Draft ETSI EN 301 091-1 V1.2.1 (2001-07)

Candidate Harmonized European Standard (Telecommunications series)

Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices; Road Transport and Traffic Telematics (RTTT); Radar equipment operating in the 76 GHz to 77 GHz and 24 GHz range; Part 1: Technical Requirements and methods of measurement

Reference

REN/ERM-RP08-0410-1

Keywords

radar, radio, testing, SRD

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

Foreword

This Candidate Harmonized European Standard (Telecommunications series) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the Public Enquiry phase of the ETSI standards Two-step Approval Procedure.

For non EU countries the present document may be used for regulatory (Type Approval) purposes.

Where equipment compliant with the present document is intended for fitment into vehicles, then it is subject to automotive EMC type approval and has to comply with directive 95/54/EC [12] . For use on vehicles outside the scope of 95/54/EC [12] compliance with an EMC directive/standard appropriate for that use is required

The present document is part 1 of a multi-part deliverable covering the Short Range Devices; Road Transport and Traffic Telematics (RTTT); Radar equipment operating in the 76 GHz to 77 GHz and 24 GHz range, as identified below:

Part 1: "Technical Requirements and methods of measurement";

Part 2: "Harmonized EN covering essential requirements of article 3.2 of the R&TTE Directive".

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

1 Scope

The present document applies to Short Range Devices (SRDs) transmitters and receivers for RTTT applications:

a) transmitters operating in range from 76 GHz to 77 GHz with peak power levels ranging up to 55 dBm;

b) receivers operating in the range from 76 GHz to 77 GHz;

c) transmitters operating in range from 24,050 GHz to 24,250 GHz with peak power levels ranging up to 20 dBm

d) transmitters operating in range from 22,625 GHz to 24,050 GHz and 24,250 GHz to 25,625 GHz with mean spectral power density levels ranging up to -30 dBm;

e) receivers operating in the range from 22,625 GHz to 25,625 GHz.

The present document contains the technical characteristics for radio equipment and is referencing to CEPT/ERC Recommendation for SRDs CEPT/ERC Recommendation 70-03 [3] and ERC Decisions.

The present document does not necessarily include all the characteristics which may be required by a user, nor does it necessarily represent the optimum performance achievable.

The present document applies to:

- low power motion and distance monitoring radars for mobile and fixed applications; operating on radio frequencies in the 76 GHz to 77 GHz band, with mean power densities of up to 0,9 W/m^2 at 3 m (50 dBm EIRP), and up to 3 W/m^2 peak at 3 m (55 dBm EIRP) for class 1, and mean power densities of up to 0,002 W/m^2 at 3 m (23,5 dBm EIRP), and up to 3 W/m^2 peak at 3m (55 dBm EIRP) for class 2.

- ultralow power motion and distance monitoring radars for mobile applications; operating on radio frequencies in the 22,625 GHz to 25,625 GHz band with a maximum spatial mean/peak power density of up to 0,9 mW/m^2 at 3 m (20 dBm EIRP) in the 24 GHz SRD band, and with spectral and spatial mean power densities of up to 9 nW/m^2 at 3m (-30 dBm EIRP @ 100 kHz RBW, PSD < -80 dBm/Hz) within a range of 2 × 2,5 GHz outside the 24 GHz SRD band.

The present document is based upon ERC/DEC/(92)02 [4]. It is a product standard covering various RTTT applications as well as vehicle based systems as ACC, Stop & Go, Collision Warning or fixed base systems as road traffic monitoring.

The present document is essential in realization of the ITS program of the European Commission Information Society DG, "The EU Approach for Road Safety and Intelligent Transport Systems(ITS)", [11].

The present document covers radars for mobile applications. It covers integrated transceivers and separate transmit/receive modules.

The present document includes standards for methods of measurement for equipment fitted with integral antennas.

Table 1a: Limits for transmitted power (fixed antenna) at 76 GHz to 77 GHz

	Class 1	Class 2
Mean Power(EIRP)	50 dBm	23,5 dBm
Peak Power(EIRP)	55 dBm	55 dBm

The radio equipment, covered by the classification SRD is divided into several power classes based on maximum output power (see tables 1a and 1b). The power class designation is based on CEPT/ERC Recommendation 70-03 [3] or ERC Decisions.

Table 1b: Limits for transmitted power (integrated antenna) at 24,05 GHz to 24,250 GHz

	Class 1 (note 1) (pulsed/time gated, Carrier in SRD band)	Class 2 (CW, Carrier in SRD band)	Class 3 (pulsed/time gated, Carrier in wideband)
Mean Power(EIRP)	0 dBm	0 dBm	0 dBm
Peak Power(EIRP)	20 dBm	0 dBm	20 dBm
Time gating/Duty Cycle	< 10 % (D = 10 dB)	No limit (D < 0 dB)	< 1 % (D < 20 dB)
NOTE 1: Carrier allocation within SRD 24,05 to 24,25 GHz, Duty < 10 %, clause 6.4.4.3. NOTE 2: Carrier allocation within SRD 24,05 to 24,25 GHz, Duty w.o. limit, clause 6.4.6.3. NOTE 3: Carrier allocation within wideband 22,625 to 25,625 GHz, Duty < 1 %, clause 6.4.5.			

On non-harmonized parameters, national administrations may impose conditions on the type of modulation, frequency, channel/frequency separations, maximum transmitter radiated field strength/maximum output current to a defined antenna, duty cycle, equipment marking and the inclusion of an automatic transmitter shut-off facility, as a condition for the issue of an individual or general licence, or as a condition for use under licence exemption.

The present document does not require measurements for radiated emissions below 25 MHz.

2 References

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

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

[1] ETSI EN 301 489-3 (V1.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 kHz and 40 GHz".

[2] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity".

[3] CEPT/ERC Recommendation 70-03 (1997): "Relating to the use of Short Range Devices (SRD)".

[4] ERC/DEC/(92)02: "ERC Decision of 22 October 1992 on the frequency bands to be designated for the co-ordinated introduction of Road Transport Telematic Systems (RTT)".

[5] CISPR 16-1: "Specifications for radio disturbance and immunity measuring apparatus and methods; Part 1: Radio disturbance and immunity measuring apparatus".

[6] CEPT/ERC Recommendation 01-06: "Procedure for mutual recognition of type testing approval for radio equipment".

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

[8] CENELEC EN 50166-2 (1995): "Human Exposure to electromagnetic fields High Frequency (10 kHz to 300 GHz)".

[9] Radio Regulations: "International Telecommunication Union Edition of 1990 revised 1994".

[10] ETSI EN 300 440: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range".

[11] Fotis Karamitsos: "The EU approach to Road Safety and Intelligent Transport Systems (ITS), www.cordis@cec.eu.int".

[12] Commission Directive 95/54/EC of 31 October 1995 adapting to technical progress Council Directive 72/245/EEC on the approximation of the laws of the Member States relating to the suppression of radio interference produced by spark-ignition engines fitted to motor vehicles and amending Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers.

3 Definitions, symbols and abbreviations

3.1 Definitions

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

assigned frequency band: frequency band within which the device is authorized to operate

associated antenna: antenna and all its associated components which are designed as an indispensable part of the equipment

mean power: Mean power supplied from the antenna during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions (see Radio Regulations [9]). For pulsed systems the mean power is equal the peak envelope power multiplied by the time gating duty factor. For CW systems without further time gating the mean power is equal the transmission power without modulation.

antenna scan duty factor: ratio of the area of the beam (measured at its 3 dB point) to the total area scanned by the antenna (as measured at its 3 dB point)

time gating duty factor: ratio of the equivalent pulse power duration with respect to an ideal rectangular pulse shape to the pulse **repetition interval**

channel dwell time: accumulated amount of transmission time of uninterrupted continuous transmission within a single given frequency channel and within one channel repetition interval

channel dwell duty: ratio of the time of uninterrupted continuous transmission within a given frequency channel to the channel repetition interval (= channel dwell time/channel repetition interval)

Equipment Under Test (EUT): radar sensor including the integrated antenna together with any external antenna components which affect or influence its performance

maximum safe level for radiated power density: That level which can be transmitted in accordance with the current recommended safety levels in EN 50166-2 [8] should be done on the vehicle.

operating frequency range: range of operating frequencies over which the equipment can be adjusted through switching or reprogramming or oscillator tuning

NOTE 1:
- For pulsed or phase shifting systems without further carrier tuning the operating frequency range is fixed on a single carrier line;
- For analogue or discrete frequency modulated systems (FSK, FMCW) the operating frequency range covers the difference between minimum and maximum of all carrier frequencies on which the equipment can be adjusted.

operating frequency (operating centre frequency): nominal frequency at which equipment is operated

NOTE 2: Equipment may be able to operate at more than one operating frequency.

peak envelope power: Mean power (round mean square for sinusoidal carrier wave type) supplied from the antenna during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions (see Radio Regulations).

permitted range of operating frequencies: frequency range over which the approved equipment may operate

Pulse Repetition Frequency (PRF): inverse of the Pulse Repetition Interval, averaged over a time sufficiently long as to cover all PRI variations

Pulse Repetition Interval (PRI): time between the rising edges of the transmitted (pulsed) output power

equivalent pulse power duration: duration of an ideal rectangular pulse which has the same content of energy compared with the pulse shape of the EUT with pulsed modulation or time gating

Spatial radiated power density: power per unit area normal to the direction of the electromagnetic wave propagation It is expressed in units of W/m^2.

Power spectral density (PSD): ratio of the amount of power to the used radio measurement bandwidth

NOTE 3: It is expressed in units of dBm/Hzor as a power in unit dBm with respect to the used bandwidth. In case of measurement with a spectrum analyser the measurement bandwidth is equal the RBW.

NOTE 4: The difference between the pulse peak power and the fundamental lobe magnitude of a spectrum analyser measurement with a RBW which is not sufficient to cover the total pulse bandwidth (see HP application note 150-2)

occupied bandwidth: bandwidth of a wideband spectral power density distribution defined by the distance between the -10 dB points with respect to the distribution maximum

average time: time interval on which a mean measurement is integrated

radiated spurious emissions: emissions at frequencies other than those of the carrier and sidebands associated with normal modulation

radome: external protective cover which is independent of the associated antenna, and which may contribute to the overall performance of the antenna (and hence, the EUT)

spread spectrum: modulation technique in which the energy of a transmitted signal is spread throughout a large portion

wideband: equipment to be used in a non-channelized continuous frequency band, or to be used in a channelized frequency band using more than one consecutive channel

3.2 Symbols

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

λ	Wavelength
1/P	repetition rate of the modulation wave form
ac	alternating current
B	Bandwidth
RBW	Resolution BandWidth used in the measurement
d	largest dimension of the antenna aperture
D_a	antenna scan Duty factor
D_t	time gating Duty factor
df	spectral distance between 2 lines with similar power levels
Δfmax	maximum frequency shift between any two frequency steps
Δfmin	minimum frequency shift between any two frequency steps
E	Field strength
E_o	Reference field strength
G	Blanking period
P	Period of time during in which one cycle of the modulation wave form is completed.
Pa	mean power within the BW
PL	Power of an individual spectral Line
R	distance
R_o	Reference distance
t	dwell time
τ	frequency step duration
T	frequency step repetition frequency
Tx	Transmitter

3.3 Abbreviations

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

dB	decibel
dBi	gain in decibels relative to an isotropic antenna
DSSS	Direct Sequence Spread Spectrum
eirp	equivalent isotropically radiated power
FHSS	Frequency Hopping Spread Spectrum
IFHSS	Interrupted Frequency Hopping Spread Spectrum
EMC	ElectroMagnetic Compatibility
ERC	European Radiocommunication Committee
EUT	Equipment Under Test
FMCW	Frequency Modulated Continuous Wave
FMICW	Frequency Modulated Interrupted Continuous Wave
FSK	Frequency Shift Keying
IFSK	Interrupted Frequency Shift Keying
IF	Intermediate Frequency
PSK	Phase Shift Keying
IPSK	Interrupted Phase Shift Keying
PM	Pulse Modulation
OATS	Open Area Test Site
PDCF	Pulse Desensitation Correction Factor
PRI	Pulse Repetition Interval
PRF	Pulse Repetition Frequency
PPM	Pulse Position modulation (staggered)
RF	Radio Frequency
R&TTE	Radio and Telecommunications Terminal Equipment
SRD	Short Range Device
SS	Spread Spectrum

VSWR Voltage Standing Wave Ratio
Tx Transmitter

4 Technical requirements specifications

4.1 Presentation of equipment for testing purposes

Each equipment submitted for testing, where applicable, shall fulfil the requirements of the present document on all frequencies over which it is intended to operate. In the case of an automotive application, EMC type approval testing to 95/54/EEC [12] should be done on the vehicle.

Additionally, technical documentation and operating manuals, sufficient to allow testing to be performed, shall be supplied.

The performance of the equipment submitted for type testing shall be representative of the performance of the corresponding production model. In order to avoid any ambiguity in that assessment, the present document contains instructions for the presentation of equipment for type testing purposes (clause 4.1), conditions of testing (clause 5) and the measurement methods (clauses 7 and 8).

Stand alone equipment shall be offered by the applicant complete with any ancillary equipment needed for testing. The applicant shall declare the frequency range(s), the range of operation conditions and power requirements, as applicable, in order to establish the appropriate test conditions.

The equipment shall be complete, and include the associated antenna structure as will be used in its final application. The inclusion of a radome (if appropriate) is optional. If the 77 GHz equipment is qualified with the radome, then the equipment shall only be used with that radome.

In case of multiple 24 GHz radar sensors to be mounted behind one common radome (e.g. the plastic fascia of a vehicle bumper), the measurements shall take into account the maximum spatial radiated power measured in an adaequate far field distance (e.g. 3 m) and in the main direction of the radome with respect to a time gated operation of the single EUTs. The radome material and thickness and color shall be choosen to reflect the best case condition concerning refraction loss.

For 77 GHz EUTs Test fixtures may be supplied by the applicant (clause 6.1).

Complete sensor modules should be supplied by the manufacturer to facilitate the tests.

These clauses are intended to give confidence that the requirements set out in the present document have been met without the necessity of performing measurements on all frequencies.

4.1.1 Choice of model for testing

The applicant shall provide one or more samples of the equipment, as appropriate for testing.

Stand alone equipment shall be offered by the applicant complete with any ancillary equipment needed for testing.

If an equipment has several optional features, considered not to affect the RF parameters then the tests need only to be performed on the equipment configured with that combination of features considered to be the most complex, as proposed by the applicant and agreed by the test laboratory.

4.2 Mechanical and electrical design

4.2.1 General

The equipment submitted by the applicant shall be designed, constructed and manufactured in accordance with good engineering practice and with the aim of minimizing harmful interference to other equipment and services.

