

ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

STANDARD ECMA-47

FOR

LIMITS AND MEASUREMENT METHODS
FOR RADIO INTERFERENCE FROM
ELECTRONIC DATA PROCESSING UNITS

March 1976

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BRIEF HISTORY

Technical Committee TC 20 of ECMA was set up in 1972 to explore the conditions necessary to guarantee reciprocal electromagnetic compatibility between electronic data processing and/or data communication systems and the outside environment.

This Standard defines the limits and the measurement methods for the emanation of radio frequency signals from single units used in the composition of electronic data processing and/or data communication systems.

This Standard is based on the work of CISPR and various National Committees. The methods of measurement and limits should ensure compliance with current requirements in various countries as far as these are known.

Work continues on the assessment of emanation from Data Processing Equipment, as a result of which changes are anticipated in at least the following subjects :

- Impedance of V-Network
- Frequency range 10 kHz - 150 kHz
- Relaxation of conducted limits above 5 MHz
- System/unit concepts and test methods
- Product qualification/certification procedures

Subsequent issues of this Standard will reflect these developments.

Adopted by the General Assembly of ECMA on December 16, 1975.

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1. SCOPE

This Standard applies to Radio Interference which may be generated by Electronic Data Processing Equipment.

The primary intent of this Standard is to limit the interference with the reception of wanted radio signals by providing the designers of Electronic Data Processing equipment with recommended limits of emanation for individual Units of Equipment. However, all electronic equipments may benefit from this reduction of the environmental pollution.

The frequency range covered extends from 150 kHz to 1000 MHz. An extension from 10 kHz to 150 kHz is under study. Frequencies above 1000 MHz are at present not considered applicable to Electronic Data Processing Equipment.

2. REFERENCES

- | | |
|----------------------|--|
| ECMA-22 | Electrical Safety Requirements for Data Processing Machines. |
| CISPR Publ. 1 (1972) | Specification for CISPR Radio Interference Measuring Apparatus for the Frequency Range 0,15 to 30 MHz. |
| CISPR Publ. 2 | Specification for CISPR Radio Interference Measuring Apparatus for the Frequency Range 25 MHz to 300 MHz. |
| CISPR Publ. 4 | Specification for CISPR Radio Interference Measuring Apparatus for the Frequency Range 300 MHz to 1000 MHz. |
| CISPR Report 21/1 | Interference from industrial radio frequency equipment.
(Propagation over 30 MHz. Suggests (1) field strength typically varies as $1/D^2$, (2) Attenuation due to buildings approx. 10dB). |
| CISPR Report 29/1 | The connection of electrical equipment to the artificial mains network.
(Guidance on use of network with screened and unscreened mains cables). |
| CISPR Report 41 | Measurements of interference at frequencies above 300 MHz.
Use of (1) Receivers with non-CISPR bandwidth, (2) Spectrum analysers. |
| CISPR Report 42 | Determination of the amplitude relationship specified in CISPR 1, 2 and 4.
(Receiver calibration by pulses). |

- CISPR Recommendation 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 Recommendation 53 Artificial mains networks for currents between 25A and 100A.
(50 Ohm V-network).

3. DEFINITIONS

For the purpose of this Standard the following terms have the meanings indicated.

3.1 Electromagnetic Disturbance

Electromagnetic noise which is liable to be superimposed on a wanted signal.

3.2 Radio Interference

Impairment of the reception of a wanted radio signal caused by an unwanted radio signal or a radio disturbance. The magnitude of radio interference is expressed as interference voltage and interference field strength.

3.3 Interference Suppression

Any action intended to reduce or eliminate the effect of radio interference.

3.4 Interference Source

Equipments or parts of equipments capable of causing interference.

3.5 Unit of Equipment

An item of data processing equipment which contains an a.c. or battery primary power interface.

3.6 Host Unit

A unit of equipment which is also designed to provide or distribute power to other data processing equipment.

3.7 Interference Voltage (Conducted Interference)

Voltage produced by an electromagnetic disturbance. Such a voltage has a precise value only when measured under specified conditions at the power interface of the equipment, as defined by the manufacturers.

3.8 Interference Field Strength (Radiated Interference)

Field Strength produced by an electromagnetic disturbance. Such a field strength has a precise value when measured under specified conditions.

3.9 Limit of Interference

Maximum permissible value of radio interference as specified in this recommendation. The specified limit varies with frequency.

3.10 Industrial District

A tract of land registered as such in the land register or building development plan and includes blind alleys, private industrially owned roadways, rail and waterway connections. Public communications (streets, including waterways, surfaces of water of public ports, and railway lines) within an industrial district are not considered as part of it.

