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NORME INTERNATIONALE

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement

Appareils industriels, scientifiques et médicaux (ISM) à fréquence radioélectrique – Caractéristiques de perturbations électromagnétiques – Limites et méthodes de mesure

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

INDUSTRIAL, SCIENTIFIC AND MEDICAL (ISM) RADIO-FREQUENCY EQUIPMENT – ELECTROMAGNETIC DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT

FOREWORD

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International Standard CISPR 11 has been prepared by CISPR Subcommittee B: Interference relating to industrial, scientific and medical radio-frequency apparatus, to other (heavy) industrial equipment, to overhead power lines, to high voltage equipment and to electric traction.

It has the status of a Product Family EMC standard in accordance with IEC Guide 107.

This consolidated version of CISPR 11 consists of the fourth edition (2003) [documents CISPR/B/295/FDIS and CISPR/B/301/RVD] and its amendment 1 (2004) [documents CISPR/B/324/FDIS and CISPR/B/327/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 4.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The main content of this standard is based on CISPR Recommendation No. 39/2 given below:

RECOMMENDATION No. 39/2

Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

The CISPR

CONSIDERING

a) that ISM r.f. equipment is an important source of disturbance;

b) that methods of measuring such disturbances have been prescribed by the CISPR;

c) that certain frequencies are designated by the International Telecommunication Union (ITU) for unrestricted radiation from ISM equipment,

RECOMMENDS

that the latest edition of CISPR 11 be used for the application of limits and methods of measurement of ISM equipment.

INDUSTRIAL, SCIENTIFIC AND MEDICAL (ISM) RADIO-FREQUENCY EQUIPMENT – ELECTROMAGNETIC DISTURBANCE CHARACTERISTICS – LIMITS AND METHODS OF MEASUREMENT

1 General

1.1 Scope and object

The limits and methods of measurement laid down in this International Standard apply to industrial, scientific and medical (ISM) equipment as defined in Clause 2, and to electro-discharge machining (EDM) and arc welding equipment.

NOTE The limits have been determined on a probabilistic basis taking into account the likelihood of interference. In cases of interference, additional provisions may be required.

Procedures are given for the measurement of radio-frequency disturbances and limits are laid down within the frequency range 9 kHz to 400 GHz.

Requirements for ISM lighting apparatus and UV irradiators operating at frequencies within the ISM frequency bands defined by the ITU Radio Regulations are contained in this standard.

Requirements for other types of lighting apparatus are covered in CISPR 15.

1.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 15, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment*

CISPR 16-1:1999, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

CISPR 16-2:1996, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2: Methods of measurement of disturbances and immunity*

CISPR 19, *Guidance on the use of the substitution method for measurements of radiation from microwave ovens for frequencies above 1 GHz*

IEC 60050(161), *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60083, *Plugs and sockets outlets for domestic and similar general use standardized in member countries of IEC*

IEC 60705:1999, *Household microwave ovens – Methods for measuring performance*

IEC 60974-10, *Arc welding equipment – Part 10: Electromagnetic compatibility (EMC) requirements*

IEC 61689, *Ultrasonics – Physiotherapy systems – Performance requirements and methods of measurement in the frequency range 0,5 MHz to 5 MHz*

2 Definitions

For the purpose of this document, the definitions of IEC 60050(161) and the following definitions apply.

2.1
ISM equipment
ISM appliance
equipment or appliances designed to generate and/or use locally radio-frequency energy for industrial, scientific, medical, domestic or similar purposes, excluding applications in the field of telecommunications and information technology and other applications covered by other CISPR publications

2.2
electromagnetic radiation

1. The phenomenon by which energy in the form of electromagnetic waves emanates from a source into space.
2. Energy transferred through space in the form of electromagnetic waves.

NOTE By extension, the term "electromagnetic radiation" sometimes also covers induction phenomena.

[IEV 161-01-10: 1990]

2.3
boundary of the equipment under test
imaginary straight line periphery describing a simple geometric configuration encompassing the equipment under test. All interconnecting cables shall be included within this boundary

2.4
click
disturbance which exceeds the limit of continuous disturbance no longer than 200 ms and which is separated from a subsequent disturbance by at least 200 ms. Both intervals are related to the level of the limit of continuous disturbance.

A click may contain a number of impulses, in which case the relevant time is that from the beginning of the first to the end of the last impulse.

2.5
electro-discharge machining (EDM) equipment
all the necessary units for the spark erosion process including the machine tool, the generator, control circuits, the working fluid container and integral devices

2.6
spark erosion
removal of material in a dielectric working fluid by electro-discharges, which are separated in time and randomly distributed in space, between two electrically conductive electrodes (the tool electrode and the work piece electrode), and where the energy in the discharge is controlled

2.7
arc welding equipment
equipment for applying current and voltage and having the required characteristics suitable for arc welding and allied processes

2.8
arc welding
fusion welding in which the heat for welding is obtained from an electric arc or arcs

3 Frequencies designated for ISM use

Certain frequencies are designated by the International Telecommunication Union (ITU) for use as fundamental frequencies for ISM equipment. These frequencies are listed in Table 1.

NOTE In individual countries different or additional frequencies may be designated for use by ISM equipment.

Table 1 – Frequencies designated by ITU for use as fundamental ISM frequencies

Centre frequency MHz	**Frequency range** MHz	**Maximum radiation limit** [b]	**Number of appropriate footnote to the table of frequency allocation of the ITU Radio Regulations** [a]
6,780	6,765 – 6,795	Under consideration	S5.138
13,560	13,553 – 13,567	Unrestricted	S5.150
27,120	26,957 – 27,283	Unrestricted	S5.150
40,680	40,66 – 40,70	Unrestricted	S5.150
433,920	433,05 – 434,79	Under consideration	S5.138 in Region 1, except countries mentioned in S5.280
915,000	902 – 928	Unrestricted	S5.150 in Region 2 only
2 450	2 400 – 2 500	Unrestricted	S5.150
5 800	5 725 – 5 875	Unrestricted	S5.150
24 125	24 000 – 24 250	Unrestricted	S5.150
61 250	61 000 – 61 500	Under consideration	S5.138
122 500	122 000 – 123 000	Under consideration	S5.138
245 000	244 000 – 246 000	Under consideration	S5.138

[a] Resolution No. 63 of the ITU Radio Regulations applies.

[b] The term "unrestricted" applies to the fundamental and all other frequency components falling within the designated band.

4 Classification of ISM equipment

The manufacturer and/or supplier of ISM equipment shall ensure that the user is informed about the class and group of the equipment, either by labelling or by the accompanying documentation. In both cases the manufacturer/supplier shall explain the meaning of both the class and the group in the documentation accompanying the equipment.

NOTE See Annex A for examples of the classification of ISM equipment.

4.1 Separation into groups

Group 1 ISM equipment: group 1 contains all ISM equipment in which there is intentionally generated and/or used conductively coupled radio-frequency energy which is necessary for the internal functioning of the equipment itself.

Group 2 ISM equipment: group 2 contains all ISM equipment in which radio-frequency energy is intentionally generated and/or used in the form of electromagnetic radiation for the treatment of material, and EDM and arc welding equipment.

Excluded from the testing requirements and limits of this standard are components and subassemblies not intended to perform any stand-alone ISM function.

4.2 Division into classes

Class A equipment is equipment suitable for use in all establishments other than domestic and those directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class A equipment shall meet class A limits.

NOTE 1 Operation of equipment which does not meet the class A limits but does not result in unacceptable degradation of radio services may be sanctioned on a case-by-case basis by the competent national authority.

NOTE 2 Although class A limits have been derived for industrial and commercial establishments, administrations may allow, with whatever additional measures are necessary, the installation and use of class A ISM equipment in a domestic establishment or in an establishment connected directly to domestic electricity power supplies.

Class B equipment is equipment suitable for use in domestic establishments and in establishments directly connected to a low voltage power supply network which supplies buildings used for domestic purposes.

Class B equipment shall meet class B limits.

5 Limits of electromagnetic disturbances

Class A ISM equipment may be measured either on a test site or *in situ* as preferred by the manufacturer.

NOTE Due to size, complexity or operating conditions some ISM equipment may have to be measured *in situ* in order to show compliance with the radiation disturbance limits specified herein.

Class B ISM equipment shall be measured on a test site.

Limits are under consideration for:

– arc stud welding equipment and arc striking and stabilizing devices for arc welding;
– radiology equipment;
– radio-frequency surgical diathermy equipment.

The limits given in Tables 2 to 9 are applicable to all electromagnetic disturbances at all frequencies not exempted according to Table 1.

The lower limit shall apply at all transition frequencies.

For ISM lighting devices operating in the ISM frequency bands 2,45 GHz and 5,8 GHz (and 915 MHz for Region 2 as defined by the ITU Radio Regulations), the limits to be applied are those for class B, group 2 ISM equipment.

5.1 Limits of terminal disturbance voltage

The equipment under test shall meet either:

a) both the average limit specified for measurements with an average detector receiver and the quasi-peak limit specified for measurements with a quasi-peak detector (see 6.2); or

b) the average limit when using a quasi-peak detector receiver (see 6.2).

Limits for signal line disturbance voltage are under consideration.

5.1.1 Frequency band 9 kHz to 150 kHz

Limits for mains terminal disturbance voltages in the frequency band 9 kHz to 150 kHz are under consideration, except for induction cooking appliances.

For class A, group 2 ISM equipment *in situ,* no limits apply unless otherwise specified in this standard.

