: 1 second.

For measuring emissions that exceed the level of 6 dB below the applicable limit, the resolution bandwidth shall be switched to 30 kHz and the span shall be adjusted accordingly. If the level does not change by more than 2 dB, it is a narrowband emission; the observed value shall be recorded in the test report. If the level changes by more than 2 dB, the emission is a wideband emission and its level shall be measured and recorded in the test report.

The method of measurement for wideband emissions, if applicable, shall be documented in the test report.

NOTE: The main spectrum of the device being tested may saturate the spectrum analyser's input circuits and so cause ghost "spurious" signals. Ghosts can be distinguished from real signals by increasing the input attenuator by 10 dB. If the spurious signal disappears, it is a ghost and should be ignored.

6.2.6 Receiver spurious emissions

The following method of measurement shall apply to both conducted and radiated measurements.

In the case of radiated measurements, using a test site as described in annex A and applicable measurement procedures as described in annex B, the spurious emissions shall be measured and recorded. In the case of conducted measurements, the receiver shall be connected to the measuring equipment via a suitable attenuator.

The measurement procedure shall be as follows:

- With the equipment in the receive mode, the applicable spectrum shall be searched for emissions that exceed the limit values given in clause 4.3 or that come to within 6 dB below the limit values given in clause 4.3. Each occurrence shall be recorded.

The measurements shall be performed only under the following conditions:

- For FHSS equipment the equipment shall be tested in the receive mode on frequencies as defined in clause 6.2.3;

- For DSSS and other equipment the test shall be made in the receive mode, at the lowest and highest operating frequencies.

Where these measurements are made with a spectrum analyser, the following settings and procedures shall be used for narrowband emissions:

- Resolution BW: 100 kHz;

- Video BW: same;

- Detector mode: positive peak;

- Averaging: off;

- Span: 100 MHz;

- Amplitude: adjust for middle of the instrument's range;

- Sweep time: 1 s.

For measuring emissions that exceed the level of 6 dB below the applicable limit the resolution bandwidth shall be switched to 30 kHz and the span shall be adjusted accordingly. If the level does not change by more than 2 dB, it is a narrowband emission; the observed value shall be recorded. If the level changes by more than 2 dB, the emission is a wideband emission and its level shall be measured and recorded.

7. MEASUREMENT UNCERTAINTY VALUES

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated in accordance with TR 100 028-1 and shall correspond to an expansion factor (coverage factor) k = 1.96 or k = 2 (which provide confidence levels of respectively 95% and 95.45% in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)). Table 5 is based on such expansion factors.

Table 5: Maximum measurement uncertainty

Parameter	Uncertainty
radio frequency	$\pm 1 \times 10^{-5}$
total RF power, conducted	±1.5 dB
RF power density, conducted	±3 dB
spurious emissions, conducted	±3 dB
all emissions, radiated	±6 dB
temperature	±1°C
humidity	±5%
DC and low frequency voltages	±3%

ANNEX A

(NORMATIVE):

TEST SITES AND ARRANGEMENTS FOR RADIATED MEASUREMENTS

A.1 Test sites

A.1.1 Open air test sites

The term "open air" should be understood from a electromagnetic point of view. Such a test site may be really in open air or alternatively with walls and ceiling transparent to the radio waves at the frequencies considered.

An open air test site may be used to perform the measurements using the radiated measurement methods described in clause 6. Absolute or relative measurements may be performed on transmitters or on receivers; absolute measurements of field strength require a calibration of the test site.

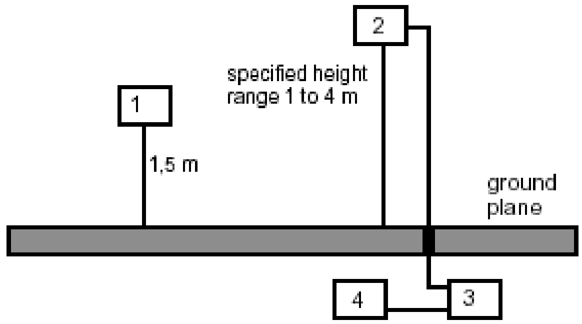
A measuring distance of at least 3 m shall be used for measurements at frequencies up to 1 GHz. For frequencies above 1 GHz, any suitable measuring distance may be used. The equipment size (excluding the antenna) shall be less than 20 % of the measuring distance. The height of the equipment or of the substitution antenna shall be 1.5 m; the height of the test antenna (transmit or receive) shall vary between 1 and 4 m.