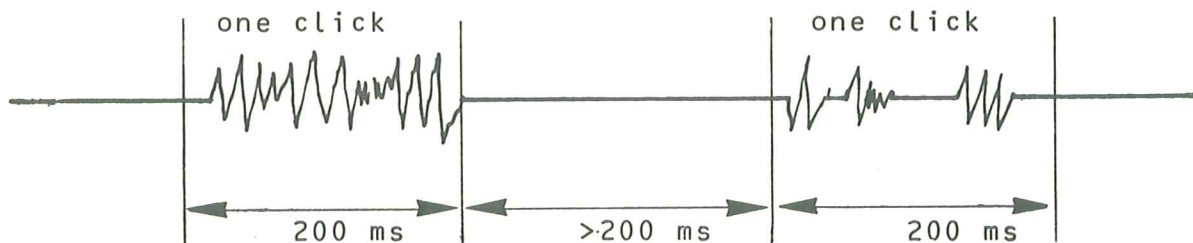
The distance at which measurements shall be taken is specified in section 7.2.

3.11 Click

A disturbance of duration less than a specified value when measured under specified conditions. A click may contain a number of impulses.

For the purpose of this Standard a click is a disturbance which lasts not more than 200 ms and is separated from a subsequent disturbance by at least 200 ms.

EXAMPLES



4. RADIO INTERFERENCE

The following phenomena are considered in this Standard as Radio Interference:

- Conducted Interference - any frequency other than the fundamental which appears on the mains power cable, customarily measured over the range of 150 kHz to 30 MHz.
- Radiated Interference - any measurable electromagnetic emanation appearing in the immediate vicinity of the equipment within the range of 150 kHz to 1000 MHz.

Each of the above phenomena can appear as continuous or impulsive. The allowable limits and measurement methods for each type of phenomena are described in sections 5 and 6. The normal measurement technique is quasi-peak so as to simulate the victim unit.

5. LIMITS

5.1 Frequencies of unlimited emanation

There is no limitation at the following frequencies:

13,56 MHz \pm 0,5 %

27,12 MHz \pm 0,6 %

40,68 MHz \pm 0,6 %

433,9 MHz \pm 0,2 %

During measurements of frequency stability, not more than 70 % of the specified departure from nominal frequency shall be exceeded, so that at the upper and lower frequency limits there are safety margins of at least 15 %.

5.2 Conduction

The limits for the interference voltage are specified in Fig. 1 in the frequency range 150 kHz to 30 MHz.

5.3 Radiation

The interference field strength shall not exceed the following limits :

- magnetic component within the range from 0,15 MHz to 30 MHz: the limits of Fig. 2 at a distance of 100 m from the equipment.
- electric component above 30 MHz: the limit of Fig. 3 at a distance of 30 m from the equipment.

5.4 Tolerances

With regard to the accuracy attainable in practice, equipments shall be rejected only if the measured values exceed the limits of interference by at least the following factors :

- in the case of interference sources operating at discrete frequencies :

2 dB up to 300 MHz

3 dB up to 1000 MHz

- in the case of interference sources producing electromagnetic noise by pulses :

3 dB up to 300 MHz
4 dB up to 1000 MHz

6. MEASUREMENT

6.1 General

The measurements in this section shall, if possible, be carried out on individual Units of Equipment (see definition 3.5.) under normal or simulated operating conditions as specified in the manufacturer's instructions.

Two or more interconnected Units of Equipment may be tested simultaneously. If the total combination of units meet the requirements of this Standard, then it shall be deemed that each individual unit meets the requirements.

Any equipment which is dependent on a Host Unit (see definition 3.6.) for its power interface shall be tested in conjunction with the host unit or a host simulator.

If a Unit of Equipment is designed to be a Host Unit to other data processing equipment, such equipment may have to be connected in order that the Host Unit shall operate under normal conditions. It shall not be necessary to connect any tools or test gear which may optionally derive their power from the equipment under test.

For assessment of interference suppression of equipments which are powered without direct connection to the mains (i.e. powered from a battery or from a Host Unit whether by an a.c. or d.c. interface) only the interference field strength measurements are applicable (see Section 6.4).

If the interference depends on the magnitude of the supply voltage, measurement shall be taken at the rated supply voltage.

Equipments for continuous duty shall be measured in a steady-state condition.

Motor-driven equipments shall be run in to the extent that their interference corresponds to that during their normal life.

In the range from 0,15 to 30 MHz continuous interference shall be measured progressively over the complete spectrum. If interference is discovered at any frequency, the highest value measured during an observation time of approx. 15 s is applicable.

If clicks as well as continuous interference occur in a circuit, they may be measured and judged separately.

Disposition of external cables other than main supply cables shall be such as to simulate actual usage.

6.2 Clicks

When clicks are measured they shall be assessed according to CISPR Rec. 50.