5.1.2 Frequency band 150 kHz to 30 MHz

5.1.2.1 Continuous disturbance

Limits for mains terminal disturbance voltages in the frequency band 150 kHz to 30 MHz for equipment measured on a test site using the 50 Ω/50 µH CISPR network or the CISPR voltage probe (see 6.2.3 and Figure 4) are given in Tables 2a and 2b, except for the ITU designated frequency bands listed in Table 1 for which the mains terminal disturbance voltage limits are under consideration.

For class A, group 2 ISM equipment *in situ*, no limits apply unless otherwise specified in this standard.

Table 2a – Mains terminal disturbance voltage limits for class A equipment measured on a test site

Frequency band MHz	Class A equipment limits dB(μV)					
	Group 1		Group 2		Group 2 [a]	
	Quasi-peak	Average	Quasi-peak	Average	Quasi-peak	Average
0,15 – 0,50	79	66	100	90	130	120
0,50 – 5	73	60	86	76	125	115
5 – 30	73	60	90 Decreasing linearly with logarithm of frequency to 70	80 60	115	105
NOTE Care should be taken to comply with leakage current requirements.						
a Mains supply currents in excess of 100 A per phase when using the CISPR voltage probe or a suitable V-network (LISN or AMN).						

For class A EDM and arc welding equipment measured on a test site, the mains terminal disturbance voltage limits of Table 2a apply.

Warning: Class A equipment is intended for use in an industrial environment. In the documentation for the user, a statement shall be included drawing attention to the fact that there may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

Table 2b – Mains terminal disturbance voltage limits for class B equipment measured on a test site

Class B equipment limits dB(μV)		
Frequency band	Groups 1 and 2	
MHz	Quasi-peak	Average
0,15 – 0,50	66 Decreasing linearly with logarithm of frequency to 56	56 Decreasing linearly with logarithm of frequency to 46
0,50 – 5	56	46
5 – 30	60	50
NOTE Care should be taken to comply with leakage current requirements.		

For class B arc welding equipment measured on a test site, the mains terminal disturbance voltage limits of Table 2b apply.

5.1.2.2 Induction cooking appliances for domestic or commercial use

For induction cooking appliances for domestic or for commercial use (group 2 class B equipment), the limits of Table 2c apply.

Table 2c – Mains terminal disturbance voltage for induction cooking appliances

Frequency range MHz	Induction cooking appliance limits dB(μV)	
	Quasi-peak	**Average**
0,009 to 0,050	110	–
0,050 to 0,1485	90 Decreasing linearly with logarithm of frequency to 80	
0,1485 to 0,50	66 Decreasing linearly with logarithm of frequency to 56	56 Decreasing linearly with logarithm of frequency to 46
0,50 to 5	56	46
5 to 30	60	50
NOTE The mains terminal disturbance voltage limits for a 100/110 V rated system are under consideration.		

5.1.2.3 Discontinuous disturbance

For diagnostic X-ray generators, operating in intermittent mode, the limit for clicks shall be the quasi-peak limit, as formulated in Table 2a or Table 2b for continuous disturbance, increased by 20 dB.

5.1.3 Frequency band above 30 MHz

No limits are specified for terminal disturbance voltage above 30 MHz.

5.2 Limits of electromagnetic radiation disturbance

Measuring apparatus and methods of measurement are specified in Clauses 6, 7 and 8. The equipment under test shall meet the limits when using a measuring instrument with a quasi-peak detector.

Below 30 MHz the limits refer to the magnetic component of the electromagnetic radiation disturbance. Between 30 MHz and 1 GHz the limits refer to the electric field strength component of the electromagnetic radiation disturbance. Above 1 GHz the limits refer to the power of the electromagnetic radiation disturbance.

5.2.1 Frequency band 9 kHz to 150 kHz

Limits for electromagnetic radiation disturbance in the frequency band 9 kHz to 150 kHz are under consideration, except for induction cooking appliances.

5.2.2 Frequency band 150 kHz to 1 GHz

Except for the designated frequency range listed in Table 1, the electromagnetic radiation disturbance limits for the frequency band 150 kHz to 1 GHz for group 1, classes A and B equipment are specified in Table 3; for group 2 class B equipment in Table 4; for group 2 class A equipment in Table 5a and for class A EDM and arc welding equipment in Table 5b. For induction cooking appliances falling within group 2 class, the limits are specified in Tables 3a and 3b. Special provisions for the protection of specific safety services are given in 5.3 and Table 9.

In certain circumstances (see 7.2.3), class A, group 2 equipment may be measured on a test site at distances between 10 m and 30 m, and class B, group 1 or 2 equipment at distances between 3 m and 10 m. In case of dispute class A, group 2 equipment shall be measured at a distance of 30 m; class B, group 1 or group 2 equipment (as well as class A, group 1 equipment) shall be measured at a distance of 10 m.

Table 3 – Electromagnetic radiation disturbance limits for group 1 equipment

Frequency band	**Measured on a test site**		**Measured *in situ***
	Group 1, class A 10 m measurement distance	**Group 1, class B 10 m measurement distance**	**Group 1, class A Limits with measuring distance 30 m from exterior wall outside the building in which the equipment is situated**
MHz	dB(μV/m)	dB(μV/m)	dB(μV/m)
0,15 – 30	Under consideration	Under consideration	Under consideration
30 – 230	40	30	30
230 – 1 000	47	37	37

NOTE For group 1, classes A and B equipment, intended to be permanently installed in X-ray shielded locations, an increase in the electromagnetic radiation disturbance limits of 12 dB for tests conducted on a test site is allowed.

Such equipment which does not meet the Table 3 limits is labelled as “Class A + 12” or “Class B + 12”. The installation instructions should contain the following warning:

“*Warning:* This equipment is allowed to be installed only in X-ray protected rooms, which provide an attenuation of at least 12 dB for radio disturbances from 30 MHz to 1 GHz.”

Table 3a – Limits of the magnetic field induced current in a 2 m loop antenna around the device under test

Frequency range MHz	**Limits in dB(µA)** **Quasi-peak**	
	Horizontal component	**Vertical component**
0,009 to 0,070	88	106
0,070 to 0,1485	88 Decreasing linearly with logarithm of frequency to 58	106 Decreasing linearly with logarithm of frequency to 76
0,1485 to 30	58 Decreasing linearly with logarithm of frequency to 22	76 Decreasing linearly with logarithm of frequency to 40
NOTE The limits of Table 3a apply to induction cooking appliances for domestic use which have a diagonal dimension of less than 1,6 m. Measurement is performed using the "Van Veen loop method" as described in 2.6.5 of CISPR 16-2.		

Table 3b – Limits of the magnetic field strength

Frequency range MHz	**Limits in dB(µA/m) at 3 m distance** **Quasi-peak**
0,009 to 0,070	69
0,070 to 0,1485	69 Decreasing linearly with logarithm of frequency to 39
0,1485 to 4,0	39 Decreasing linearly with logarithm of frequency to 3
4,0 to 30	3
NOTE The limits of Table 3b apply to induction cooking appliances for commercial use and those for domestic use with a diagonal diameter of more than 1,6 m. Measurements are performed at 3 m distance with a 0,6 m loop antenna as described in 5.5.2.1 of CISPR 16-1. The antenna shall be vertically installed, with the lower edge of the loop at 1 m height above the floor.	

Table 4 – Electromagnetic radiation disturbance limits for group 2, class B equipment measured on a test site

Frequency band	Electric field Measurement distance 10 m		Magnetic field Measurement distance 10 m Quasi-peak limits
	Quasi–peak limits	**Average limits** [a]	
MHz	dB(µV/m)	dB(µV/m)	dB(µA/m)
0,15 to 30	–	–	39 Decreasing linearly with logarithm of frequency to 3
30 to 80,872	30	25	–
80,872 to 81,848	50	45	–
81,848 to 134,786	30	25	–
134,786 to 136,414	50	45	–
136,414 to 230	30	25	–
230 to 1 000	37	32	–

[a] The average limits apply to magnetron driven equipment only. If magnetron driven equipment exceeds the quasi–peak limit at certain frequencies, then the measurement shall be repeated at these frequencies with the average detector and the average limits specified in this table apply.

Table 5a – Electromagnetic radiation disturbance limits for group 2, Class A equipment

Frequency band MHz	Limits with measuring distance *D* m	
	Distance *D* from exterior wall of the building dB(µV/m)	**On a test site *D* = 10 m from the equipment** dB(µV/m)
0,15 – 0,49	75	95
0,49 – 1,705	65	85
1,705 – 2,194	70	90
2,194 – 3,95	65	85
3,95 – 20	50	70
20 – 30	40	60
30 – 47	48	68
47 – 53,91	30	50
53,91 – 54,56	30(40)[a]	50(60)[a]
54,56 – 68	30	50
68 – 80,872	43	63
80,872 – 81,848	58	78
81,848 – 87	43	63
87 – 134,786	40	60
134,786 – 136,414	50	70
136,414 – 156	40	60
156 – 174	54	74
174 – 188,7	30	50
188,7 – 190,979	40	60
190,979 – 230	30	50
230 – 400	40	60
400 – 470	43	63
470 – 1 000	40	60

[a] The limits in the frequency band of 53,91 MHz to 54,56 MHz can be relaxed by 10 dB on a national basis.

For equipment measured *in situ*, the measuring distance *D* from the exterior wall of the building in which the equipment is situated equals (30 + *x/a*) m or 100 m whichever is smaller, provided that the measuring distance *D* is within the boundary of the premises. In the case where the calculated distance *D* is beyond the boundary of the premises, the measuring distance *D* equals *x* or 30 m, whichever is longer.

For the calculation of the above values:

x is the nearest distance between the outside wall of the building in which the equipment is situated and the boundary of the user's premises in each measuring direction;

a = 2,5 for frequencies lower than 1 MHz;

a = 4,5 for frequencies equal to or higher than 1 MHz.