Sufficient precautions shall be taken to ensure that reflections from extraneous objects adjacent to the site do not degrade the measurement results, in particular:

- No extraneous conducting objects having any dimension in excess of a quarter wavelength of the highest frequency tested shall be in the immediate vicinity of the site;

- All cables shall be as short as possible; as much of the cables as possible shall be on the ground plane or preferably below; and the low impedance cables shall be screened.

The general measurement arrangement is shown in figure A.1.



1) equipment under test
2) test antenna
3) high pass filter (as required)
4) spectrum analyser or measuring receiver

Figure A.1: Measuring arrangement

A.1.2 Anechoic chamber

A.1.2.1 General

An anechoic chamber is a well shielded chamber covered inside with radio frequency absorbing material and simulating a free space environment. It is an alternative site on which to perform the measurements using the radiated measurement methods described in clause 6. Absolute or relative measurements may be performed on transmitters or on receivers. Absolute measurements of field strength require a calibration of the anechoic chamber. The test antenna, equipment under test and substitution antenna are used in a way similar to that at the open air test site, but are all located at the same fixed height above the floor.

A.1.2.2 Description

An anechoic chamber should meet the requirements for shielding loss and wall return loss as shown in figure A.2. Figure A.3 shows an example of the construction of an anechoic chamber having a base area of 5 m by 10 m and a height of 5 m. The ceiling and walls are coated with pyramidally formed absorbers approximately 1 m high. The base is covered with special absorbers which form the floor. The available internal dimensions of the chamber are 3 m x 8 m x 3 m, so that a maximum measuring distance of 5 m in the middle axis of this chamber is available. The floor absorbers reject floor reflections so that the antenna height need not be changed. Anechoic chambers of other dimensions may be used.

A.1.2.3 Influence of parasitic reflections

For free-space propagation in the far field, the relationship of the field strength E and the distance R is given by E = Eo x (Ro/R), where Eo is the reference field strength and Ro is the reference distance. This relationship allows relative measurements to be made as all constants are eliminated within the ratio and neither cable attenuation nor antenna mismatch or antenna dimensions are of importance.

If the logarithm of the foregoing equation is used, the deviation from the ideal curve may be easily seen because the ideal correlation of field strength and distance appears as a straight line. The deviations occurring in practice are then clearly visible. This indirect method shows quickly and easily any disturbances due to reflections and is far less difficult than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions given above at low frequencies below 100 MHz there are no far field conditions, but the wall 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 to the distance meets the expectations very well. Above 1 GHz, because more reflections will occur, the dependence of the field strength to the distance will not correlate so closely.

A.1.2.4 Calibration and mode of use

The calibration and mode of use is the same as for an open air test site, the only difference being that the test antenna does not need to be raised and lowered whilst searching for a maximum, which simplifies the method of measurement.

