

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz –**

**Part 6: Measurement of conducted emissions – Magnetic probe method**

**Circuits intégrés – Mesure des émissions électromagnétiques, 150 kHz à 1 GHz –  
Partie 6: Mesure des émissions conduites – Méthode de la sonde magnétique**

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# INTERNATIONAL STANDARD

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INTEGRATED CIRCUITS –  
MEASUREMENT OF ELECTROMAGNETIC EMISSIONS,  
150 kHz TO 1 GHz –****Part 6: Measurement of conducted emissions –  
Magnetic probe method**

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

International Standard IEC 61967-6 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

Annex A forms an integral part of this standard.

Annexes B, C, D and E are for information only.

This standard should be read in conjunction with IEC 61967-1.

IEC 61967 consists of the following parts, under the general title *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz*:

Part 1: General conditions and definitions

Part 2: Measurement of radiated emissions – TEM-cell method<sup>1</sup>

Part 3: Measurement of radiated emissions – Surface scan method (technical specification)<sup>1</sup>

Part 4: Measurement of conducted emissions – 1 Ω/150 Ω direct coupling method<sup>2</sup>

Part 5: Measurement of conducted emissions – Workbench Faraday cage method<sup>2</sup>

Part 6: Measurement of conducted emissions – Magnetic probe method

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<sup>1</sup> Under consideration.

<sup>2</sup> To be published.



# INTEGRATED CIRCUITS – MEASUREMENT OF ELECTROMAGNETIC EMISSIONS, 150 kHz TO 1 GHz –

## Part 6: Measurement of conducted emissions – Magnetic probe method

### 1 Scope

This part of the IEC 61967 specifies a method for evaluating RF currents on the pins of an integrated circuit (IC) by means of non-contact current measurement using a miniature magnetic probe. This method is capable of measuring the RF currents generated by the IC over a frequency range of 0,15 MHz to 1 000 MHz. This method is applicable to the measurement of a single IC or a chip set of ICs on the standardized test board for characterization and comparison purposes. It is also usable to evaluate the electromagnetic characteristics of an IC or group of ICs on an actual application PCB for emission reduction purposes. This method is called the "magnetic probe method".

### 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.

IEC 61967-1, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 1: General conditions and definitions*

IEC 61967-4, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 4: Measurement of conducted emissions – 1 Ω/150 Ω direct coupling method*<sup>3</sup>

### 3 Definitions

For the purposes of this part of IEC 61967 the definitions found in IEC 61967-1 apply.

### 4 General

#### 4.1 Measurement philosophy

The emissions radiated from a PCB are, in part, caused by RF current generated by the onboard IC which drives PCB traces, PCB ground and supply planes, and cables connected to the PCB. All of these can act as RF antennas to radiate the emissions. The emission level is proportional to the driving RF current, and is also affected significantly by PCB design, radiation effectiveness of the pseudo-antennas, and noise coupling path coefficients from the IC to the pseudo-antennas.

For this emission mechanism, the driving force of the IC can be a significant parameter for both users and manufacturers to estimate and predict the electromagnetic characteristics of a PCB, module, or system. A measure of the emission driving force can be obtained by measuring the RF currents generated by the IC under test. Thus, the measured RF noise current can be regarded as an indicator of the undesirable electromagnetic emission driving force generated by the IC.

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<sup>3</sup> To be published.

## 4.2 Measurement principle

Using this test method, the RF current on the power supply pins and I/O pins of an IC under test can be measured using a miniature triplate-structured magnetic probe. This probe measures the magnetic field at a specified height over a power supply or I/O strip conductor on the standardized test board in a controlled manner. The RF current is calculated from the measured magnetic field using the formula described in 8.2. With accurate mechanical placement of the magnetic probe, this method provides a high degree of repeatability. In addition, the frequency range of this method can be extended subject to the limitations described in 5.2. Higher frequencies can be obtained without a substantial influence on accuracy. The estimation of the RF current over the power supply or I/O strip conductor is an easy and handy way of characterizing and comparing the ICs.

## 5 Test conditions

### 5.1 General

General test conditions are described in IEC 61967-1.

### 5.2 Frequency range

The effective frequency range of this measurement method is 0,15 MHz to 1 000 MHz. The maximum frequency can be extended, if desired, subject to the limitations of the test set-up. The upper limit of the frequency range is directly related to high frequency characteristics of the magnetic probe and its distance from the line under test as described in annex B. At a low frequency region of 0,15 MHz to 10 MHz, however, it may be advisable to use a low noise pre-amplifier to improve dynamic range of the measurement.