Transmitters and receivers may be individual or combination units.

4.2.2 Controls

Those controls which, if maladjusted, might increase the interfering potentialities of the equipment shall only be accessible by partial or complete disassembly of the device and requiring the use of tools. This also applies (if applicable) to the mechanism which selects between class 1 and class 2 as defined in the present document for 77 GHz EUTs. This also applies (if applicable) to the mechanism which selects between the modulation types as defined for the 24 GHz EUTs.

4.2.3 Transmitter shut-off facility

If the transmitter is equipped with an automatic transmitter shut-off facility, it should be made inoperative for the duration of the test.

4.2.4 Void

4.2.5 Marking (equipment identification)

The equipment shall be marked in a visible place. This marking shall be legible and durable. Where this is not possible due to physical constraints, the marking shall be included in the users manual.

4.2.5.1 Equipment identification

The marking shall include as a minimum:

- the name of the manufacturer or his trademark;
- the type designation;
- equipment classification, clause 4.1.1.

4.2.5.2 Regulatory marking

The equipment shall be marked, where applicable, in accordance with CEPT/ERC Recommendation 70-03 [3] or the Directive 1999/5/EC [2], whichever is applicable. Where this is not applicable the equipment shall be marked in accordance with the National Regulatory requirements.

4.3 Declarations by the applicant

Where appropriate, the applicant shall supply the necessary information required by the appropriate application form.

4.4 Auxiliary test equipment

All necessary test signal sources and set-up information shall accompany the equipment when it is submitted for type testing.

4.5 Interpretation of the measurement results

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

- the measured value relating to the corresponding limit shall be used to decide whether an equipment meets the requirements of the present document;
- the measurement uncertainty value for the measurement of each parameter shall be included in the test report;
- the recorded value of the measurement uncertainty shall, for each measurement, be equal to, or lower than, the figures in the table of measurement uncertainty (clause 8).

5 Test conditions, power sources and ambient temperatures

5.1 Normal and extreme test conditions

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

The test conditions and procedures shall be as specified in clauses 5.2 to 5.4.

5.2 External test power source

During type tests the power source of the equipment shall be replaced by an external test power source, capable of producing normal and extreme test voltages as specified in clauses 5.3.2 and 5.4.2. The internal impedance of the external test power source shall be low enough for its effect on the test results to be negligible.

For battery operated equipment the battery shall be removed and the external test power source shall be suitably de-coupled and applied as close to the equipment battery terminals as practicable. For radiated measurements any external power leads should be so arranged so as not to affect the measurements. If necessary, the external test power source may be replaced with the supplied or recommended internal batteries at the required voltage, or a battery simulator. This shall be stated on the test report. For radiated measurements on portable equipment with an integral antenna, fully charged internal batteries should be used. The batteries used should be as supplied or recommended by the applicant.

If the equipment is powered from an external source, the test voltage shall be measured at the point of connection of the power cable to the equipment.

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

If internal batteries are used, at the end of each test the voltage shall be within a tolerance of ±5 % relative to the voltage at the beginning of each test.

5.3 Normal test conditions

5.3.1 Normal temperature and humidity

The normal temperature and humidity conditions for tests shall be 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 tests under these conditions, a note to this effect, stating the ambient temperature and relative humidity during the tests, shall be added to the test report.

5.3.2 Normal test 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. For the purpose of the present document, 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 Hz and 51 Hz.

5.3.2.2 Regulated lead-acid battery power sources

When the radio equipment is intended for operation with the usual types of regulated lead-acid battery power source, the normal test voltage shall be 1,1 multiplied by the nominal voltage of the battery (e.g. 6 V, 12 V etc.).

5.3.2.3 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 applicant and agreed by the accredited test laboratory. Such values shall be stated in the test report.

5.4 Extreme test conditions

5.4.1 Extreme temperatures

5.4.1.1 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 stabilization circuits designed to operate continuously, the temperature stabilization circuits shall be switched on for 15 minutes after thermal balance has been obtained, and the equipment shall then meet the specified requirements.

If the 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 accredited test 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.

5.4.1.2 Extreme temperature ranges

For tests at extreme temperatures, measurements shall be made in accordance with the procedures specified in clause 5.4.1.1, at the upper and lower temperatures of one of the following ranges:

Temperature: - 20 °C to +55 °C

5.4.2 Extreme test source voltages

5.4.2.1 Mains voltage

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

5.4.2.2 Regulated lead-acid battery power sources

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

For float charge applications using "gel-cell" type batteries the extreme voltage shall be 1,15 and 0,85 multiplied by the nominal voltage of the declared battery voltage.

5.4.2.3 Power sources using other types of batteries

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

- for equipment with a battery indicator, the end point voltage as indicated;
- for equipment without a battery indicator the following end point voltages shall be used:
  - for the Leclanché or the lithium type of battery:
    - 0,85 multiplied by the nominal voltage of the battery;
  - for the nickel-cadmium type of battery:
    - 0,9 multiplied the nominal voltage of the battery;
- for other types of battery or equipment, the lower extreme test voltage for the discharged condition shall be declared by the equipment applicant.

The nominal voltage is considered to be the upper extreme test voltage in this case.

5.4.2.4 Other power sources

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

6 General conditions

Detailed descriptions of the radiated measurement arrangements are included in annexes A and B. In general, measurements should be carried out under far field conditions, however measurements in the 76 GHz to 77 GHz band may be carried out in the near field e.g. by using the test fixture as described in clause 6.1 and shown in figure 1.

The far field condition for 24 GHz EUTs is supposed to be fulfilled in a minimum radial distance of 1m for a single device measurement.

In case of several 24 GHz EUTs mounted behind a common radome a measurement of the accumulated spatial power density is required if the following conditions are simultaneously fulfilled:

a) time-parallel operation of more then one EUT is a feasible system running mode;

b) the 3dB- spatial antenna planes of two or more time parallel transmitting EUTs overlap in a longitudinal distance of 3 m from the radome.

The best case of material propagation loss of the radome should be taken into account. The maximum propagation loss accepted for EIRP increase of the limits specified without further loss shall be 2dB. The worst case condition of several EUTs located over *a bended mounting plane* shall be considered by a flat plane with identical lateral location and the antenna direction of each EUT in the normal direction of the flat plane.
In case of carrier incoherence between the EUTs, the far field measurement condition is supposed to be fulfilled in a longitudinal distance of 3m with respect to the geometrical center of the radome. The geometrical point of maximum field strength shall be reported and referenced for the measurements as defined below.
In case of carrier coherence between the EUTs the single antennas may build a synthetic aperture. The far field condition shall be fullfilled in a longitudinal distance of $L = 2s^2/\lambda$ (s = lateral distance between the single EUT antennas). If the calculated far field distance is greater then 5 m, the measurements shall be provided in a longitudinal distance of 5 m with respect to the geometrical centre of the radome.

Absolute power measurements shall be made using an appropriate method to ensure that the wave front is properly formed (i.e. operating in far field conditions). This prohibits the use of the test fixture, shown in figure 1.

For different frequency bands, different test sites, test antennas and standard positions are suitable and/or may be used.

Each test site shall meet the appropriate requirements as defined in published guidelines/standards (e.g. for OATS the requirements are defined in CISPR 16-1 [5].

6.1 Test fixture

The test fixture enables the EUT to be physically supported, together with a wave guide horn antenna (which is used to couple/sample the transmitted energy), in a fixed physical relationship. The test fixture should be designed for use in an anechoic environment and allows certain measurements to be performed in the near field. Only relative or comparative measurements may be performed, and only those at the frequencies in the 76 GHz to 77 GHz band over which the test fixture has been calibrated.

The 24 GHz EUTs are designed for much shorter detection areas and therewith much lower power levels then the EUTs at 77GHz. Furthermore no EIRP increase for scanning/switching antennas is foreseen. Therefore it is expected to completely qualify the EUTs under free space propagation conditions (OATS). This is under the assumption that measurements within a maximum measurement distance of 3 meters are appropriate.

At set-up, the EUT shall be aligned in the test fixture so that the maximum power is detected at the coupled output (see also clause 7.2. Orientation of the horn will take into account the polarization of the EUT.

In addition, the test fixture shall provide a connection to an external power supply.

The test fixture shall be provided by the manufacturer together with a full description, which should meet with the approval of the selected accredited test laboratory.

The performance characteristics of the test fixture shall be measured and shall be approved by the accredited test laboratory. It shall conform to the following basic parameters:

- the gain of the waveguide horn shall not exceed 10 dB;
- the physical distance between the front face of the EUT and the waveguide horn shall be between 50 cm and 60 cm;
- the physical height between the centre of the EUT and the supporting structure of the test fixture shall be between 50 cm and 60 cm;
- circuitry associated with the RF coupling shall contain no active or non-linear devices;
- the Voltage Standing Wave Ratio (VSWR) at the waveguide flange at which measurements are made shall not be greater than 1,5: 1 over the frequency range of the measurements;
- the performance of the test fixture when mounted in the anechoic environment, on an open test site, or in a temperature chamber, shall be unaffected by the proximity of surrounding objects or people outside the environment. The performance shall be reproducible if the EUT is removed and then replaced;
- the performance of the test fixture shall remain within the defined limits of the calibration report, when the test conditions are varied over the limits described in clauses 5.3 and 5.4.

The characteristics and calibration of the test fixture shall be included in a calibration report

6.1.1 Calibration

The calibration of the test fixture establishes the relationship between the detected output from the test fixture, and the transmitted power (as sampled at the position of the antenna) from the EUT in the test fixture. This can be achieved by using a calibrated horn with a gain of equal to or less than 10 dB, fed from an external signal source, in place of the EUT to determine the variations in detected power with temperature and over frequency.

The calibration of the test fixture shall be carried out by either the manufacturer or the accredited test laboratory. The results shall be approved by the accredited test laboratory.

The calibration should be carried out over the operating frequency band, at least three frequencies, for the declared polarization of the EUT, and over the temperature ranges specified in clause 5.4.1.2.

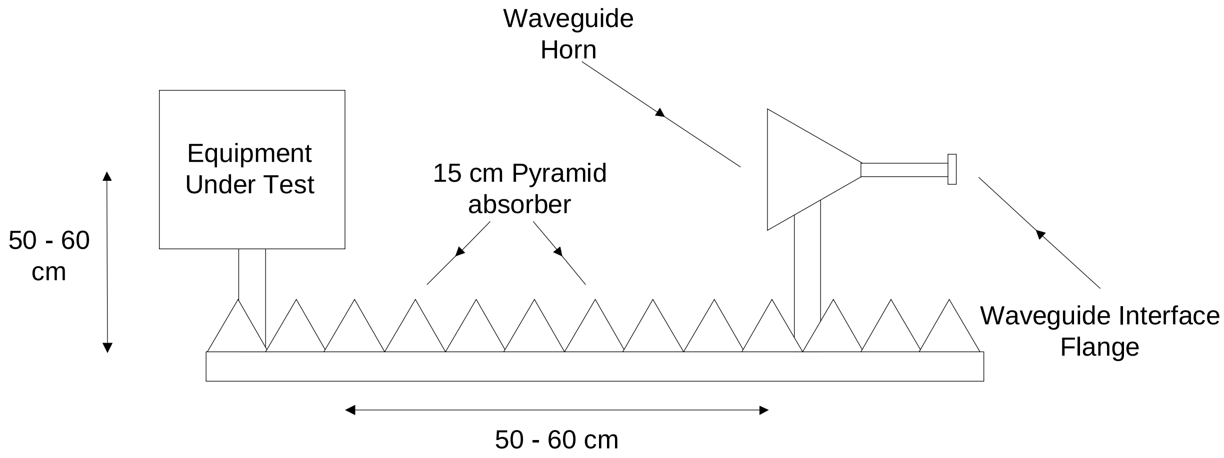


Figure 1: Test fixture

7 Methods of measurement and limits for transmitter parameters

To meet the requirements for all applications the EUT shall be measured at its maximum mean output power level and maximum antenna gain. Antenna polar diagrams, together with any antenna sweep profiles (for systems with antenna beam steering capability) and details of polarization, shall be presented and agreed with the accredited test laboratory if they are necessary to enable the measurements described in clause 7 to be performed.

Alternative test methods to those described within the present document may be used with the agreement of the manufacturer, and at the discretion of the accredited test laboratory. Procedures shall comply with CEPT/ERC Recommendation 01-06 [6] and CISPR 16-1 [5].

For 77 GHz EUTs There are two classes defined within the present document: class 1 and class 2. The only difference between the two class numbers is the permitted level of transmitted power. The class for which approval is sought, shall be stated in the application form for type approval.

For 24 GHz EUTs there are three types of modulation defined. For all modulation types, one common PSD average limit has to be fullfilled according transmission mask of clause 7.1.3. The type of modulation has to be stated in the application form for type approval. If mixed or time gated modes of different modulation types are applied this should be stated.

7.1 Permitted range of operating frequencies

7.1.1 Definition

The permitted range of operating frequencies is the frequency range over which the equipment is authorized to operate.

7.1.2 Method of measurement

The minimum and maximum output frequencies at which the permitted spurious levels as specified in clause 7.6, are exceeded and which are produced from the selected modulation scheme(s) shall be measured using the method shown in figure 2. If more than one modulation scheme can be generated by the EUT, then the maximum and minimum frequencies generated by each modulation scheme shall be measured and recorded.

The measuring receiver may be a spectrum analyser, oscilloscope, selective power meter or any measuring receiver which is appropriate to perform the intended measurement of the device under test.

