



BSI Standards Publication

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

Part 4: Measurement of conducted emissions - 1
ohm/150 ohm direct coupling method

National foreword

This British Standard is the UK implementation of EN 61967-4:2002, incorporating amendment A1:2006 and corrigendum December 2006. It is identical to IEC 61967-4:2002, incorporating amendment 1:2006 and corrigendum June 2017.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors.

A list of organizations represented on this committee can be obtained on request to its secretary.

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30 April 2018	Implementation of IEC corrigendum June 2017: Figure 5 corrected

English version

**Integrated circuits -
Measurement of electromagnetic emissions, 150 kHz to 1 GHz
Part 4: Measurement of conducted emissions -
1 ohm/150 ohm direct coupling method
(IEC 61967-4:2002)**

Circuits intégrés -
Mesure des émissions électromagnétiques,
150 kHz à 1 GHz
Partie 4: Mesure des émissions conduites -
Méthode par couplage direct
1 ohm/150 ohm
(CEI 61967-4:2002 + A1:2006)

Integrierte Schaltungen -
Messung von elektromagnetischen
Ausstrahlungen im Frequenzbereich
von 150 kHz bis 1 GHz
Teil 4: Messung der leitungsgeführten
Ausstrahlungen -
Messung mit direkter
1 Ohm/150 Ohm-Kopplung
(IEC 61967-4:2002 + A1:2006)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 47A/636/FDIS, future edition 1 of IEC 61967-4, prepared by SC 47A, Integrated circuits, of IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61967-4 on 2002-06-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2003-03-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2005-06-01

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A and ZA are normative and annexes B, C, D and E are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61967-4:2002 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 47A/735/FDIS, future amendment 1 to IEC 61967-4:2002, prepared by SC 47A, Integrated circuits, of IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 61967-4:2002 on 2006-02-01.

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- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2009-02-01

This European Standard makes reference to International Standards. Where the International Standard referred to has been endorsed as a European Standard or a home-grown European Standard exists, this European Standard shall be applied instead. Pertinent information can be found on the CENELEC web site.

Endorsement notice

The text of amendment 1:2006 to the International Standard IEC 61967-4:2002 was approved by CENELEC as an amendment to the European Standard without any modification.

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

Part 4: Measurement of conducted emissions – 1 Ω /150 Ω direct coupling method

1 Scope

This part of IEC 61967 specifies a method to measure the conducted electromagnetic emission (EME) of integrated circuits by direct radio frequency (RF) current measurement with a 1 Ω resistive probe and RF voltage measurement using a 150 Ω coupling network. These methods guarantee a high degree of repeatability and correlation of EME measurements.

IEC 61967-1 specifies general conditions and definitions of the test methods.

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 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

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

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

CISPR 16-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-1-3, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*

CISPR 16-1-4, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances*

CISPR 16-1-5, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration test sites for 30 MHz to 1 000 MHz* Ⓐ

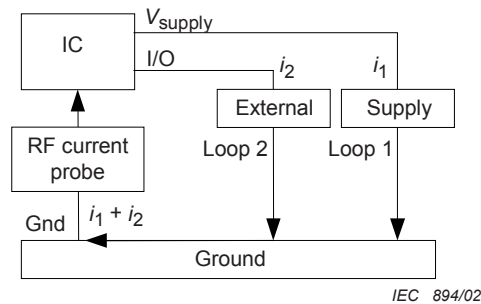


Figure 1 – Example of two emitting loops returning to the IC via common ground

The emission of an IC is generated by sufficiently fast changes of voltages and currents inside the IC. These changes drive RF currents inside and outside the IC. The RF currents cause conducted EME, which is mainly distributed via the IC pins conductor loops in the printed circuit board (PCB) and the cabling. These loops are regarded as the emitting loop antennas. In comparison to the dimension of these loops, the loops in the internal IC structure are considered to be small.

The RF currents that accompany ICs action are different in amplitude, phase and spectral content. Any RF current has its own loop that returns to the IC. All loops return mostly via the ground or supply connection back to the IC. In figure 1, this is shown for two loops returning via ground. Loop 1 represents the supply wiring harness for the IC while loop 2 represents the routing of an output signal. The common return path via ground is a suitable location to measure the conducted EME as the measurement of the common RF sum current of the ground pin. This test is named the “RF current measurement”.

