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EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

# STANDARD ECMA-172

## PROCEDURE FOR MEASUREMENT OF EMISSIONS OF ELECTRIC AND MAGNETIC FIELDS FROM VDUs FROM 5 Hz TO 400 kHz

June 1992

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## Brief History

In recent years there has been considerable publicity concerning emissions from VDUs. Many experiments have been conducted but no scientific basis for any health concern has been shown. However, in recognizing the desire for lower emission levels, measurement of these emissions is a clear requirement.

The extremely low frequency (ELF) - very low frequency (VLF) part of the spectrum has had no agreed method of measurement; this ECMA Standard represents an agreed method of measuring these fields.

The measurement practice defined in this ECMA Standard draws on work from the Swedish National Board for Measurement and Testing (MPR) and from IEEE Project P-1140.

This ECMA Standard provides a basis for a common and consistent method of measurement in the ELF and VLF frequency range from 5 Hz to 400 kHz.

As an illustration of considered and informed opinion, it is worth noting the following extract from the U.K. Health & Safety Commission Consultative Document published in January 1992:

> «The Schedule requires radiation with the exception of the visible part of the electromagnetic spectrum (i.e. visible light) to be reduced to negligible levels from the point of view of the protection of users' health and safety. In fact so little radiation is emitted from current designs of display screen equipment that no special action by users is necessary to meet this requirement.»
>
> *(extracted from "Work with Display Screen Equipment - Proposals for Regulations and guidance", published by the U.K. Health & Safety Commission (HSC) in January 1992, and obtainable from: Sir Robert Jones Memorial Workshops, Units 3 and 5-9, Grain Industrial Estate, Harlow Street, Liverpool L8 4UH, United Kingdom)*

Adopted as an ECMA Standard by the General Assembly of June 1992.

## Table of contents

## 1 Scope

This ECMA Standard defines a procedure for the measurement of electric and magnetic fields from visual display units using cathode ray tube technology (VDUs). This procedure applies to the measurement of electric and magnetic fields from 5 Hz to 400 kHz.

## 2 Conformance

A procedure for the measurement of electric and magnetic fields from visual display units using cathode ray tube technology (VDUs) from 5 Hz to 400 kHz is in conformance with this Standard if all mandatory requirements of this Standard are satisfied.

## 3 References

MPR 1990:8 Testmethods for Visual Display Units - visual ergonomics and emission characteristics

MPR 1990:10 Users handbook for evaluating Visual Display Units

The above MPR documents are published by the Swedish National Board for Measurement and Testing (MPR), and are obtainable from SWEDAC (C. Lindborg), Box 878, S-501 15 Borås, Sweden .

IEEE Project P-1140: Draft IEEE Standard Procedures for Measurement of Emissions of Electric and Magnetic Fields from VDTs from 5 Hz to 400 kHz

Ongoing uncertainties in the measurement of magnetic fields - analysis of the uncertainties, their effect, and recommendations for limiting rules: paper by Mr. Bengt Carlquist of Combinova AB

The above document, reference CU 322/90, may be ordered from Combinova AB, Fredsforsstigen 22-24, Box 20050, S-161 02 Bromma, Sweden - no. fax: +46 8 295 985.

## 4 Definitions

For the purpose of this Standard the following definitions apply:

### 4.1 Band I

The frequency band 5 Hz to 2 kHz.

### 4.2 Band II

The frequency band 2 kHz to 400 kHz.

### 4.3 Centre-centre point

The point on the front surface of the VDU screen that is both the horizontal and vertical mid-point.

### 4.4 Electric field

The term «electric field» is used in this context for the electric field strength. It is measured in volts per metre (V/m) as the true root-mean-square (rms) value of the amplitude of the electric field strength at the measuring probe within a given measuring bandwidth and measuring time.

### 4.5 Magnetic field

The term «magnetic field» is used in this context for the magnetic flux density. It is measured in teslas (T) as the root-mean-square (rms) value of the amplitude of the magnetic flux density vector within given measuring bandwidths and measuring time.

### 4.6 Tangential plane

The plane which is tangential to the front surface of the VDU screen at the centre-centre point.

## 5 General conditions

All testing and calibration shall be performed under normal environmental laboratory conditions.

### 5.1 Location of the VDU under test and measuring probe

The VDU under test and the measuring probe shall be positioned at least 1 m from all metallic structures and objects.