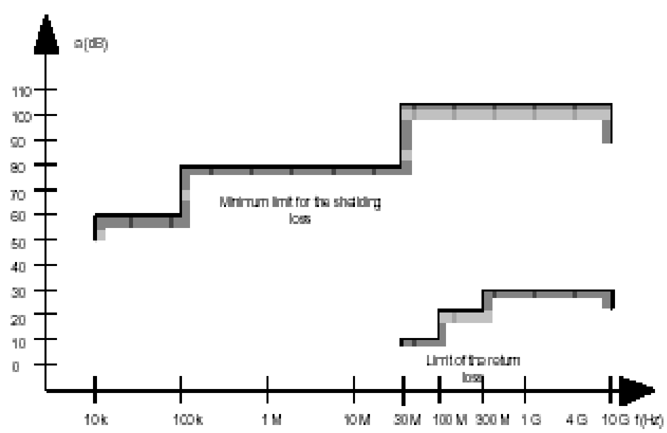


Figure A.2: Specification for shielding and reflections

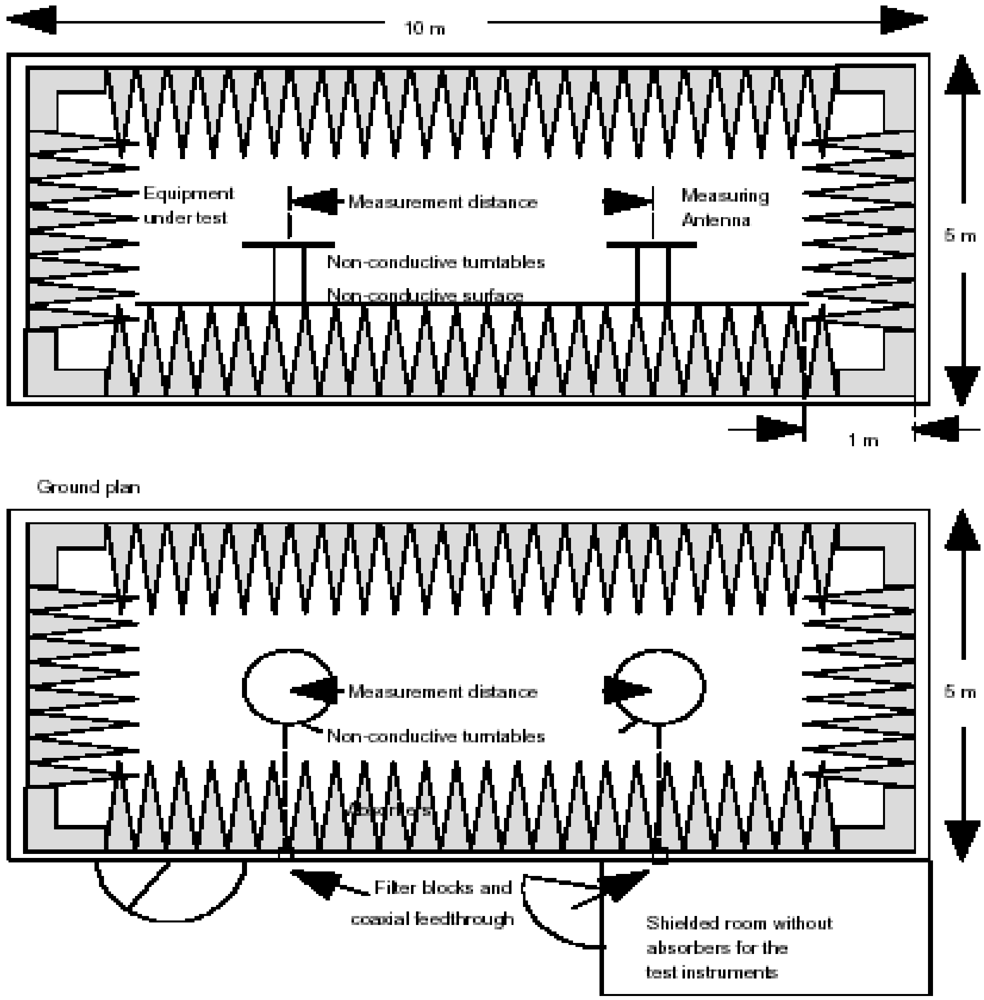


Figure A.3: Anechoic shielded chamber for simulated free space measurements

A.2 Test antenna

When the test site is used for radiation measurements the test antenna shall be used to detect the field from both the test sample and the substitution antenna. When the test site is used for the measurement of receiver characteristics the antenna shall be used as a transmitting antenna. This antenna shall be mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and for the height of its centre above the ground to be varied over the specified range.

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.

A.3 Substitution antenna

The substitution antenna shall be used to replace the equipment under test in substitution measurements. For measurements below 1 GHz the substitution antenna shall be a half wavelength dipole resonant at the frequency under consideration, or a shortened dipole, calibrated to the half wavelength dipole. For measurements between 1 and 4 GHz either a half wavelength dipole or a horn radiator may be used. For measurements above 4 GHz a horn radiator shall 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 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.

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

ANNEX B (NORMATIVE): GENERAL DESCRIPTION OF MEASUREMENT

This annex gives the general methods of measurements for RF signals using the test sites and arrangements described in annex A.