For the protection of specific aeronautical services in particular areas, national authorities may require that specific limits be met at 30 m distance.

Table 5b – Electromagnetic radiation disturbance limits for class A EDM and arc welding equipment measured on a test site

Frequency band MHz	**Quasi-peak limits** **(at 10 m measurement distance)** dB(μV/m)
30 to 230	80 Decreasing linearly with logarithm of frequency to 60
230 to 1 000	60

Warning: Class A equipment is intended for use in an industrial environment. In the documentation for the user, a statement shall be included drawing attention to the fact that there may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

5.2.3 Frequency band 1 GHz to 18 GHz

Group 1 ISM equipment

Limits are under consideration.

NOTE Radiated disturbance limits for group 1 ISM equipment are intended to be identical to the limits currently under consideration for information technology equipment (ITE) above 1 GHz.

Group 2 ISM equipment

a) ISM equipment operating at frequencies below 400 MHz

Limits are under consideration.

NOTE When finalized, these limits will be introduced together with the following conditional testing Clause. If, in the band from 400 MHz to 1 GHz, all emissions are below the class B limits and the fifth harmonic of the highest internally generated source is lower than 1 GHz (i.e. highest source <200 MHz), no testing above 1 GHz is required.

b) ISM equipment operating at frequencies above 400 MHz

The electromagnetic radiation disturbance limits for the frequency range 1 GHz to 18 GHz are specified in Tables 6 to 8; the ISM equipment shall meet either the limits of Table 6 or the limits of both Table 7 and Table 8 (see decision tree, Figure 5).

Special provision for the protection of specific safety services are given in 5.3 and Table 9.

For microwave-powered UV irradiators, the limits specified in Table 6 apply.

Table 6 – Electromagnetic radiation disturbance peak limits for group 2, class A and class B ISM equipment producing CW type disturbances and operating at frequencies above 400 MHz

Frequency band	**Field strength at a measurement distance of 3 m** dB(μV/m)	
1 GHz to 18 GHz	class A	class B
Within harmonic frequency bands	82 [a]	70
Outside harmonic frequency bands	70	70
NOTE 1 For the protection of radio services, competent national authorities may require lower limits. NOTE 2 Peak measurements with a resolution bandwidth of 1 MHz and a video signal bandwidth higher than or equal to 1 MHz. NOTE 3 In this table, "harmonic frequency bands" means the frequency bands which are multiples of the ISM bands allocated above 1 GHz.		
[a] At the upper and lower edge frequency of harmonic frequency bands, the lower limit of 70 dB(μV/m) applies.		

Table 7 – Electromagnetic radiation disturbance peak limits for group 2, class B ISM equipment producing fluctuating disturbances other than CW and operating at frequencies above 400 MHz

Frequency band GHz	**Field strength at a measurement distance of 3 m** dB(µV/m)
1 – 2,3	92
2,3 – 2,4	110
2,5 – 5,725	92
5,875 – 11,7	92
11,7 – 12,7	73
12,7 – 18	92
NOTE 1 For the protection of radio services, competent national authorities may require lower limits. NOTE 2 Peak measurements with a resolution bandwidth of 1 MHz and a video signal bandwidth higher or equal to 1 MHz. NOTE 3 Limits in this table were derived considering fluctuating sources such as magnetron-driven microwave ovens.	

Table 8 – Electromagnetic radiation disturbance weighted limits for group 2, class B ISM equipment operating at frequencies above 400 MHz

Frequency band GHz	**Field strength at a measurement distance of 3 m** dB(µV/m)
1 – 2,4	60
2,5 – 5,725	60
5,875 – 18	60
NOTE 1 For the protection of radio services, competent national authorities may require lower limits. NOTE 2 Weighted measurements with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz. NOTE 3 To check the limits of this table, measurements need only be performed around two centre frequencies: the highest emission in the 1 005 MHz – 2 395 MHz band and the highest peak emission in the 2 505 MHz to 17 995 MHz band (outside the band 5 720 MHz – 5 880 MHz). At these two centre frequencies, measurements are performed with a span of 10 MHz on the spectrum analyser.	

5.2.4 Frequency band 18 GHz to 400 GHz

Limits for the frequency band 18 GHz to 400 GHz are under consideration.

5.3 Provisions for protection of safety services

ISM systems should be designed to avoid fundamental operations or radiation of high-level spurious and harmonic signals in bands used for safety-related radio services. A list of these bands is provided in Annex E.

For the protection of specific services, in particular areas, national authorities may require measurements to be made *in situ* and require the limits specified in Table 9 to be met in the frequency band listed.

Table 9 – Limits for electromagnetic radiation disturbances to protect specific safety services in particular areas

Frequency band MHz	**Limits** dB(µV/m)	**Measuring distance from exterior wall outside the building in which the equipment is situated** m
0,2835 – 0,5265	65	30
74,6 – 75,4	30	10
108 – 137	30	10
242,95 – 243,05	37	10
328,6 – 335,4	37	10
960 – 1 215	37	10
NOTE Many aeronautical communications require the limitation of vertically radiated electromagnetic disturbances. Work is continuing to determine what provisions may be necessary to provide protection for such systems.		

5.4 Provisions for protection of specific sensitive radio services

For the protection of specific sensitive services, in particular areas, national authorities may request additional suppression measures or designated separation zones for cases where harmful interference may occur. It is, therefore recommended to avoid fundamental operations or the radiation of high level harmonic signals in the bands. Some examples of these bands are listed for information in Annex F.

6 General measurement requirements

Class A equipment may be measured either on a test site or *in situ* as determined by the manufacturer. Class B ISM equipment shall be measured on a test site.

Specific requirements for making measurements on a test site are given in Clauses 7 and 8, for making measurements *in situ* in Clause 9.

The requirements of the present clause are to be met for both test site and/or *in situ* measurements.

6.1 Ambient noise

A test site for type testing shall allow emissions from the equipment under test to be distinguished from ambient noise. The suitability in this respect can be determined by measuring the ambient noise levels with the equipment under test inoperative and ensuring that the ambient noise levels are at least 6 dB below the limits specified in 5.1, 5.2 or 5.3, as appropriate for the measurement being carried out.

It is not necessary to reduce the ambient noise level to 6 dB below the specified limit where the combination of the ambient noise plus the emission from the equipment under test does not exceed the specified limit. Under these conditions the equipment under test is considered to satisfy the specified limit.

When carrying out measurements on mains terminal disturbance voltage, local radio transmissions may increase the ambient noise level at some frequencies. A suitable r.f. filter may be inserted between the artificial mains network and the mains supply, or measurements may be performed in a shielded enclosure. The components forming the r.f. filter should be enclosed in a metallic screen directly connected to the reference earth of the measuring system. The requirements for the impedance of the artificial mains network shall be satisfied at the frequency of measurement when the r.f. filter is connected.

If, when measuring the electromagnetic radiation disturbance, the 6 dB ambient noise conditions cannot be met, then the antenna may be located at a distance closer to the equipment under test than specified in Clause 5 (see 7.2.3).

6.2 Measuring equipment

6.2.1 Measuring instruments

Receivers with quasi-peak detectors shall be in accordance with CISPR 16-1. Receivers with average detectors shall be in accordance with CISPR 16-1.

NOTE Both detectors may be incorporated in a single receiver and measurements carried out by alternately using the quasi-peak detector and the average detector.

The measuring receiver used shall be operated in such a way that a variation in frequency of the disturbance being measured does not affect the results.

NOTE Measuring instruments having other detector characteristics may be used provided the measurement of the disturbance values can be proved to be the same. Attention is drawn to the convenience of using a panoramic receiver or a spectrum analyzer, particularly if the working frequency of the equipment under test changes appreciably during the work cycle.

To avoid the possibility of the measuring instrument incorrectly indicating non-compliance with the limits, the measuring receiver shall not be tuned closer to the edge of one of the bands designated for ISM use than the frequency at which its 6 dB bandwidth point aligns with the edge of the designated band.

NOTE Care should be taken to ensure that screening and the spurious response rejection characteristics of the measuring receiver are adequate when making measurements on high power equipment.

For measurements at frequencies above 1 GHz, a spectrum analyser with characteristics as defined in CISPR 16-1 shall be used.

NOTE Precautions which should be taken in the use of a spectrum analyzer are given in Annex B.

6.2.2 Artificial mains network

Measurement of the mains terminal disturbance voltage shall be made using an artificial mains network consisting of 50 Ω/50 μH V-network as specified in CISPR 16-1.

The artificial network is required to provide a defined impedance at r.f. across the mains supply at the point of measurement and also to provide for isolation of the equipment under test from ambient noise on the power lines.

6.2.3 Voltage probe

The voltage probe shown in Figure 4 shall be used when the artificial mains network cannot be used. The probe is connected sequentially between each line and the reference earth chosen (metal plate, metal tube). The probe consists mainly of a blocking capacitor and a resistor such that the total resistance between the line and earth is at least 1 500 Ω. The effect on the accuracy of measurement of the capacitor or any other device which may be used to protect the measuring receiver against dangerous currents shall be either less than 1 dB or allowed for in calibration.

6.2.4 Antennas

In the frequency range below 30 MHz the antenna shall be a loop as specified in CISPR 16-1. The antenna shall be supported in the vertical plane and be rotatable about a vertical axis. The lowest point of the loop shall be 1 m above ground level.

In the frequency range from 30 MHz to 1 GHz the antenna used shall be as specified in CISPR 16-1. Measurements shall be made for both horizontal and vertical polarization. The nearest point of the antenna to the ground shall be not less than 0,2 m.