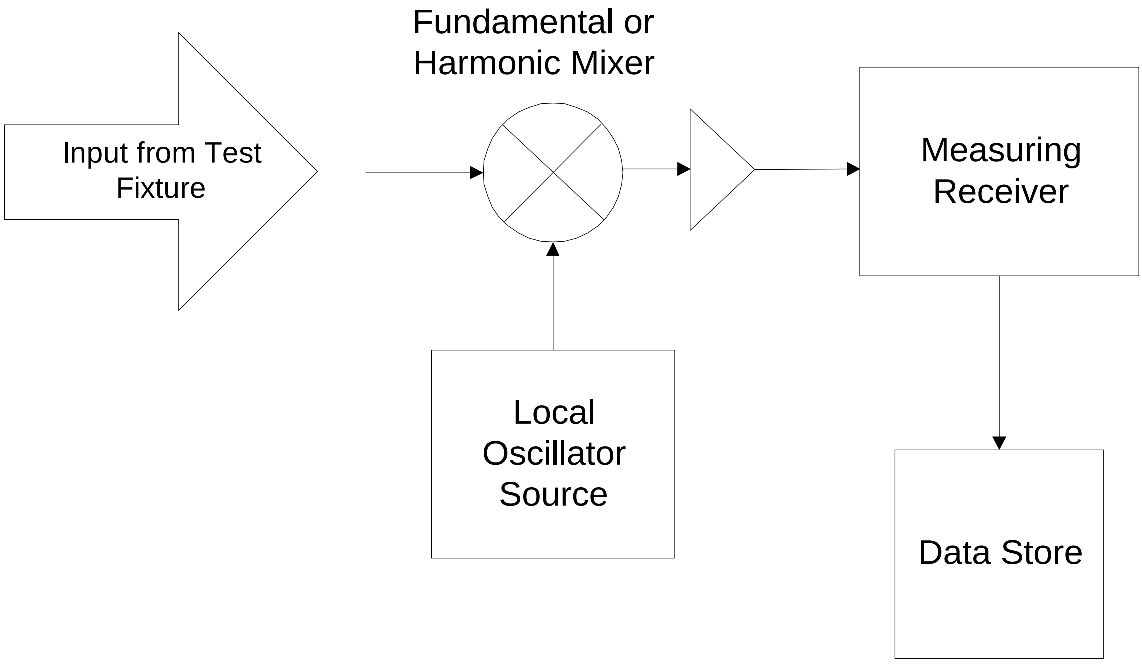


Figure 2: Test equipment for measuring the operating frequency range

This measurement shall be performed at normal and at extreme test conditions (clauses 5.3 and 5.4).

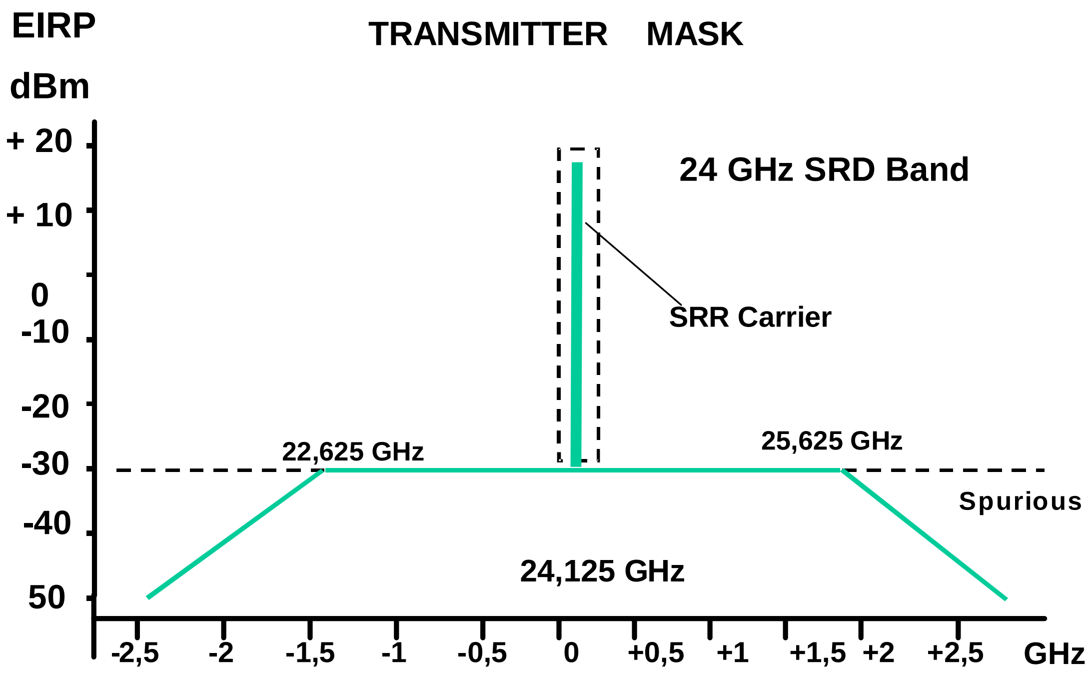
The method of measurement shall be documented in the test report.

7.1.3 Limits

The permitted range of operating frequency shall be 76 GHz to 77 GHz.

In case of narrow band low power systems, the permitted range of operating frequency shall be 24,05 GHz to 24,25 GHz (according to CEPT/ERC Recommendation 70-03 [3], annex 5).

The permitted range of operating frequency for wideband ultra low power emission with mean PSD level below the spurious level shall be 22,65 GHz to 25,65 GHz. Below 22,65 GHz and above 25,65 GHz the mean PSD level shall decrease with a slope of -20 dB/1 GHz.



Measured at 100 kHz RBW with maximum dwell times of 10 µsec.

NOTE: Final approval for measurement specifications to be determined.

The mean PSD defined in the transmitter mask shall be measured with a minimum RBW of 100 kHz.
If the system concept utilizes additional time gating, the minimum VBW is specified to 100 kHz. Furthermore the SA shall be switched into "peak (max) hold" mode. If the system does not utilize further time gating, the minimum VBW is specified to 1 kHz.

7.2 Radiated spatial power density

7.2.1 Definition

The radiated spatial power density is defined as the power per unit area normal to the direction of the electromagnetic wave propagation measured in the permitted range of operating frequencies (clause 7.1) and is expressed as an EIRP (dBm).

7.2.2 Method of measurement

7.2.2.1 Equipment with a fixed beam antenna (i.e. non-steerable by either mechanical or electronic means)

Using an applicable measurement procedure e.g. as described in annexes A and B, the power output shall be measured and recorded in the test report. Absolute power measurements should be carried under far field conditions, however measurements over temperature may be carried out using comparative measurements in the near field e.g. by using the test fixture as described in clause 6.1.
Measurements of the spatial power density corresponding to the antenna pattern have to be provided over the normal and extreme temperature range if the transmit antenna gain is more than 20 dB. Otherwise one measurement at 20°C is sufficient. EIRP and carrier frequency measurements versus extreme temperature range should be provided under maximum EIRP conditions and at 20°C.

The method of measuring the power may be either by the use of a calibrated power meter, or by using a calibrated receiver. For both methods the substitution technique described in annex B shall be used to calibrate the measuring equipment.

The polar diagram together with details of the polarization for the transmit beam (if required to enable the measurement to be carried out) shall be submitted by the manufacturer and approved by the accredited test laboratory.

The maximum EIRP shall then be recorded.

The EIRP shall be measured under far field conditions under normal test conditions (clause 5.3.1).

EIRP under extreme test conditions (clause 5.4.1) may be measured in the near field e.g. with the defined test fixture (clause 6.1).

This measurement should be carried out in an anechoic environment or there should be no physical obstruction within a sector defined as "three times the 3 dB beamwidth of the antenna" during this test.

This measurement shall be performed at normal and at extreme test conditions (clauses 5.3 and 5.4).

The method of measurement shall be documented in the test report.

7.2.2.2 Equipment with (electronically or mechanically) steerable antenna(s)

Using an applicable measurement procedure e.g. as described in annexes A and B, the power output shall be measured and recorded in the test report. Absolute power measurements should be carried under far field conditions, however measurements over temperature may be carried out using comparative measurements in the near field e.g. by using the test fixture as described in clause 6.1.

The method of measuring the power may be either by the use of a calibrated power meter, or by using a calibrated receiver. For both methods, the substitution technique described in annex B shall be used to calibrate the measuring equipment.

Peak EIRP to be measured using a standard gain horn and spectrum analyser set to slow sweep and peak hold mode. This enables the EUT to be fully tested according to clause 7.2.2.1.
In case that the bandwidth of the measurement equipment is smaller then the occupied bandwidth of the pulse spectrum, a PDCF has to be applied. Alternatively a time domain measurement with a sampling scope of sufficient system bandwidth may be provided to determine the pulse envelope. Alternatively if the EUT can be switched in a CW mode comparable to the lowest insertion loss of the AM modulator (switch) without any bandstop filtering, the related EIRP shall be assumed to be equal the pulse peak power.

The manufacturer shall provide information relating to the scanning. The limits for the EIRP are shown in table 2.

The EIRP shall be measured in the far field under normal test conditions (clause 5.3.1).

EIRP under extreme test conditions (clause 5.4.1) may be measured in the near field e.g. with the defined test fixture (clause 6.1). Extreme test condition measurements concerning temperature variations of the spatial power density are only required for transmit antennas with gain more than 20 dB.

This measurement should be carried out in an anechoic environment or there should be no physical obstruction within a sector defined as "three times the 3 dB beamwidth of the antenna" during this test.

This measurement shall be performed at normal and at extreme test conditions (clauses 5.3 and 5.4).

The method of measurement shall be documented in the test report.

7.2.3 Limits

7.2.3.1 Equipment with fixed beam antenna

The transmitted power for 77 GHz equipment with fixed beam antennas shall be less than the limits shown in table 2a.

Table 2a: Limits for transmitted power (fixed antenna)

	Class 1	Class 2
Mean Power(EIRP)	50 dBm	23,5 dBm
Peak Power(EIRP)	55 dBm	55 dBm

The transmitted power for 24 GHz equipment with fixed beam antennas shall be less than the limits shown in table 2b.

Table 2b: Limits for transmitted power (fixed antenna)

	PN-PPM	PN-PSK	PN-FHSS
Mean Power(EIRP) (note 2)	0 dBm	0 dBm	0 dBm
Peak Power(EIRP)	20 dBm (note 3)	0 dBm (note 1)	0 dBm (note 1)
NOTE 1: Peak power is equivalent CW power, if no further switching or time gating is applied on the CW systems PN-PSK and PN-FHSS. NOTE 2: The maximum average time for mean power measurements shall be limited to 50 msec. NOTE 3: The increase of the peak power limit by 20 dB above the mean power limit for time gated or pulsed systems (PM, IPSK, IFSK, IFHSS) is only allowed under the following conditions: a) the carrier location is positioned within the SRD Band 24,05 GHz to 24,25 GHz and the time or carrier duty cycle is less then 10 %; b) the carrier location is positioned within the wideband 22,625 GHz to 25,625 GHz and the time- or channel duty is less then 1 %.			

7.2.3.2 Equipment with (electronically or mechanically) steerable antennas (77 GHz Equipment)

The transmitted power for 77 GHz equipment with steerable antennas shall be less than the limits shown in table 3.

Table 3: Limits for transmitted power (steerable antenna)

	Class 1		Class 2	
maximum antenna signal dwell time	t < 100 ms	t > 100 ms	t < 100 ms	t > 100 ms
Mean Power (EIRP) (note 1)	[55 dBm + 10 log(D)] or 50 dBm (whichever is the greater)	50 dBm	[55 dBm + 10 log(D)] or 23,5 dBm (whichever is the greater)	23,5 dBm
Peak Power (EIRP)	55 dBm	55 dBm	55 dBm	55 dBm
NOTE 1: The duty factor (D) is the ratio of the area of the beam (measured at its 3 dB point) to the total area scanned by the antenna. NOTE 2: The dwell time (t) is the largest dwell time at any angle.				

The transmitted power for 24GHz equipment with steerable antennas is specified according table 2b. An decrease of the mean power limit is not applicable with respect to an antenna duty cycle factor and an antenna dwell time.

7.2.3.3 Limitation of vertical Antenna pattern for 24 GHz Equipment

The vertical antenna pattern for 24 GHz EUTs shall be limited according to table 3a with respect to the maximum antenna gain. The vertical antenna angle is positioned on 0° for a vector direction parallel to ground and on -90° for a vector direction from top to ground. The vertical antenna pattern shall be measured within the azimuth plane of EIRP_max.

Table 3a: Limitation of vertical antenna pattern

Vertical antenna angle θ in °	spatial antenna gain
θ < -75° and θ > 45°	G_dBi_max –30 dB
-75° < θ < -30°	G_dBi_max + 0,666 × [dB/°](θ +30°)
-30° < θ < 0°	G_dBi_max
0° < θ < 45°	G_dBi_max – 0,666 × θ [dB/°]

7.2.3.4 Limitation of mounting height

The mounting height from 24 GHz EUTs is limited to maximum 1,5 m.

7.3 Maximum safe level for radiated power density

It is necessary for every EUT to comply with the current regulations regarding safe levels for radiated power. This is detailed in annex D of the present document.

7.4 Modulation schemes

Only the modulation schemes described in clauses 7.4.1, 7.4.2 and 7.4.3 may be used for 77GHz EUTs.
Only the modulation schemes described in clauses 7.4.4, 7.4.5 and 7.4.6 may be used for 24 GHz EUTs.

7.4.1 Pulse modulation 77 GHz

7.4.1.1 Definition

For pulse modulation, the Tx "amplitude" is periodically switched on for a short time (called pulse duration**)** and switched off during the subsequent reception period. A typical example is shown in figure 3.

The time between the rising edges of the pulsed output power is called the Pulse Repetition Interval (PRI). The PRI may vary between subsequent pulses, in which case the modulation is called staggered PRI.

The Pulse Repetition Frequency (PRF) is the inverse of the PRI averaged over a time sufficiently long to cover all PRI variations.

The duty cycle is the product of the PRF and the pulse duration.

The radiated power averaged over the pulse duration is called the peak output power.

The peak output power multiplied by the average duty cycle is called the average output power.

Subsequent pulses may be on different frequencies (i.e. stepped frequency), but they shall be linearly sequential. This does not include unintentional frequency drift with temperature.

During the pulse duration, the frequency shall not be intentionally modulated (i.e. chirped). This does not include unintentional frequency drift with temperature.

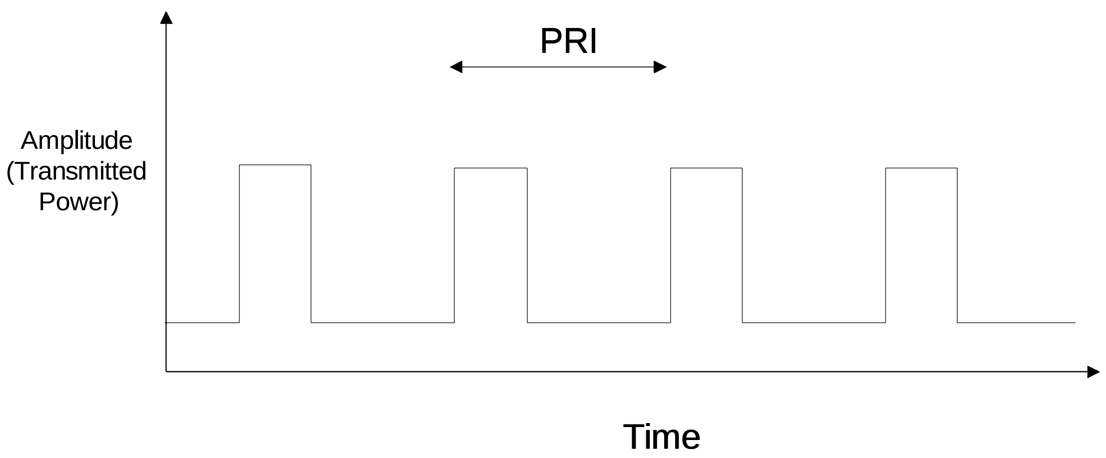


Figure 3: Typical pulse modulation scheme

7.4.1.2 Methods of measurement

Using the standard test fixture shown in figure 1 (clause 6.1.2), the test equipment shown in figure 4 is connected to the test fixture.

