

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

RADIO INTERFERENCE FROM DP/OE LIMITS AND MEASUREMENT METHODS

TR/12

September 1982

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114 Rue du Rhône – 1204 Geneva (Switzerland)

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BRIEF HISTORY

Technical Committee TC20 of ECMA was set up in 1972 to explore the conditions necessary to guarantee reciprocal electromagnetic compatibility between data processing equipment and the outside environment.

This Technical Report defines the limits and the measurement methods for the emanation of radio frequency signals from data processing systems and office equipment.

This Technical Report is based on the current work of CISPR and various National Committees. While the methods of measurement and limits should ensure compliance with current requirements in various countries as far as these are known, it should be noted that some national requirements are undergoing revision.

This Technical Report replaces Standard ECMA-47, now obsolete, on the same subject, pending finalization of the CISPR work. It is the intention of TC20 to replace it with an ECMA Standard as soon as possible.

This Technical Report has been adopted by the General Assembly of ECMA as ECMA/TR-12 on June 7, 1982.

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1. SCOPE

This document applies to radio interference which may be generated by electronic data processing and office equipment (DP/OE).

The primary intent of this document is to limit interference with the reception of wanted radio signals by providing the designers with recommended limits of emanation for DP/OE equipment.

The limits defined in this document are not designed to protect radio communication services used by the DP/OE user.

In certain cases it may be appropriate to use limits of emanation lower than those specified, for example, in radio receiver stations, hospitals, airports, etc. Such a requirement would be the subject of a special contract between user and supplier.

Conducted and radiated emanation are considered in this document as potential radio interference phenomena.

Each of the above phenomena can appear as continuous or impulsive. The allowable limits and measurement methods for each type of phenomenon are described. The measurement technique is quasi-peak but other measurement techniques can be used, provided that correlation of the results can be demonstrated.

The limits are defined for two classes of equipment: Class A and Class B.

- Class A: Equipment that is marketed for use in a commercial, industrial or business environment; exclusive of equipment which is marketed for use by the general public, or which is intended to be used in the home.
- Class B: Equipment that is marketed for use in a residential environment irrespective of use in commercial, business and industrial environment. Examples of such devices include, but are not limited to, electronic games, personal computers, calculators, and similar electronic devices that are marketed for use by the general public.

2. CONFORMANCE

Conformance to this document means that the equipment conforms to the limits defined in Section 5, when measured according to the methods defined in Sections 6, 7, 8 and 9.

In general the limits for the class of equipment apply which correspond to the environment where the equipment is installed. In the case of a complaint of interference on Class A equipment in a mixed commercial/domestic environment the manufacturer will co-operate in finding a solution. This will not necessarily imply modifying the equipment to conform to Class B.

3. REFERENCES

- | | |
|-------------------------------|--|
| CISPR Publ. 16
Amendment 1 | Specification for radio interference measuring apparatus and measurement methods. |
| CISPR Rec. 50 | Measurement and evaluation of the radio noise produced by switching operations of electrical appliances for household and similar purposes in the frequency range 0,15 to 300 MHz. (Assessment of clicks). |
| CISPR Rec. 53/1 | Artificial mains network for currents between 25 A and 100 A. (50 Ohm V-network) |

4. DEFINITIONS

For the purpose of this document the following terms have the meaning indicated.

4.1 Electronic Data Processing and Office Equipment (DP/OE)

Electrical/electronic units or systems designed to perform office operations and data processing functions such as electronic computation, data transformation, recording, filing, sorting, storage, retrieval and transfer, and reproduction of data and/or images.

4.2 Test Unit

A representative DP/OE or functionally interactive group of DP/OE (i.e. a system) which contains radio frequency sources, including one or more host units and is used for evaluation purposes.

4.3 Host Unit

A part of DP/OE system or unit that:

- provides the mechanical housing for modules,
- may contain radio frequency sources and,
- may provide power distribution to other DP/OE.

Power distribution may be a.c. or d.c. between the host unit and modules or other DP/OE.

4.4 Module

A part of a DP/OE or host unit which provides functions and may contain radio frequency sources.

4.5 Identical DP/OE and Modules

Units of DP/OE and modules produced in quantity and falling within normal manufacturing tolerances and expected to exhibit equivalent emanation characteristics.

4.6 Class A Equipment

Equipment that is marketed for use in a commercial, industrial or business environment; exclusive of equipment which is marketed for use by the general public, or which is intended to be used in the home.