If the IC under test has only one ground pin and all other pins are suspected to contribute essentially to the EME, then the RF sum current is measured between the ground pin of the IC under test and the ground (see $i_1 + i_2$ in figure 1).

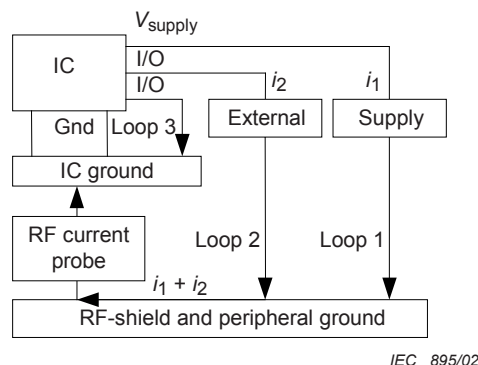


Figure 2 – Example of IC with two ground pins, a small I/O loop and two emitting loops

If the IC under test has more than one ground pin or some of the pins are not suspected to contribute much to the whole EME, then the IC under test gets its own ground plane as shown in figure 2. This ground plane is named “IC ground”. It is kept separately from the other ground, that is named “RF-shield and peripheral ground”. The RF current is measured between the IC ground and the peripheral ground.

ICs are often used in different configurations based on the application. For instance, a microcontroller could be used as a single chip controller, with the I/O ports directly connected to the external cabling system. In order to understand the influence of a single I/O pin on the emission level of the IC, an additional measurement procedure, using the same equipment, is provided. This measurement is named “single pin RF voltage measurement at IC pins” (see also 4.3). In addition to the RF sum current measurement, the RF current measurement of a single supply pin may be of interest in the analysis of an IC. This can also be attained with application of the RF current measurement probe. For example, the RF current probe can be applied to any of the multiple ground or supply pins in order to quantify the contribution of the measured pin to the whole emission.

4.2 RF current measurement

In the test procedure this measurement shall be made by measuring the voltage across the $1\ \Omega$ resistance of a RF current probe using a test receiver. The measurement shall be made at the location shown in figure 1 and figure 2. The construction of the RF current probe is specified in 6.2. The RF voltage level measured by the receiver is the voltage resulting from all of RF currents returning to the IC through the probe impedance. The voltage measurement can be converted to current by dividing the voltage by the probe impedance.

4.3 RF voltage measurement at IC pins

This measurement is used to identify the contribution of a single pin or a group of pins to the EME of the IC under test. This measurement is only applied to those pins of the IC under test that are intended to be connected directly to long (longer than 10 cm) PCB traces or wiring harness. These pins are loaded by a typical antenna impedance of $150\ \Omega$, as specified in IEC 61000-4-6. In order to connect the test receiver, that has an input-impedance of $50\ \Omega$, the load has to be built as an impedance matching network. This matching network is defined in 6.4.

Other I/O-pins of an IC may be loaded as specified in the general part of IEC 61967-1.

4.4 Assessment of the measurement technique

The above techniques have the following properties:

- high measurement reproducibility, because few parameters influence the result;
- capability to compare different IC configurations (e.g. packages);
- single pin EME measurements of the various I/O pins are dependent on their importance for the emission in a specific application;
- assessment of the EME contribution of the IC using current sum measurement;
- linear transfer function with constant frequency response as the measurement is made using resistive impedance;
- simple calibration of the measurement impedance using insertion loss measurement;
- measurement is also possible at very low frequencies.

With these characteristics it is possible to measure the EME of ICs with a high degree of reproducibility and therefore this technique offers a good method for comparison.

Annex D gives an example of how the measurement techniques may be used for the assessment of ICs.

5 Test conditions

All test conditions needed in this standard are specified in IEC 61967-1.

6 Test equipment

6.1 Test receiver specification

The measurement equipment has to fulfil the requirements described in IEC 61967-1.

6.2 RF current probe specification

Figure 3 shows the basic construction of the RF current probe.