The VDU under test shall be connected to the mains supply via the power cord supplied by the manufacturer as part of the equipment. It shall be laid horizontally for 0,1 m from the test object and then vertically.

If the power plug permits an interchange of the phase and the neutral conductors, measurement shall be taken with the connection that gives the highest Band I reading.

Additional units and connecting cables necessary for the operation of the VDU but which are not part of the test shall be positioned such that they do not influence the measured values. It is acceptable to add shielding to these units and cables provided that the 1 m separation distance is maintained.

The cables between the measuring probe and the measuring instrument shall be positioned in such a way that they do not influence the measured electric field values.

*NOTE 1*

*The cables do not affect magnetic field measurements.*

### 5.2 Background electric field levels

Background electric field levels in the test area, including power line transmitted disturbances and internally generated noise in the measuring system, shall at any measurement point be at least 6 dB below the measured value.

The background electric field levels shall be measured with the VDU in place. All signal and power cables required for operation shall be connected to the VDU, which shall be un-powered. If grounding and shielding of peripheral equipment is required to achieve the specified ambient levels, the grounds and shields shall be tied to a common ground and a 1 m minimum clearance shall still be maintained.

If the measuring probe is repositioned, rather than the VDU being rotated, the background electric field levels shall be measured for each unique location of the measuring probe prior to measurement of the electric fields. The background level for each location shall be recorded in the test report (see 7.4).

### 5.3 Background magnetic field (magnetic flux density)

The background magnetic field in the test area, including power line transmitted disturbances and internally generated noise in the measuring system, shall at any measurement point be at least 6 dB below the measured value.

The background magnetic field levels shall be measured with the VDU in place. All signal and power cables required for operation shall be connected to the VDU, which shall be un-powered. If grounding and shielding of peripheral equipment is required to achieve the specified ambient levels, the grounds and shields shall be tied to a common ground and a 1 m minimum clearance shall still be maintained.

If the measuring probe is repositioned, rather than the VDU being rotated, the background magnetic field shall be measured for each unique location of the measuring probe prior to measurement of the magnetic fields. The background level for each location shall be recorded in the test report (see 7.4).

### 5.4 Power line voltage

The power line voltage of the VDU under test shall be within 3 % of its nominal value as stated on the manufacturer's name plate. The nominal value of the power line voltage shall be specified in the test report and the actual measured value shall be recorded (see 7.4).

If a voltage range is specified, then the selected test voltage shall be the one that produces the highest measured value. For this latter case, the power line voltage shall be recorded in the test report (see 7.4).

## 6 Test equipment for the measurement of electric fields

### 6.1 Probe

The alternating electric field emission from the VDU under test shall be determined by measuring the displacement current passing a given surface of a measuring probe; see annex A.

The probe shall consist of a disk of double-sided printed circuit board laminate, of diameter 300 mm. The copper layer shall be removed on the front side of the board in the annular zone between radii 50 mm and 52 mm (see figure 1). The copper disk remaining shall have a diameter of 100 mm inside this zone and shall be the active measuring surface, and shall be connected to one input terminal of an operational amplifier with capacitive feedback. The other input terminal of the operational amplifier shall be connected to the copper ring outside the active measuring surface, and shall also be connected to the back side of the board. These two surfaces shall then be connected to ground.

The output voltage V from the probe active surface with surface area A is related to the incident electric field E averaged over the active surface according to the formula:

$$V = \varepsilon_0 \times E \times \frac{A}{C}$$

where $\varepsilon_0$ is the permittivity of free-space and C is the feedback loop capacitor.

The feedback circuit of the operational amplifier is a capacitor C in parallel with a high value resistor R (see figure 1) to ensure that there is no DC voltage across capacitor C.

The signals from the probe shall be filtered according to table 1 for Band I and table 2 for Band II.