In outline this method is as follows :

The number of clicks in a given period of time is counted, and the click rate N , clicks/min, is calculated. According to these measurements the interference level is assessed as follows :

$N > 30$ <u>OR</u> more than two clicks in any two seconds <u>OR</u> Interference is discontinuous but does not fall within definition of clicks	Treated as continuous Interference
$0,2 < N < 30$	Limit of interference at any frequency is increased by a factor $\frac{30}{N}$, shown in Fig. 4
$N < 0,2$	Limit of interference at any frequency is increased by a factor of 150 (44 dB)

The following conditions apply to measurements of clicks:

- Only clicks which exceed the Limit for continuous interference are counted.
- At least 40 clicks should be counted but the inspection time does not need to exceed two hours.
- Counting of the clicks is carried out at certain spot frequencies only.
- The Upper Quartile method of assessment is used, i.e. equipment is deemed to comply provided that not more than one quarter of the counted clicks exceed the permitted limit.

Additional rules apply, for example, to highly intermittent click patterns and to equipment (such as on-demand peripherals) which cause interference only when called into operation manually or by program. The above outline of CISPR Rec. 50 is therefore not exhaustive.

6.3 Conducted Interference

This Section specifies the requirement for the measurement of interference voltages generated by Data Processing Equipment.

6.3.1 Interference Measuring Apparatus

The interference measuring apparatus to be used for the measurement of Conducted Interference shall comply with the specifications published in CISPR Publ. 1.

6.3.2 Artificial Mains Networks (V-network)

An artificial mains network is required to provide a defined impedance at high frequencies across the terminals of the equipment under test, and also to isolate the test circuit from unwanted radio-frequency signals on the supply mains (CISPR Publ. 1, section 2.1.1 and CISPR Rec. 53).

By the use of a V-network the measurement of asymmetrical terminal voltages is possible.

For the measurement of Conducted Radio Frequency Interference an artificial mains network with the impedance characteristics of Fig. 5 shall be used above 25 A.

The use of a 50 Ohms Artificial Mains Network for all equipment is under consideration as it is believed that this impedance is more realistic than the 150 Ohms Artificial Mains Network specified at present for currents up to 25 A. It is hoped that such an impedance will eventually be standardized for all EDP equipment.

To ensure that, at the frequency of measurement, the impedance of the mains does not affect the impedance of the artificial mains network, a suitable radio frequency impedance shall be inserted between the artificial mains network and the supply mains. The impedance will also reduce the effect of unwanted signals existing on the supply mains. The V network shall be enclosed in a metallic screen directly connected to the reference ground of the measuring system. With the isolation network the impedance requirement (Fig. 5) of the artificial mains network shall be satisfied, at all frequencies.

Conducted Interference not generated by the equipment under test (arising from the supply mains or caused by extraneous

fields) shall be below the limit of interference. The conducted interference not generated by the equipment is measured with the equipment under test connected but not operated.

6.3.3 Test Configuration

The measurements shall be made with the frame of the equipment connected to the ground of the measuring apparatus.

Conducted Interference shall be measured with instruments as defined in section 3.1 at the Power Interface as defined in section 3.7.

In order to ensure reproducible results and eliminate spurious effects, it will be necessary to take the following steps:

- Establish a low impedance ground connection between the equipment under test and the artificial mains network (CISPR, Rep. 29/1).
- Ensure that spurious effects, which bypass the filter of the unit under test, are not introduced into the flexible mains cable. This can be achieved by placing a solid earthed barrier immediately adjacent to the machine through which the flexible mains cable is passed to the test equipment. This barrier must provide sufficient shielding and as such, must be a complete screened enclosure, which will be bonded to the ground plane. An alternative would be to provide a shielded mains cable with suitable shielding material to cause effective "E" and "H" field shielding. If this latter alternative is used then it must only be regarded as a means of testing and such shielding shall not be regarded as part of the equipment under test.
- Avoid spurious voltage being induced into the supply leads by direct pick-up. It may be necessary to screen the measuring set and its supply leads. (CISPR, Publ. 1, section 4.3.4).

When isolating and artificial mains networks cannot be used, the probe method shown in Fig. 6 may be used. The measurements shall be made between each line and a suitable ground (earth plate, water pipe, metal tube) with a blocking capacitor C and a resistor such that total resistance between line and earth is 1500 Ohms. The effect on the accuracy of measurements of any device, which may be used to protect the measuring set against dangerous currents shall either be less than 1 dB or be allowed in calibration. (CISPR, Publ. 1, section 4.3.4).

6.4 Radiated Interference

This Section specifies the general requirements for the measurement of interference fields generated by Data Processing Equipment.

6.4.1 Measuring Equipment

The interference measuring apparatus to be used for the measurement of radiation shall comply with the specifications published in CISPR, Publ. 1, Publ. 2 and Publ. 4.

6.4.2 Test Conditions

Data Processing Equipment shall be tested at the manufacturers test site.

For frequencies below 30 MHz only the magnetic component of the radiated field shall be measured. For frequencies above 30 MHz both the vertically and horizontally polarized components of the electric field are to be measured.