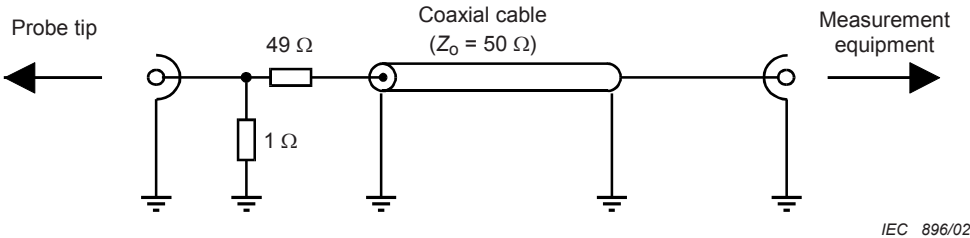


Figure 3 – Construction of the RF current probe¹

Table 1 presents a detailed specification of the RF current probe.

Table 1 – Specification of the RF current probe

Frequency range	DC – 1 GHz
Measurement resistor	RF resistor (low inductance) 1 Ω (1 %). The measurement resistor can also consist of resistors in parallel, which increases the maximum permissible current through the probe (e.g. 2 Ω//2 Ω)
Matching resistor	49 Ω (1%)
Maximum current	<0,5 A
Output impedance Z_o	40 Ω – 60 Ω
Insertion loss in calibration circuit	34 dB ± 2 dB
Decoupling in calibration circuit	See figure A.1 and figure A.5.
Cable connection	Flexible, double shielded coaxial cable with 50 Ω ± 2 Ω line impedance. The RF connector shall be mounted with low reflection. The insertion loss includes the cable and the probe. Changes to the cable length will result in additional attenuation to be considered with the measurement results.
Construction	Coaxial probe or comparable construction, which can be connected to a 4 mm coaxial socket. The measurement resistor shall be as close as possible to the probe tip. It shall be built in such a way that no mechanical damage is possible. The connection of the probe cable shall be coaxial; the probe tips should be replaceable, but nevertheless firmly connected to the cable.

¹ To prevent the measurement equipment from being damaged by DC voltage, the use of a DC block is recommended. This shall have an attenuation of <0,5 dB at the lowest frequency to be measured.

6.3 Test of the RF current probe capability

The current probe shall be tested for qualification and calibration in a test circuit shown and described in detail in annex A.

6.4 Matching network specification

Based on IEC 61000-4-6, a cabling network can be represented in most cases by an antenna with an impedance of $150\ \Omega$. In order to get accurate measurement results over the full frequency range, a termination network of $150\ \Omega \pm 20\ \Omega$ shall be used. Usual measurement equipment provides an input impedance of $50\ \Omega$ so that the matching network shall match the signal line impedance to the equipment impedance. The circuitry is shown in figure 4, and the characteristics of the impedance matching network used are shown in table 2.

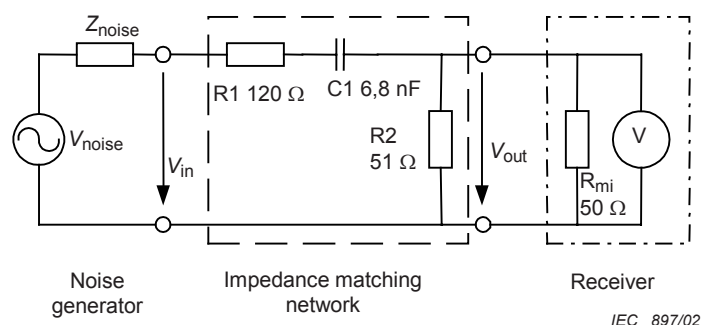


Figure 4 – Impedance matching network corresponding with IEC 61000-4-6

Table 2 – Characteristics of the impedance matching network

Frequency range B_f	150 kHz – 1 GHz
Input impedance with $50\ \Omega$ termination Z_i	$145\ \Omega \pm 20\ \Omega$
Insertion loss within a $50\ \Omega$ system	0,2586 (–11,75 dB $\pm$ 2 dB)
Voltage ratio V_{out} / V_{in}	0,1738 (–15,20 dB $\pm$ 2 dB)

7 Test set-up

7.1 General test configuration

The test set-up shall be in accordance with figure 5. This general test configuration can be built up in the form of a special test configuration (an example is described in E.2) or in any other configuration, e.g. also in a real application.