The measuring receiver may be a modulation domain analyser, spectrum analyser, oscilloscope, selective power meter or any measuring receiver which is appropriate to perform the intended measurement of the EUT.

The EUT shall be operated under normal and extreme conditions (clauses 5.3 and 5.4), and the resultant modulation waveforms monitored and recorded.

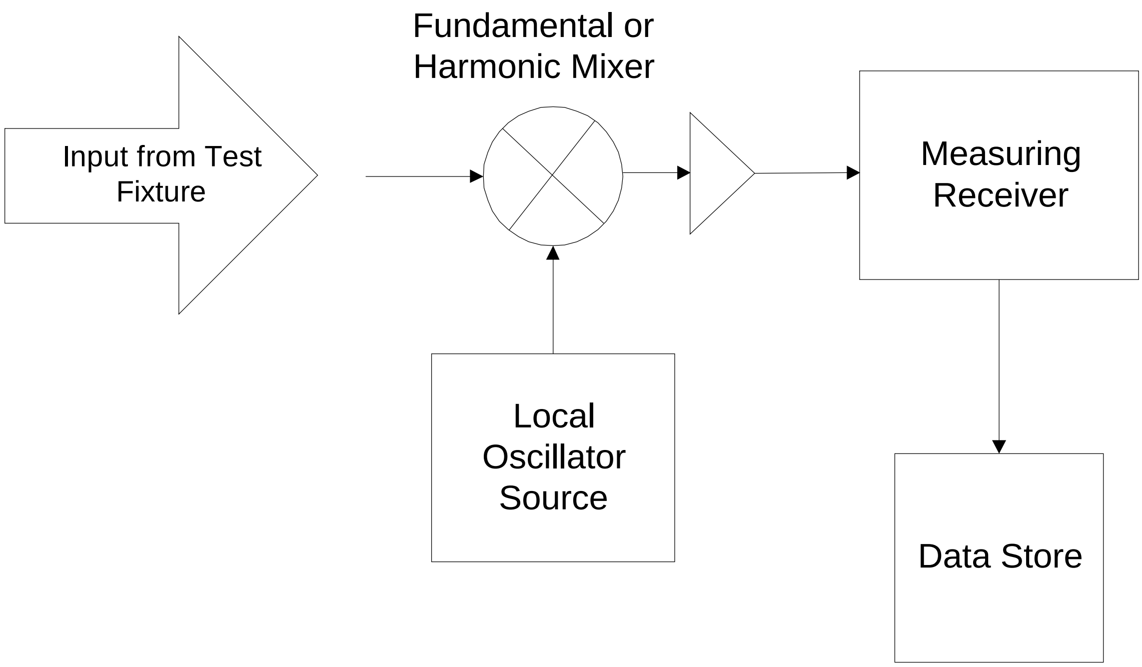


Figure 4: Test equipment for measuring the modulation waveform

7.4.1.3 Limits

The limits are shown in table 4.

Table 4: Limits for pulse modulation

Parameter	Minimum	Maximum
PRF	no limit	3 MHz
PRI	300 ns	no limit
Pulse length	20 ns	no limit
Maximum frequency step	no limit	100 MHz/ns
Duty cycle	no limit	10 %

No further limits apply to the parameters defined as long as the resulting signal spectrum satisfies the requirements defined in the other clauses of the present document.

7.4.2 Frequency modulated continuous wave 77 GHz

7.4.2.1 Definition

For Frequency Modulated Carrier Wave (FMCW) modulation, the transmitted waveform is frequency modulated over a period of time (P). This period of time may be constant, or may be varied within the limits shown in clause 7.4.2.3. An example of a typical modulation scheme is shown in figure 5. During the time (P), the frequency may either increase or decrease, monotonically. The modulation may assume (but is not limited to) the form of a "sawtooth", "triangular" or a "sinusoidal" waveform. Also a constant frequency may be maintained and transmitted during one or more periods of time. Also the transmitted power may be switched off during one or more periods of time (e.g. Frequency Modulated Interrupted Continuous Wave (FMICW)). The modulation waveform may be repeated or varied over several periods of time, and a limited variation of the duration of time period (P) is permitted. The amplitude of the transmitted waveform shall not be intentionally modulated. At the beginning or end of each period of time (P), there may be a time "G" (the "blanking period") where the transmitted waveform is adjusting to the requirements of the beginning of the next period.

No use is made of the transmitted waveform during the "blanking period" period. The blanking period may either be constant, or it may vary within the limits defined in table 5.

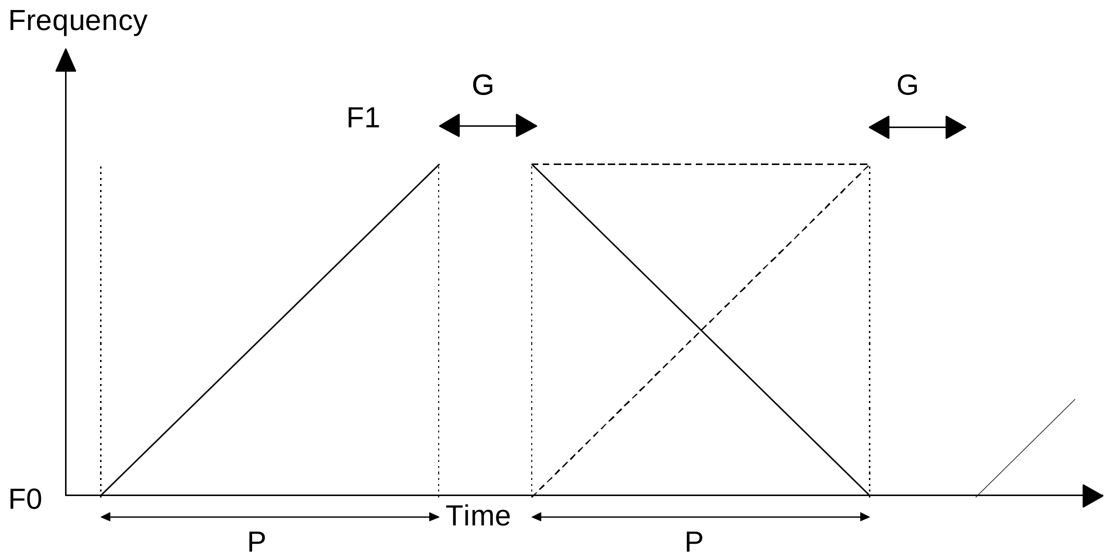


Figure 5: Typical FMCW modulation scheme

7.4.2.2 Methods of measurement

Using the standard test fixture shown in figure 1 (clause 6.1.2), the test equipment shown in figure 6 is connected to the test fixture.

The measuring receiver may be a modulation domain analyser, spectrum analyser, oscilloscope, selective power meter or any measuring receiver which is appropriate to perform the intended measurement of the EUT.

The EUT shall be operated under normal and extreme conditions (clauses 5.3 and 5.4), and the resultant modulation waveforms monitored and recorded.

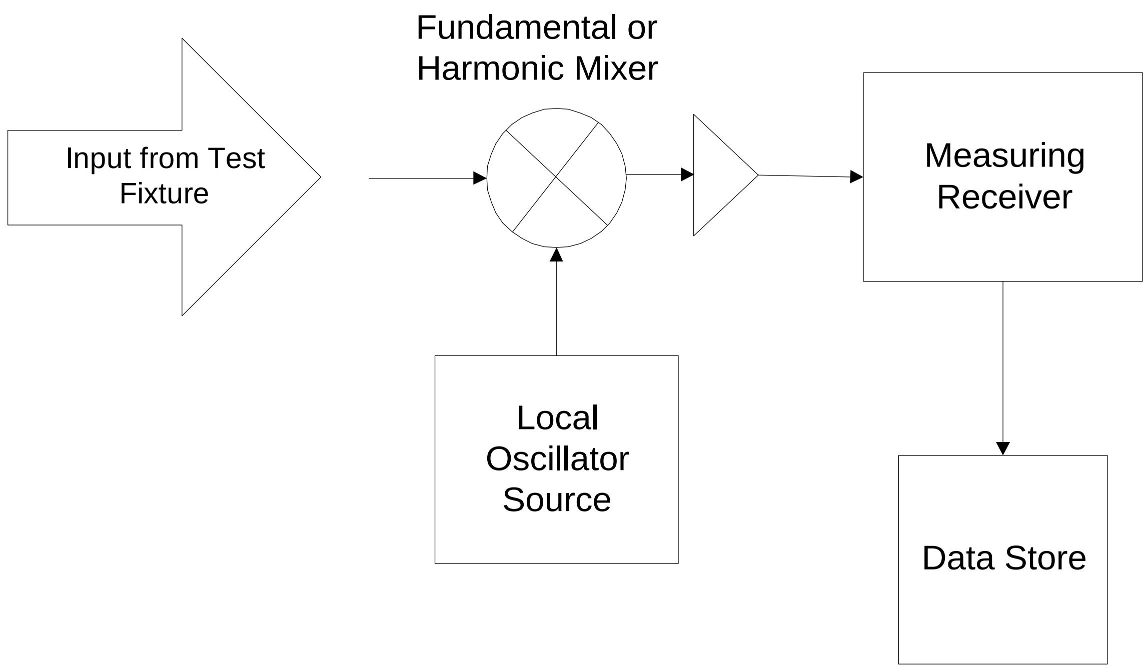


Figure 6: Test equipment for measuring the modulation waveform

7.4.2.3 Limits

The limits for FMCW modulation schemes are shown in table 5.

Table 5: Limits for FMCW Modulation Schemes

Parameter	Minimum Limit	Maximum Limit
Frequency deviation in one period	0 Hz	1 000 MHz
Rate of frequency modulation during a period (P)	0 Hz/ms	10 000 MHz/ms
Period of time for modulation (P)	100 µs	40 ms
Variation of centre frequency between periods	no limit	no limit
Blanking Period (G)	0	2 ms

Blanking period "G": during this period of time, no intentional use shall be made of the transmitted waveform. The frequency during this period may change, but shall not deviate from a monotonic increase or decrease by more than 100 MHz.

7.4.3 Frequency Shift Keying (FSK) 77GHz

7.4.3.1 Definition

With FSK modulation, an interleaved continuous FSK waveform is transmitted. The modulation frames are composed of interleaved continuously linearly stepped and sequential digital frequency steps.

During each frequency step the transmitted signal has a constant frequency.

The generic modulation scheme is characterized by the parameters shown in figures 7 and 8.

In a frame, the sequence of transmitted frequencies are:

$f_{01}, f_{02}, \ldots f_{0j}, \ldots f_{0p}, f_{11}, f_{12}, \ldots f_{1j}, \ldots f_{1p}, \ldots f_{n1}, f_{n2}, \ldots f_{nj}, \ldots f_{np}$

Where:

P is the number of interleaved linearly stepped waveforms;

n + 1 is the number of steps per linearly stepped waveform.

With:

$f_{(a+1)j} = f_{aj} + \varepsilon_j \times \Delta fj$ for $1 \leq j \leq n$;

and where f_{aj} and $f_{(a+1)j}$ are sequential steps in the waveform identified by the "j" index.

Where:

Δfj is the frequency deviation step of the waveform identified by the "j" index;

$\varepsilon_j = 1$ (positive slope) or $\varepsilon_j = -1$ (negative slope);

$\Delta Fj = n \times \Delta fj \leq \Delta F_{max} = 200$ MHz (negative or positive slope).

With:

τ = frequency step duration (constant within 1 frame);

ΔF_{max} = maximum frequency deviation of one stepped frequency waveform;

T = frame repetition period (constant).

The bandwidth (B) is defined as the bandwidth at which the level of the power spectral density (W/Hz) is 27 dB below the peak level of the power spectral density.

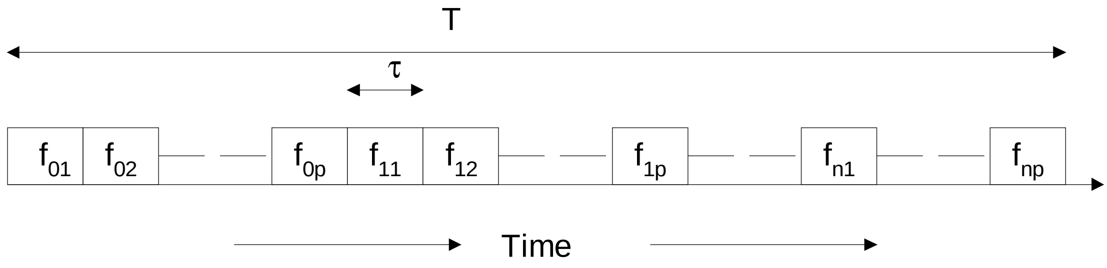


Figure 7: Typical FSK modulation scheme

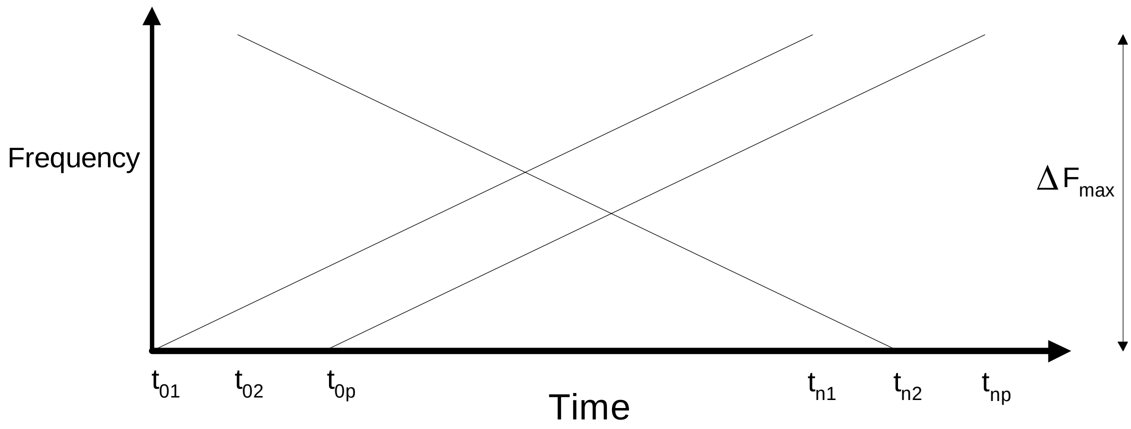


Figure 8: Typical FSK modulation sequence

7.4.3.2 Method of measurement

Using the standard test fixture shown in figure 1 (clause 6.1.2), the test equipment shown in figure 9 is attached to the test fixture.