4.7 Class B Equipment

Equipment that is marketed for use in a residential environment irrespective of use in commercial, business and industrial environment. Examples of such devices include, but are not limited to, electronic games, personal computers, calculators, and similar electronic devices that are marketed for use by the general public.

4.8 Radio Interference

Impairment of the reception of a wanted radio signal caused by an unwanted radio signal or a radio disturbance.

4.9 Conducted Emanation

Emanation of radio frequency energy which appears on the mains power cable, measured over the range 150 kHz to 30 MHz.

NOTE 1

Some countries (e.g. Germany) regulate in the range 9 kHz to 150 kHz. This range is under consideration.

4.10 Radiated Emanation

Electromagnetic emanation radiated from the equipment measured over the range 30 MHz to 1000 MHz.

NOTE 2

Some countries (e.g. Germany) regulate in the range 9 kHz to 30 MHz.

4.11 Discontinuous Emanation

Emanation of a duration less than a specified value when measured under specified conditions.

5. LIMITS

5.1 Conducted Emanation

The limits for conducted emanation, measured at the mains power interface, for Class A and Class B equipment are specified in Tables 1 and 2.

Class A Equipment		
Frequency Range (MHz)	Limits (dB/uV)	
	Quasi-peak	Average
0,15 to 0,2	83	70
0,2 to 0,5	79	66
0,5 to 5	73	60
5 to 30	79	66

Table 1

Class B Equipment		
Frequency Range (MHz)	Limits (dB/uV)	
	Quasi-peak	Average
0,15 to 0,2	70	57
0,2 to 0,5	66	53
0,5 to 5	60	47
5 to 30	66	53

Table 2

Measurements are carried out using quasi-peak and average detector receivers described in 7.1. 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 test unit shall meet both the average limit and the quasi-peak limit when using, respectively, an average detector and a quasi-peak detector. However, if the average limit is met when using a quasi-peak detector the test unit shall be deemed to meet both limits and measurement using the average detector receiver is unnecessary.

5.2 Radiated Emission

The limits for the radiated emission for Class A and Class B equipment are specified in Table 3.

The measuring distance shall be 30 m for Class A equipment, and 10 m for Class B equipment.

Frequency Range (MHz)	Limits	
	dB	(uV/m)
30 to 88	30	
88 to 230	35	
230 to 1000	40	

Table 3

5.3 Discontinuous Emission

Discontinuous emission appears in the form of pulses, called clicks. The limits in Tables 1 to 3 are applied, increased by a factor taking into account the repetition rate of the clicks, as defined in 9.

5.4 Application of Limits

The significance of the limits for type approved equipment shall be that on a statistical basis at least 80% of the mass-produced equipment complies with the limits with at least 80% confidence.

Type tests can be made:

- On a sample of test units of the type in question with statistical evaluation in accordance with Appendix B.
- For simplicity, on one test unit only. In this case the limits are to be reduced by 2 dB.

Subsequent tests from time to time on test units taken at random from production are necessary especially in the case that the type test was made on one test unit only.

In the case of controversy involving the possible withdrawal of type approval, withdrawal shall be considered only after tests on an adequate sample.

6. MEASUREMENT

6.1 General Measurement Conditions

A test site shall permit emanation from the test unit to be distinguished from ambient noise. The suitability of the site in this respect can be determined by measuring the ambient noise levels with the test unit inoperative and ensuring that the noise levels are at least 6 dB below the specified limit.

It is not necessary to reduce the ambient noise level to 6 dB below the specified limit where both ambient noise and test unit emanation combined do not exceed the specified limit: the emanation is then considered to satisfy the specified limit.

Where the combined ambient noise and test unit emanation exceed the specified limit the test unit emanation may still satisfy the specified limit. Particular methods to handle such cases are shown in subsection 7.2.1 and 8.1.4.

6.2 Test Unit Configuration

A test unit shall be configured and operated in a manner which tends to maximize its emanation characteristics in a typical application. Power and signal distribution, earthing, interconnecting cabling and physical placement of DP/OE or modules of the test unit shall simulate the typical application and usage. At least one module of each type shall be operative in each DP/OE evaluated in a test unit, and for system test units, at least one of each type of DP/OE that can be included in the possible system configuration shall be included in the test unit. Following this procedure will permit the

results of an evaluation of test units having more than one type of DP/OE or module to be applied to configurations having more than one of each of those DP/OE or modules.

In the case of test units which functionally interact with other DP/OE, including any unit that is dependent on a host unit for its power interface, either the actual interfacing DP/OE or simulators may be used to provide representative operating conditions, provided that the effects of the simulator can be isolated or identified.

