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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Integrated circuits – Measurement of electromagnetic immunity, 150 kHz to 1 GHz –
Part 3: Bulk current injection (BCI) method

Circuits intégrés – Mesure de l'immunité électromagnétique, 150 kHz à 1 GHz –
Partie 3: Méthode d'injection de courant (BCI)

IEC 62132-3:2007

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62132-3 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

The text of this standard is based on the following documents:

FDIS	Report on voting
47A/773/FDIS	47A/776/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 62132 series, published under the general title *Integrated circuits – Measurement of electromagnetic immunity, 150 kHz to 1 GHz* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
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INTEGRATED CIRCUITS – MEASUREMENT OF ELECTROMAGNETIC IMMUNITY, 150 kHz TO 1 GHz –

Part 3: Bulk current injection (BCI) method

1 Scope and object

This part of IEC 62132 describes a bulk current injection (BCI) test method to measure the immunity of integrated circuits (IC) in the presence of conducted RF disturbances, e.g. resulting from radiated RF disturbances. This method only applies to ICs that have off-board wire connections e.g. into a cable harness. This test method is used to inject RF current on one or a combination of wires.

This standard establishes a common base for the evaluation of semiconductor devices to be applied in equipment used in environments that are subject to unwanted radio frequency electromagnetic signals.

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 62132-1:2006, *Integrated circuits – Measurement of electromagnetic immunity, 150 kHz to 1 GHz – Part 1: General conditions and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62132-1 apply.

4 General

The characterization of RF immunity (or susceptibility) of an integrated circuit (IC) is essential to define the optimum design of a printed circuit board, filter concepts and for further integration into an electronic system. This document defines a method for measuring the immunity of ICs to RF current induced by electromagnetic disturbance.

This method is based on the bulk current injection (BCI) method used for equipment and systems [1, 2, 3]. The BCI method simulates the induced current as a result of direct radiated RF signals coupled onto the wires and cables of equipment and systems.

In general, in electronic systems, off-board wire connections or traces on the printed circuit board act as antennas for electromagnetic fields. Via this coupling path, these electromagnetic fields will induce voltages and currents at the pins of the IC and may cause interference. ICs are often used in various configurations dependent on their application. In this case, immunity levels of electronic equipment are closely linked to the ability of an IC to withstand the effects of an electromagnetic field represented.

To characterize the RF immunity of an IC, the induced current level necessary to cause the IC's malfunction is measured. The malfunction may be classified from A to E according to the performance classes defined in IEC 62132-1.

A principal set-up for the bulk current injection method is presented in Figure 1.

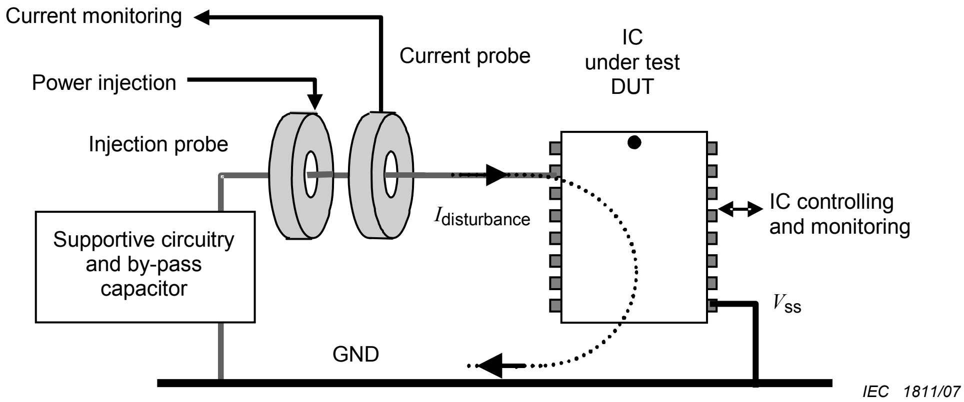

Figure 1 – Principal current path when using BCI

Two electrically shielded magnetic probes are clamped on one wires or a combination of wires that is/are connected to the device under test. The first probe is for the injection of RF power that induces $I_{disturbance}$ onto the wires. The second probe is used for monitoring the induced current on those wires.