## 6 Test equipment

### 6.1 General

For general information on test equipment see IEC 61967-1.

### 6.2 Magnetic probe

The magnetic probe shall be a triplate-structured strip line composed of a three-layer PCB. Recommended probe construction details are shown in figures 1, 2, 3 and 4.

An SMA connector is attached at the edge of the PCB opposite to the rectangular loop portion of the probe as shown in the figures. Attachment pads for the SMA connector are on layers 1 and 3, which are connected to each other through four vias. The strip conductor pattern is on layer 2, which is connected to the centre pin of the SMA connector.

### 6.3 Probe spacing fixture and placement

The probe output voltage depends on the distance between the probe tip and the strip conductor under measurement. This makes it very critical to maintain a 1 mm space between the strip conductor and the magnetic probe tip during this measurement. Therefore, a probe spacing fixture shall be used to maintain  $1,0 \text{ mm} \pm 0,1 \text{ mm}$  spacing between the bottom of the rectangular loop portion of the probe and strip line on the IC test board, or the entire probe can be molded into a piece of fixing block which houses the probe so as to maintain the specified space precisely as shown in figure 10.

In addition, the probe output voltage depends on probe placement angle ( $\varphi$ ) to direction of microstrip line under measurement. According to an experimental measurement on angle patterns of probe directional placement, the angle shall be less than  $15^\circ$  for amplitude error to be less than  $-2$  dB. See annex D for details.

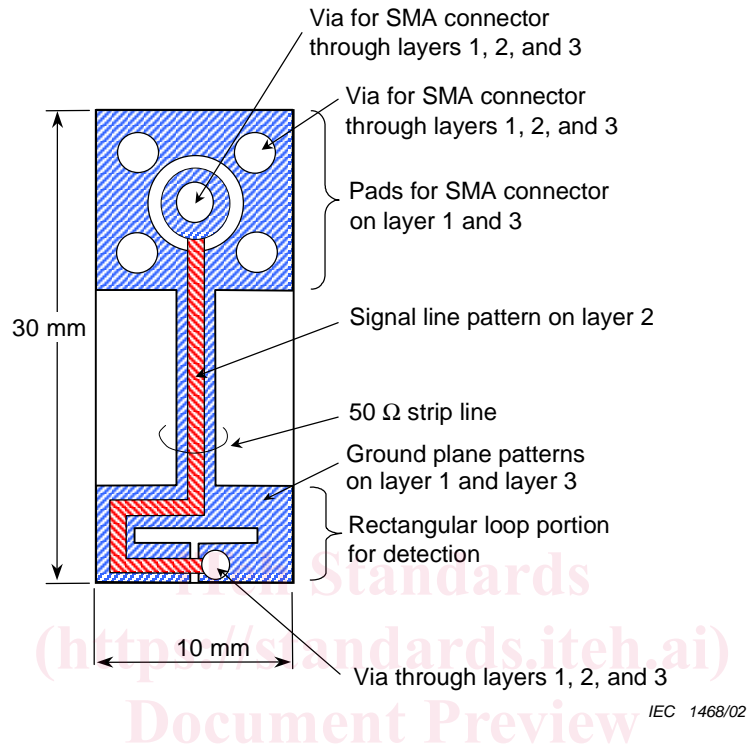


Figure 1 – Magnetic probe

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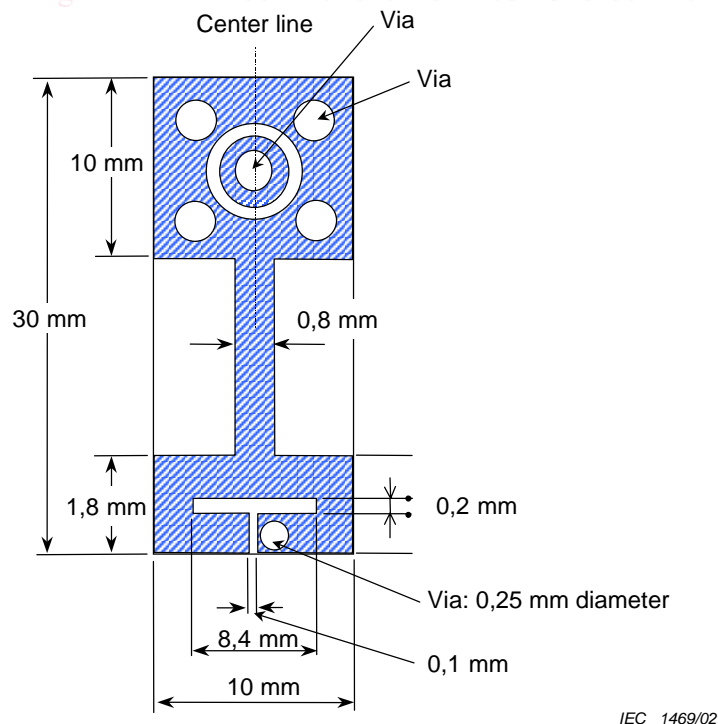