The apparatus under test shall be placed on a ground plane or equivalent and be isolated from it. Power at the nominal voltage shall be supplied.

For measurements at a standard test site, the distance between the measuring antenna and the periphery of the equipment under test, shall be as defined in section 5.3.

If physical conditions at the test site, or the high ambient noise levels do not permit an antenna distance as specified, measurements may be made at shorter distances. The criterion for close-in measurement shall be the greater of

- The limit corrected for distance by the formula

$$\frac{E_1}{E_2} = \left(\frac{d_2}{d_1} \right)^2, \quad f \geq 30 \text{ MHz};$$

$$\frac{E_1}{E_2} = \left(\frac{d_2}{d_1} \right)^3, \quad f < 30 \text{ MHz} \quad \text{or}$$

- the measurement option in section 6.4.3.3.

The test site shall be free from reflecting objects so that the results will not be affected. (CISPR, Publ. 1 and Publ. 2).

As an example, a suitable test site is one which is free from reflecting objects within the perimeter of an ellipse having a major diameter equal to twice the distance between foci, and a minor diameter equal to $\sqrt{3}$ times this

distance. The equipment under test and the measuring apparatus are placed at each of the foci respectively. 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.

When the equipment is installed at a standard test site, precautions must be taken with the layout of cables, etc. to ensure that spurious effects do not occur. The equipment shall be installed on a ground plane. The equipment under test shall be isolated from it.

When equipment is fitted with a special grounding terminal, this shall be connected to the ground plane by a lead as short as possible. When no earth terminal is fitted the equipment shall be tested as normally connected, that is, any grounding is obtained through the mains supply.

When necessary the calibration checking of the test site may be made by a radiation-substitution method.

The suitability of the site shall be determined as follows. A transmitting antenna shall be mounted at the position where the approximate radiation centre (usually the volume centre) of the equipment under test is intended to be placed. The transmitting antenna shall have the same radiation properties as a half-wave dipole. The receiving antenna shall be placed at the same position as chosen for the actual measurements. The two antennas shall be placed so that they have both horizontal polarization. Tests shall be made with the plane of polarization horizontal and vertical.

The site shall be considered suitable for the purpose of measurement at a test frequency if the indication on the measuring set changes by not more than $\pm 1,5$ dB when the centre of the transmitting antenna is moved 0 to 15 cm in any direction from its initial position.

6.4.3 Antenna Characteristics

6.4.3.1 Antennas for Frequencies below 30 MHz

The antenna shall be a balanced loop of dimensions such that it will be completely enclosed by a square having sides 60 cm in length, or an unbalanced loop of the same dimensions with screening to reduce electric pick-up. The antenna shall be supported in a vertical plane and be rotatable about a vertical axis. The lowest point of the loop shall be 1 m above the ground.

For balancing of the antenna, see section 3.2.2 of CISPR, Publ. 1.

6.4.3.2 Antennas for Frequencies above 30 MHz

The antenna shall be as described in section 3.2 of CISPR, Publ. 2 and section 2.2 of CISPR, Publ. 4. The centre of the antenna shall be supported $3,0 \pm 0,2$ m above ground.

Precautions should be taken to ensure that the antenna is adjusted in position and orientation for maximum reception when measurements are being made in an actual location, i.e. not on a test site.

6.4.3.3 Measurement Procedure

Measurements shall be made with the antenna having both horizontal and vertical polarization. Preferably a turntable shall be used and the equipment under test be rotated to measure radiation from at least 4 azimuth positions spaced by 90°. If directional patterns are suspected, additional azimuths are necessary. The highest level or radiation measured, in an observation time of 15 seconds shall be the characteristic level for that measuring frequency.

If the ambient field is too high and the equation in 6.4.4 for E-Fields cannot be applied, the following alternate method may be used:

- The environmental ambient at the close-in measurement point (machine off) shall be at such level that when extrapolated to the limit distance by the formula

$$\frac{E_1}{E_2} = \left(\frac{d_2}{d_1} \right)^2$$

it is at, or below, the limit.

- The product would be judged to meet the limit when the close-in measurement (machine on) did not exceed the measured ambient by more than 6 dB.

6.4.4 Measurement of Radiation in Presence of Signals from Radio Transmitters

For the data processing equipment having a stable frequency so that the reading of the CISPR measuring set does not vary more than $\pm 0,5$ dB during measurements, the field strength of the radiation can be calculated sufficiently accurately from the expression:

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

where

E_g (V/m) is the field strength from the DP equipment.

E_t (V/m) is the measured value.

E_s (V/m) is the field strength of the signal(s) which disturb the measurement.

The formula has been found to be valid for disturbing signals from AM and FM sound and television transmitters having a total amplitude up to twice the amplitude of the Data Processing Interference which is to be measured.

For all the measurements where the above equation may not be used, the ambient levels shall not exceed the interference limits given in section 5. Consideration should be given to special testing during hours when transmitters are off.