For measurements on a test site the centre of the antenna shall be varied between 1 m and 4 m height for maximum indication at each test frequency.

For measurements *in situ* the centre of the antenna shall be fixed at 2,0 m ± 0,2 m height above the ground.

NOTE Other antennas may be used provided the results can be shown to be within ±2 dB of the results which would have been obtained using a balanced dipole antenna.

For measurements at frequencies above 1 GHz, the antenna used shall be as specified in CISPR 16-1.

6.2.5 Artificial hand

In order to simulate the influence of the user's hand, application of the artificial hand is required for hand-held equipment during the mains disturbance voltage measurement.

The artificial hand consists of metal foil which is connected to one terminal (terminal M) of an RC element consisting of a capacitor of 220 pF ± 20 % in series with a resistance of 510 Ω ± 10 % (see Figure 6); the other terminal of the RC element shall be connected to the reference ground of the measuring system (see CISPR 16-1). The RC element of the artificial hand may be incorporated in the housing of the artificial mains network.

6.3 Frequency measurement

For equipment which is intended to operate with a fundamental frequency in one of the designated bands listed in Table 1, the frequency shall be checked with measuring equipment having an inherent error of measurement not greater than 1/10 of the permissible tolerance for the midband frequency of the designated band. The frequency shall be measured over all the load range from the lowest power normally used up to the maximum.

6.4 Configuration of equipment under test

Consistent with typical applications of the equipment under test, the level of the disturbance shall be maximized by varying the configuration of the equipment.

NOTE The extent to which this subclause is applicable to the measurement of an installation *in situ* will depend on the flexibility inherent in each particular installation. The provisions of this subclause apply to *in situ* measurements in so far as a particular installation allows for the position of cables to be varied and different units within the installation to be operated independently, the extent to which the position of the installation can be moved within the premises, etc.

The configuration of the equipment under test shall be precisely noted in the test report.

6.4.1 Interconnecting cables

This subclause applies to equipment in which there are interconnecting cables between various parts of the equipment, or systems where a number of equipments are interconnected.

NOTE The observation of all provisions in this subclause permits the application of the results of an evaluation to a number of system configurations using the same types of equipment and cables as tested, but no other, each system configuration being in effect a subsystem of the one evaluated.

Interconnecting cables shall be of the type and length specified in the individual equipment requirements. If the length can be varied, the length shall be selected to produce maximum emission when performing field strength measurements.

If shielded or special cables are used during the tests then the use of such cables shall be specified in the instruction manual.

The connection of signal leads, except for the leads supplied by the manufacturer, is not required during RF emission test for portable test and measurement apparatus, group 1, or those intended for use in laboratories and operated by competent persons. Examples are signal generators, network and logic analysers and spectrum analysers.

When performing terminal voltage measurements excess length of cables shall be bundled at the approximate centre of the cable with bundles of 30 cm to 40 cm in length. If it is impracticable to do so the disposition of the excess cable shall be noted precisely in the test report.

Where there are multiple interface ports all of the same type, connecting a cable to just one of that type of port is sufficient provided that it can be shown that the additional cables would not significantly affect the results.

Any set of results shall be accompanied by a complete description of the cable and equipment orientation so that results can be repeated. If there are conditions of use, those conditions shall be specified, documented and included in the instructions for use.

If an equipment can perform separately any one of a number of functions then the equipment shall be tested while performing each of these functions. For systems which may include a number of different equipments, one of each type of equipment which is included in the system configuration shall be included in the evaluation.

A system which contains a number of identical equipments, but has been evaluated using only one of those equipments, does not require further evaluation if the initial evaluation was satisfactory.

NOTE This is permissible because it has been found that in practice emissions from identical modules are not additive.

When equipment is being evaluated which interacts with other equipment to form a system then the evaluation may be carried out using either additional equipment to represent the total system or with the use of simulators. In either method care shall be taken to ensure that the equipment under test is evaluated with the effects of the rest of the system or simulators satisfying the ambient noise conditions specified in 6.1. Any simulator used in lieu of actual equipment shall properly represent the electrical and in some cases the mechanical characteristics of the interface, especially with respect to r.f. signals and impedances, as well as cable configuration and types.

NOTE This procedure is required to permit the evaluation of equipment which will be combined with other equipment from different manufacturers to form a system.

6.4.2 Connection to the electricity supply network on a test site

When performing measurements on a test site, the V-network specified in 6.2.2 is to be used whenever possible. The V-network shall be located so that its closest surface is no less than 0,8 m from the nearest boundary of the equipment under test.

Where a flexible mains cord is provided by the manufacturer this shall be 1 m long or, if in excess of 1 m, the excess cable shall be folded to and forth to form a bundle not exceeding 0,4 m in length.

Mains power at the nominal voltage shall be supplied.

Where a mains cable is specified in the manufacturer's installation instructions a 1 m length of the type specified shall be connected between the test unit and the V-network.

Earth connections, where required for safety purposes, shall be connected to the reference “earth” point of the V-network and where not otherwise provided or specified by the manufacturer shall be 1 m long and run parallel to the mains connection at a distance of not more than 0,1 m.

Other earth connections (e.g. for EMC purposes) either specified or supplied by the manufacturer for connection to the same terminal as the safety earth connection shall also be connected to the reference earth of the V-network.

Where the equipment under test is a system comprising more than one unit, each unit having its own power cord, the point of connection for the V-network is determined from the following rules:

a) each mains cable which is terminated in a mains supply plug of a standard design (e.g., IEC 60083) shall be tested separately;
b) mains cables or terminals which are not specified by the manufacturer to be connected to another unit in the system for the purposes of supplying mains power shall be tested separately;

c) mains cables or terminals which are specified by the manufacturer to be connected to another unit in the system for the purposes of supplying mains power shall be connected to that unit, and the mains cables or terminals of that unit are connected to the V-network;

d) where a special connection is specified, the necessary hardware to effect the connection shall be used during the evaluation of the equipment under test.

6.5 Load conditions of equipment under test

Load conditions of the equipment under test are specified in this subclause. Equipment not covered by this subclause are to be operated so as to maximize the interference generated while still conforming with normal operating procedures as provided in the operating manual of the equipment.

6.5.1 Medical equipment

6.5.1.1 Therapeutic equipment using frequencies from 0,15 MHz to 300 MHz

All measurements shall be made under operating conditions as provided for in the operating manual of the equipment. The output circuit to be used to load the equipment depends on the nature of the electrodes with which it is to be used.

For equipment of the capacitive type, a dummy load shall be used for the measurements. The general arrangement is shown in Figure 3. The dummy load shall be substantially resistive and capable of absorbing the rated maximum output power of the equipment.

The two terminals of the dummy load shall be at opposite ends of the load and each terminal shall be joined directly to a circular flat metal plate having a diameter of 170 mm ± 10 mm. Measurements shall be made with each of the output cables and capacitive electrodes supplied with the equipment. The capacitive electrodes are to be disposed parallel to the circular metal plates at the ends of the dummy load, the spacing between them being adjusted to produce the appropriate power dissipation in the dummy load.

Measurements shall be made with the dummy load both horizontal and vertical (see Figure 3). In each case, the equipment, together with the output cables, capacitive electrodes and dummy load, shall be rotated around its vertical axis during measurements of electromagnetic radiation disturbance in order that the maximum value can be measured.

NOTE The following arrangement of lamps has been found suitable for testing many types of equipment in the power range tested:

a) nominal output power 100 W to 300 W:
four lamps 110 V/60 W in parallel, or five lamps 125 V/60 W in parallel;

b) nominal output power 300 W to 500 W:
four lamps 125 V/100 W in parallel, or five lamps 150 V/100 W in parallel.

For equipment of the inductive type, measurements shall be made using the cables and coils supplied with the equipment for the treatment of the patient. The test load shall consist of a vertical tubular container of insulating material, having a diameter of 10 cm, filled to a height of 50 cm with a solution consisting of 9 g of sodium chloride to 1 litre of distilled water.

The container shall be placed within the coil with the axis of the container coincident with the axis of the coil. The centres of the coil and the liquid load shall also coincide.

Measurements shall be made at both maximum and half-maximum power and, where the output circuit can be tuned, it shall be tuned to resonance with the fundamental frequency of the apparatus.

All measurements shall be made under all operating conditions as provided in the operating manual of the equipment.

6.5.1.2 UHF and microwave therapeutic equipment using frequencies above 300 MHz

Measurements shall be made initially with the output circuit of the equipment connected to a load resistor having the same value as the characteristic impedance of the cable used to supply the equipment load.

Secondly, having regard to the specifications in the operating manual of the equipment, measurements shall be made with each of the applicators supplied with the equipment in each possible position and direction and with no absorbing medium.

The highest of the levels measured using the two arrangements shall be used to determine compliance with the limits.

NOTE 1 Where necessary, the maximum power output of the equipment should be measured with the first arrangement. In order to determine the matching of the terminating resistor to the output-circuit of the equipment, the standing wave ratio should be measured on the line between the generator and the terminating resistor. The V.S.W.R. should not exceed the value of 1,5.

NOTE 2 Methods of loading other medical equipment are under consideration.

6.5.1.3 Ultrasonic therapy equipment

Measurements shall be made with the transducer connected to the generator. The transducer shall be dipped in a non-metallic container having a diameter of about 10 cm and filled with distilled water.

Measurement shall be made at both maximum and half-maximum power and, where the output circuit can be tuned, it shall be tuned to resonance and then detuned. The specifications in the operating manual of the equipment are to be considered.

NOTE The measurement of the maximum output of the equipment should be made, where necessary, in accordance with the method published in IEC 61689 or using a derived arrangement.