It is important that such a simulator properly represents the electrical and mechanical characteristics of the unit which it simulates, and in particular does not disturb the normal emanation characteristics of the test unit.

Following this procedure will permit the results of measurements of individual DP/OE to remain valid for system application and integration of the DP/OE with other similarly tested DP/OE, including DP/OE produced and tested by different manufacturers.

If a DP/OE is designed to be a host unit to other DP/OE, such DP/OE may have to be connected in order that the host unit shall operate under normal conditions.

Where test units contain switched mode power supplies which provide power to other units the emanation may change with load current. In this case the worst case configuration shall be considered.

6.3 Ground Plane

The relationship of the test unit to a ground plane shall be equivalent to that occurring in use, i.e. floor standing equipment is tested on a ground plane or on an isolating floor (e.g. wood) and close to a ground plane, and desktop or portable equipment is tested on a non-metallic table. The power and signal cables shall be related to the ground plane in a manner also equivalent to actual use. A ground plane may be of metal but may be a "natural" ground plane consisting of concrete, earth, etc.

Specific ground plane requirements are given in subsections 7.2.3 and 8.2.

7. MEASUREMENT OF CONDUCTED EMANATION

7.1 Measuring Receivers

Receivers with quasi-peak detectors shall be in accordance with the specification given in CISPR Publication 16, Section 1. Receivers with average detectors shall be in accordance with CISPR Publication 16, Section 5, Clause 23.

7.2 Method of Measurement

7.2.1 General

Conducted emanation is measured only at the mains power interface to the DP/OE. An artificial mains network is used in order to provide a defined impedance at high frequencies across the power feed at the point of measurement of terminal voltage, and isolation of the circuit under test from the ambient radio frequency energy on the power lines.

The test unit shall be placed at a distance of 0,8 m from the artificial network and connected thereto.

Where a mains flexible cord is provided by the manufacturer this shall be at least 1 m long. The cord in excess of 1 m shall be folded back and forth so as to form a bundle not exceeding 0,4 m in length.

Other mains cables specified or supplied by the manufacturer shall be 1 m long between the test unit and the artificial mains network.

If specified by the manufacturer the cable shall be installed in a conduit.

The test unit shall be arranged and connected with other cables (e.g. signal cables) terminated in accordance with the manufacturer's instructions.

Earth connections, where required for safety purposes, shall be made to the reference earth point of the artificial mains network and shall be the same length as the phase and neutral wires and, where not included in the power cord, shall run parallel to the mains connection at a distance of not more than 0,1 m from it.

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

It may not be possible to measure at some frequencies because of conducted ambient noise from local broadcast services. In this case, a suitable additional radio frequency filter may be inserted between the artificial mains network and the power network, or measurements may be performed in a shielded enclosure. The components forming the additional radio frequency 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 should be satisfied, at the frequency of the measurement, with the additional radio frequency filter connected.

NOTE 3

In some countries (e.g. Germany) there are special requirements for the connection to the artificial network.

7.2.2 Connection of artificial mains network to multiple units

Where the test unit is a group of assemblies or sub-assemblies, each having its own power input, the point of connection for the artificial mains network is determined from the following rules:

- Each test unit having a power cord which is intended to be terminated in a mains supply plug of a standard design (IEC 83 for example) shall be tested separately.
- A test unit having a power supply cord or terminals which are not specified by the manufacturer to be connected via any other device shall be tested separately.
- Power supply cord or terminals of a DP/OE which are specified by the manufacturer to be connected via a host unit or other power supplying equipment shall be connected to that host unit or other power supplying equipment and the terminals of cord of that host unit or other power supplying equipment are those considered for connection to the artificial mains network and tested.
- Test units which are designed to be connected to the public power network only via host unit shall be tested with the host unit. Other test units shall be connected direct to the artificial mains network and tested separately.

NOTE 4

Where a special connection is specified the necessary hardware to effect that connection shall be supplied by the manufacturer for the purpose of this test.

7.2.3 Ground plane

The test unit if not floor-standing, shall be placed 0,4 m from a reference ground plane consisting of a horizontal or vertical metal surface of at least 2 m x 2 m and shall be kept at least 0,8 m from any other metal surface or other ground plane which is not part of the test unit. If the measurement is made in a screened enclosure, the distance of 0,4 m may be referred to one of the walls of the enclosure.