The measuring receiver may be a modulation domain analyser, spectrum analyser, oscilloscope, selective power meter or any measuring receiver which is appropriate to perform the intended measurement of the EUT.

The EUT shall be operated under normal and extreme conditions (clauses 5.3 and 5.4), and the resultant modulation waveforms monitored and recorded.

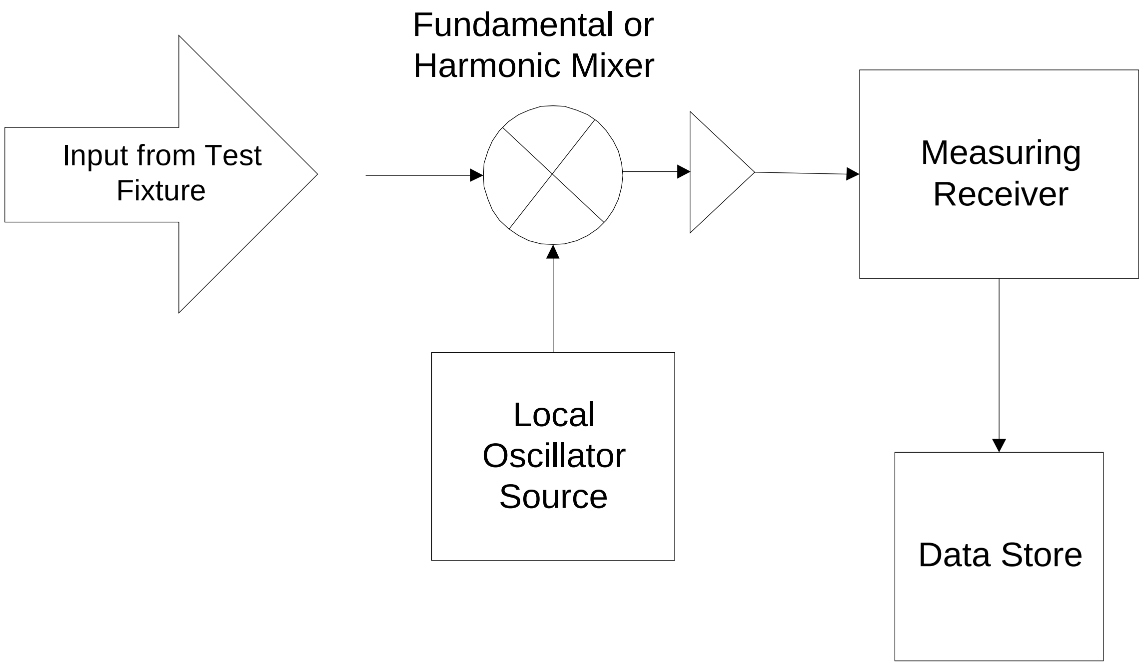


Figure 9: Test equipment for measuring the modulation waveform

7.4.3.3 Limits

The limits for FSK Modulation are shown in table 6.

Table 6: Limits for FSK Modulation

Parameter	Minimum	Maximum
τ	0,5 µs	10 µs
ΔFmax	100 KHz	200 MHz
T	2 µs	
B	no limit	280 MHz
n + 1	1	8 192
P	1	10
(Δfj/T) max	no limit	100 MHz/1µs

7.4.4 PN PPM (Pseudonoise Pulse position modulation) 24 GHz

7.4.4.1 Definition

For pulse modulation, the Tx "amplitude" is periodically switched on for a short time (called pulse duration**)** and switched off during the subsequent reception period. A typical example is shown in figure 10. Due to finite switch isolation a residual CW emission can occur during the subsequent reception period.

The time between the rising edges of the pulsed output power is called the Pulse Repetition Interval (PRI). The PRI may vary between subsequent pulses, in which case the modulation is called staggered PRI.

In case of a pseudeonoise variation of the PRI a wideband spectrum with very homogeneous spectral power density and noise like emissions with respect to narrow band receivers can be achieved.

The Pulse Repetition Frequency (PRF) is the inverse of the PRI averaged over a time sufficiently long to cover all PRI variations.

The pulse duty cycle is the product of the PRF and the pulse duration. The equivalent pulse power duration has to be applied in case of nonrectangular pulse shapes, which is defined to be the duration of an ideal rectangular pulse which has the same content of energy compared with the nonrectangular pulse shape of the EUT.

The radiated power (rms) on the crest of the pulse shape is called the peak output power.

The peak output power multiplied by the average duty cycle is called the average output power.

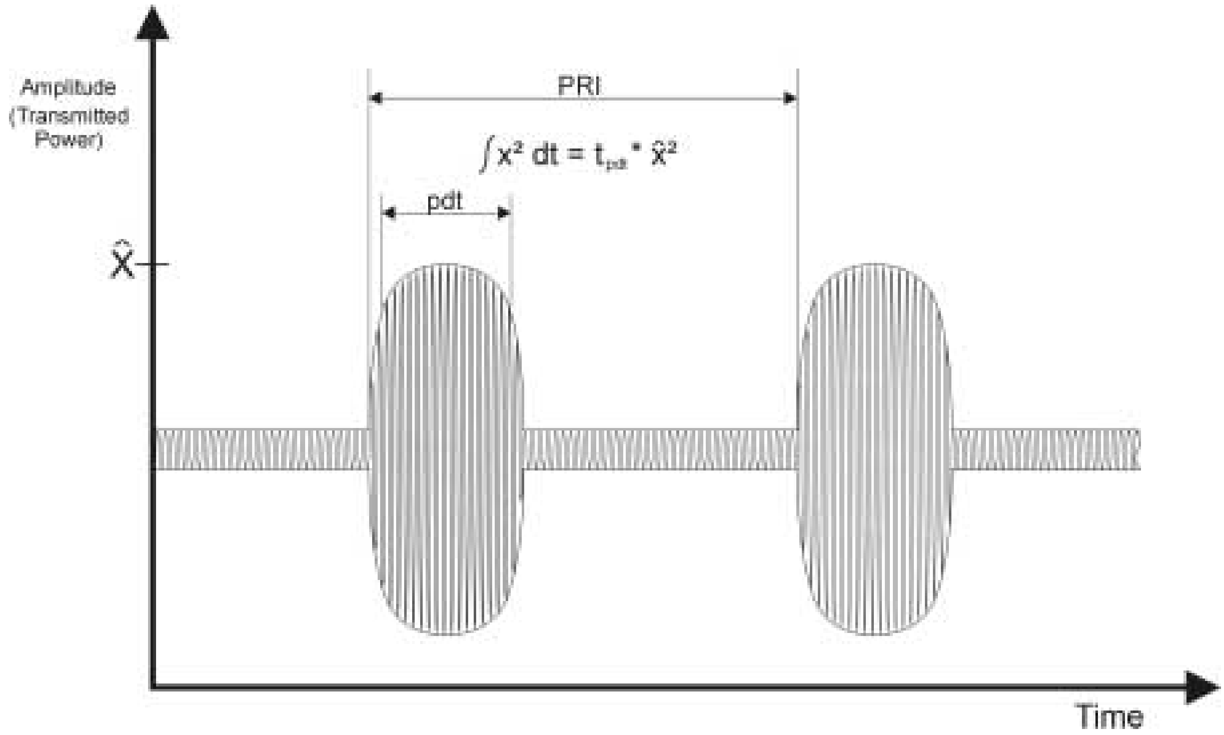


Figure 10: Typical pulse modulation scheme

7.4.4.2 Methods of measurement

Using the standard test fixture shown in figure 1 (clause 6.1.2), the test equipment shown in figure 11 is connected to the test fixture.

The measuring receiver may be a modulation domain analyser, spectrum analyser, oscilloscope, selective power meter or any measuring receiver, which is appropriate to perform the intended measurement of the EUT.

The EUT shall be operated under normal and extreme conditions (clauses 5.3 and 5.4), and the resultant modulation waveforms monitored and recorded.

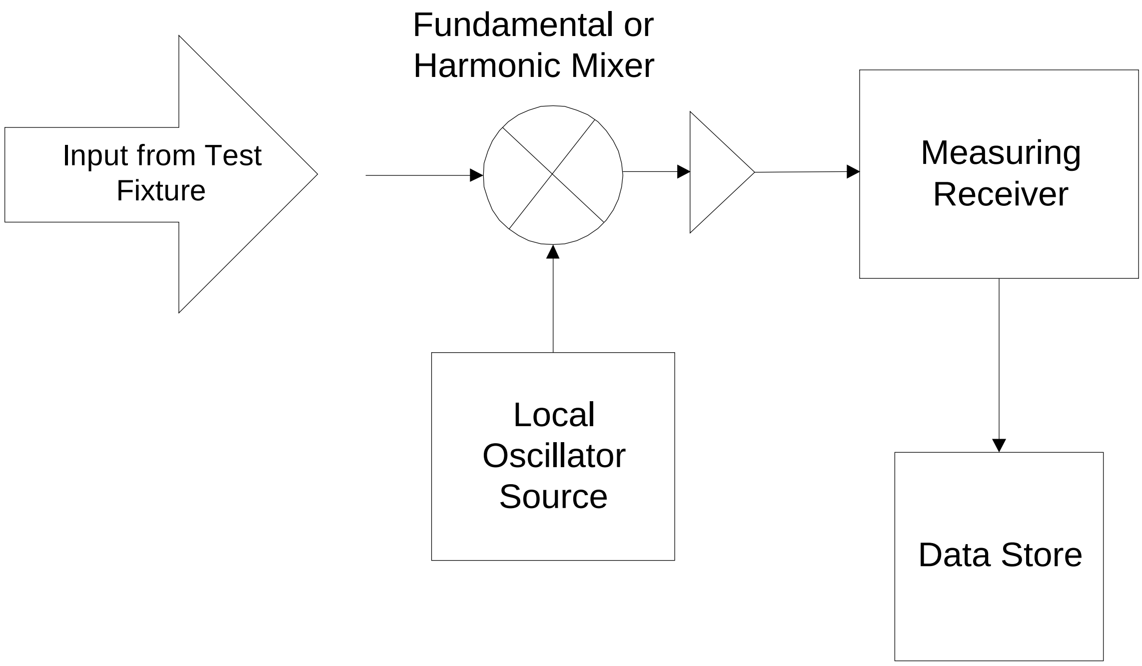


Figure 11: Test equipment Set-up for measuring the modulation waveform

7.4.4.3 Limits

The limits are shown in table 6.

Table 6: Limits for pulse modulation

Parameter	Minimum	Maximum
PRF	No limit	100 MHz
PRI	10 ns	No limit
Equivalent pulse power duration	400 ps	10 µs No limit, if carrier fixed within 24,05 GHz to 24,25 GHz
Average output power	No limit	0 dBm
Peak output power	No limit	20 dBm 0 dBm without duty cycle limit
Duty cycle	No limit	10 % if carrier allocated within 24,05 GHz to 24,25 GHz 1 % if carrier located within wideband 22,625 GHz to 24,625 GHz
AM degree (switch isolation)	No limit	-20 dB
Average spectral power density(e.i.r.p.) within B_{FHSS} (c.f. emission mask, w.o. blanking)	no limit	-30 dBm @100 kHz -80 dBm/Hz
Occupied Bandwidth (DSB_{-10dB}) including FM/PM	No limit	5 GHz

No further limits apply to the parameters defined as long as the resulting signal spectrum satisfies the requirements defined in the other clauses of the present document.

7.4.5 PN FH (Pseudonoise coded Frequency hopping) 24 GHz

7.4.5.1 Definition

For frequency hopping modulation a frequency carrier is stepped over a given frequency bandwidth B_{FHSS} within frequency slots that are interleaved by the slot interleave bandwidth Δf_i. The coding of the frequency step pattern can be realized with both randomly and predefined sequences at a given hopping frequency $f_{hop.}$ The granularity of the frequency slots determines the spectral distribution, which in case of a pseudonoise randomized sequence of frequency steps, results in a spectrum similar to white noise (PN-FHSS).

The continuous emission of FHSS can be further time gated with a given pulse width T_{pw}. (e.g. Interrupted FHSS (IFHSS)). If the pulse repetition frequency PRF is varied over time (staggered PRF), the frequency distribution of the IFHSS is further dithered over the frequency bandwidth B_{FHSS}.With a Staggered Pulse Position Modulated Frequency.

Hopping system (SPM FHSS) UWB spread spectrum characteristics can be independently tuned by either varying pulse modulation or frequency slot spreading individually.

For a PPM system the number of different hopping frequencies n_{slot} and the pulse width T_{pw} can vary from frame to frame according to the limits given in clause 7.4.5.3.

In the case of a pure Doppler measurement (n_{slot} = 1) the carrier frequency f_{c_norm} has to stay within the 24 GHz SRD band and power levels (20 dBm e.i.r.p.) according to CEPT/ERC Recommendation 70-03, annex 6. with a maximum duty cycle of 10 %.

The accumulated dwell time T_{dw} within a frequency slot depends on the pulse width T_{pw} and the hopping frequency f_{hop} in combination with the number of slots during a complete frame time T_{fr}.

Both pulse width T_{pw} and slot changing frequency f_{hop} can be changed within the frame time T_{fr} as long as the limits in clause 7.4.5.3 are fulfilled.

Between consecutive frames there may be a blanking period T_{blk} where no waveform or a constant waveform with the carrier frequency f_{c_norm} located in the 24 GHz SRD band (according to CEPT/ERC Recommendation 70-03, annex 6) is transmitted.

In a general sense the SPM FHSS can be seen as an extended PN PPMSS with intensive carrier frequency dithering applied. By individually tuning the frequency dithering (i.e. FH) and the pulse gating (i.e. SPM) of the frequency carrier similar spectral spreading of both FH and SPM can be achieved resulting in compact, 'Gabor-boxes' like time-frequency distributed frequency packets.

A typical PMFH modulation is shown in figure 12.