**Table 1 - Specification of filters for Band I**

| Frequency | < 5 Hz | 5 Hz | 100 Hz | 2 kHz | > 2 kHz |
|---|---|---|---|---|---|
| Attenuation | > 80 dB/dec | 3 dB | 0 dB | 3 dB | > 40 dB/dec |

**Table 2 - Specification of filters for Band II**

| Frequency | < 2 kHz | 2 kHz | 30 kHz | 400 kHz | > 400 kHz |
|---|---|---|---|---|---|
| Attenuation | > 80 dB/dec | 3 dB | 0 dB | 3 dB | > 40 dB/dec |

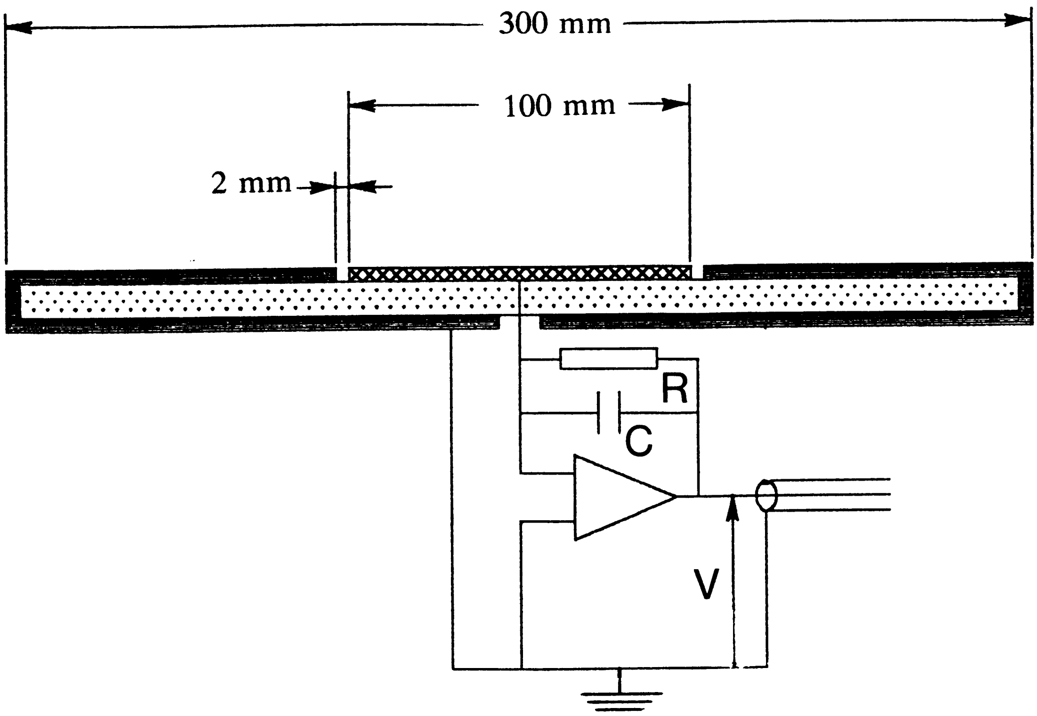


**Figure 1 - Electric field test probe**

After amplification, integration and filtering the output voltage of the measuring probe shall be used to determine the rms value of the electric field strength in both frequency bands.

The measuring time shall be sufficiently long to enable measurements of the specified accuracy at 50/60 Hz.

*NOTE 2*

*This enables use of commercially-available rms voltmeters if their ability to handle non-sinusoidal waveforms at high frequencies is taken into account.*

If the measured voltage varies by more than ± 5 % with time due to the limited measuring time, the measurements shall be repeated until the mean of the samples is stable within ± 5 %.

*NOTE 3*

*This can occur when testing VDUs with vertical refresh rates close to the power line frequency.*

## 6.2 Lowest measurable level

The lowest measurable level $L_l$ is related to the ambient level of the test site by the following expression:

$$L_l = \frac{B \times 100\%}{25\% - 5\%} = B \times 5$$

where B is the ambient level in V/m and 25 % is the maximum error of the measuring protocol.

Example: the lowest measurable level $L_l$ for an ambient level of 30 V/m, in Band I, is:

$L_l$ = 30 V/m x 5 = 150 V/m

*NOTE 4*

*See the publication by B. Carlquist referenced in clause 3 of this Standard.*

**6.3 Calibration**

Uniform fields of known magnitude and direction can be created for calibration purposes with parallel plates provided that the spacing of the plates, relative to the plate's dimension, is sufficiently small. The uniform field value E is given by V/d, where V is the applied potential difference and d is the spacing. The measuring probe shall be calibrated using a parallel-plate capacitor with air dielectric consisting of the measuring probe and a metal plate. The active measuring surface of the probe shall be at a distance of 25 mm from the other plate. The dimensions of the capacitor plate shall be at least 300 mm. The distance to the nearest ground plane, or other metallic structures and objects, shall be at least 1 m.