Floor-standing test units are subject to the same provisions with the exception that they shall be placed on a floor, the point or points of contact being not more than 0,4 m above a ground plane. In order to stabilize the measurements, the height shall be specified by the manufacturer. This ground plane is now the reference ground plane (see 6.3).

The reference ground plane shall extend at least 0,5 m beyond the boundaries of the test unit, minimum dimensions being 2 m x 2 m.

The reference ground plane shall be connected to the reference earth point of the artificial mains network with a conductor which is as short as possible.

Natural earth planes (see 6.3) shall be coupled to the artificial mains network via a conducting mat of at least 2m x 2 m placed on the surface of the natural earth plane.

7.2.4 Artificial mains network

The artificial mains network with a nominal 50 Ohm impedance, as defined in Fig. 1, shall be used. The 50 μ H network described in Appendix C conforms to the above specifications.

NOTE 5

Of the artificial mains networks described in CISPR draft Recommendation 53/1 the 50 Ohm 50 μ H network is the more representative of the mains impedance in the DP/OE installations. Being broadly applicable to the range of mains operating currents of DP/OE, it permits the use of one network for all DP/OE measurements.

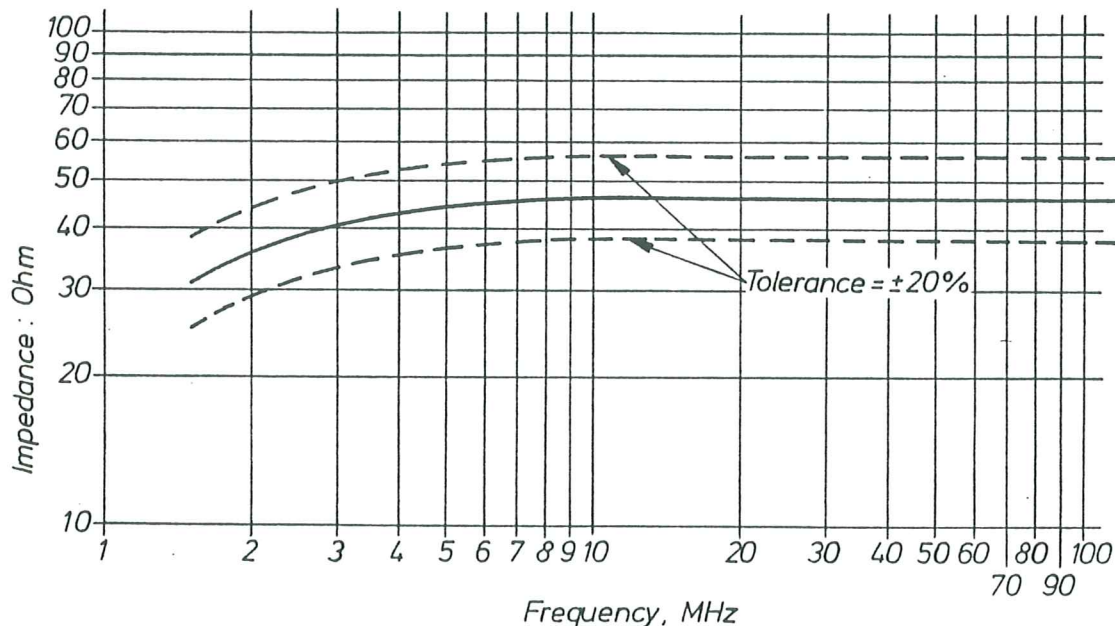


Fig. 1

7.2.5 User installation testing

In case where measurement at a user installation is necessary, a network as described in Fig. 2 shall be used instead of the network defined in 7.2.4.

This form of compliance verification is valid only for the installation site since the site properties affect the measurement. However, additional type tested and compliant units can be added to the system without invalidating the compliance status of the site in which the system was previously tested.

