BRITISH STANDARD

BS EN 62132-3:2007

Integrated circuits — Measurement of electromagnetic immunity, 150 kHz to 1 GHz —

Part 3: Bulk current injection (BCI) method

The European Standard EN 62132-3:2007 has the status of a British Standard

ICS 31.200

British Standards

National foreword

This British Standard is the UK implementation of EN 62132-3:2007. It is identical to IEC 62132-3:2007.

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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(IEC 62132-3:2007)

Circuits intégrés -
Mesure de l'immunité électromagnétique,
150 kHz à 1 GHz -
Partie 3: Méthode d'injection
de courant (BCI)
(CEI 62132-3:2007)

Integrierte Schaltungen -
Messung der elektromagnetischen
Störfestigkeit im Frequenzbereich
von 150 kHz bis 1 GHz -
Teil 3: Stromeinspeisungs-
(BCI-)Verfahren
(IEC 62132-3:2007)

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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 47A/773/FDIS, future edition 1 of IEC 62132-3, 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 62132-3 on 2007-10-01.

The following dates were fixed:

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– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2010-10-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62132-3:2007 was approved by CENELEC as a European Standard without any modification.

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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.

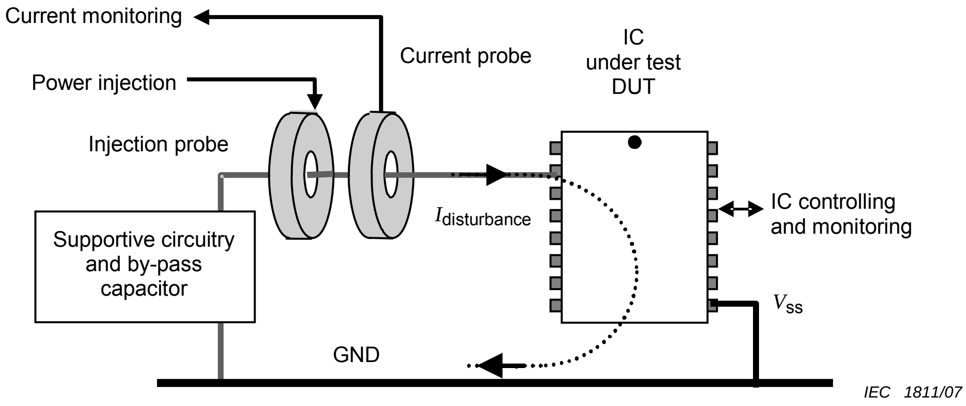

Figure 1 – Principal current path when using BCI

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.

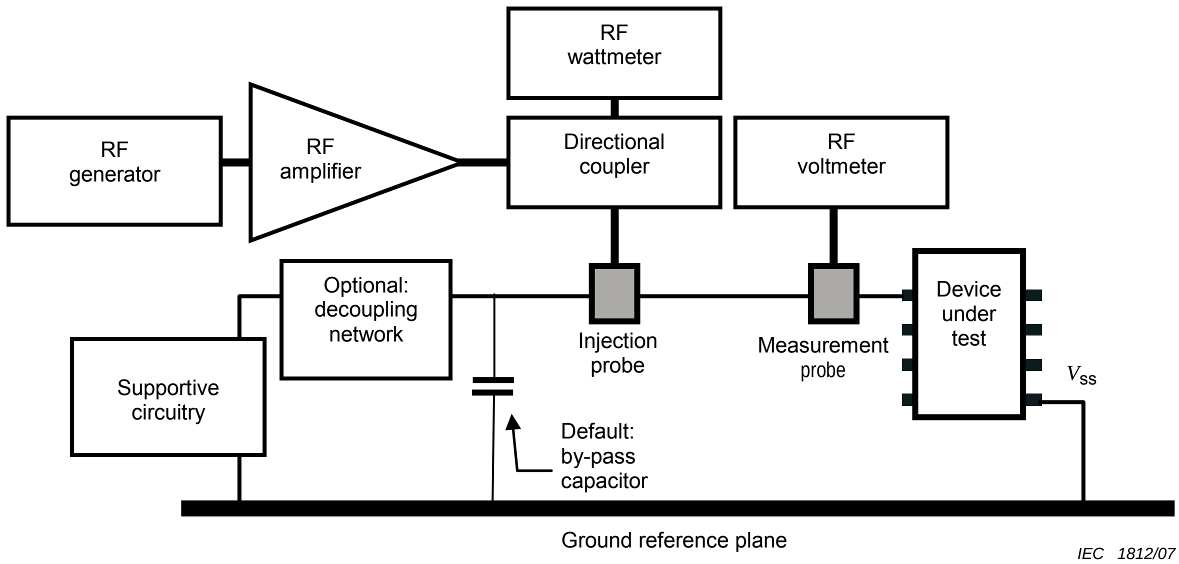

Figure 2 – Schematic diagram of BCI test set-up

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.