The calibration shall be performed with sinusoidal voltages applied to the parallel-plate capacitor at the frequencies and levels specified below:

Band I : 50 Hz, 100 Hz, 500 Hz, and 1 kHz; 10 V/m, 50 V/m, and 250 V/m

Band II : 15 kHz, 30 kHz, 60 kHz, and 120 kHz; 1 V/m, 10 V/m, and 100 V/m

Recorded values at this calibration shall not deviate by more than ± 5 % from the nominal value.

**6.4 Procedure for the measurement of the electric field strength**

The true rms value of the amplitude of the electric field strength vector shall be measured in front of the test object for Band I, and at its four sides for Band II; see figure 2.

The VDU shall be positioned such that the horizontal plane is at right angles to the tangential plane of the VDU screen. The right angle distance L along the normal to the tangential plane through the centre-centre point between the screen surface and the back side of the VDU shall be measured. The origin of the cylindrical coordinate system shall be chosen to be situated at a distance of L/2 behind the screen surface on the normal to the tangential plane through the centre-centre point, as shown in figure 2.

The Z-axis is defined as perpendicular to the horizontal plane. The angular reference direction is then along the above-mentioned normal in the direction pointing outwards from the screen. Angle θ is positive in the counter-clockwise direction. Measurements shall be taken at all points which have a minimum clearance of 0,3 m to the outer surface of the VDU and with coordinates according to:

$Z = 0$

$r = L/2 + 0,5$ m

$\theta = 0°$ for Band I

$\theta = 0°, 90°, 180°$ and $270°$ for Band II

The measuring probe and the VDU shall be connected to common ground.

The VDU shall display a full screen pattern of upper case scrolling H. The brightness and contrast controls shall be set to their centre positions.

If the VDU has a stand-by mode where nothing is displayed on the screen then this mode shall be measured at all points.

Care shall be taken when measuring Band I electric fields, since position and movement of personnel and objects affect the results.

When a removable screen filter is a part of the equipment under test, its type, manufacturer and dimensions shall be reported.

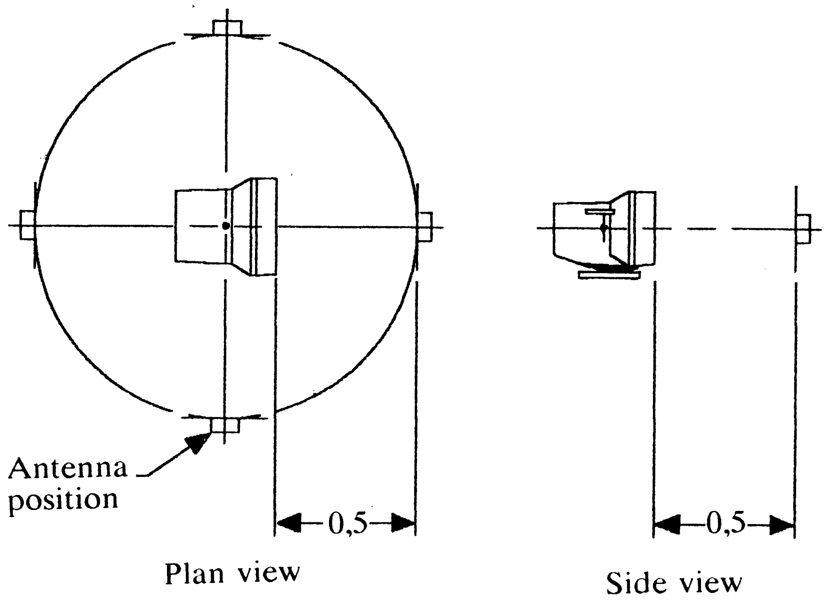


**Figure 2 - Geometry of the electric field test points**

### 6.5 Measurement tolerance

The test shall be performed in such a way that the total measurement tolerance in the test result is not greater than:

± (10 % of reading + $L_1$) V/m

where $L_1$ is the lowest measurable level.