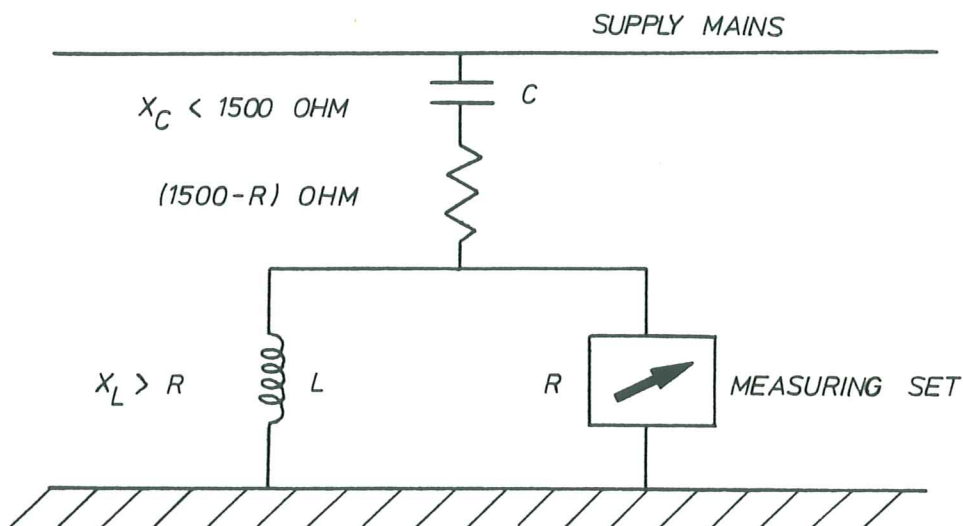


Fig. 2.

8. MEASUREMENT OF RADIATED EMANATION

8.1 General

8.1.1 Measurement method

Limits and measurement methods are defined in terms of the radiation field which is directly related to a protective level provided for receivers.

Measurements of radiated field from a test unit should be made at a distance measured from a boundary defined by an imaginary straight line periphery describing a simple geometric configuration encompassing the emanating units (peripheral string method).

All units, inter-system cables and connecting units shall be included within this boundary.

8.1.2 Measuring receivers

Receivers with quasi-peak detectors shall be in accordance with the specification given in CISPR Publication 16, Section 1.

8.1.3 Antenna

The antenna shall be a balanced dipole. For frequencies of 80 MHz or above the antenna shall be resonant in length, and for frequencies below 80 MHz it shall have a length equal to the 80 MHz resonant length and shall be tuned and matched to the feeder by a suitable transforming device. Input to the measuring apparatus shall be made through a balanced-unbalanced transformer if required.

NOTE 6

Other antenna may be used, provided the results can be correlated with the balanced dipole antenna.

8.1.4 Measurement in presence of ambient noise

According to the specification of the test site (6.1) the ambient noise levels shall be at least 6 dB below the specified limit. However, it may be necessary to measure the radiated emanation of the test unit in test sites where this condition is not met. If the ambient noise, with the test unit inoperative, is higher than the limit in table 3, the following procedure shall be followed:

Select the distance d_2 so that $L_2 = E_2$, where

$$L_2 = L_1 \cdot \frac{d_1}{d_2} \text{ (as specified in 8,2).}$$

d_1 = distance specified in 5.2

L_1 = limit specified in 5.2

E_2 = ambient noise

then measure the noise N_2 at d_2 with the test unit operating

The test unit is considered to comply if

$$N_2 \leq L_2 + 6 \text{ dB}$$

or

$$N_2 \leq 2 \cdot L_2 \leq 2 \cdot L_1 \cdot \frac{d_1}{d_2} \text{ (uV/m).}$$

8.2 Measurement Site

The test site shall characteristically be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit antenna placement at the specified distance and provide adequate separation between antenna, test unit and reflecting structures. One such test site is defined in Appendix D.

Floor-standing test units shall be placed as close as possible to the ground plane of the test site.

Portable equipment shall be placed on a non-metallic table 0,8 m above the ground plane.

In some cases it might be necessary to conduct tests at sites that do not have all characteristics described. Testing at such alternative sites should produce results that can be correlated with those that would be obtained at a preferred site.

The relationship of the measured change in field strength resulting from change in distance to the test unit shall never be less than 20dB/decade of distance for the frequencies of interest.

At sites where space limitations do not normally permit measurements at the specified test distance, measurements shall be normalized to the specified distance using the relationship that the measured field strength is inversely proportional to distance (20 dB/decade)

NOTE 7

There may be a penalty in the use of inverse proportionality to distance, in that the calculated value may be higher than that encountered when measured at 30 m.

8.3 Antenna Position

The antenna height at the measuring distance specified in 5.2 shall be varied in order to find the maximum field strength readings, with a maximum height of 4 m.

Antenna position in azimuth and the two antenna polarisations (horizontal and vertical) shall also be varied during the measurements in order to find the maximum field strength readings.

For measurement purposes it may be possible to rotate the test unit. When this is not practicable the test unit remains in a fixed position and measurements are made around the test unit.

8.4 User Installation Testing

Where measurements at the user's installation are necessary for Class A equipment, the measurements shall be made preferably at the boundary of the user's premises, or if such boundary is less than 30 m the measurements shall be made at a distance of 30 m from the equipment.