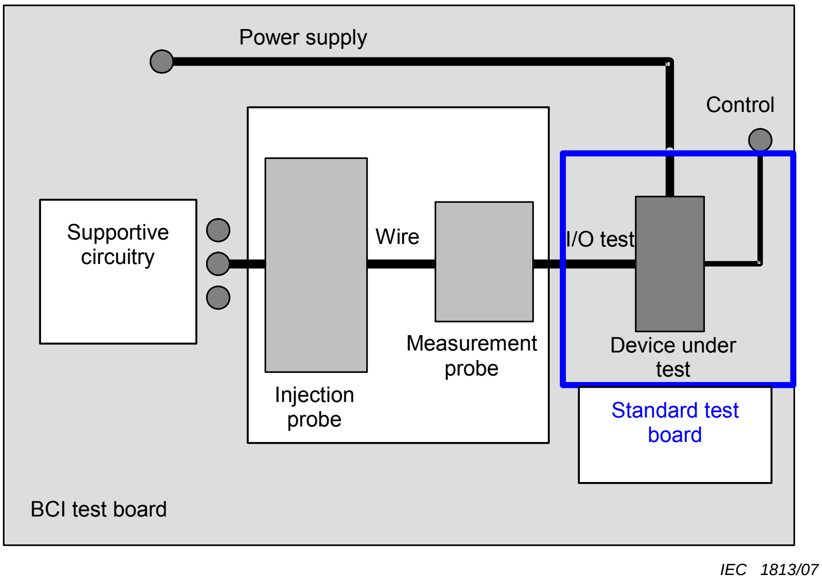

Figure 3 – Example test board, top view

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.

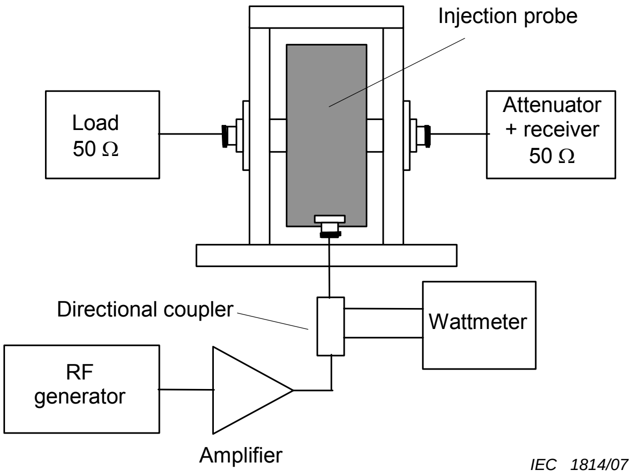

Figure 4 – Calibration set-up

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 $I_{\text{disturbance}}$ 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 $I_{\text{disturbance}}$ 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.