Figure 2 – Magnetic probe – First and third layers

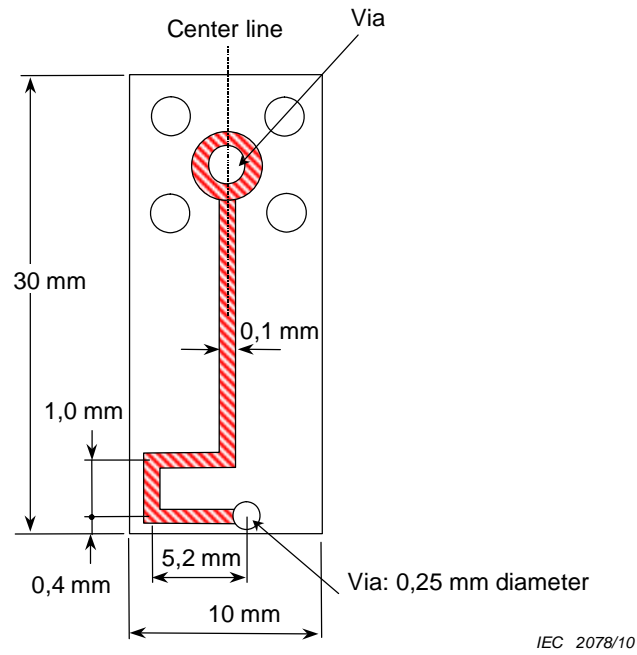


Figure 3 – Magnetic probe – Second layer

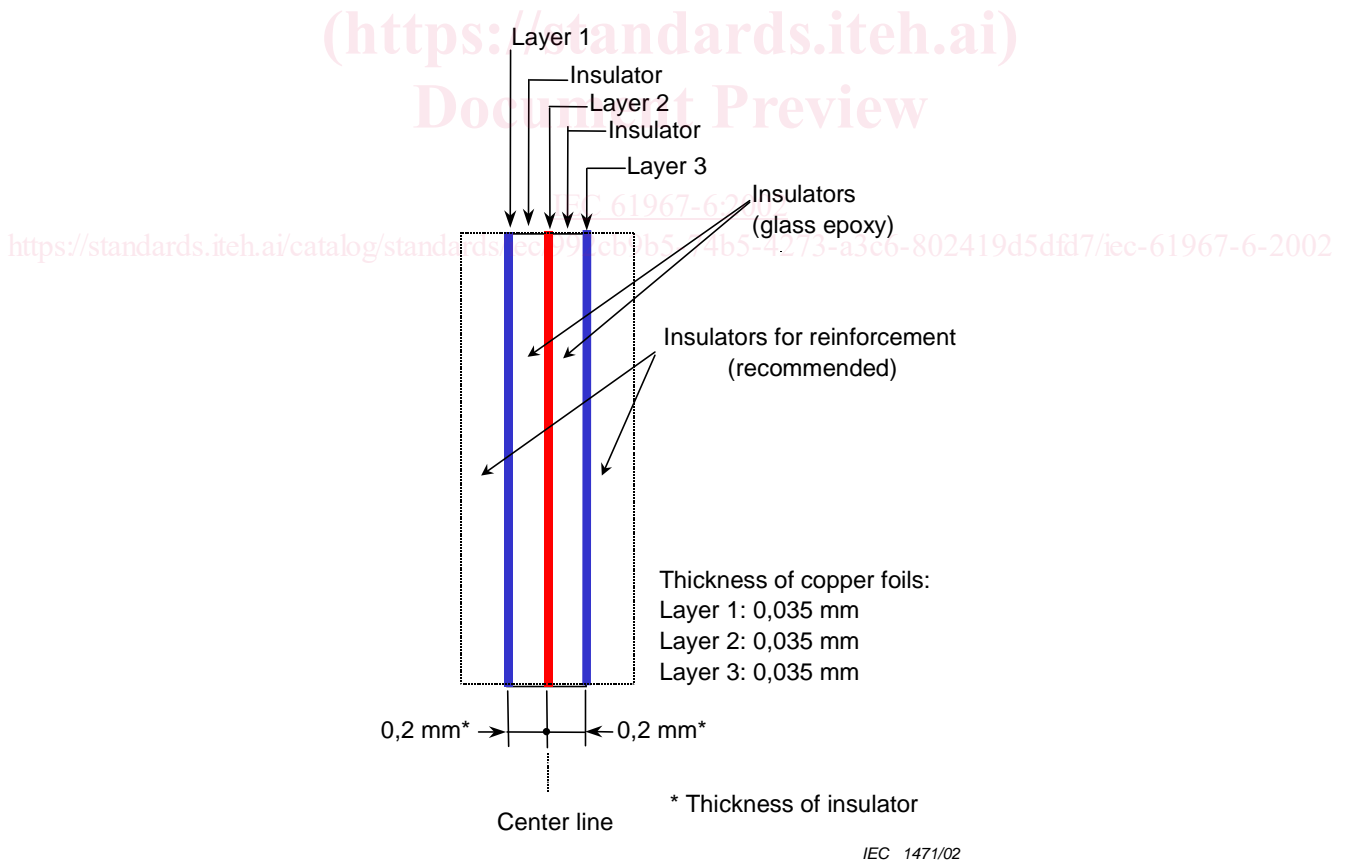


Figure 4 – Magnetic probe – Layer construction

## 7 Test set-up

### 7.1 General

General test set-up requirements are described in IEC 61967-1.

The measurement set-up and circuit schematic of the magnetic probe measurement method are shown in figures 10 and 11, respectively.

### 7.2 Probe calibration

The magnetic probe used shall be calibrated to obtain accurate correlation between the measured magnetic field intensity and the estimated RF current. The probe calibration shall be in accordance with the method described in annex A (microstrip line method).

### 7.3 Modifications to standardized IC test board

The standardized IC test board described in IEC 61967-1 shall be used. However, it shall be adapted as shown in figures 5, 6, 7, 8, and 9.

#### 7.3.1 Layer arrangement

The IC test board shall have a minimum of four layers. It is recommended to use a four-layer IC test board as shown in figures 5 and 6. If necessary, additional layers may be inserted between the top layer and the microstrip ground layer to accommodate additional signal and/or power routing. The construction of the IC test board shall be as specified in IEC 61967-1, except as noted below in the case of  $n$  layers in general.

- 1) Top layer (layer 1): The IC under test shall be put on layer 1. See IEC 61967-1.
- 2) Layer next to the bottom layer (layer  $n-1$ ): A ground plane area shall be formed on layer  $n-1$  to provide a reference for the microstrip structures on the bottom layer. The ground plane can cover the entire layer or can be limited to the area under the microstrip structures as shown in the dotted line area of figures 7 and 8. This ground plane area shall have a minimum width of 11 mm and a minimum length of 14 mm.
- 3) Bottom layer (layer  $n$ ): The microstrip conductor lines for measurement and peripheral ground planes shall be on layer  $n$ . The microstrip conductor lines shall be in accordance with figures 7 and 8 for power lines and I/O lines, respectively. The width of the strip conductor line shall be 1,0 mm at maximum to achieve a high spatial resolution. See annex C for details. The length of the microstrip conductor lines should be between 14 mm and 25 mm in length to avoid standing waves.