This form of compliance verification is valid only for the installation site since the site properties affect the measurement. However, additional type tested and compliant units can be added to the system without invalidating the compliance status of the final site in which the system was previously tested.

9. MEASUREMENT OF DISCONTINUOUS EMANATION

9.1 General

Switching operations in equipment generate discontinuous emanation. The subjective effect of discontinuous interference with sound radio and television varies with repetition rate and amplitude. For that purpose, distinction is made between various kinds of discontinuous interference.

Discontinuous emanation appears in the form of pulses, called clicks. To be counted as a click, the emanation should last no more than 200 ms and be separated from the subsequent emanation by more than 200 ms; in addition its value shall be higher than the corresponding limit indicated in Tables 1 to 3.

A click may contain a number of pulses.

When clicks occur more frequently than twice in any two second period, or the click rate N , as defined in 9.2 is greater than 30, they are considered continuous interference.

When click rate N is lower than 0,2 and the typical value not greater than 44 dB above the relevant limit for continuous interference the clicks are considered non disturbing.

9.2 Determination of the Click Rate N

The click rate N is the number of counted clicks per minute, determined from the formula:

$$N = \frac{40}{T}$$

where T is the time, in minutes, taken to register 40 clicks, or, where relevant, 40 switching operations.

Clicks are counted at the frequencies of 0,16 MHz, 0,55 MHz and 45 MHz.

9.3 Application of Limits

Having determined N , as indicated in 9.2, the factor:

$$20 \log_{10} \frac{30}{N} \text{ dB}$$

is calculated and the emanation at the frequencies of 0,16 MHz, 0,55 MHz, 1,4 MHz, 10 MHz, 45 MHz, 90 MHz and 220 MHz is measured. This emanation shall be lower than the emanation permitted at the corresponding frequencies in Tables 1 to 3, increased by the above factor.

The test unit shall be deemed to comply with the limit if not more than a quarter of the counted clicks are higher than the permitted limits (upper-quartile method).

The measurement shall be carried out under the conditions specified in 6, 7 and 8.

APPENDIX A

Considerations Leading to the Definition of this Document

Data processing and office equipment generating a multiplicity of periodic, binary pulsed electrical/electronic waveforms which, in addition to sources already considered in CISPR Publications, can constitute a potential source of interference to radio reception.

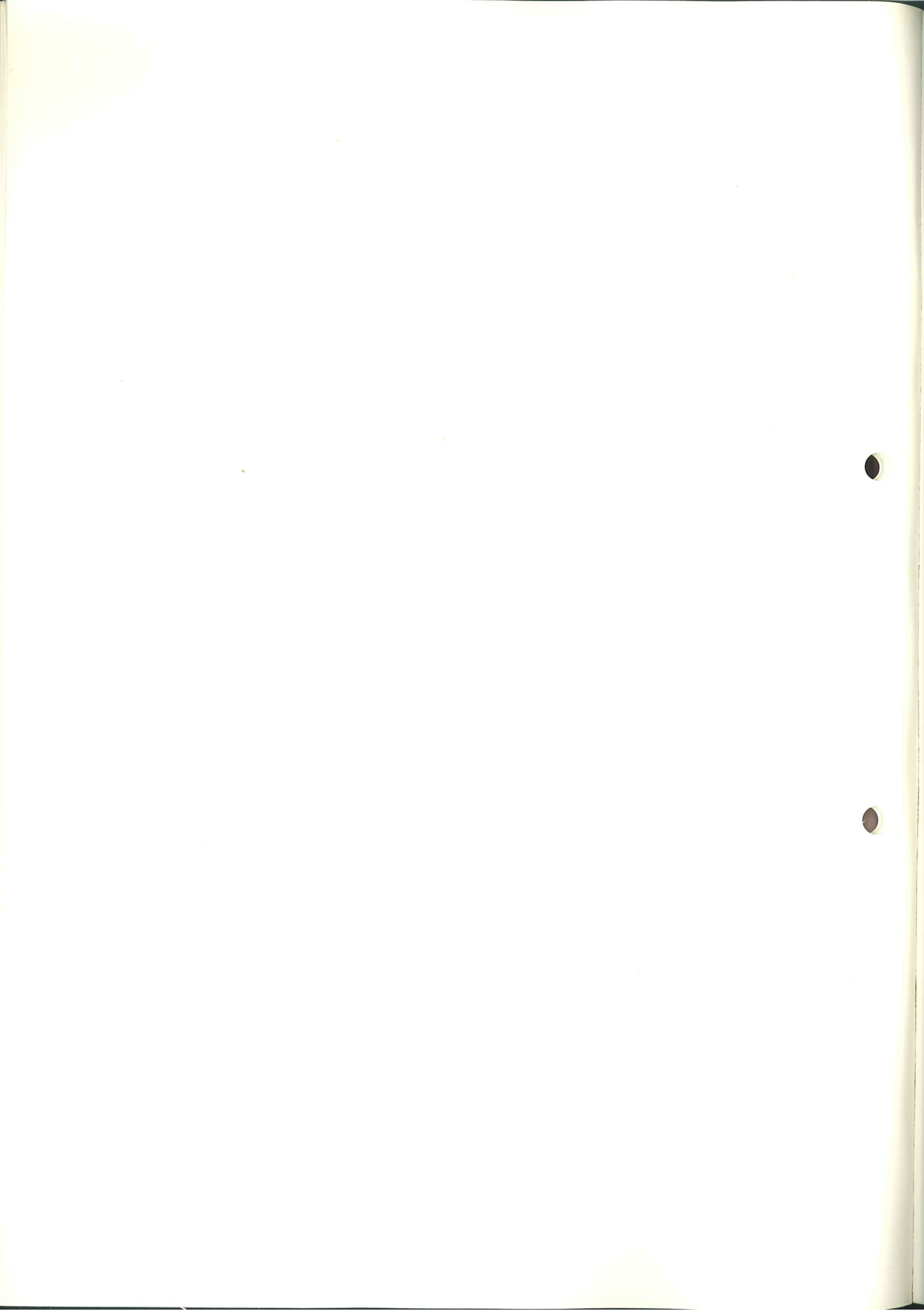
The interference potential of this equipment differs when used in a commercial establishment, than when used by the general public at home.