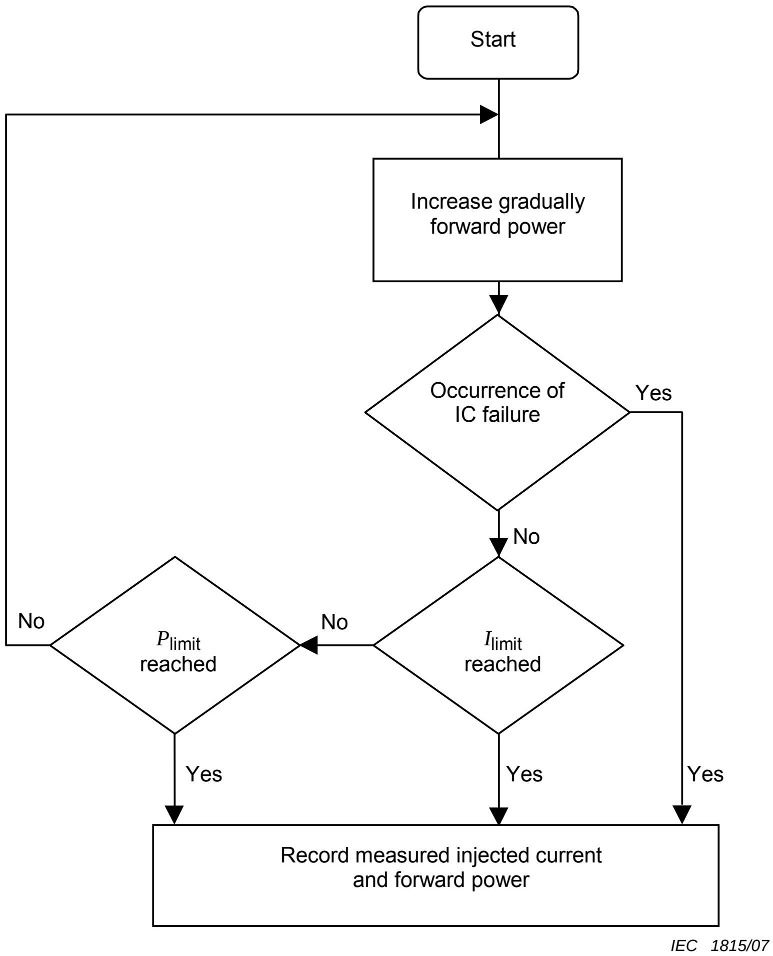

Figure 5 – BCI test procedure flowchart for each frequency step

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.

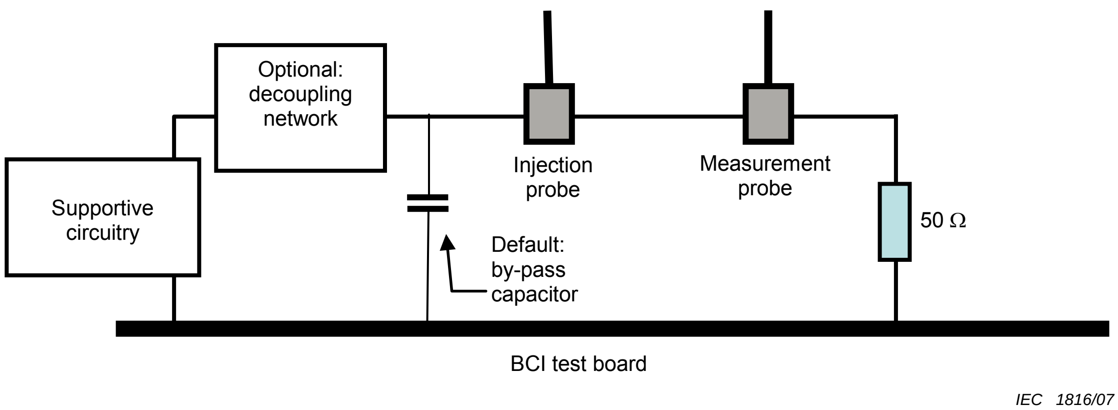

Figure 6 – Impedance validation test set-up

During the validation over the whole frequency range, the value of injected current is fixed. A value of 10 mA for the disturbance current injected is recommended. For each frequency step, the RF forward power needed shall be noted.

Test board validation could be characterized by transfer impedance defined with:

$$Z(f) = \frac{P_{\text{forward}}(f)}{I^2}$$

In cases involving use of several test boards, the $Z(f)$ values should be the same. That allows comparison of IC immunity tests results done under the same conditions.

7 Test report

The test report shall be prepared in accordance with the requirements given in IEC 62132-1.

Immunity acceptance criteria should be clearly described in the test report. The test board configuration should also be described in detail to reproduce the results.

In all cases, such parameters as injected RF current $I_{\text{disturbance}}$, the applied forward RF power P_{forward}, calibration power P_{limit} and the current $I_{\text{disturbance}}$, which are recorded during the calibration and measurement processes, shall be documented in the test report.

Additional critical items such as test board description and value of by-pass capacitor (default) and decoupling (when used) should be listed in the test report.

Annex A
(informative)

Examples for test levels and frequency step selection

A.1 Typical values for current injection

The test signals severity level is the test current of the calibrated test current applied. These test severity levels are expressed in terms of the equivalent RMS (root-mean-square) mA value of the unmodulated current signal. These test levels are taken from the requirements for module testing in automotive/avionic applications. The levels applied at IC testing shall be provided by the end-user and are determined by the criticality of the function(s) controlled. Other application environments require less stringent limits.

Examples of severity levels are given in Table A.1. Levels of injected current are related to IC pin connection. Pins connected to external wiring could be tested with the highest current values, whereas pins with only local connections could be allowed to withstand the lower levels. Values should be clearly detailed in the IC test plan.