6.5 Measurement of Frequency Stability

If equipments are operated within one of the permissible frequency bands, measurement shall prove that the frequency remains within the specified limits, possibly under all operating conditions. In such a case, attention shall be paid to the following points :

- The accuracy of measurement of the frequency meters used shall be better than 1 in 10^5 .
- In order to determine the thermal influences on the operating frequency, the frequency shall be observed for at least 2 hours under operating conditions.

7. MISCELLANEOUS CONSIDERATIONS

7.1 Levels lower than the specified limits

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

7.2 Tests at the Customer Site

Normally all testing will be carried out at the manufacturer's premises on individual Units of Equipment as described in section 5. In the event that tests become necessary on the customer site, for example if tests at the factory are not practical as with low production or very large Units of Equipment, tests may be conducted at the customer site at the manufacturers discretion and the following limits apply to individual Units of Equipment.

- Conducted Interference

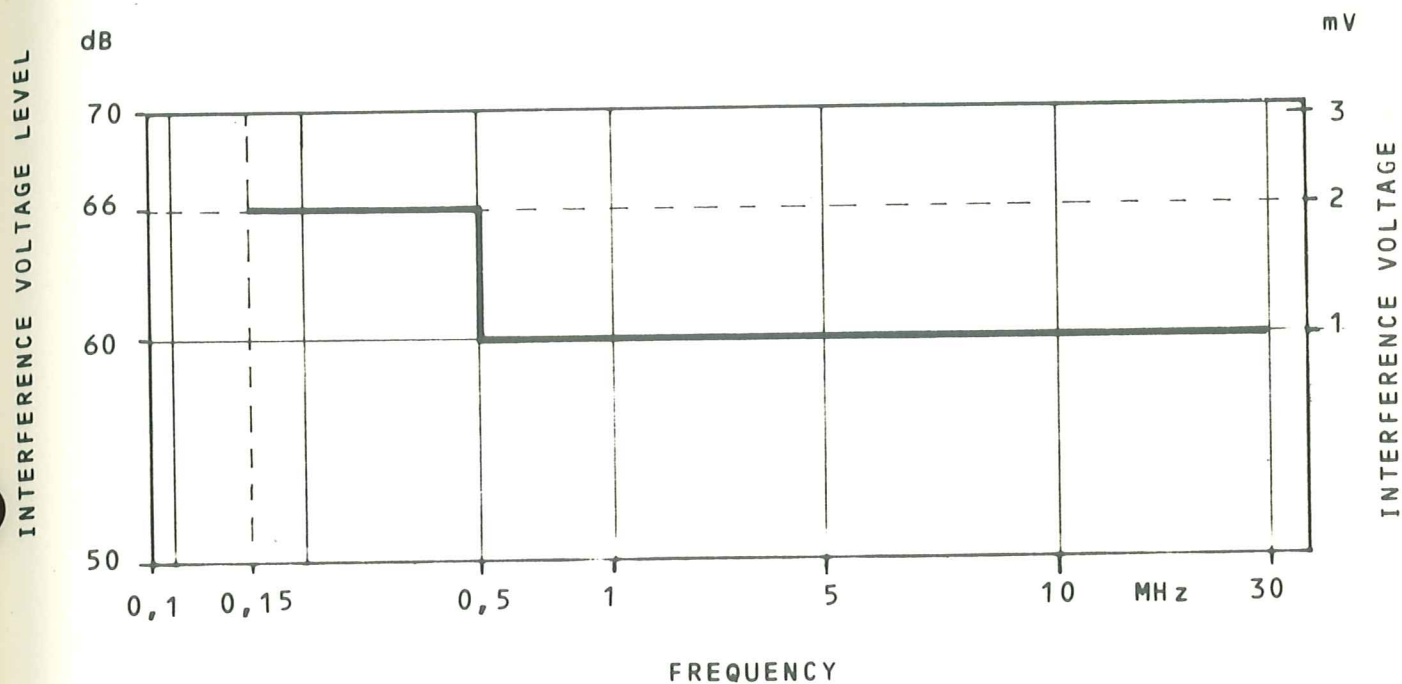
Tests carried out as in the factory, on individual Units of Equipment and to the same limits.

- Radiated Interference

The limits of section 5 and 6 and the measuring methods of section 6 apply. The distances shall be measured from the boundaries of contiguous operating rooms or, if they are situated in an industrial district, from the nearest boundary of the industrial district.

8. SAFETY CONSIDERATIONS

The safety of the equipments shall not be impaired by the application of interference suppressors. To this end, the interference suppressors must be in accordance with Standard ECMA-22.