Data processing and office equipment which is customarily used in commercial establishments, e.g. manufacturing, medical, educational, governmental and similar enterprises, may be used in residential areas as well as in commercial or industrial areas.

Use in a commercial establishment defines propagation factors which may be different from those when used in the home and these different propagation factors require different recommendations for interference limits.

Electromagnetic energy may be propagated from the source to nearby radio systems by conductive, inductive or capacitive coupling or by radiation.

In the frequency range below 30 MHz conductive propagation along the mains and subsequent inductive and capacitive coupling are dominant. In the frequency range above 30 MHz radiation is dominant but inductive and capacitive coupling from cables connecting host units to other units may be significant in some cases.



APPENDIX B

Compliance with Limits for Equipment in Large-Scale Production

Statistical assessment of compliance with limits shall be made according to one of the two tests described below or to some other test which ensures compliance with the requirements of this Standard.

B.1 Test based on the non-central t-distribution

This test should be performed on a sample of five or more test units of the type in question, but if, in exceptional circumstances, five test units are not available, then a sample of not less than three shall be used. Compliance is judged from the following relationship:

$$\bar{x} + ks_n \leq L$$

where:

\bar{x} = arithmetic mean value of the levels of n test units in the sample.

$$s_n^2 = \sum (x_n - \bar{x})^2 / (n - 1)$$

x_n = level of individual test units

k = factor derived from tables of the non-central t-distribution with 80% confidence that 80% of the type test units in question is below the limit; the value of k depends on the sample size n and is stated below.

L = permissible limit.

The quantities x_n , \bar{x} , s_n and L are expressed logarithmically (dB(uV), dB(uV/m) or dB(pW)).

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

B.2 Test based on the binomial distribution

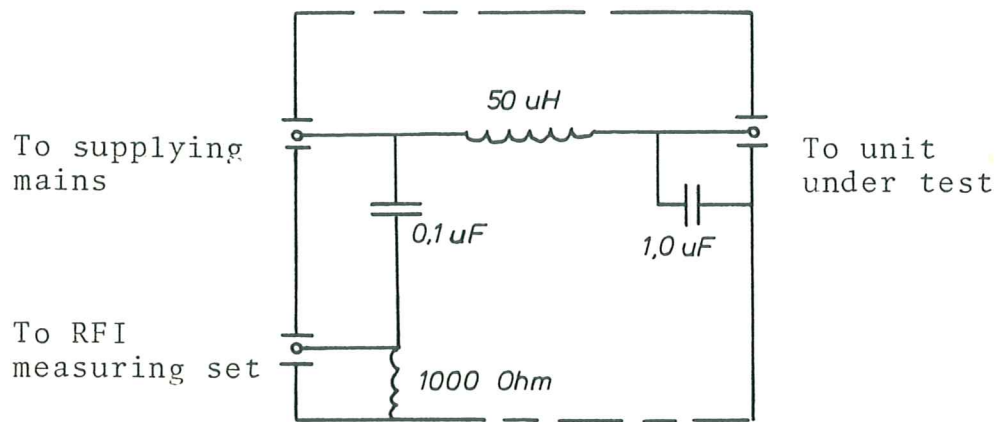
This test should be performed on a sample of not less than seven test units. Compliance is judged from the condition that the number of test units with an interference level above the permissible limit may not exceed c in a sample of size n.