B.1 Conducted measurements and use of test fixture

In view of the low power levels of the equipment to be tested under this standard, conducted measurements may be applied to equipment provided with an antenna connector e.g. by means of a spectrum analyser.

Where the equipment to be tested does not provide a suitable connector, a test fixture may be provided.

B.2 Radiated measurements

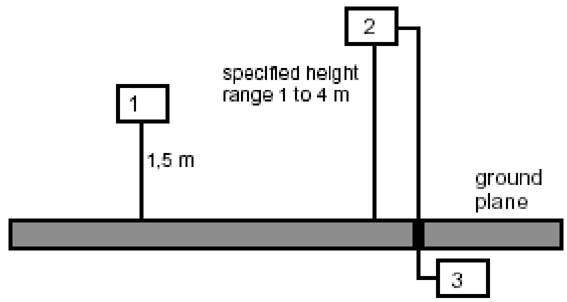
Radiated measurements shall be performed with the aid of a test antenna and measurement instruments as described in annex A. The test antenna and measurement instrument shall be calibrated according to the procedure defined in this annex. The equipment to be measured and the test antenna shall be oriented to obtain the maximum emitted power level. This position shall be recorded in the measurement report. The frequency range shall be measured in this position.

Preferably, radiated measurements shall be performed in an anechoic chamber. For other test sites corrections may be needed (see annex A). The following test procedure applies:

a) A test site which fulfils the requirements of the specified frequency range of this measurement shall be used. The test antenna shall be oriented initially for vertical polarization unless otherwise stated and the transmitter under test shall be placed on the support in its standard position and switched on;

b) For average power measurements a non-selective voltmeter or wide band spectrum analyser shall be used. For other measurements a spectrum analyser or selective voltmeter shall be used and tuned to the measurement frequency;

In either case a) or b), the test antenna shall be raised or lowered, if necessary, through the specified height range until the maximum signal level is detected on the spectrum analyser or selective voltmeter. The test antenna need not be raised or lowered if the measurement is carried out on a test site according to subclause A.1.2.



1) equipment under test
2) test antenna
3) spectrum analyser or measuring receiver

Figure B.1: Measurement arrangement No.1

c) The transmitter shall be rotated through 360° about a vertical axis until a higher maximum signal is received;

d) The test antenna shall be raised or lowered again, if necessary, through the specified height range until a maximum is obtained. This level shall be recorded.

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

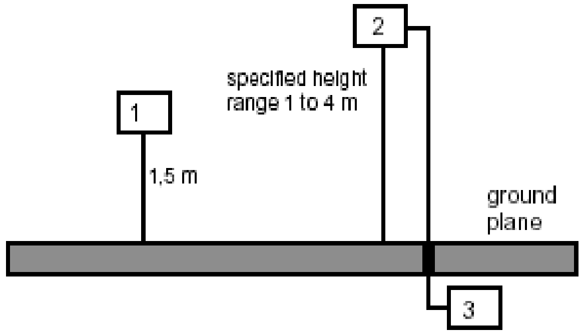
The test antenna need not be raised or lowered if the measurement is carried out on a test site according to subclause A.1.2.

This measurement shall be repeated for horizontal polarization.

B.3 Substitution measurement

The actual signal generated by the measured equipment may be determined by means of a substitution measurement in which a known signal source replaces the device to be measured, see figure B.2.

Preferably, this method of measurement shall be used in an anechoic chamber. For other test sites corrections may be needed, see annex A.



1) equipment under test
2) substitution antenna
3) spectrum analyser or selective voltmeter
4) signal generator

Figure B.2: Measurement arrangement No.2

a) Using measurement arrangement No.2, the substitution antenna shall replace the transmitter antenna in the same position and in vertical polarization. The frequency of the signal generator shall be adjusted to the measurement frequency. The test antenna shall be raised or lowered, if 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 test antenna need not be raised or lowered if the measurement is carried out on a test site according to subclause A.1.2;

- The radiated power is equal to the power supplied by the signal generator, increased by the known relationship if necessary and after corrections due to the gain of the substitution antenna and the cable loss between the signal generator and the substitution antenna;

b) This measurement shall be repeated with horizontal polarization.