#### 7.3.2 Layer thickness

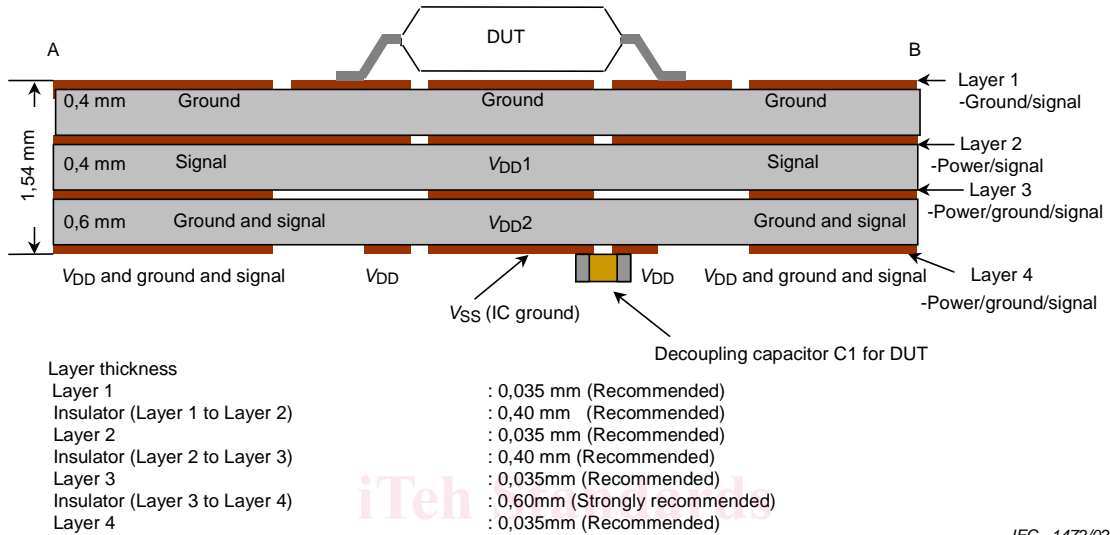
The PCB insulator thickness of 0,6 mm between layer  $n-1$  and layer  $n$  is strongly recommended. The coplanar gap between the measurement line and coplanar ground planes shall be at least 2,0 mm and shall be at least three times the insulator thickness.

#### 7.3.3 Decoupling capacitors

Decoupling capacitors (C1, C2) shall be used between the power supply lines and ground planes on the test board as shown in figure 11. The capacitor (C2) shall be placed as close as possible to the measurement area of the power supply line to provide low RF impedance. The distance between C2 and the via to the  $V_{DD}$  land shall be no more than 25 mm as shown in figure 7. The capacitor (C1) shall be placed between the IC  $V_{DD}$  land and the IC ground as shown in figure 9.

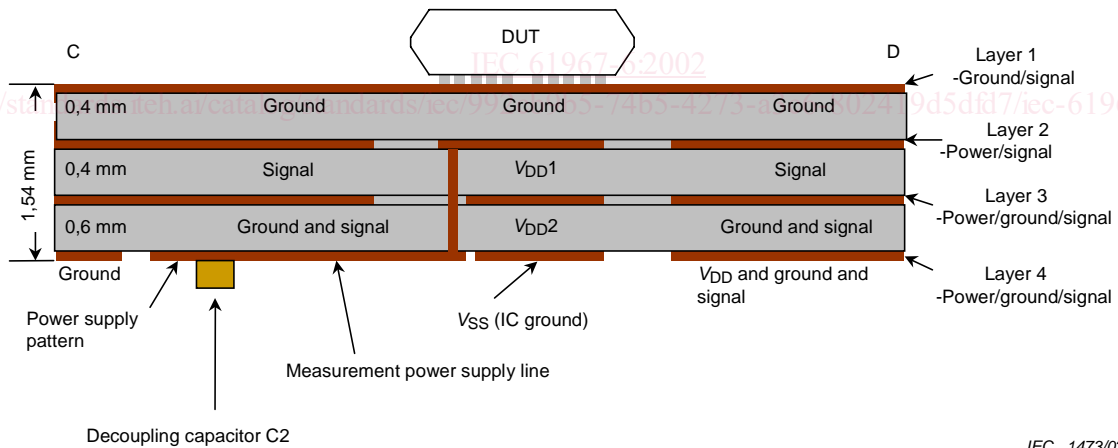
7.3.4 I/O pin loading

This measurement can be used to measure the RF current of a single I/O pin. The I/O pin current shall be measured pin by pin. The layout of the pin loading shall be in accordance with figures 8 and 9. This pin should be loaded with an impedance matching network with a resistance of 150 Ω as shown in figure 11. The impedance matching network should be loaded by a 50 Ω resistor (R3) or a 50 Ω input impedance of normal measurement equipment (receiver).



IEC 1472/02

Figure 5 – Standardized IC test board – Sectional view 1



IEC 1473/02

Figure 6 – Standardized IC test board – Sectional view 2 – Measurement line