0 dB(μ V) = 1 μ V

Fig. 1

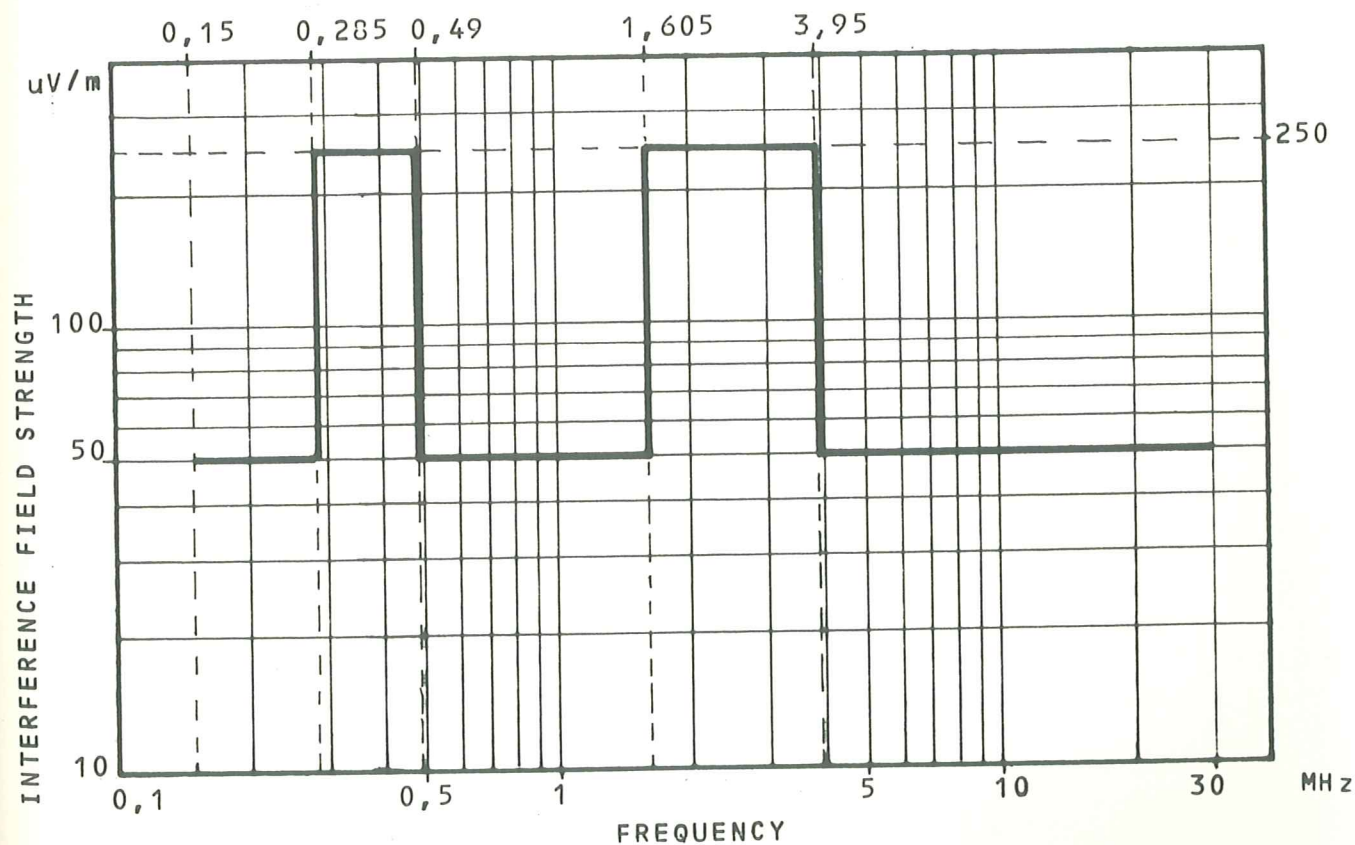


Fig. 2

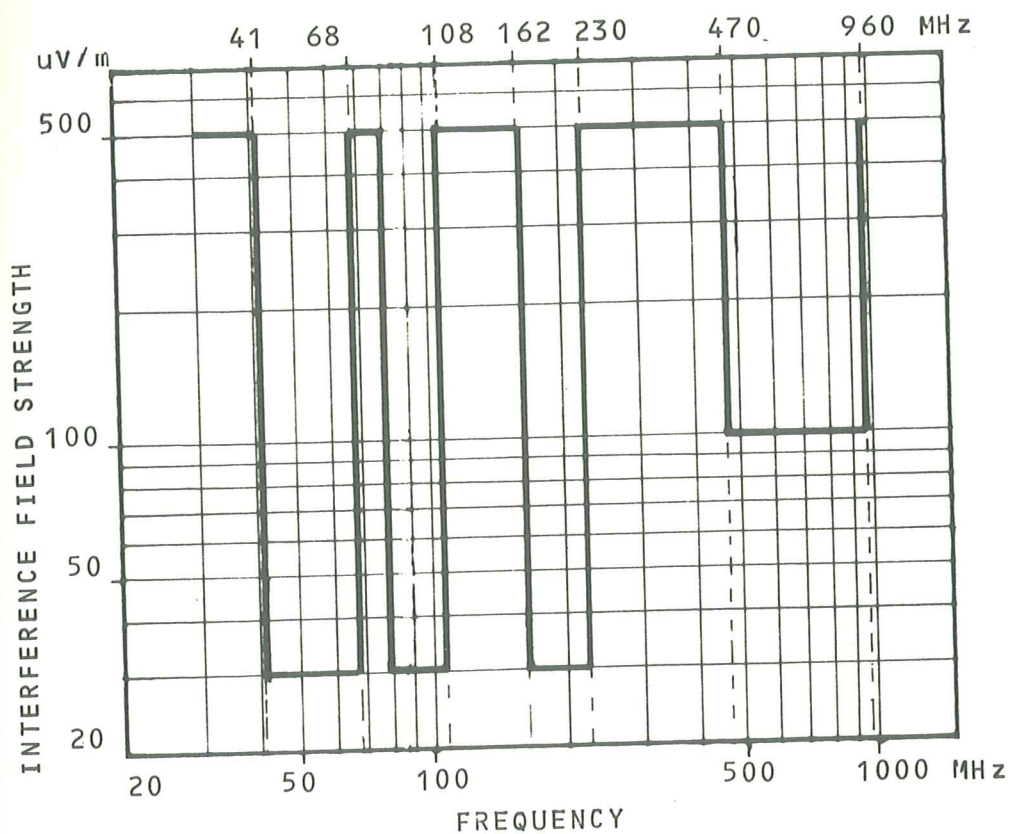