Table A.1 – Test severity levels

Test severity level	Current (CW value) No insertion loss
I	50 mA
II	100 mA
III	200 mA
IV	300 mA
V	Specific value agreed between the users of this standard

In case of use of additional protection components applied on the test board, in order to withstand higher current values, a description of this protection circuitry and its layout should be added in the IC test report.

A.2 Frequency steps

Injected current induced by electromagnetic disturbances on wire is obtained at discrete frequencies. The distance between 2 test frequencies is defined as the frequency step.

The choice of the frequency steps should cover the whole immunity range of IC and avoid skipping frequencies on which an immunity problem may occur. In general, the root causes of IC disturbances are due to impedance resonances. These are often very narrow and the frequency step should take into account this phenomenon.

There are 2 ways to define frequency steps: with a linear or a logarithmic approach.

An example of a linear frequency step (automotive and aerospace applications) is given in Table A.2.

Table A.2 – Linear frequency step

Frequency band	Maximum frequency size step
10 kHz to 100 kHz	2 kHz
100 kHz to 1 MHz	20 kHz
1 MHz to 10 MHz	200 kHz
10 MHz to 100 MHz	2 MHz
100 MHz to 1 GHz	5 MHz

An example of a logarithmic frequency step (automotive applications) is given in Table A.3.

Table A.3 – Logarithmic frequency step

Frequency min.	Frequency max.	Frequency step
10 kHz	100 kHz	10 %
100 kHz	100 MHz	5 %
100 MHz	1 GHz	2 %

Annex B
(informative)

Example of BCI test board and set-up

B.1 Example of BCI test board and set-up

The BCI test set-up presented in this example uses injection probes, e.g. model F140 from FCC. The probes shall be able to inject high current values with a frequency range of 100 kHz to 1 GHz. Probes associated to a small current probe, e.g. 94111 model, allow the needs of the test to be covered.

Due to the size of the two probes, 110 mm wide for both, a test board with an opening of 120 mm to put the two probes is required to allow the probes used in the lower frequency range
(< 500 MHz). Figure B.1 shows a general view of the test board. The recommended distance between probes is 10 mm.

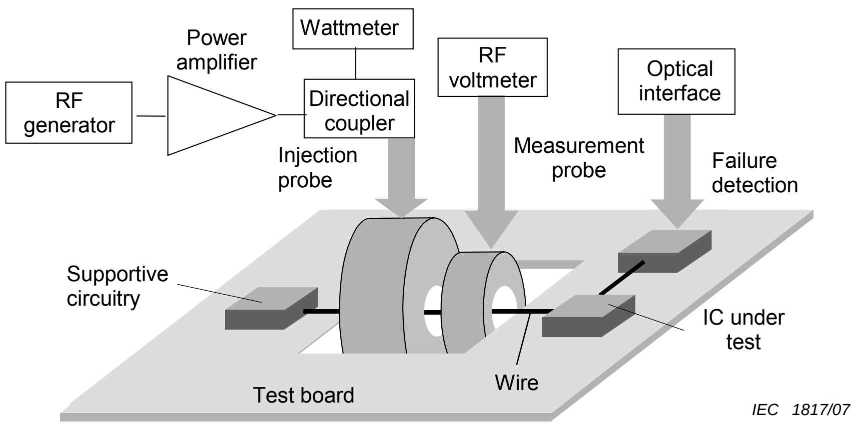

Figure B.1 – General view

A hole, typical size: 120 mm × 150 mm shall permit placement of the two probes used in the lower frequencies, when using conventional BCI probes. Distance between probes may be limited to 1 mm.

When smaller injection and measurement probes are used to enable testing up to higher frequencies, a metal plate shall cover this hole in the test board with a hole exceeding these probes by 10 mm on each side. This sub-board shall make firm electrical contact at each edge of the test board.

The position of the current measurement probe should be close to the IC, required length less than 20 mm, which permit to measure the current injected in the IC. In this case, it is more appropriate to measure the surface currents induced in the differential lines than to create a discontinuity in the differential transmission line path. The distance between probes should be limited to 1 mm.

To minimize effects due to the test board, each side of the test board should be wide enough to be considered as a ground reference plane. Recommended size is minimum 30 mm, see Figure B.2.