The disturbance current flows in a loop comprising: wire(s), the selected IC's pin(s), V_{ss} terminal, ground path and supportive circuitry. This supportive circuit provides the IC functional elements as source and/or load(s). The supportive circuitry is directly connected to the IC. When the equivalent RF impedance of the supportive circuitry is larger than 50 Ω, then a by-pass capacitor is recommended. The by-pass capacitor, to be used at the supportive circuitry side, may also be needed to confine the loop area in which the induced current will be flowing. By default, the lumped by-pass capacitor of 1 nF shall be used. It represents the capacitance from the wire onto a cable harness or chassis. Deviation from using this bypass capacitor (e.g. as functional performance becomes affected) shall be given in the test report

The by-pass capacitor may be supplemented with optional decoupling network, see Figure 3, to achieve the required attenuation towards the supportive circuitry. The decoupling impedance is determined by the RF immunity of the supportive circuitry. It shall not adversely affect the response of the device under test, i.e. the result of the test.

The disturbance current $I_{disturbance}$ induced into the wire(s) flows through the IC and may create a failure in the device's operation. This failure is defined by parameters called the immunity acceptance criteria, which are checked by a controlling and monitoring system.

5 Test conditions

5.1 General

The general test conditions are described in the IEC 62132-1.

During the immunity tests, either a continuous wave (CW) or an amplitude modulated (AM) RF signal shall be used as the disturbance signal. The device under test (DUT) shall be exposed at each frequency for sufficient dwell time. By default, an amplitude modulated RF signal using 1 kHz sinusoidal signal with a modulation index of 80 % is recommended for testing.

When an AM signal is used, the peak power shall be the same as for CW, see IEC 62132-1. When other modulation schemes are used, they shall be noted in the EMC IC test report.

The levels of disturbance current required to test the IC's immunity depend on the application environment. Table A.1 in Annex A gives some examples of typical values for disturbance current injection.

NOTE Where required by the customer, to satisfy high test levels, additional protection components could be used to permit high current injection. All other pins must be left loaded according to 6.4 of IEC 62132-1.

5.2 Test equipment

The test equipment comprises the following equipment and facilities:

- ground reference plane;
- current injection probe(s);
- current measurement probe(s);
- RF signal generator with AM and CW capability;
- RF power amplifier(s). A minimum 50 Watt RF power amplifier is recommended;
- RF wattmeter or equivalent instrument, to measure the forward (and reflected) power;
- RF voltmeter or equivalent instrument which, together with the current measurement probe, measures the disturbance current induced;
- directional coupler;
- DUT monitoring equipment (optional: optical interface(s)).

A schematic diagram of the test set-up is shown in Figure 2.