6.5.2 Industrial equipment

The load used when industrial equipment is tested may be either the load used in service or an equivalent device.

Where means for connecting auxiliary services such as water, gas, air, etc. are provided, connection of these services to the equipment under test shall be made by insulating tubing not less than 3 m long. When testing with the load used in service, the electrodes and cables shall be disposed in the manner of their normal use. Measurements shall be made at both maximum output power and at half-maximum output power. Equipment which will normally operate at zero or very low output power shall also be tested in these conditions.

NOTE A circulating water load has been found suitable for many types of dielectric heating equipment.

6.5.3 Scientific, laboratory and measuring equipment

Scientific equipment shall be tested under normal operating conditions.

6.5.4 Microwave cooking appliances

Microwave cooking appliances shall conform to the limits of radiation in Clause 5, when tested with all normal components such as shelves in place, and with a load of 1 l of tap water initially at 20 °C ± 5 °C placed at the centre of the load-carrying surface provided by the manufacturer. The water container shall be made of electrically non-conductive material such as glass or plastic (for example, the container defined in Clause 8 of IEC 60705 may be used).

For peak measurements above 1 GHz (Table 6 or Table 7), measurements shall be made with the azimuth of the EUT varying every 30° (starting position perpendicular to the front door). At each of these 12 positions, a maximum hold shall be made for a period of 20 s. Then, at the position where the maximum occurred, a maximum hold for a period of 2 min shall be made, and the result compared to the relevant limit (see Table 6 or Table 7).

Weighted measurements above 1 GHz (see Table 8) shall be performed at the position where the maximum occurred during the peak measurements and shall be the result of a maximum hold during at least five sweeps.

In all cases, the starting phase of the oven (a few seconds) is to be ignored.

6.5.5 Other equipment in the frequency band 1 GHz to 18 GHz

Other equipment shall conform to the limits of radiation in Clause 5 when tested with a dummy load consisting of a quantity of tap water in a non-conductive container. The size and shape of the container, its position in the equipment and the quantity of water contained therein shall be varied as required to produce maximum power transfer, frequency variation or harmonic radiation depending on the characteristics under examination.

6.5.6 Single and multiple-zone induction cooking appliances

Each cooking zone is operated with an enamelled steel vessel filled with tap water up to 80 % of its maximum capacity.

The position of the vessel shall match the hob marking on the plate.

Cooking zones shall be operated separately in sequence.

Energy controller settings shall be selected to give the maximum input power.

The vessel bottom shall be concave and shall not deviate from flatness by more than 0,6 % of its diameter at the ambient temperature 20 °C ± 5 °C.

The smallest usable standard vessel shall be placed in the centre of each cooking zone. For the dimension of the vessels, the manufacturer’s instructions take precedence.

Standard cooking vessels (dimension of the contact surface) are:

110 mm

145 mm

180 mm

210 mm

300 mm

Material of the vessel: the induction cooking method has been developed for ferromagnetic utensils. For this reason, measurements shall be made with enamelled steel vessels.

NOTE Some vessels on the market are manufactured from alloys with a ferromagnetic portion. However, these utensils might influence the sensing circuit for vessel displacement.

6.5.7 Arc welding equipment

During the test, the arc welding operation is simulated by loading the equipment with a conventional load. Load conditions and test configuration for arc welding equipment are specified in IEC 60974-10.

7 Special provisions for test site measurements (9 kHz to 1 GHz)

A ground plane shall be used when making measurements on a test site. The relationship of the equipment under test to the ground plane shall be equivalent to that occurring in use, i.e., floor-standing equipment resting on the ground plane or isolated from it by a thin insulating covering, portable and other non-floor-standing equipment placed on a non-metallic table 0,8 m above the ground plane.

A ground plane shall be used for radiation measurement and the measurement of terminal disturbance voltage. The requirements for the radiation test site are given in 7.2 and, for the ground plane for the measurement of terminal disturbance voltage, in 7.1.

NOTE For the larger commercial microwave ovens it is necessary to ensure that the measurement results are not affected by near field effects. CISPR 19 should be consulted for guidance.

7.1 Measurement of mains terminal disturbance voltage

The measurement of the mains terminal disturbance voltage may be carried out:

a) on the radiation test site with the equipment under test having the same configuration as used during the radiation measurement;
b) above a metal ground plane which shall extend at least 0,5 m beyond the boundary of the equipment under test and have a minimum size of 2 m $\times$ 2 m; or
c) within a screened room. Either the floor or one wall of the screened room shall act as the ground plane.

Option a) shall be used where the test site contains a metal ground plane. In options b) and c) the test unit, if non-floor-standing, shall be placed 0,4 m from the ground plane. Floor-standing test units shall be placed on the ground plane, the point(s) of contact being insulated from the ground plane but otherwise consistent with normal use. All test units shall be at least 0,8 m from any other metal surface.

The ground plane shall be connected to the reference earth terminal of the V-network with a conductor as short as possible.

The power and signal cables shall be oriented in relation to the ground plane in a manner equivalent to actual use and precautions taken with the layout of the cables to ensure that spurious effects do not occur.

When the equipment under test is fitted with a special earthing terminal, this shall be connected to earth with a lead as short as possible. When no earthing terminal is fitted, the equipment shall be tested as normally connected, i.e. any earthing being obtained through the mains supply.

7.1.1 Handheld equipment which are normally operated without an earth connection

For this equipment additional measurement shall be made using the artificial hand described in 6.2.5.

The artificial hand shall be applied only on handles and grips and those parts of the appliance specified as such by the manufacturer. Failing the manufacturer's specification the artificial hand shall be applied in the following way.

The general principle in applying the artificial hand is that the metal foil shall be wrapped around all handles (one artificial hand per handle), both fixed and detachable, supplied with the equipment.

Metalwork which is covered with paint or lacquer is considered as exposed metalwork and shall be directly connected to the terminal M of the RC element.

When the casing of the equipment is entirely of metal, no metal foil is needed, but the terminal M of the RC element shall be connected directly to the body of the equipment.

When the casing of the equipment is of insulating material, a metal foil shall be wrapped around the handles.

When the casing of the equipment is partly metal and partly insulating materials, and has insulating handles, a metal foil shall be wrapped around the handles.

7.2 Radiation test site for 9 kHz to 1 GHz

The radiation test site for ISM equipment shall be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit adequate separation between antenna, test unit and reflecting structures.

A radiation test site which meets the criteria is within the perimeter of an ellipse having a major axis equal to twice the distance between the foci and a minor axis equal to the square root of three times of this distance. The equipment under test and the measuring equipment are placed at each of the foci respectively. The path length of any ray reflected from an object on the perimeter of this radiation test site will be twice the length of the direct path length between the foci. This radiation test site is depicted in Figure 1.

For the 10 m test site, the natural ground plane shall be augmented with a ground plane of metal which shall extend at least 1 m beyond the boundary of the equipment under test at one end and at least 1 m beyond the measurement antenna and its supporting structure at the other end (see Figure 2). The ground plane shall have no voids or gaps other than any perforations which do not exceed 0,1 λ at 1 GHz (about 30 mm).

7.2.1 Validation of the radiation test site (9 kHz to 1 GHz)

NOTE See CISPR 16-1 for the validation of test sites.

7.2.2 Disposition of equipment under test (9 kHz to 1 GHz)

If it is possible to do so, the equipment under test shall be placed on a turntable. The separation between the equipment under test and the measuring antenna shall be the horizontal distance between the measuring antenna and the nearest part of the boundary of the equipment under test in one rotation.

7.2.3 Radiation measurements (9 kHz to 1 GHz)

The separation between the antenna and the equipment under test shall be as specified in Clause 5. If the field strength measurement at the specified distance cannot be made because of high ambient noise levels or for other reasons (see 6.1), measurements may be made at a closer distance. When this is done, the test report shall record the distance and the circumstances of the measurement. For the test site measurements, an inverse proportionality factor of 20 dB per decade shall be used to normalize the measured data to the specified distance for determining compliance. Care should be taken in measuring a large test unit at 3 m at a frequency near 30 MHz due to near-field effects.

For equipment under test located on a turntable, the turntable shall be rotated fully with a measurement antenna oriented for both horizontal and vertical polarization. The highest recorded level of the electromagnetic radiation disturbance at each frequency shall be recorded.

For equipment under test not located on a turntable the measurement antenna shall be positioned at various points in azimuth for both horizontal and vertical polarization. Care shall be taken that measurements be taken in the directions of maximum radiation and the highest level at each frequency be recorded.

NOTE At each azimuthal position of the measurement antenna the radiation test site requirements specified in 7.2 should be met.

7.3 Alternative radiation test sites for the frequency range 30 MHz to 1 GHz

Measurements may be conducted on radiation test sites which do not have the physical characteristics described in 7.1. Evidence shall be obtained to show that such alternative sites will yield valid results. An alternative radiation test site in the frequency range 30 MHz to 1 GHz is acceptable if the horizontal and vertical site attenuation measurements made as per 5.6.6.2 of CISPR 16-1 are within ±4 dB of the theoretical site attenuation as given in Tables G.1, G.2 or G.3 of CISPR 16-1.

Alternative radiation test sites shall allow for, and be validated for, the measurement distance in the frequency range 30 MHz to 1 GHz specified elsewhere in Clause 5 and/or 7 of this standard.

8 Radiation measurements: 1 GHz to 18 GHz

8.1 Test arrangement

The equipment under test shall be placed on a turntable at a suitable height. Power at the normal voltage shall be supplied.