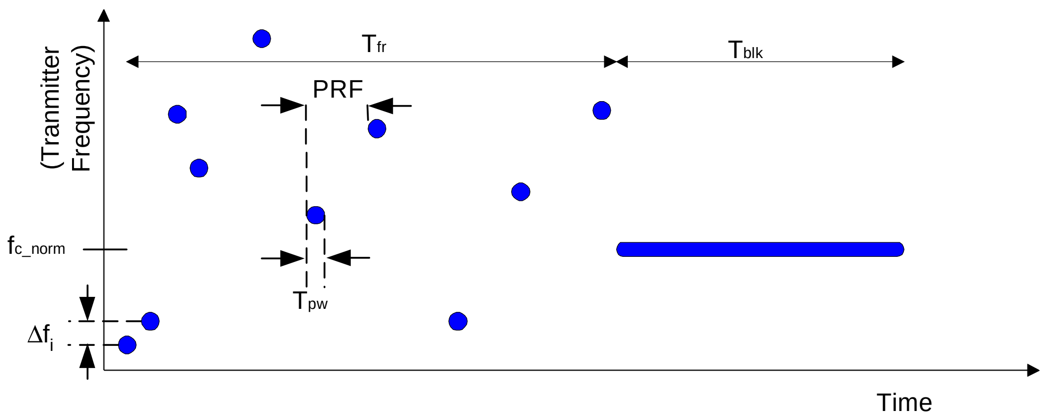


Figure 12: PMFH Modulation

7.4.5.2 Methods of measurement

Using the standard test fixture shown in figure 1 (clause 6.1.2), the test equipment shown in figure 12 is connected to the test fixture.

The measuring receiver may be a modulation domain analyser, spectrum analyser, oscilloscope, selective power meter or any measuring receiver which is appropriate to perform the intended measurement of the EUT.

The EUT shall be operated under normal and extreme conditions (clauses 5.3 and 5.4), and the resultant modulation waveforms monitored and recorded.

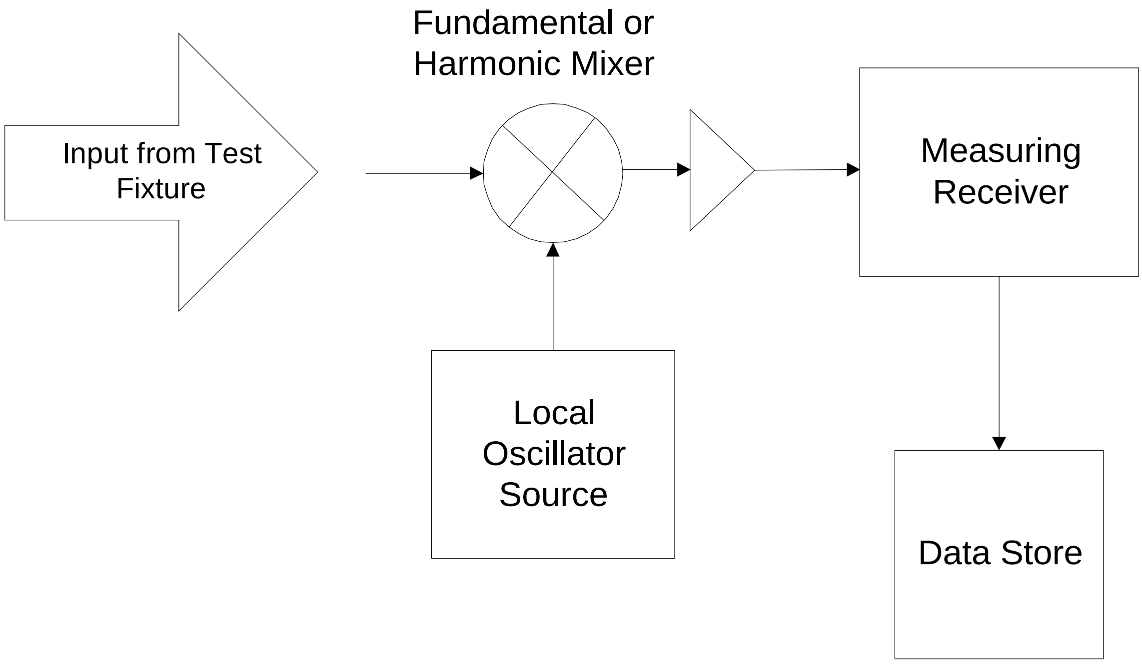


Figure 13: Test equipment for measuring the modulation waveform

7.4.5.3 Limits

The limits are shown in table 7.

Table 7: Limits for FHSS modulation

Parameter	Minimum	Maximum
Number of slots n_{slot} per frame	2^3 (within SRD band (CEPT/ERC Recommendation 70-03)) 2^6 (within B_{FHSS})	no limit
Dwell time per slot T_{dw}	no limit	10 µs
Hopping frequency f_{hop}	$1/T_{dw}$	no limit
Frame time periode T_{fr}	no limit	10 ms
Equivalent pulse power duration T_{pw}	400 ps	10 µs no limit, if carrier fixed within SRD band at 24,05 GHz to 24,25 GHz
Duty cycle for pulse train	no limit	10 %, if carrier allocated within 24,05 GHz to 24,25 GHz 1 %, if carrier allocated within wideband 22,625 GHz to 25,625 GHz
Blank Time periode T_{blk}	no limit	10 ms
Occupied Bandwidth B_{FHSS} ($DSB_{-10\ dB}$)	no limit	5 GHz
slot interleave bandwidth Δf_I	100 kHz	no limit
Average spectral power density (e.i.r.p.) within B_{FHSS} (c.f. emission mask without blanking)	no limit	30 dBm @100 kHz -80 dBm/Hz
Peak output power	No limit	20 dBm, 0 dBm without duty cycle limit
Average output power (e.i.r.p.) without blanking)	no limit	-0 dBm

7.4.6 PN-2-PSK (Pseudonoise binary coded phase shift keying) 24 GHz

7.4.6.1 Definition

With PN-2-PSK modulation, the transmitted continous wave radiation is modulated in phase by a pseudo noise code, i. e. the direct sequence signal (DSS), that represents the states of the base band signal of a BPSK modulation.

A generic binary DSS impulse c(t) and the corresponding transmitted signal s(t) are shown in figure 14. The binary DSS impulse c(t) and the transmitted signal s(t) can be expressed as:

$$c(t) = \sum_{i=0}^{L-1} C_i \cdot u(t - i \cdot T_c)\,;$$

$$s(t) = c(t) \cdot \sin(2 \cdot \pi \cdot f_T \cdot t)\,.$$

Where:

C_i defines the states {+1, -1} of the elementary signals (chips);

u(t) defines the rectangular signal: $u(t) = \begin{cases} 1 \text{ for } 0 \le t < T_c \\ 0 \text{ else} \end{cases}$;

f_T defines the carrier frequency;

T_c defines the duration of a chip (chip period);

L defines number of chips per PN-sequence.

The bandwidth (B) of the transmitted signal s(t) is defined by the bandwidth of the main lobe and corresponds to twice the inverse of the chip rate, from null to null:

$$B = 2 \times \frac{1}{T_c}$$

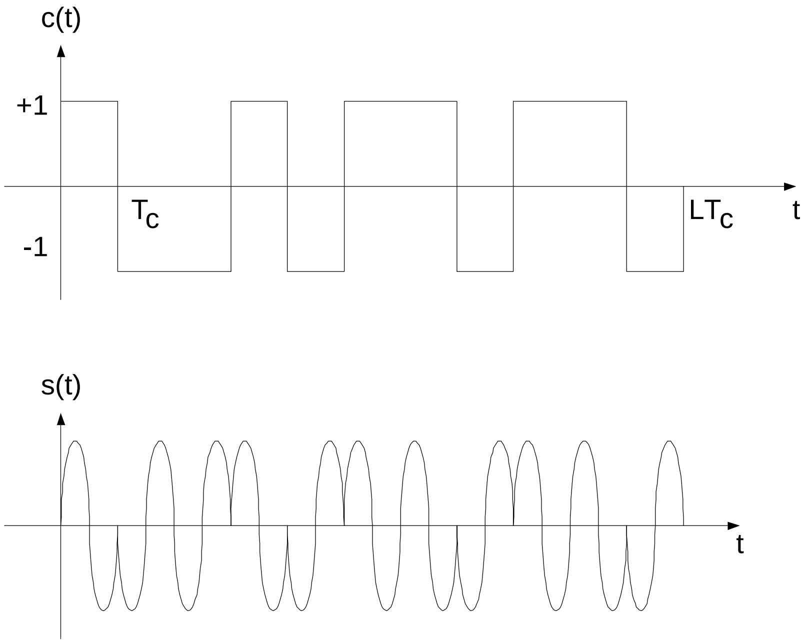


Figure 14: Typical binary direct sequence impulse c(t) and the transmitted PN-2-PSK signal s(t)

The PN-PSK can furthermore be time-gated or pulsed as described in the FHSS section.

7.4.6.2 Method of measurement

Using the standard test fixture shown in figure 1 (clause 6.1.2), the test equipment shown in figure 15 is attached to the test fixture.

The measuring receiver may be a modulation domain analyser, spectrum analyser, oscilloscope, selective power meter or any measuring receiver which is appropriate to perform the intended measurement of the EUT.

The EUT shall be operated under normal and extreme conditions (clauses 5.3 and 5.4), and the resultant modulation waveforms monitored and recorded.

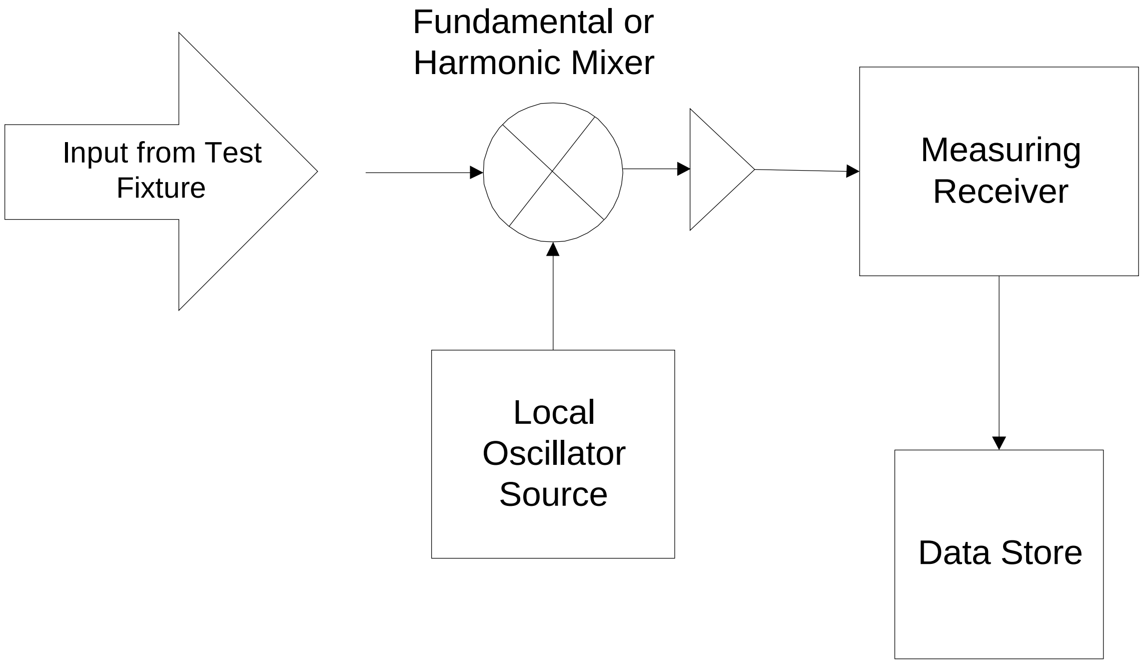


Figure 15: Test equipment for measuring the modulation waveform

7.4.6.3 Limits

The limits for PN-2-PSK Modulation are shown in table 8.

Table 8: Limits for PN-BPSK Modulation

Parameter	Minimum	Maximum
Chip period T_c	400 ps	no limit
PN-sequence period ($L \times T_c$)	No limit	10 µs
Occupied Bandwidth B (DSB_{-10dB})	No limit	5 GHz
Average output power w.o. blanking	No limit	0 dBm
Peak output power	No limit	20 dBm, 0 dBm without Duty cycle limit
Average spectral power density(e.i.r.p.) within B_{FHSS} (c.f. emission mask) without blanking	no limit	-30 dBm@100 kHz -80 dBm/Hz
Duty cycle	No limit	10 %, if carrier allocated within 24,05 GHz to 24,25 GHz 1 %, if carrier allocated within wide-band 22,625 GHz to 25,625 GHz

7.5 Radiated spurious emissions

7.5.1 Definition

For 77 GHz EUTs spurious emissions are emissions at frequencies other than those of the carrier and sidebands associated with normal modulation and include all emissions outside the 76 GHz to 77 GHz band. For 24 GHz EUTs the spurious emissions include all emissions outside the occupied bandwidth which is defined by $B_{-10\ dB}$. The level of spurious emissions shall be measured as their effective radiated power when radiated by the EUT, with the modulation on.

7.5.2 Measuring receiver

The term "measuring receiver" refers to either a selective voltmeter or spectrum analyser. The bandwidth of the measuring receiver shall, where possible, be according to CISPR 16-1 [5]. In order to obtain the required sensitivity a narrower bandwidth may be necessary, this shall be stated in the test report form.

The bandwidth of the measuring receiver shall be less than the maximum given in table 9.

Table 9: Maximum receiver bandwidths

Frequency being measured	Maximum measuring receiver bandwidth
f < 1 000 MHz	100 kHz to 120 kHz
f ≥ 1 000 MHz	1 MHz

7.5.3 Method of measurement for radiated spurious emission

A test site such as one selected from annex A, which fulfils the requirements of the specified frequency range of this measurement shall be used. The test method employed should be as described in annex B. The bandwidth of the measuring receiver shall be set to a suitable value to correctly measure the spurious emission. This bandwidth shall be recorded in the test report. For frequencies above 40 GHz a downconverter shall be used as shown in figure 10. The local oscillator used to downconvert the received signals shall be stable and with a phase noise of better than -80 dBc/Hz at 100 kHz offset. The local oscillator frequency shall be selected such that the downconverted signal is within the accepted band of the spectrum analyser, and maintaining an adequate Intermediate Frequency (IF) bandwidth to capture the full spectrum of the signal. The EIRP of the EUT shall be measured and recorded.

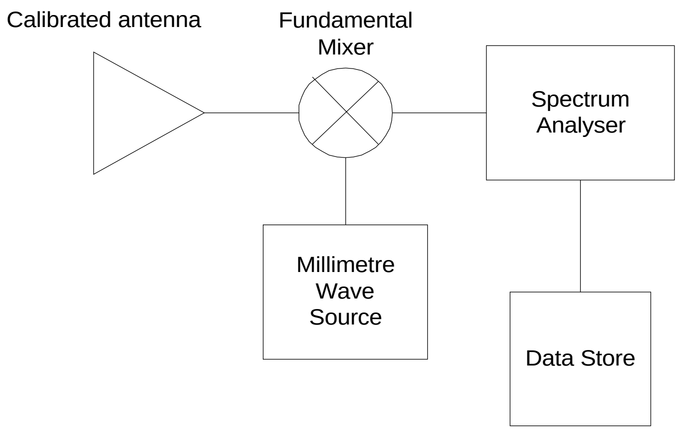


Figure 10: Test equipment for measuring spurious radiation above 40 GHz

7.5.4 Limits

The effective radiated power of any spurious emission shall not exceed the values given in table 10.