## 7 Test equipment for the measurement of magnetic fields

The measurement probe shall consist of three mutually-perpendicular concentric circular coils each with an area of 0,01 $m^2$. The coils may depart from circular shape where they cross. The minimum inner diameter shall be 110 mm and the maximum outer diameter 116 mm. The measuring coils shall not be sensitive to electric fields.

The resonant frequency of each coil appropriately connected to cables and amplifiers shall be greater than 12 kHz for Band I and greater than 2,5 MHz for Band II. The resonances shall be suppressed by resistive loading of each coil.

Each coil shall be followed by amplifiers and integrating networks to make the output voltage proportional to the magnetic flux density independent of frequency. The requirement on the frequency response is given by the calibration procedure.

The signals from the coil systems shall be filtered by high pass and low pass filters. The specifications of the filters are given in tables 1 and 2.

After amplification, integration and filtering the signals from the three coils in each coil set shall be used as input for calculations of the rms value of the magnitude of the magnetic flux density vector in both frequency bands. It is permissible to calculate the rms value for each of the coil signals and use the root of the square sum of rms values as the test result.

The measuring time shall be sufficiently long to enable measurements of the specified accuracy at 50/60 Hz.

*NOTE 5*

*This enables use of commercially-available rms voltmeters, if their ability to handle non-sinusoidal waveforms at high frequencies is taken into account.*

## 7.1 Calibration

The measuring system shall be calibrated using a Helmholtz-coil type calibration coil. Calibration shall be performed with sinusoidal fields at the following frequencies and levels:

Band I : 50 Hz, 100 Hz, 500 Hz, and 1 kHz; 100 nT, 500 nT, and 2500 nT

Band II : 15 kHz, 30 kHz, 60 kHz, and 120 kHz; 10 nT, 50 nT, and 250 nT

Recorded values at this calibration shall not deviate by more than ± 5 % from the nominal value.

The calibration shall be performed in the three individual planes of the measuring coils, and for one situation where approximately the same flux density passes through all three coils.

## 7.2 Procedure for the measurement of the magnetic flux density

The true rms value of the amplitude of the magnetic field density vector shall be measured at at least 24 points on a cylindrical surface around the test object for both Band I and Band II. The frequency ranges are selected by specified filters in the measuring equipment.

The measuring geometry is illustrated in figure 3, and the measuring points are mathematically defined below.

*NOTE 6*

*Test results show that 24 points adequately describe the magnetic field profile of the equipment under test (EUT) although other specifications may require additional test points.*

The VDU shall be positioned such that the horizontal plane is at right angles to the tangential plane of the VDU screen. The right angle distance L along the normal to the tangential plane through the centre-centre point between the screen surface and the back side of the VDU shall be measured. The origin of the cylindrical coordinate system shall be chosen to be situated at a distance of L/2 behind the screen surface on the normal to the tangential plane through the centre-centre point, as shown in figure 3.

The Z-axis is defined as perpendicular to the horizontal plane. The angular reference direction is then along the above-mentioned normal in the direction pointing outwards from the screen. Angle θ is positive in the counter-clockwise direction. Measurements shall be taken at all points which have a minimum clearance of 0,3 m to the outer surface of the VDU and with coordinates according to:

$Z = -0{,}3$

$Z = 0$

$Z = 0{,}3$

$r = L/2 + 0{,}5$ m

$\theta = p \times 45°$

where p represents all integers in the range $0 \leq p \leq 7$.

The measuring coils and the VDU shall be stationary during measurements.

The VDU shall display a full screen pattern of upper case scrolling H. The brightness and contrast controls shall be set to their centre positions.

If the VDU has a stand-by mode where nothing is displayed on the screen the measurements shall be repeated for both modes of operation at the point Z = 0 and θ = 0. If the measured values at this point differ by more than ± 5 % between the two modes, then all points shall be measured in both modes.