8.2 Receiving antenna

The measurements shall be made with a directive antenna of small aperture capable of making separate measurements of the vertical and horizontal components of the radiated field. The height above the ground of the centre line of the antenna shall be the same as the height of the approximate radiation centre of the equipment under test. The distance between the receiving antenna and the EUT shall be 3 m.

8.3 Validation and calibration of test site

The measurements shall take place in free-space conditions, i.e. the reflections on the ground shall not influence the measurements. The measurement distance shall be 3 m.

Tolerance with regard to the ideal free-space conditions for a test site to be suitable are under consideration. Until such a specification is included in CISPR 16-2, test sites validated for field measurements between 30 MHz and 1 GHz, may be used for measurements above 1 GHz, provided that absorbing material is placed on the ground between the EUT and the receiving antenna.

8.4 Measuring procedure

The general measuring procedure above 1 GHz specified in CISPR 16-2 should be consulted for guidance. Measurement shall be made with the antenna having both horizontal and vertical polarizations and the turntable with the appliance under test shall be rotated. It shall be ascertained that, when the apparatus under test is switched off, the level of background noise is at least 10 dB below the reference limit, otherwise the reading may be significantly affected.

Peak measurements above 1 GHz (see Table 6 or Table 7) shall be the result of a maximum hold on the spectrum analyser.

Weighted measurements above 1 GHz (see Table 8) shall be the result of a maximum hold and shall be performed with the spectrum analyser in logarithmic mode (values displayed in decibels).

NOTE A video bandwidth of 10 Hz together with logarithmic values provides a level closer to the average level of the measured signal in logarithmic values. This result is lower than the average level that would be obtained in linear mode.

9 Measurement *in situ*

For equipment which is not tested on a radiation test site, measurements shall be made after the equipment has been installed on the user's premises. Measurements shall be made from the exterior wall outside the building in which the equipment is situated at the distance specified in Clause 5.

The number of measurements made in azimuth shall be as great as reasonably practical, but there shall be at least four measurements in orthogonal directions, and measurements in the direction of any existing radio systems which may be adversely affected.

NOTE For the larger commercial microwave ovens it is necessary to ensure that the measurement results are not affected by near field effects. CISPR 19 should be consulted for guidance.

10 Safety precautions

ISM equipment is inherently capable of emitting levels of electromagnetic radiation that are hazardous to human beings. Before testing for electromagnetic radiation disturbance, the ISM equipment should be checked with a suitable radiation monitor.

11 Assessment of conformity of equipment

The assessment of conformity of equipment tested on a test site shall be in accordance with the specifications of Clause 6. For equipment in series production, there shall be 80 % confidence that at least 80 % of manufactured items comply with the limits given. The statistical assessment procedure is specified in 11.1. For small-scale production the assessment procedure contained in 11.2 or 11.3 is applicable. Measurement results obtained for an equipment measured in its place of use and not on a test site shall relate to that installation only, and shall not be considered representative of any other installation and so shall not be used for the purpose of a statistical assessment.

11.1 Statistical assessment of compliance of series produced equipment

The measurements shall be performed on a sample of not less than five and not more than 12 pieces of equipment of the type in series production, but if in exceptional circumstances five pieces of equipment are not available a sample of three or four may be used.

NOTE The assessment made on a sample of the measurement results obtained for a sample of size n relates to all identical units and allows for the variations that can be expected to arise due to quantity production techniques.

Compliance is achieved when the following relationship is met:

$$\overline{X} + kS_\mathrm{n} \leq L$$

where

$\overline{X}$ is the arithmetic mean value of the disturbance levels of n equipments in the sample;

S_n is the standard deviation of the sample where

$$S_\mathrm{n}^2 = \frac{1}{n-1} \cdot \sum \left(X - \overline{X} \right)^2$$

X is the disturbance level of an individual equipment;

L is the permitted limit;

k is the factor derived from tables of the non-central t-distribution which ensures with 80 % confidence that 80 % or more of the production is below the limit. Values of k as a function of n are given in Table 10.

$\overline{X}$, X, S_n and L are expressed logarithmically: dB(μV), dB(μV/m) or dB(pW).

Table 10 – The non-central *t*-distribution factor *k* as a function of the sample size *n*

n	3	4	5	6	7	8	9	10	11	12
k	2,04	1,69	1,52	1,42	1,35	1,30	1,27	1,24	1,21	1,20

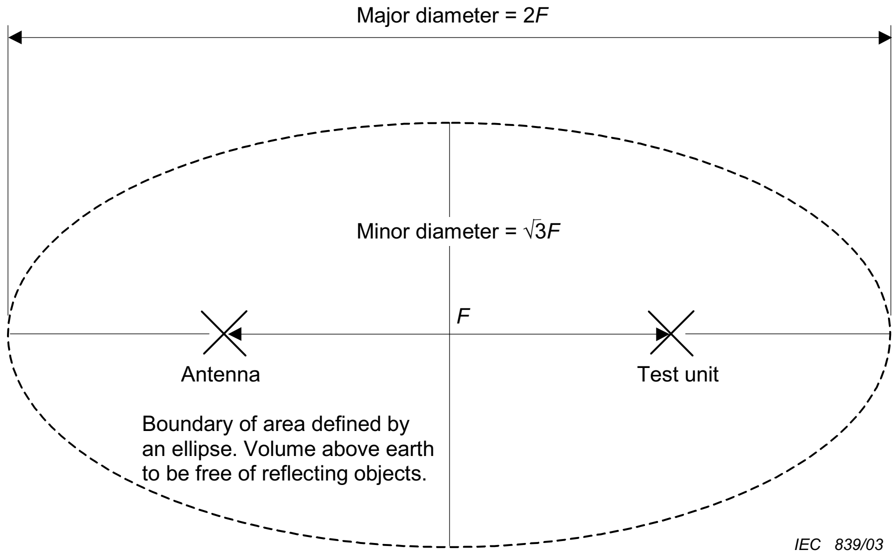
11.2 Equipment in small-scale production

For equipment manufactured on a continuous or batch production basis, the evaluation for compliance may be made on a single sample.

The sample shall be randomly chosen from a production lot or, to allow for the evaluation of a product prior to it being in full production, a pre-production or pilot unit may be evaluated. If the single sample fails to meet the appropriate limits, a statistical assessment may be made according to the method in 11.1.

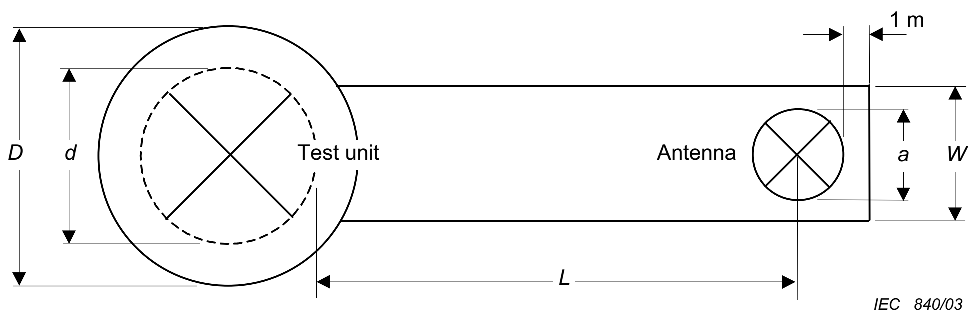
11.3 Equipment produced on an individual basis

All equipment not produced in series shall be tested on an individual basis. Each individual equipment is required to meet the limits when measured by the methods specified.



NOTE The characteristics of the test site are described in 7.2. For the values of F see Clause 5.

Figure 1 – Test site

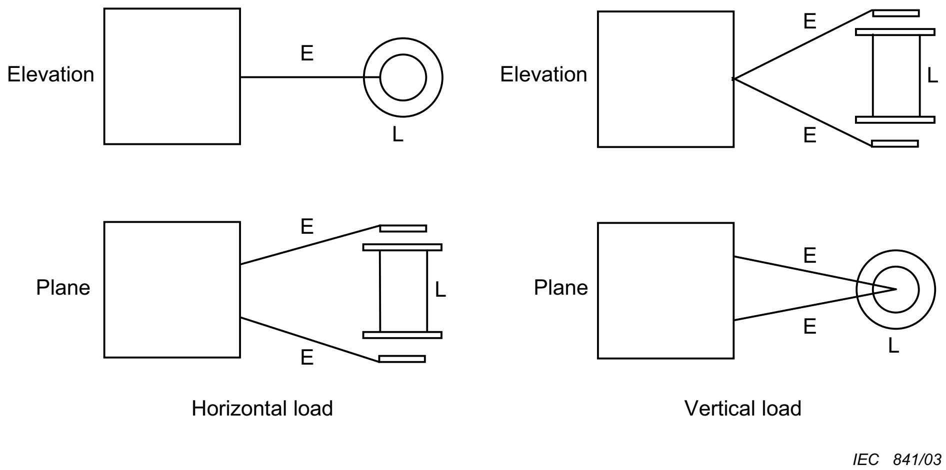


D = (d + 2)m, where d is the maximum test unit dimension

W = (a + 1)m, where a is the maximum test unit dimension

L = 10 m

Figure 2 – Minimum size of metal ground plane



E = electrode arms and cables

L = dummy load

Figure 3 – Disposition of medical (capacitive type) and dummy load (see 6.5.1.1)