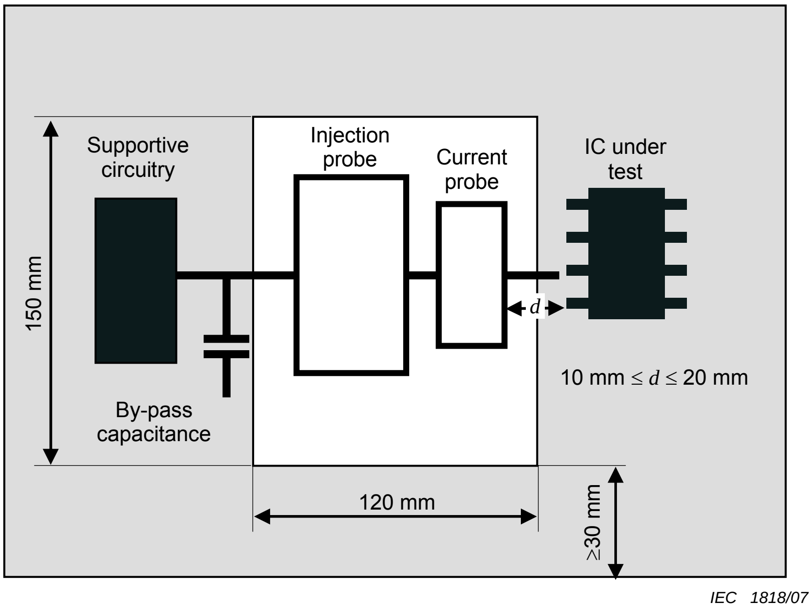

Figure B.2 – Example of top view of the test board

The ground reference plane (GRP) is considered to be a solid ground plane. The disturbance current return path is considered through this GRP in the test set-up. Up to 1 GHz, this ground reference plane will have neglectable influence on the measurement set-up and can be disregarded.

The test board consists of at least two copper layers on an FR4 carrier material. The device under test, associated devices and tracks are placed on the topside. The bottom side is dedicated to a solid ground plane. A test board build-up is presented in Figure B.3.

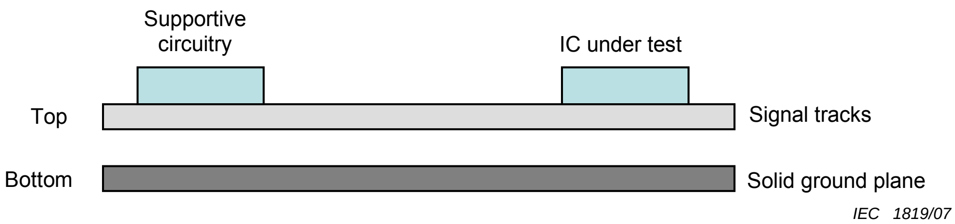

Figure B.3 – Test board build-up

The test board bottom side, being a GND plane, is placed on the copper test fixture, connected to the ground reference plane as shown in Figure B.4. The copper test fixture shall be able to carry the BCI bottom test board conductively. The test fixture is placed on a copper ground reference plane (GRP). The shield of the injection probe has to be grounded underneath the copper test fixture to the GRP. It is recommended in order to ensure reproducibility, when large current probes have to be supported.

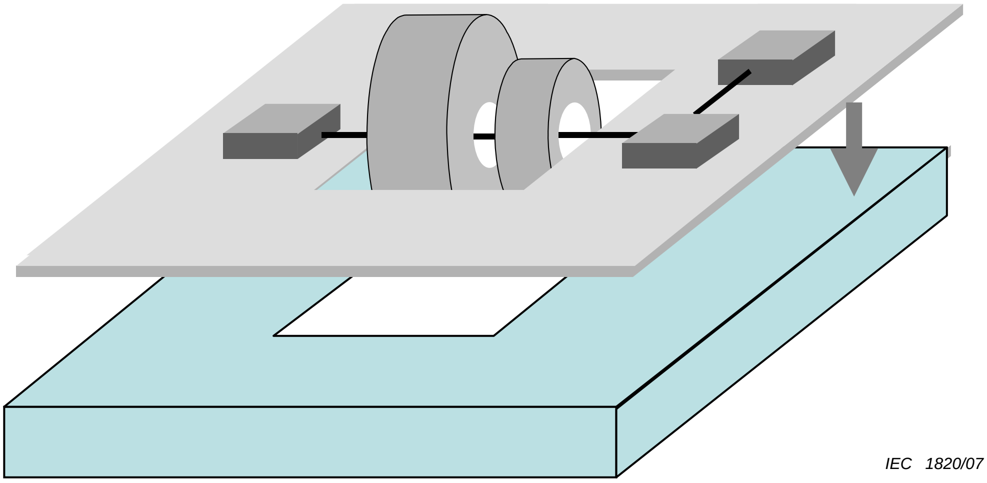

Figure B.4 – Test board and copper fixture

To fix the position of probes, a specific support is recommended. An example of that support is shown in Figure B.5. The probe support shall be made of non-conductive materials, with an ε_r of around 4.