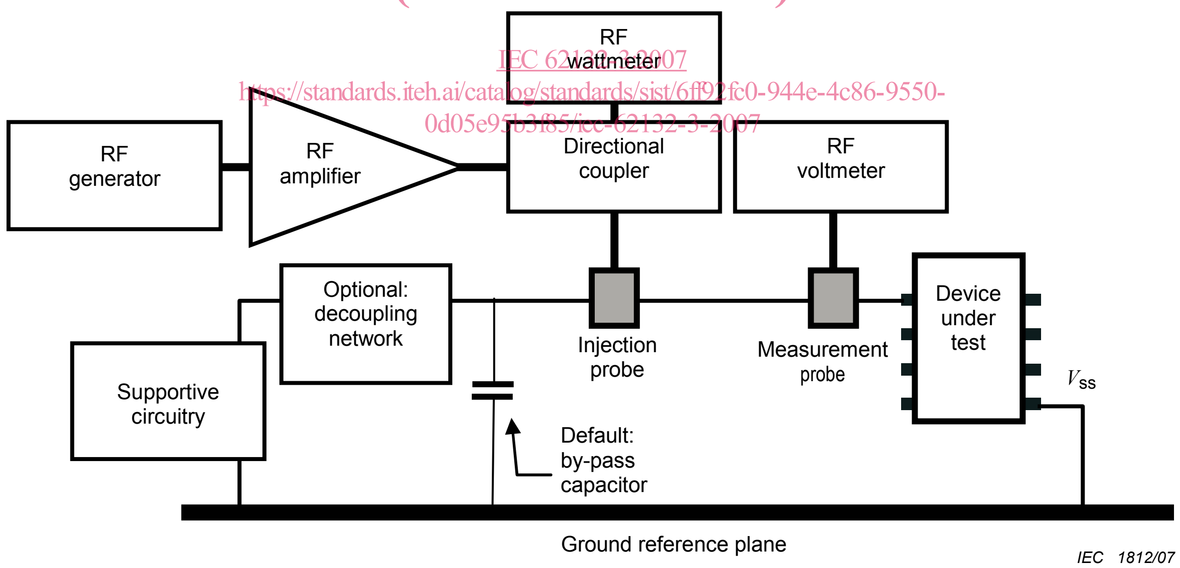

Figure 2 – Schematic diagram of BCI test set-up

An injection probe or set of probes capable of operating over the test frequency range is required to couple the disturbance signal into the connecting lines of the DUT. The injection probe is a transformer.

NOTE An optical interface can be used for monitoring the DUT response against the immunity criteria given. Use of optical interface is not mandatory but recommended.

5.3 Test board

An example of a BCI test board is shown in Figure 3. This example of the BCI test board has an opening in the middle to accommodate the two current probes.

The standard test board as defined in IEC 62132-1 needs to be modified to fulfil the BCI test condition requirements. If the standard test board is used, a low impedance ground connection between standard test board and the BCI test board shall be made. Gasket, contact springs or multiple screws shall be used to contact the BCI test board to the BCI test fixture support at the inner hole when the GRP is not included with the BCI test board layer stack-up.

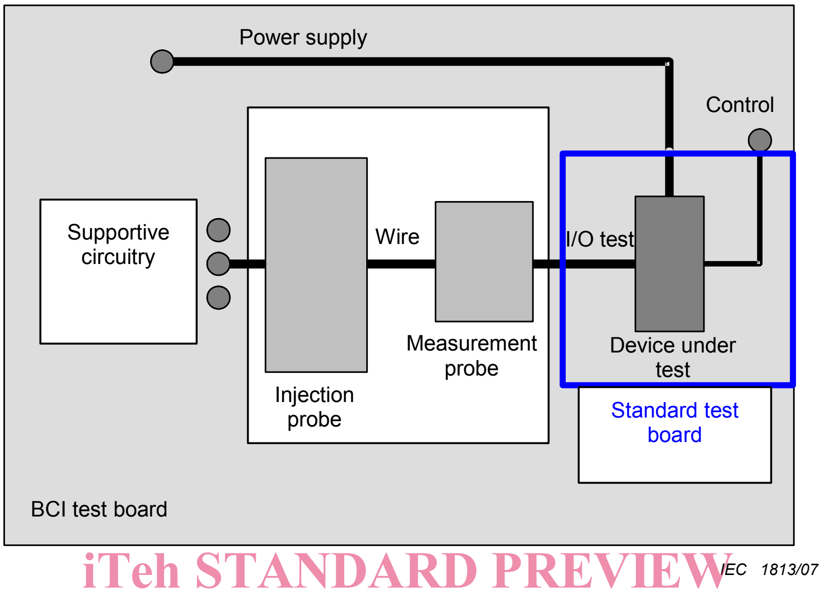

Figure 3 – Example test board, top view

The wire(s) to which the current is injected to is/are connected at one end to the selected IC pin(s) and on the other end connected to the support circuitry. The support circuitry may comprise a load, a supply or a signal source necessary to operate the device under test as intended.

The BCI test board has the advantage of fixing the position of the probes resulting in a more reproducible measurement. The size of the holes and the injection wire length should be at least designed to the size of the probes used. The hole shall exceed the size of the probes on all sides by at least 10 mm, with a maximum of 30 mm. In general, the wire length shall be limited to a quarter of a wavelength at the maximum frequency used with the BCI test method (≈ 75 mm in air at 1 GHz).

The BCI test board is placed on a copper test fixture connected to the ground reference plane (GRP), shown in Annex C. Size of GRP is typically table top size extended to a minimum of 0,1 m beyond the footprint of the test fixture. The copper test fixture needs to be high enough to allow the injection probe-carrying fixture.

NOTE 1 The GRP may also be incorporated in one of the BCI test board copper layers. In this case, the copper test fixture support is no longer necessary.

The shield of the injection probe and the measurement probe shall be grounded with a short connection underneath the copper test fixture to the GRP.

NOTE 2 Coaxial feed-through connectors can be mounted through the GRP (underneath the copper test fixture) to be connected to the current injection and measurement probes directly.