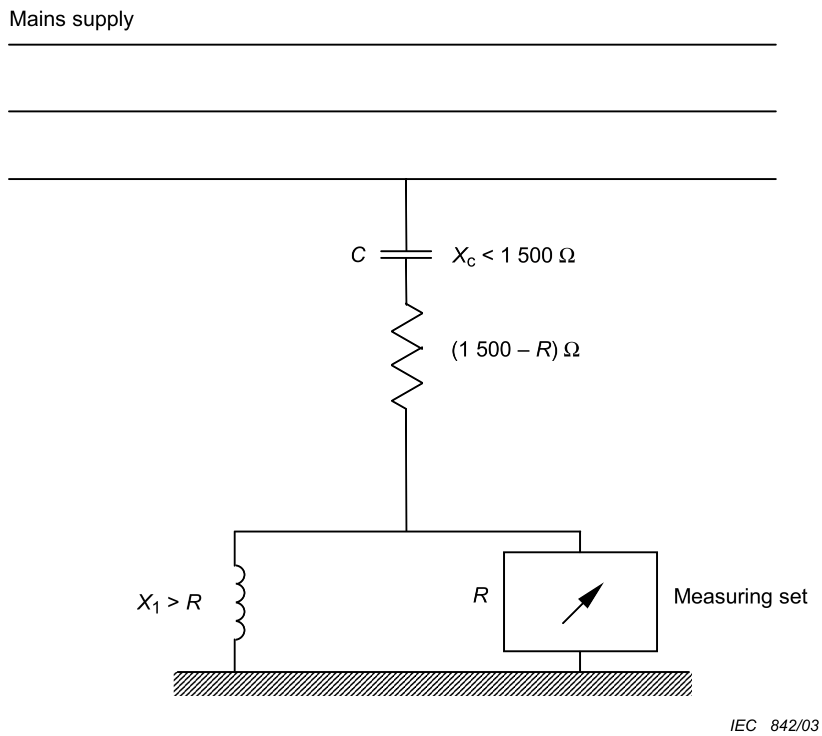


Figure 4 – Circuit for disturbance voltage measurements on mains supply (see 6.2.2)

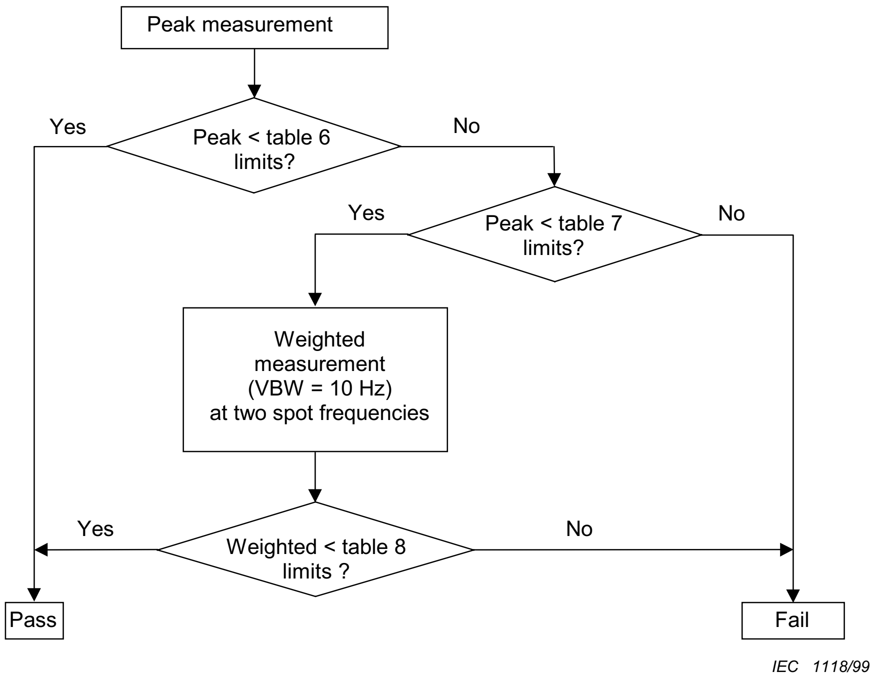


Figure 5 – Decision tree for the measurement of emissions from 1 GHz to 18 GHz of class B, group 2 ISM equipment operating at frequencies above 400 MHz

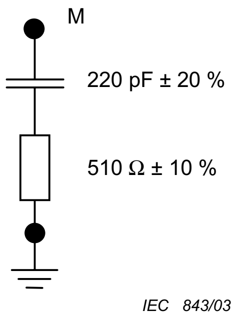


Figure 6 – Artificial hand, RC element (see 6.2.5)

Annex A
(informative)

Examples of equipment classification

Many ISM equipment contain two or more types of interference sources, for example an induction heater might incorporate semiconductor rectifiers in addition to its heating coil. For testing purposes the equipment is to be defined in terms of the purpose for which it was designed. For example, the induction heater incorporating semiconductor rectifiers is to be tested as an induction heater (with all disturbance meeting the prescribed limits whatever the source of disturbance) and is not to be tested as if it were a semiconductor power supply.

The standard gives general definitions of group 1 and group 2 ISM equipment and for official purposes the group to which a particular piece of apparatus belongs shall be identified from these definitions. It will, however, be helpful to users of the standard to have a comprehensive list of types of apparatus which have been identified as belonging to a particular group. This will also help in developing the specification where variations in test procedures may be found by experience to be necessary in dealing with specific types of apparatus.

The following lists of group 1 and group 2 equipment are intended as a nucleus around which a comprehensive list may be developed.

Group 1

General: Laboratory equipment
Medical equipment
Scientific equipment

Detailed: Signal generators, measuring receivers, frequency counters, flow meters, spectrum analyzers, weighing machines, chemical analysis machines, electronic microscopes, switched mode power supplies (when not incorporated in an equipment).

Group 2

General: Microwave-powered UV irradiating apparatus
Microwave lighting apparatus
Industrial induction heating equipment
Domestic induction cookers
Dielectric heating equipment
Industrial microwave heating equipment
Domestic microwave ovens
Medical apparatus
Arc welding equipment
Electro-discharge machining (EDM) equipment
Thyristor-controlled equipment
Spot welders
Demonstration models for education and training

Detailed: Metal melting, billet heating, component heating, soldering and brazing, tube welding, wood gluing, plastic welding, plastic preheating, food processing, biscuit baking, food thawing, paper drying, textile treatment, adhesive curing, material preheating, short-wave therapy equipment, microwave therapy equipment.

Demonstration models of high-voltage Tesla transformers, belt generators, etc.

Annex B
(informative)

Precautions to be taken in the use of a spectrum analyzer (see 6.2.1)

Most spectrum analyzers have no r.f. selectivity: that is, the input signal is fed directly to a broadband mixer, where it is heterodyned to a suitable intermediate frequency. Microwave spectrum analyzers are obtainable with tracking r.f. pre-selectors which automatically follow the frequency being scanned by the receiver. These analyzers overcome to a considerable degree the disadvantages of attempting to measure the amplitudes of harmonic and spurious emissions with an instrument which can generate such components in its input circuits.

In order to protect the input circuits of the spectrum analyzer from damage when measuring weak disturbance signals in the presence of a strong signal, a filter should be provided in the input to give at least 30 dB of attenuation at the frequency of the strong signal. A number of such filters may be required to deal with different operating frequencies.

Many microwave spectrum analyzers employ harmonics of the local oscillator to cover various portions of the tuning range. Without r.f. pre-selection, such analyzers may display spurious and harmonic signals. It thus becomes difficult to determine whether a displayed signal is actually at the indicated frequency, or is generated within the instrument.

Many ovens, medical diathermy equipments and other microwave ISM apparatus receive their input power from rectified a.c. but unfiltered energy sources. Consequently, their emissions are simultaneously modulated in amplitude and frequency. Additional AM and FM are caused by the movement of stirring devices used in ovens.

These emissions have spectral line components as close together as 1 Hz (due to modulation by the oven stirring device), and 50 Hz or 60 Hz (due to the modulation at mains frequency). Considering that the carrier frequency is generally rather unstable, distinguishing these spectral line components is not feasible. Rather, it is the practice to display the envelope of the true spectrum by employing an analyzer bandwidth which is larger than the frequency interval between spectral components (but as a rule small in relation to the width of the spectral envelope).

When the analyzer bandwidth is wide enough to contain a number of adjacent spectral lines, the indicated peak value increases with bandwidth up to the point where the analyzer bandwidth is comparable to the width of the spectrum of the signal. It is essential, therefore, to obtain agreement to use a specified bandwidth in order to compare the amplitudes displayed by different analyzers when measuring emissions typical of present heating and therapeutic devices.

It has been indicated that many oven emissions are modulated at a rate as low as 1 Hz. It has been observed that the displayed spectral envelopes of such emissions are irregular, appearing to vary from scan to scan, unless the number of scans per second is low compared with this lowest frequency component of the modulation.

A suitable rate for investigation of the emission may require 10 s or more to accomplish one scan. Such low scanning rates are not suitable for visual observation unless suitable storage is employed, such as that provided by a storage-type cathode ray tube, a photograph, or a chart recording device. Some attempts have been made to increase the useful scanning frequency by removing or stopping the stirring devices in the oven. However, this may be considered unsatisfactory because the amplitude, frequency and shape of the spectrum are found to vary with the position of the stirrers.

The spectrum analyzer shall not register such instantaneous interference peaks which would not be recorded with a quasi-peak detector (meeting the requirements for the range 30 MHz to 1 GHz) connected to the analyzer.

Annex C
(normative)

Measurement of electromagnetic radiation disturbance in the presence of signals from radio transmitters

For equipment under test having a stable operating frequency so that reading of the CISPR quasi-peak measuring receiver does not vary more than ±0,5 dB during measurement, the electric field strength of the electromagnetic radiation disturbance can be calculated sufficiently accurately from the expression:

$$E_g^{1,1} = E_t^{1,1} - E_s^{1,1}$$

where

E_g is the electromagnetic radiation disturbance (μV/m);

E_t is the measured value of electric field strength (μV/m);

E_s is the electric field strength of the radio transmitter signal (μV/m).