Fig. 3

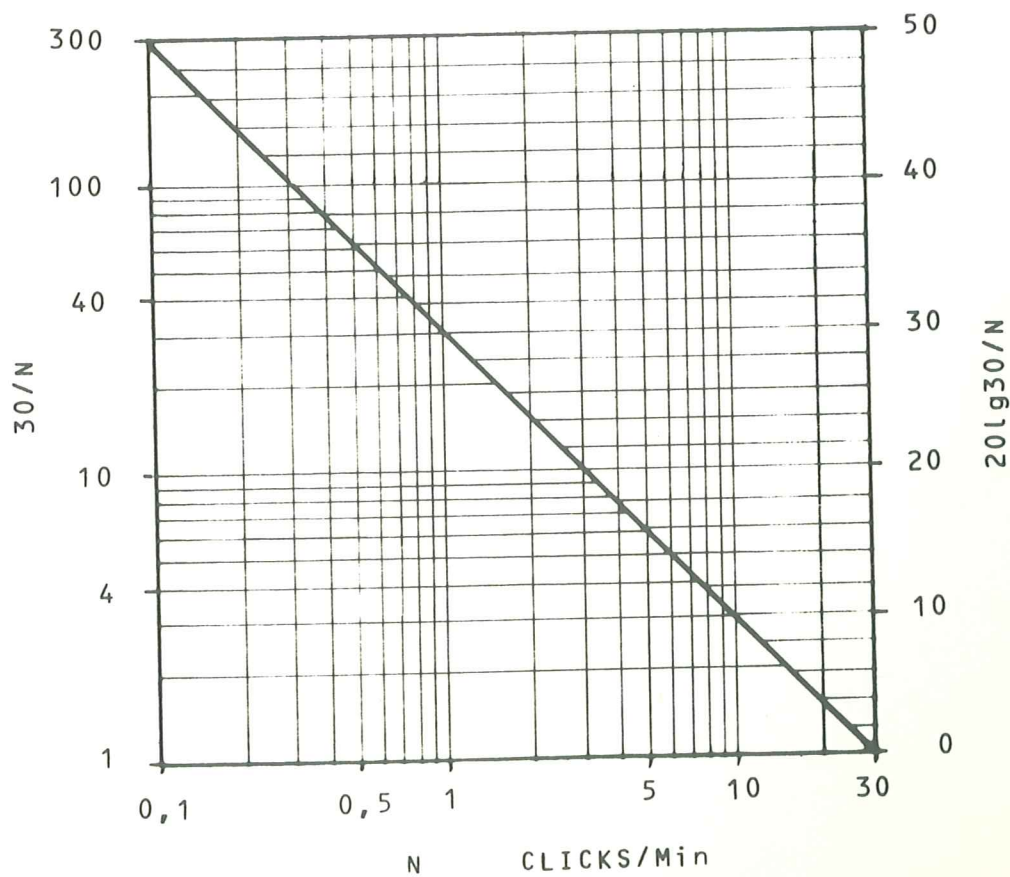
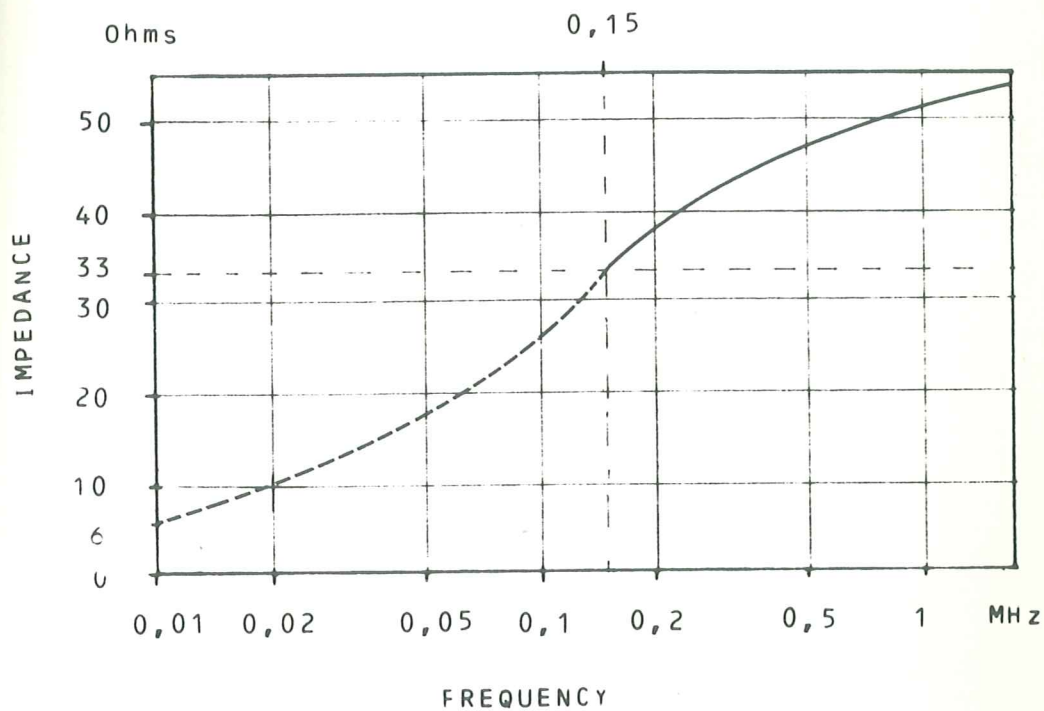