6 Test procedure

6.1 Hazardous electromagnetic fields

RF fields may exist within the test area. Care shall be taken to ensure that the requirements for limiting the exposure of human to RF energy are met. It is preferable to perform the RF immunity test in an enclosure providing sufficient RF shielding.

6.2 Calibration of forward power limitation

The required forward RF power from the RF generator and RF amplifier is determined in the BCI test set-up calibration procedure of the injection probe. In this process the level of forward RF power (in CW mode) supplied to the injection probe is established, which is necessary to generate the desired current $I_{\text{disturbance}}$.

Calibration is performed in the calibration fixture, composed of an electrically short section of a transmission line. The short section permits the measurement of current in the central conductor of the line, while the current injection probe is clamped around the central conductor. The output terminals of the fixture are terminated with a 50 Ω load each with minimum of 0,5 W power dissipation, spectrum analyser or RF voltmeter. Measurement of the voltage established across the 50 Ω input impedance of RF receiver permits the calculation of current flowing in the central conductor.

The calibration procedure shall be as follows.

a) The injection probe shall be clamped in the calibration fixture as shown in Figure 6. Fix the probe in the central position, equidistant from either end of the fixture walls.

The calibration fixture will be terminated by a 50 Ω RF load at one end and a 50 Ω RF receiver (spectrum analyser, voltmeter, etc.) at the other, with an attenuator if necessary. Caution: use a load with an adequate power rating.

NOTE Lower power ratings can be used during calibration assuming that the system behaves linearly.

b) Connect the components of test equipment as shown in Figure 4.

c) Increase the amplitude of the test signal to the injection probe until the required current level, as measured by the RF receiver, is reached.

d) Record the forward RF power necessary to generate the desired current $I_{\text{disturbance}}$. This forward RF power is admitted as the maximum forward power limit, P_{limit}.

e) Repeat steps d) to e) for each frequency step within the specified frequency range.

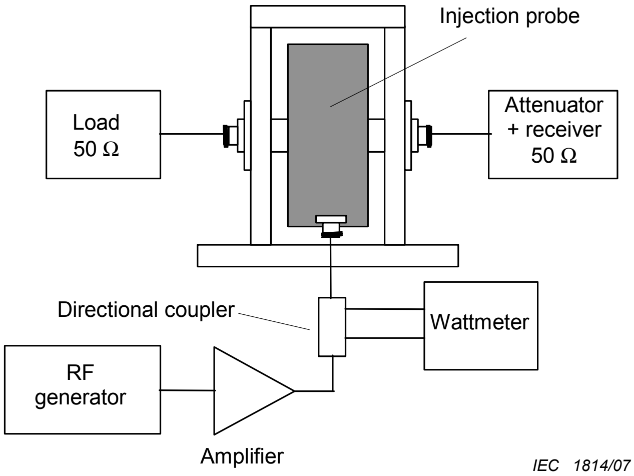

Figure 4 – Calibration set-up

6.3 BCI test

For the RF immunity tests, a substitution method with power and current limitation is used, which allows keeping track of RF power and RF current up to the limits. Substitution method is well adapted in this IC immunity test method and related to the ISO method.

- Connect the current probes, other test equipment and test board.
- Supply the DUT and check for a proper operation.
- For each test frequency, increase the amplitude of the signal gradually to the injection probe until
  - – target test current limit level for $I_{disturbance}$ is reached as indicated by monitoring the output of the measurement current probe, or
  - – the calibrated maximum forward power P_{limit} supplied to the injection probe is reached. Also in this case, although the injected current level is not reached, the maximum current level is recorded, or
  - – the RF immunity level of the IC is found. If a failure of IC occurs or the limit for $I_{disturbance}$ is met or P_{limit} target level is reached, in all cases the monitored current and the forward power are recorded.

NOTE 1 For the purpose of investigation, the details regarding the RF immunity determination could be recorded too.

NOTE 2 Assuming no glitches are generated during frequency transitions, the RF amplitude at the next frequency may be chosen e.g. 10 dB less than the previous level (taken into account the frequency dependency of the system) to speed up the test.

Test procedure is depicted in detail in the flowchart given in Figure 5. That flowchart applies for only one frequency step.