n	7	14	20	26	32
c	0	1	2	3	4

Should the test on the sample result in non-compliance with the requirements of this Standard then a second sample may be tested, the results combined with those from the first sample and compliance checked for the larger sample.

APPENDIX C

Artificial Mains Network for Currents up to 100 A (50 Ohm 50 uH)



NOTES

- Since high capacitance values are used in this unit, it must either be solidly bonded to earth or a mains isolating transformer with an unearthed secondary must be used.
- Connection to RFI measuring set via 50 Ohm impedance coaxial cable.

APPENDIX D

Standard Test Site

A suitable test site is one which is free from reflecting objects within the perimeter of an ellipse having a major axis equal to twice the distance between foci, and a minor axis equal to $\sqrt{3}$ times this distance. The approximate radiation centre of the test unit (usually the volume centre) shall be located at one focus and the receiving antenna of the measuring apparatus at the other. It may be noted that the path of the ray reflected from any object on the perimeter of this ellipse will be twice the length of the direct ray path between the foci.

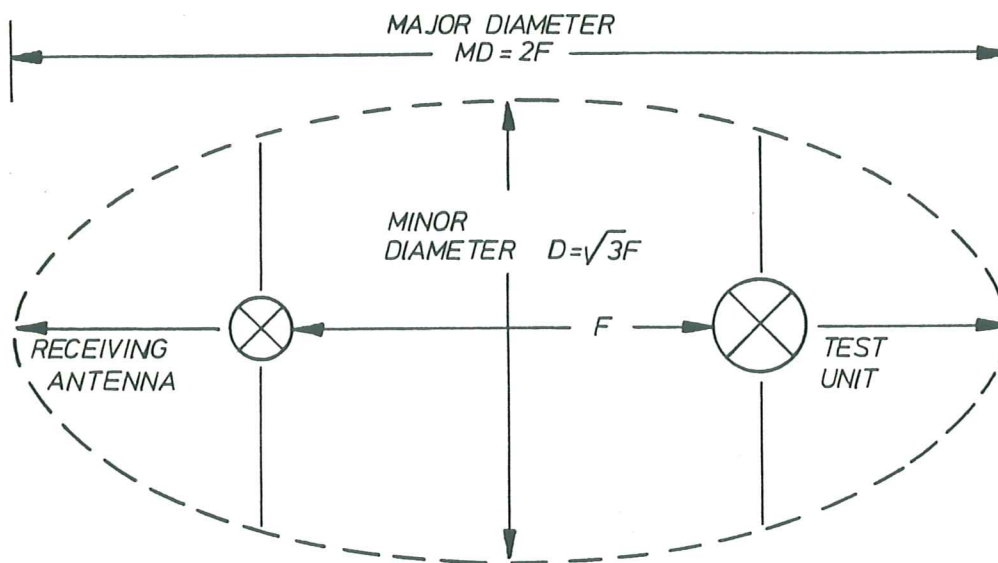
Care shall be taken that external enclosures, if any, are non reflective, and that the area outside the test area is free of major reflecting objects.

The suitability of the site shall be determined as follows. Prior to installation of the test unit a transmitting antenna shall be mounted at one focus of the ellipse with the receiving antenna at the other. The transmitting antenna should have the same radiation properties as a half-wave dipole. The two antennas shall both have the same polarisation. Test shall be made with the plane of polarisation horizontal and vertical.

The site shall be considered suitable for the purpose of measurement at a given test frequency if the indication on the measuring set changes by not more than ± 3 dB when the antenna is moved up to 15 cm in any direction from its initial position.

NOTE

Other methods of evaluating the test site are under consideration.



NOTE:

Boundary of area defined by an ellipse. Volume above ground to be free of reflecting objects.