Table 10: Limits of radiated spurious emissions

Frequency range (MHz)	Limit values for spurious radiation
47 to 74	-54 dBm
87,5 to 118	-54 dBm
174 to 230	-54 dBm
470 to 862	-54 dBm
otherwise in band 30 to 1 000	-36 dBm
1 000 to 25 000	-30 dBm
25 000 to 40 000	-25 dBm
40 000 to 100 000	-20 dBm

The PSD limits for spurious emissions of 24 GHz EUTs , the applicable measurement bandwidth, and the frequency measurement range are according to EN 300 440 [10] (-30 dBm @1MHz, up to 48 GHz).

7.6 Unwanted emissions caused by the application of the modulation

7.6.1 Definition

The unwanted emissions caused by the application of the 77 GHz modulation are measured as the spectral power density contained in the sidebands associated with normal modulation, falling into frequency bands outside the 76 GHz to 77 GHz band.

The unwanted emissions caused by 24 GHz application of the modulation are measured as the spectral power density contained in the sidebands associated with normal modulation, falling into frequency bands outside the 21,625 GHz to 26,625 GHz band (compare with transmitter mask in clause 7.1.3, DSB 5 GHz, PSD -100 dBm/Hz) .

The level of the unwanted emissions shall be calculated as the effective radiated power density.

For line spectra the level of the unwanted emissions is regarded as the level of a single line.

The power density is defined for a line spectrum by:

- PL/df where PL = power of an individual spectral line;
- df = spectral distance between two lines with similar power levels.

The power density is defined for a continuous spectrum by:

- Pa/BW where Pa = mean power within the BW;
- RBW = resolution bandwidth.

7.6.2 Measuring receiver

The term "measuring receiver" refers to either a selective voltmeter or spectrum analyser. The bandwidth of the measuring receiver shall, where possible, be according to CISPR 16-1 [5]. In order to obtain the required sensitivity a narrower bandwidth may be necessary, this shall be stated in the test report form.

The bandwidth of the measuring receiver shall be less than the maximum given in table 11.

Table 11: Maximum receiver bandwidths

Frequency being measured	Maximum measuring receiver bandwidth
f < 1 000 MHz	100 kHz to 120 kHz
f ≥ 1 000 MHz	1 MHz

7.6.3 Method of measurement

A test site such as one selected from annex A, which fulfils the requirements of the specified frequency range of this measurement shall be used. The test method employed should be as described in annex B. The bandwidth of the measuring receiver shall be set to a suitable value to correctly measure the unwanted emission. This bandwidth shall be recorded in the test report. For frequencies above 40 GHz a downconverter shall be used as shown in figure 11. The local oscillator used to downconvert the received signals shall be stable and with a phase noise of better than -80 dBc/Hz at 100 kHz offset. The local oscillator frequency shall be selected such that the downconverted signal is within the accepted band of the spectrum analyser, and maintaining an adequate IF bandwidth to capture the full spectrum of the signal. The EIRP of the EUT shall be measured and recorded.

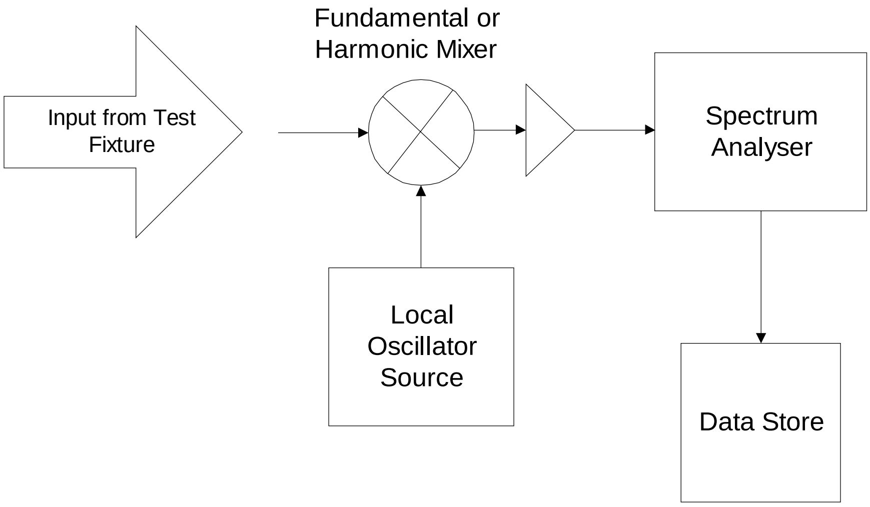


Figure 11: Test equipment for measuring out of band radiation

For 77 GHz EUTs the spectral power density of the signal with normal modulation shall be measured and recorded in frequency bands adjacent to the 76 GHz to 77 GHz band, up to the frequencies where the spectral density is 40 dB below its maximum value.

For 24 GHz EUTs the spectral power density of the signal with normal modulation shall be measured and recorded in frequency bands adjacent to the 21,625 GHz to 26,625 GHz band, up to the frequencies where the spectral density is 30 dB below its maximum value or drops below the sensivity level of the measurement equipment (-70 dBm at RBW = VBW = 100 kHz).

7.6.4 Limits

The mean power density radiated outside the 76 GHz to 77 GHz band shall not exceed the values shown in table 9.

Table 9: Limits for out of band radiation

Frequency	Maximum mean power density (dBm/Hz)
47 MHz to 74 MHz	-84
87,5 MHz to 118 MHz	-84
174 MHz to 230 MHz	-84
470 MHz to 862 MHz	-84
otherwise in the band 30 MHz to 1 000 MHz	-66
1 MHz to 25 GHz	-60
25 MHz to 76 GHz	-60
77 MHz to 100 GHz	-60

The mean spectral power density of unwanted emissions radiated outside the 21,625 GHz to 26,625 GHz band shall not exceed the value -100 dBm/Hz.

8 Measurement uncertainty

The accumulated measurement uncertainties of the test system in use, for the parameters to be measured, should not exceed those given in table 12 to ensure that the measurements remain within an acceptable standard.

Table 12: Absolute measurement uncertainty

Parameter	Uncertainty
Radio Frequency (out of band)	$\pm 1 \times 10^{-7}$
Radio Frequency (in band)	$\pm 1 \times 10^{-6}$
Out of band Radiated Emission (valid to 100 GHz)	± 6 dB
In-band Radiated Emission	± 3 dB
Temperature	± 1 K
Humidity	± 10 %

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

- the measured value related to the corresponding limit shall be used to decide whether an equipment meets the requirements of the present document:

  a) the value of the measurement uncertainty for the measurement of each parameter shall be separately included in the test report;

  b) the value of the measurement uncertainty shall be, for each measurement, equal to or lower than the figures in table 11.

For the test methods, according to the present document the uncertainty figures shall be calculated according to the methods described in the ETR 028 [7] 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 case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)).

Table 11 is based on such expansion factors.

The particular expansion factor used for the evaluation of the measurement uncertainty shall be stated.

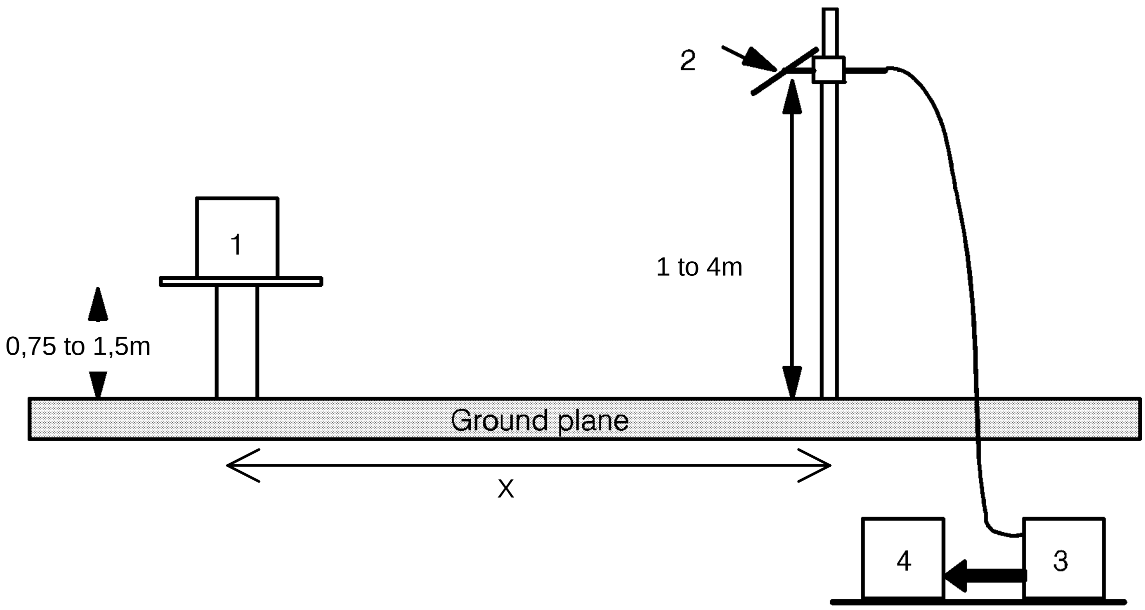
Annex A (normative): Radiated measurements

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

A.1.1 Open Area Test Site (OATS)

The OATS shall be on a reasonably level surface or ground. At one point on the site, an elliptical ground plane conforming to CISPR 16-1 [5] shall be provided. At one of the foci of this ground plane, a non-conducting support shall be located, capable of rotation in the horizontal and vertical planes, which is used to support the EUT in its standard position, between 0,75 m and 1,5 m above the ground plane. The test antenna shall be sited at the other focus. For measurements below 40 GHz, the test site shall be large enough to allow the erection of a measuring or transmitting antenna at a distance of λ /2 or 3 m whichever is greater. For measurements above 40 GHz an anechoic environment should be used, which should be large enough to allow the erection of a test antenna in the far field (i.e. at a distance of not less than $2d^2/\lambda$). The distance actually used shall be recorded with the results of the tests carried out on the site. The suitability of a test site shall be verified by the procedure recommended in CISPR 16-1 [5] and its amendments where applicable.

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



NOTE:
1 equipment under test
2 test antenna
3 high pass filter (may not be necessary)
4 spectrum analyser or measuring receiver

Figure A.1: Measuring arrangement

A.1.2 Test antenna

The test antenna is used to detect the radiation from the EUT, when the site is used for radiation measurements.

This antenna shall be 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 m to 4 m. A test antenna with pronounced directivity should be used. The size of the test antenna along the measurement axis shall not exceed 20 % of the measuring distance.

For radiation measurements, the test antenna shall be connected to a measuring receiver, capable of being tuned to any frequency under investigation and of measuring accurately the relative levels of signals at its input.

When measuring in the frequency range up to 1 GHz the test antenna shall be a $\lambda/2$ dipole, resonant at the operating frequency, or a shortened dipole, calibrated to the $\lambda/2$ dipole. When measuring in the frequency range above 4 GHz a horn radiator shall be used. For measurements between 1 and 4 GHz either a $\lambda/2$ dipole or a horn radiator may be used.

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

For far field measurements, distance "X" should be a minimum of $2d^2/\lambda$, where d = largest dimension of the antenna aperture of the EUT.

Calibrated test antennae shall be used in all measurements.

The distance between the lower extremity of the test antenna and the ground shall not be less than 0,3 m.

A.1.3 Standard position

The standard position in all test sites, shall be as follows:

- for equipment with integral antenna, it shall be placed in the position closest to normal use as declared by the manufacturer;
- the polarization of the test antenna and the equipment antenna shall be identical within the bandwidth of the equipment antenna; at other frequencies the test antenna shall be vertical.

A.1.4 Optional additional indoor site

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

Care should be taken as it may not be appropriate to conduct far field measurements above 40 GHz on such a test site.

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

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

The potential reflections from the wall behind the EUT shall be reduced by placing a barrier of absorbent material in front of it. The corner reflector around the test antenna shall be 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 the lower part of the frequency range (below approximately 175 MHz) no corner reflector or absorbent barrier is needed. For practical reasons, the $\lambda/2$ antenna in figure A.2 may be replaced by an antenna of constant length, provided that this length is between $\lambda/4$ and λ at the frequency of measurement and the sensitivity of the measuring system is sufficient. In the same way the distance of $\lambda/2$ to the apex may be varied.

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

A.2 Guidance on the use of radiation test sites

For general guidance on the use of radiation test sites refer to CISPR 16-1 [5].

For measurements involving the use of radiated fields, use may be made of a test site in conformity with the requirements of clause A.1. For measurements above 40 GHz care shall be taken to ensure that the selected test site is appropriate. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

A.2.1 Measuring distance

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

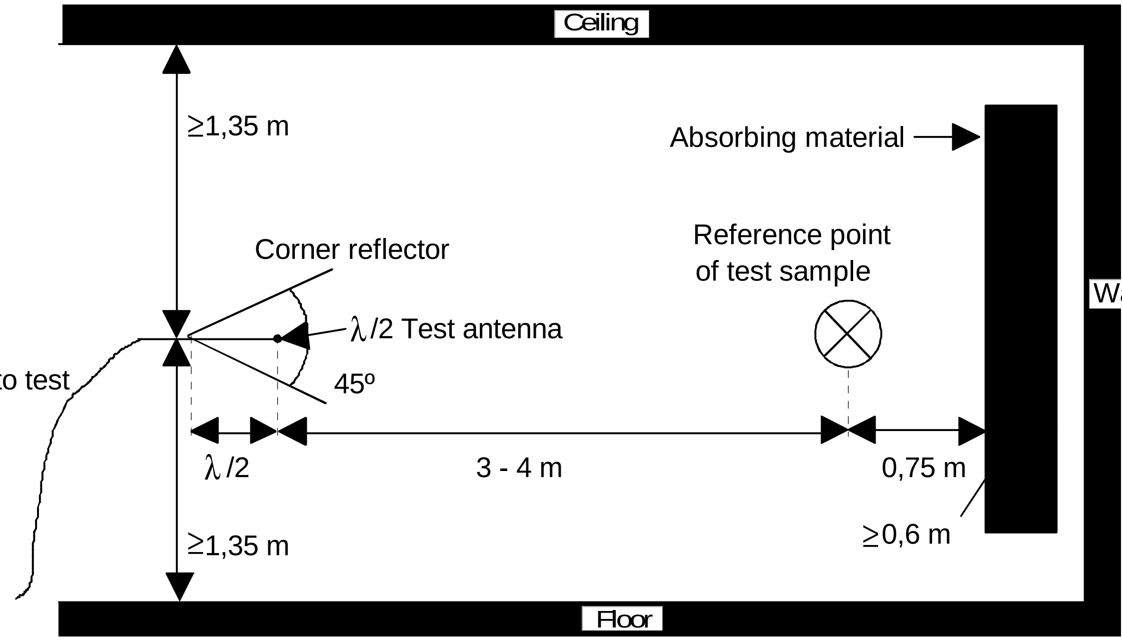


Figure A.2: Indoor site arrangement (shown for horizontal polarization)

A.2.2 Test antenna

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

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

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

A.2.3 Substitution antenna

The substitution antenna and signal generator is used to replace the EUT in substitution measurements. For measurements below 1 GHz the substitution antenna shall be half wavelength dipole resonant at the frequency under consideration, or a shortened dipole, calibrated to the half wavelength dipole. For measurements between 1 GHz 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 EUT 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 300 mm.