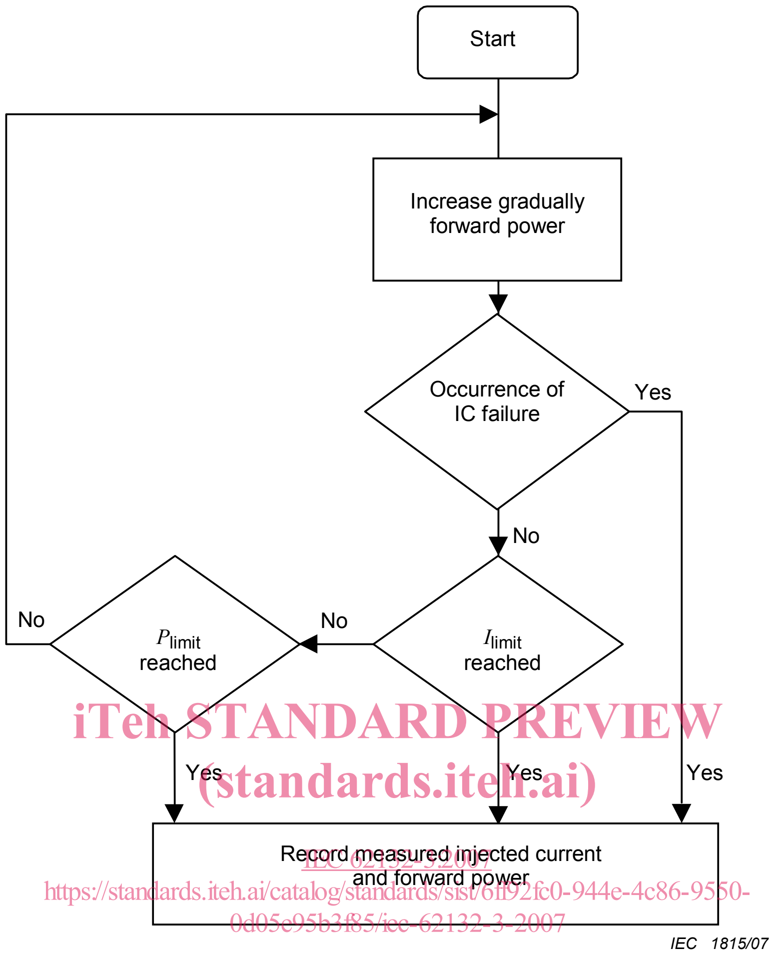

Figure 5 – BCI test procedure flowchart for each frequency step

6.4 BCI test set-up characterization procedure

In order to validate the BCI test board impedance, a validation procedure is required.

For this validation, all components of the test set-up shall be used, except for the device under test. The port represented by the selected pin(s) under IC test is replaced with a 50 Ω reference impedance. Figure 6 shows a schematic of the validation test set-up.

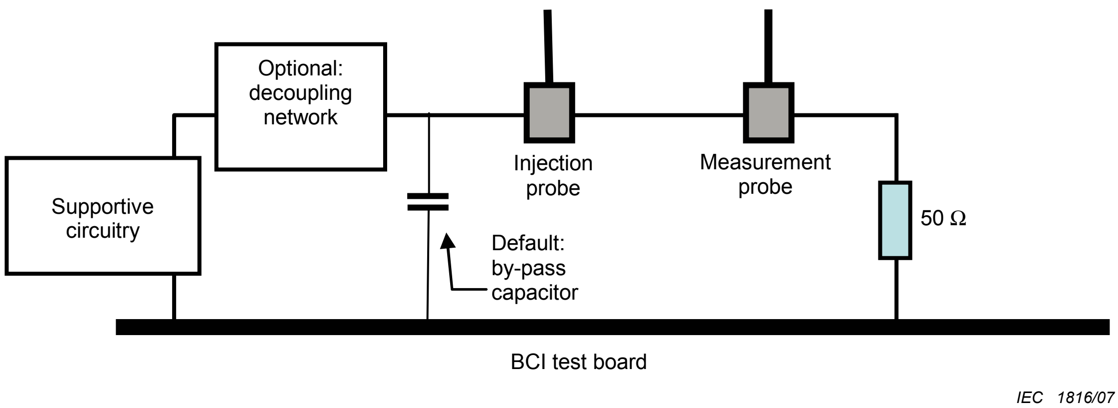

Figure 6 – Impedance validation test set-up