The formula has been found to be valid when unwanted signals are from AM or FM sound and television transmitters having a total amplitude up to twice the amplitude of the electromagnetic radiation disturbance which is to be measured.

It is advisable to restrict the use of the formula to cases where it is not possible to avoid the disturbing effect of radio transmitters. If the frequency of the electromagnetic radiation disturbance is unstable then a panoramic receiver or spectrum analyzer should be used, and the formula is not applicable.

Annex D
(informative)

Propagation of interference from industrial r.f. equipment at frequencies between 30 MHz and 300 MHz

For an industrial radio-frequency equipment which is situated on or near ground level, the attenuation of the field with distance from source, at a height of between 1 m and 4 m above ground, depends on the ground and on the nature of the terrain. A model for electric field propagation above plane-earth in the region from 1 m to 10 km from the source is described in [1][1].

Although the influence of the nature of the ground, and of the obstacles on it, on the actual attenuation of the electromagnetic wave increases with frequency, an average attenuation coefficient can be taken for the frequency range 30 MHz to 300 MHz.

As ground irregularity and clutter increase, the electromagnetic fields will be reduced because of shadowing, absorption (including attenuation caused by buildings and vegetation), scattering, divergence and defocusing of the diffracted waves [2]. The attenuation can then be described only on a statistical basis. For distances from the source greater than 30 m, the expected or median field strength at a defined height varies as $1/D^n$ where D is the distance from the source, and n varies from about 1,3 for open country areas to about 2,8 for heavily built-up urban areas. It seems from the different measurements for all kinds of terrain that an average value of n = 2,2 can be used for approximate estimations. Large deviations of measured values of field strengths from those predicted from the average field strength/distance law occur, with standard deviations of up to about 10 dB in an approximately log-normal distribution. The polarization of the field cannot be predicted. These results are in agreement with measurements in a number of countries.

The screening effect of buildings on the radiation is a very variable quantity, depending on the material of the buildings, the wall thickness and the amount of window space. For solid walls without windows, the attenuation depends on their thickness relative to the wavelength of the radiation and an increase in attenuation with frequency may be expected.

Generally, however, it is considered unwise to expect buildings to give protection of much more than 10 dB.

1 Figures in square brackets refer to the Bibliography.

Annex E
(informative)

Safety related service bands

Frequency MHz	**Allocation/use**
0,010 – 0,014	Radionavigation (Omega on board ships and aircraft only)
0,090 – 0,11	Radionavigation (LORAN-C and DECCA)
0,2835 – 0,5265	Aeronautical radionavigation (non-directional beacons)
0,489 – 0,519	Maritime safety information (coastal areas and shipboard only)
1,82 – 1,88	Radionavigation (LORAN-A region 3 only, coastal areas and on board ships only)
2,1735 – 2,1905	Mobile distress frequency
2,09055 – 2,09105	Emergency position indicating radio beacon (EPIRB)
3,0215 – 3,0275	Aeronautic mobile (search and rescue operations)
4,122 – 4,2105	Mobile distress frequency
5,6785 – 5,6845	Aeronautic mobile (search and rescue operations)
6,212 – 6,314	Mobile distress frequency
8,288 – 8,417	Mobile distress frequency
12,287 – 12,5795	Mobile distress frequency
16,417 – 16,807	Mobile distress frequency
19,68 – 19,681	Maritime safety information (coastal areas and shipboard only)
22,3755 – 22,3765	Maritime safety information (coastal areas and shipboard only)
26,1 – 26,101	Maritime safety information (coastal areas and shipboard only)
74,6 – 75,4	Aeronautical radionavigation (marker beacons)
108 – 137	Aeronautical radionavigation (108-118 MHz VOR, 121,4-123,5 MHz distress frequency SARSAT uplink, 118-137 MHz air traffic control)
156,2 – 156,8375	Maritime mobile distress frequency
242,9 – 243,1	Search and rescue (SARSAT uplink)
328,6 – 335,4	Aeronautical radionavigation (ILS glideslope indicator)
399,9 – 400,05	Radionavigation satellite
406 – 406,1	Search and rescue (emergency position-indicating radio beacon (EPIRB), SARSAT uplink)
960 – 1 238	Aeronautical radionavigation (TACAN), air traffic control beacons
1 300 – 1 350	Aeronautical radionavigation (long range air search radars)
1 544 – 1 545	Distress frequency-SARSAT downlink (1 530 - 1 544 MHz mobile satellite downlink may be pre-empted for distress purposes)
1 545 – 1 559	Aeronautical mobile satellite (R)
1 559 – 1 610	Aeronautical radionavigation (GPS)
1 610 – 1 625,5	Aeronautical radionavigation (radio altimeters)
1 645,5 – 1 646,5	Distress frequency-uplink (1 626,5 - 1 645,5 MHz mobile satellite uplink may be pre-empted for distress purposes)
1 646,5 – 1 660,5	Aeronautical mobile satellite (R)
2 700 – 2 900	Aeronautical radionavigation (terminal air traffic control radars)
2 900 – 3 100	Aeronautical radionavigation (radar beacons – coastal areas and shipboard only)
4 200 – 4 400	Aeronautical radionavigation (altimeters)
5 000 – 5 250	Aeronautical radionavigation (microwave landing systems)
5 350 – 5 460	Aeronautical radionavigation (airborn radars and beacons)
5 600 – 5 650	Terminal doppler weather radar - windshear
9 000 – 9 200	Aeronautical radionavigation (precision approach radars)
9 200 – 9 500	Radar transponders for maritime search and rescue. Maritime radar beacons and radionavigation radars. Airborne weather and ground mapping radar for airborne radionavigation, particularly under poor visibility conditions
13 250 – 13 400	Aeronautical radionavigation (doppler navigation radars)

Annex F
(informative)

Sensitive service bands

Frequency MHz	**Allocation/Use**
13,36 – 13,41	Radio astronomy
25,5 – 25,67	Radio astronomy
29,3 – 29,55	Satellite downlink
37,5 – 38,25	Radio astronomy
73 – 74,6	Radio astronomy
137 – 138	Satellite downlink
145,8 – 146	Satellite downlink
149,9 – 150,05	Radionavigation satellite downlink
240 – 285	Satellite downlink
322 – 328,6	Radio astronomy
400,05 – 400,15	Standard frequency and time signal
400,15 – 402	Satellite downlink
402 – 406	Satellite uplink 402,5 MHz
406,1 – 410	Radio astronomy
435 – 438	Satellite downlink
608 – 614	Radio astronomy
1 215 – 1 240	Satellite downlink
1 260 – 1 270	Satellite up link
1 350 – 1 400	Spectral line observation of neutral hydrogen (radio astronomy)
1 400 – 1 427	Radio astronomy
1 435 – 1 530	Aeronautical flight test telemetry
1 530 – 1 559	Satellite downlink
1 559–1 610	Satellite downlink
1 610,6 – 1 613,8	Spectral line observations of OH radical (radio astronomy)
1 660 – 1 710	1 660 – 1 668,4 MHz: Radio astronomy 1 668,4 – 1 670 MHz: Radio astronomy and radiosonde 1 670 – 1 710 MHz: Satellite downlink and radiosonde
1 718,8 – 1 722,2	Radio astronomy
2 200 – 2 300	Satellite downlink
2 310 – 2 390	Aeronautical flight test telemetry
2 655 – 2 900	2 655 – 2 690 MHz: Radio astronomy and satellite downlink 2 690 – 2 700 MHz: Radio astronomy
3 260 – 3 267	Spectral line observations (radio astronomy)
3 332 – 3 339	Spectral line observations (radio astronomy)
3 345,8 – 3 358	Spectral line observations (radio astronomy)
3 400 – 3 410	Satellite downlink
3 600 – 4 200	Satellite downlink
4 500–5 250	4 500 – 4 800 MHz: Satellite downlink 4 800 – 5 000 MHz: Radio astronomy 5 000 – 5 250 MHz: Aeronautical radionavigation
7 250–7 750	Satellite downlink
8 025 – 8 500	Satellite downlink
10 450 – 10 500	Satellite downlink
10 600 – 12 700	10,6 – 10,7 GHz: Radio astronomy 10,7 – 12,2 GHz: Satellite downlink 12,2 – 12,7 GHz: Direct broadcast satellite
14 470 – 14 500	Spectral line observations (radio astronomy)
15 350 – 15 400	Radio astronomy
17 700 – 21 400	Satellite downlink
21 400 – 22 000	Broadcast satellite (Region 1 and Region 2)
22 010 – 23 120	22,01 – 22,5 GHz: Radio astronomy 22,5 – 23,0 GHz: Broadcast satellite (Region 1) (22,81 – 22,86 GHz is also radio astronomy) 23,0 – 23,07 GHz: Fixed/intersatellite/mobile (used to fill in the gap between frequency bands) 23,07 – 23,12 GHz: Radio astronomy
23 600 – 24 000	Radio astronomy
31 200 – 31 800	Radio astronomy
36 430 – 36 500	Radio astronomy
38 600 – 40 000	Radio astronomy
Above 400 GHz	Numerous bands above 400 GHz are designated for radio astronomy, satellite downlink, etc.

Bibliography

[1] A.A. Smith, Jr, *Electric field propagation in the proximal region,* IEEE Transactions on electromagnetic compatibility, Nov 1969, pp.151-163.

[2] CCIR Report 239-7: 1990, *Propagation statistics required for broadcasting services using the frequency range 30 to 1 000 MHz*

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