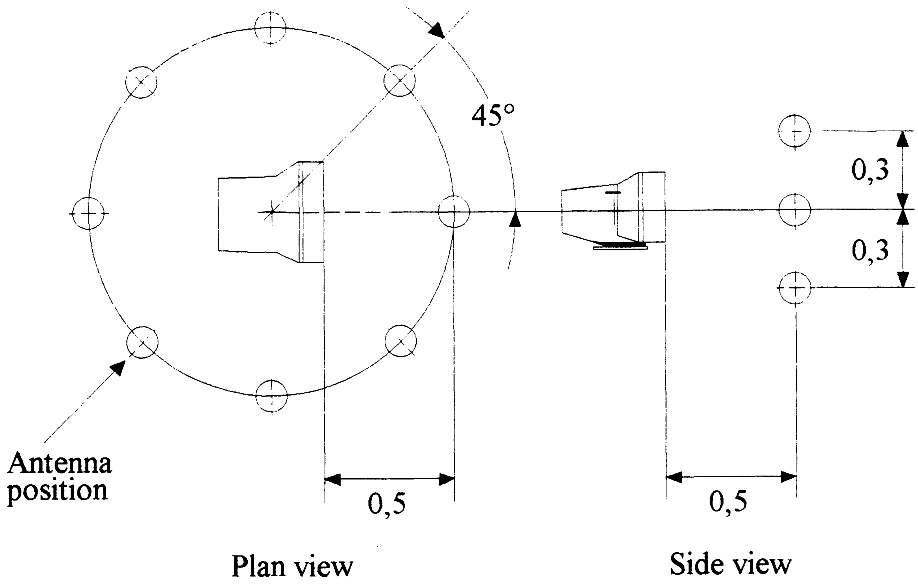


**Figure 3 - Geometry of the magnetic field test points**

## 7.3 Measurement tolerance

The test shall be performed in such a way that the total measurement tolerance in the test result is not greater than:

± (10 % of reading + $L_1$) nT

where $L_1$ is the lowest measurable level in nanoteslas.

## 7.4 Presentation of results

All results shall be presented as rms values of the magnetic flux density expressed in nanoteslas for the two frequency ranges. The values in front of the screen, and the maximum value and its position shall be given both for normal and for stand-by operation if they differ.

The test report shall record a full description of the VDU to identify it and its type, and also its grounding configuration during test.

Annex B gives an example of a test report.

# Annex A

**(informative)**

**Mode of Operation of the Measuring Probe for Electric Fields**

The pickup probe recommended in this Standard is based on capacitive coupling. Figure A.1 shows a simplified setup. The voltage source is tied to the plate A and ground; plate B is connected to ground. Initially, assume that there is no charge on either plate, and therefore no electric field between them. For the potential of plate A to rise, the voltage source must inject charge onto plate A, thereby creating a positive electric field. An equal amount of negative charge must flow onto plate B if its potential is to remain at ground. This is the origin of the displacement current. A conductor requires charge movement (current) in order to maintain a fixed potential in a changing electric field. Conversely, if plate B is disconnected from ground, its potential will rise and fall in function of the changes at plate A.

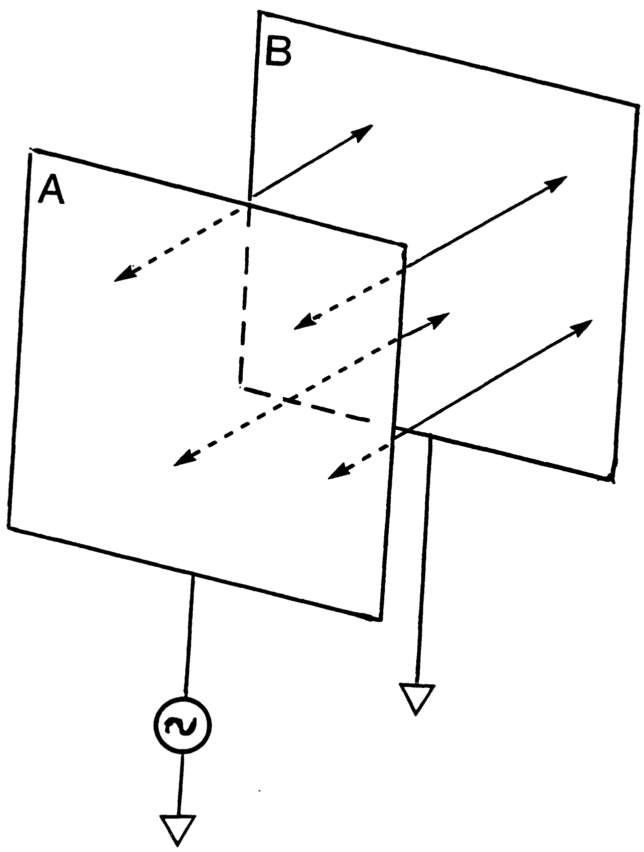


**Figure A.1 - Simplified setup**

The pickup probe is shown schematically in figure A.2. Its design relies on the concepts discussed above, which can be realised in practice as follows:

- the outer copper ring of the probe is tied to ground; its potential will not vary, and so will provide a reference voltage to the non-inverting input of the amplifier;
- the central disk, connected to the inverting input of the amplifier is electrically isolated from the outer copper ring;
- the output of the amplifier is connected to the inverting input through a feedback capacitor.