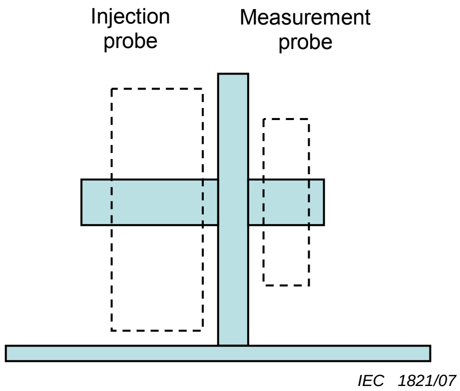

Figure B.5 – Example of a non-conductive probes support fixture

Annex C
(informative)

Example of RF test board and set-up

As an RF probe injection, a multi-wire RF transformer can be used, e.g. a SMD type. Coupling onto a differential transmission line with a ground plane underneath can be performed with a 3-wire RF transformer, and its frequency range can be extended by adding capacitive coupling (increase capacitances: C4/C5 in Figure C.1). The center wire is then used for injection where the off center wires are in series with the differential transmission line.

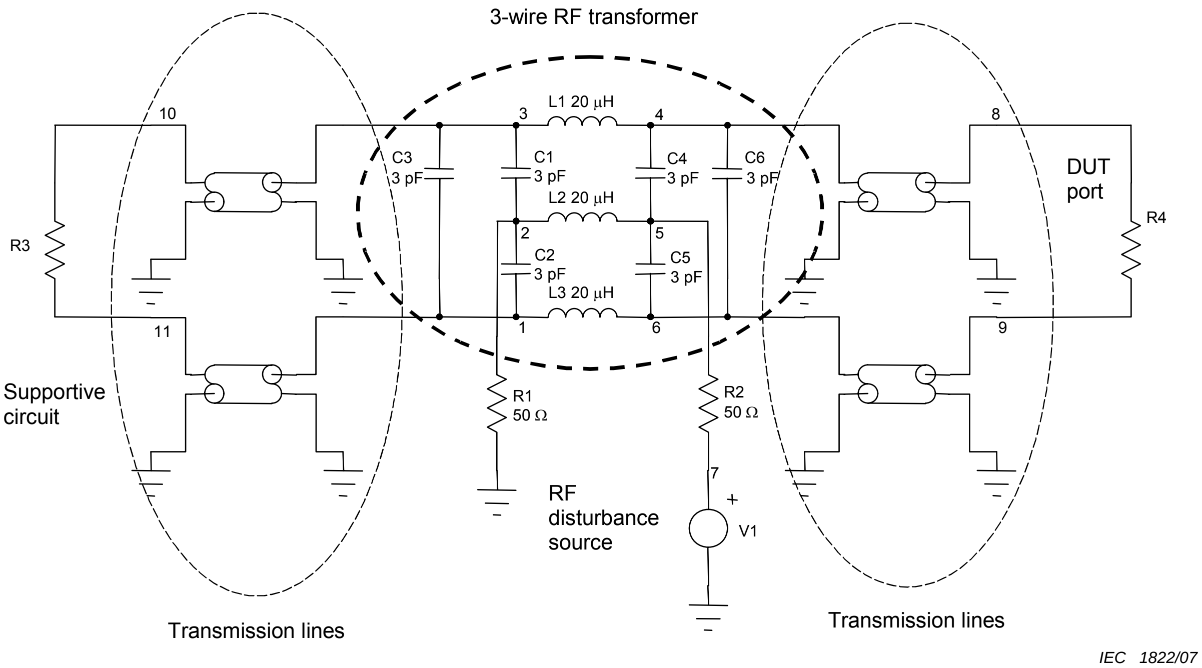

Figure C.1 – Compact RF coupling to differential IC ports

Bibliography

[1] ISO 11452-4:2005, *Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI)*

[2] DO160D section 20.4: Conducted Immunity (CS) test

[3] MIL-STD-461E: Requirements for the Control of Electromagnetic Interference Characteristics of Equipments and Subsystems (CS114)

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 62132-1	2006	Integrated circuits - Measurement of electromagnetic immunity, 150 kHz to 1 GHz - Part 1: General conditions and definitions	EN 62132-1 + corr. November	2006 2006

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