Fig. 4



NOTE 1 Measurements below 0,15 MHz are not yet specified but are under study.

NOTE 2 The tolerance of the impedance shall be $\pm 20\%$ and the phase angle shall not exceed 20° between each terminal and earth.

Fig. 5

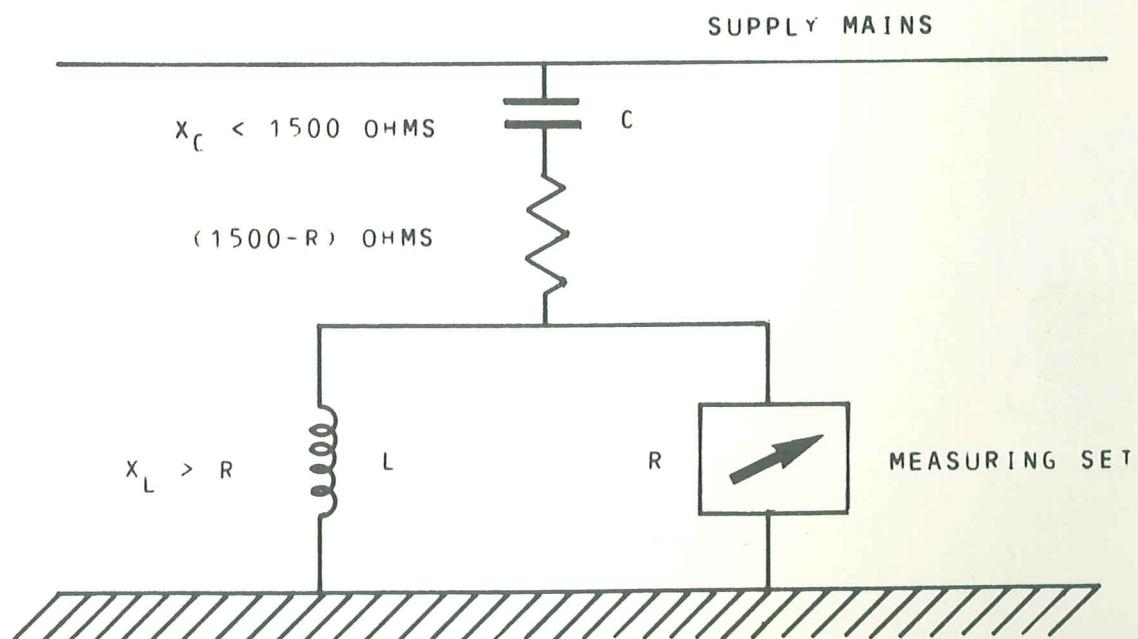


Fig. 6