In this fashion, the amplifier will attempt to keep its two inputs at the same voltage by changing its output and transferring charge from its output through the feedback capacitor. The amount of charge required is proportional to the electric field impinging on the disk. Thus, the output voltage of the amplifier is proportional to the electric field at the disk.

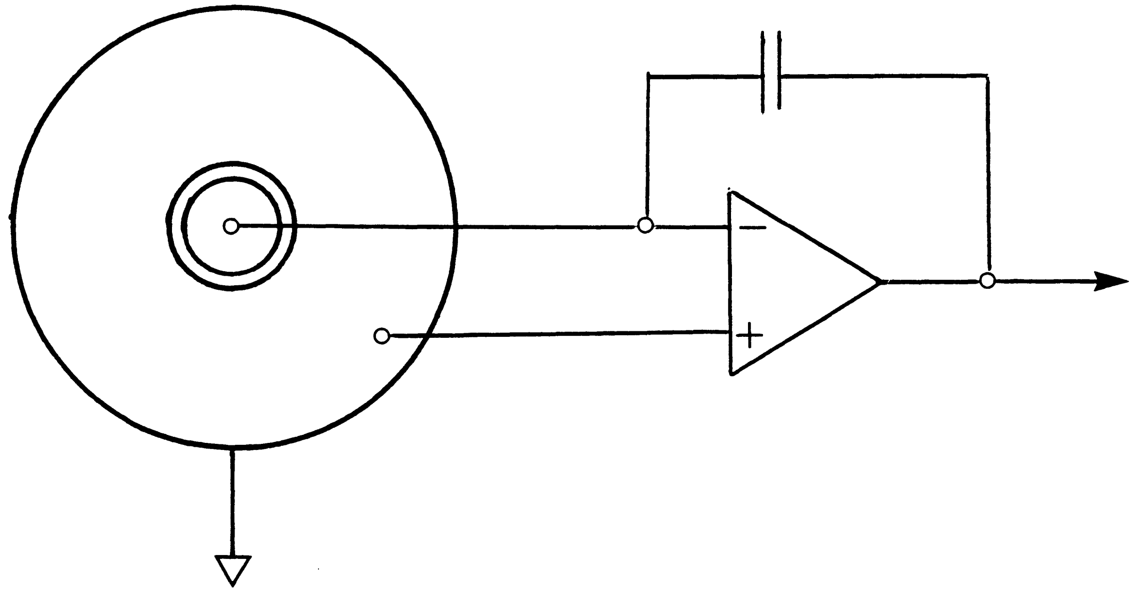

**Figure A.2 - Schematic view of the probe**

# Annex B

**(informative)**

## VDU Characterization - An Example of a Test Report Proforma

Manufacturer: ________________________________

Model: ________________________________

Serial Number: ________________________________

Nominal Line Voltage: ________________________________

Measured Line Voltage: ________________________________

Test Mode: Ambient / Scrolling Hs / Standby Mode

Brightness and Contrast Position: ________________________________

Software: ________________________________

Tested By: ________________________________

Test Date: ________________________________

**Table B.1 - Magnetic flux density (nT)**

| | Z = - 0,3 m | | Z = 0 | | Z = 0,3 m | |
|---|---|---|---|---|---|---|
| Angle | Band | | Band | | Band | |
| θ | I | II | I | II | I | II |
| 0° | | | | | | |
| 45° | | | | | | |
| 90° | | | | | | |
| 135° | | | | | | |
| 180° | | | | | | |
| 225° | | | | | | |
| 270° | | | | | | |
| 315° | | | | | | |

**Table B.2 - Electric field strength**

| Angle | Band | |
|---|---|---|
| θ | I | II |
| 0° | | |
| 90° | not applicable | |
| 180° | not applicable | |
| 270° | not applicable | |