A.2.4 Auxiliary cables

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

A.3 Further optional alternative indoor test site using a fully anechoic RF chamber

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

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

An example of a typical measurement site may be an electrically shielded anechoic chamber being 10 m long, 5 m broad and 5 m high. Walls and ceiling should be coated with RF absorbers of 1 m height. The base should be covered with absorbing material 1 m thick, and a wooden floor, able to carry test equipment and operators. A measuring distance of 3 m to 5 m in the long middle axis of the chamber can be used for measurements up to 12,75 GHz. For frequencies above 12,75 GHz the chamber may be used provided it has been calibrated for use at the frequency being measured. The construction of the anechoic chamber is described in the following clauses.

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

Free-field measurements can be simulated in a shielded measuring chamber where the walls are coated with RF absorbers. Figure A.3 shows the requirements for shielding loss and wall return loss of such a room. As dimensions and characteristics of usual absorber materials are critical below 100 MHz (height of absorbers < 1 m, reflection attenuation < 20 dB) such a room is preferably suitable for measurements above 100 MHz. Figure A.4 shows the construction of a shielded measuring chamber having a base area of 5 m by 10 m and a height of 5 m.

Ceilings and walls are coated with pyramidal formed RF absorbers approximately 1 m high or equivalent material with the same performance. The base is covered with absorbers which form a non-conducting sub-floor, or with special ground floor absorbers. The available internal dimensions of the room are 3 m × 8 m × 3 m, so that a measuring distance of maximum 5 m length in the middle axis of this room is available.

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

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

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

A.3.2 Influence of parasitic reflections in anechoic chambers

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

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

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

With an anechoic chamber of the dimensions suggested in clause A.3 at low frequencies up to 100 MHz there are no far field conditions, and therefore reflections are stronger so that careful calibration is necessary. In the medium frequency range from 100 MHz to 1 GHz the dependence of the field strength on the distance meets the expectations very well. In the frequency range of 1 GHz to 100 GHz, because more rejections will occur, the dependence of the field strength on the distance will not correlate so closely.

A.3.3 Calibration of the shielded RF anechoic chamber

Calibration of the chamber shall be performed over the range 30 MHz to 100 GHz.

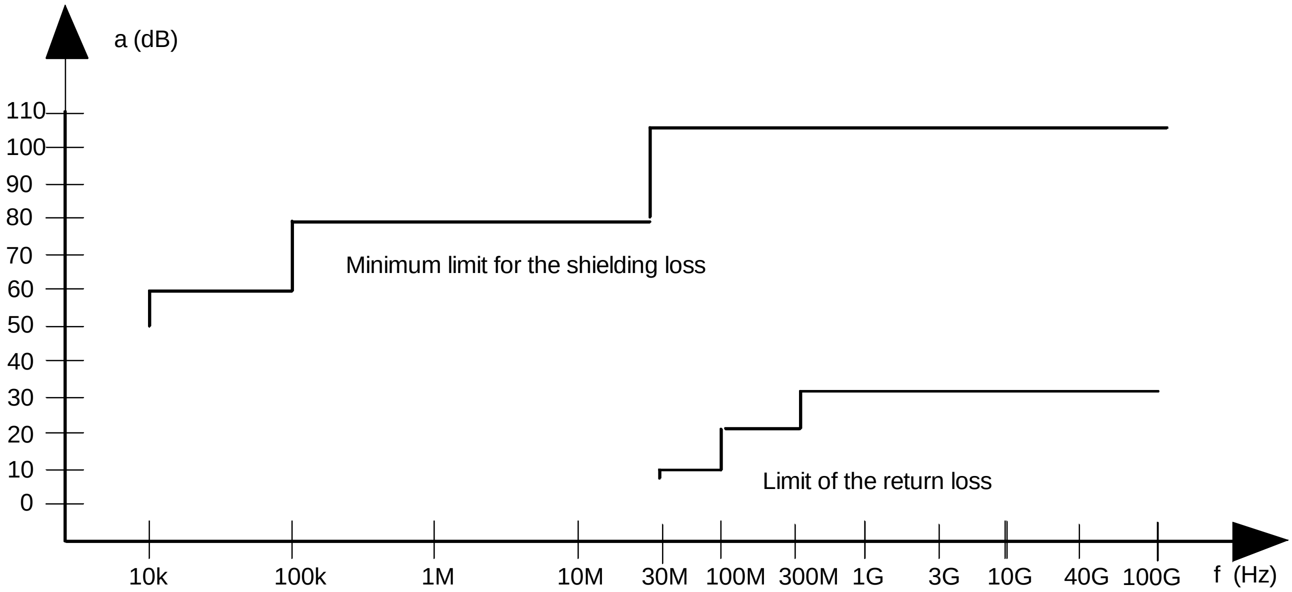


Figure A.3: Specification for shielding and reflections

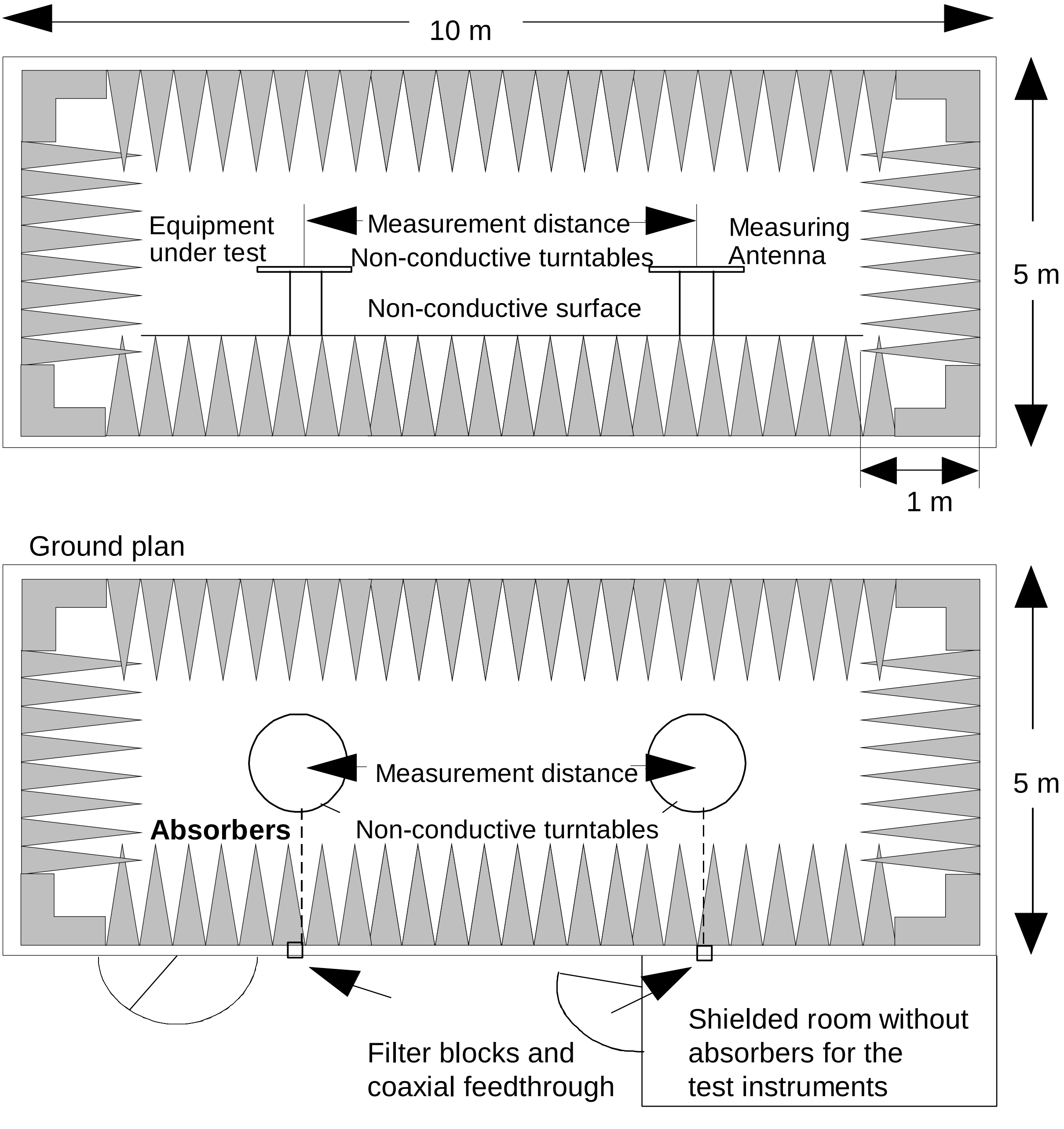


Figure A.4: Example of construction of an anechoic shielded chamber

Annex B (normative): General description of measurement methods

B.1 Radiated measurements

Radiated measurements shall be performed with the aid of a test antenna and measuring receiver as described in annex A. The test antenna and measurement receiver, spectrum analyser or selective voltmeter (including all cables) shall be calibrated according to the procedure defined in this annex. The EUT 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.

For equipment with multiple fixed beam antennas, the tests shall be carried out with the test antenna oriented to obtain the maximum emitted power level, and repeated for each beam position. If the equipment transmits more than one beam at a time, then the maximum EIRP shall be recorded.

If the equipment has an antenna which is either mechanically or electronically scanned, then the scanning shall be inhibited for these tests. With the scanning stopped, the EIRP for the EUT shall be measured with the antenna in its position of highest gain (i.e. highest output power) as stated by the manufacturer.

Measurements of absolute power levels below 40 GHz shall be carried out at a distance of $\lambda/2$ or 3m whichever is greater. For measurements of absolute power above 40 GHz an anechoic environment or test site is necessary which should be large enough to allow the erection of a test antenna in the far field (i.e. at a distance of not less than $2d^2/\lambda$).

Radiated measurements should be performed either with the EUT in the approved test fixture in an anechoic environment, or using the OATS as described in annex A.

The following conditions shall be fulfilled if an OATS is used for measurements;

a) an OATS which fulfils the requirements of the specified frequency range of this measurement (CISPR 16-1 [5]) shall be used;

b) the EUT shall be placed on the support in its standard position (clause A.1.3) and switched on;

c) the test antenna shall be oriented initially for vertical polarization unless otherwise stated. The test antenna shall be raised or lowered, through the specified height range until the maximum signal level is detected on the measuring receiver;

d) the EUT shall be capable of rotation through 360° about a vertical axis to maximize the received signal;

e) 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:

   (this maximum may be a lower value than the value obtainable at heights outside the specified limits);

f) this measurement shall be repeated for horizontal polarization;

g) the substitution (calibrated) antenna shall replace the EUT, in the same position and in vertical polarization. The frequency of the signal generator shall be adjusted to the Tx (carrier) frequency;

h) steps c) to f) shall be repeated as necessary;

i) the input signal to the substitution (calibrated) antenna shall be adjusted in level via a calibrated attenuator/signal generator until an equal or a known related level to that detected from the Tx is obtained in the test receiver;

j) this measurement shall be repeated with horizontal polarization;

k) the radiated power is equal to the power supplied by the signal generator, increased by the gain of the substitution antenna and the cable losses between the signal generator and the substitution antenna.

If an anechoic chamber is used as opposed to an OATS, the following change to this procedure applies:

- the test antenna shall be oriented initially for vertical polarization unless otherwise stated.

Annex C (informative): Maximum safe level of radiated power density

It is necessary for every EUT to comply with the current regulations regarding safe levels for radiated power. This is detailed in this annex.

C.1 Definition

The maximum safe level for the radiated power density is defined as that level which can be transmitted in accordance with the *current* recommended safety levels (see EN 50166-2 [8]).

C.2 Method of measurement

The EUT should be tested as per clause 7.2.2 (in accordance with the procedures outlined in clause 5 of EN 50166-2 [8]).

C.2.1 Equipment with a fixed beam antenna(s) (i.e. non-steerable by either mechanical or electronic means)

The polar diagram together with details of the polarization for the transmit beam (if required to enable the measurement to be carried out) should be submitted by the manufacturer and approved by the accredited test laboratory.

The maximum EIRP is then recorded.

C.2.2 Equipment with (electronically or mechanically) steerable antenna

It is necessary to engage a mode in the EUT whereby the antenna steering is disabled i.e. the unit operates with a fixed beam. This will enable the EUT to be fully tested as per clause 7.2.2.1.

With the scanning stopped, the EIRP for the EUT should be measured with the antenna in its position of highest gain (i.e. highest output power) as stated by the manufacturer.

The manufacturer should provide all necessary information relating to the scanning.

C.3 Limit

The maximum safe level for the mean radiated power density is defined in clause 4.2.2.1 of EN 50166-2 [8]. The maximum safe level for the peak radiated power density is defined in clause 4.2.2.2 of EN 50166-2 [8].

The power density should not exceed the value given in this clause at any point accessible without partial or complete disassembly of the device requiring the use of tools.

Annex D (informative): Conversion of power density to EIRP

This annex offers an example of the conversion from "power/unit area" (power density) to EIRP.

D.1 Assumptions

EIRP is conventionally the product of "power into the antenna" and "antenna gain".

EIRP is the total power transmitted, assuming an isotropic radiator.

Area of a sphere = πd^2.

D.2 Example

For a power density of 200 nW/cm^2 (measured at 3 m):

200 nW/cm^2 (at 3 m) = power measured in a 1 cm^2 area at 3 m distance.

EIRP = total radiated power over the whole area of a sphere

EIRP = [power measured in a 1cm^2 area at 3 m distance (W)] × [area of sphere at 3 m (in cm^2)]

area of 1 cm^2

EIRP = [(200 × 10^{-9}) × (π€×€36 × 10^4)] W

EIRP = 226,19 mW

Hence: 200 nW/cm^2 (at 3 m) ≡ 23,54 dBm

History

Document history		
V1.1.1	June 1998	Publication as EN 301 091
V1.2.1	July 2001	Public Enquiry PE 20011123: 2001-07-25 to 2001-11-23