INTERNATIONAL STANDARD

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Electromagnetic compatibility (EMC) –

Part 4:
Testing and measurement techniques –
Section 4: Electrical fast transient/burst immunity test
Basic EMC publication

Compatibilité électromagnétique (CEM) –

Partie 4:
Techniques d'essai et de mesure –
Section 4: Essais d'immunité aux transitoires électriques rapides en salves
Publication fondamentale en CEM

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- **IEC Bulletin**
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Terminology, graphical and letter symbols

For general terminology, readers are referred to IEC 60050: *International Electrotechnical Vocabulary* (IEV).

For graphical symbols, and letter symbols and signs approved by the IEC for general use, readers are referred to publications IEC 60027: *Letter symbols to be used in electrical technology,* IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets* and IEC 60617: *Graphical symbols for diagrams.*

* See web site address on title page.

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters, prepared by technical committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
3) They have the form of recommendations for international use published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

International Standard IEC 1000-4-4 has been prepared by sub-committee 77B: High-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms section 4 of part 4 of IEC 1000. It has the status of a basic EMC publication in accordance with IEC guide 107.

It is based on IEC 801-4 (first edition: 1988): Electromagnetic compatibility for industrial-process measurement and control equipment − Part 4: Electrical fast transient/ burst requirements, prepared by IEC technical committee 65: Industrial-process measurement and control.

According to a recommendation of ACEC at its meeting of December 1989, the scope of this standard has been extended to all kinds of electrical and electronic equipment. For this purpose it has been decided to transfer the 801 series of publications to IEC 1000, Part 4: EMC testing and measurement techniques, of technical committee 77.

No technical changes, only editorial amendments have been made with this transfer and reference to IEC 801-4 (1988) or IEC 1000-4-4 is equivalent.

The text of IEC 801-4, first edition, is based on the following documents:

Six Month's Rule	Report on voting
65(CO)39	65(CO)43

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

The text of this standard IEC 1000-4-4, is based on the following documents:

DIS	Report on voting
77B(CO)22	77B/146/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.

Annex A is for information only.

INTRODUCTION

IEC 1000-4 is a part of the IEC 1000 series, according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 9: Miscellaneous

Each part is further subdivided into sections which are to be published either as international standards or as technical reports.

These sections of IEC 1000-4 will be published in chronological order and numbered accordingly.

This section is an international standard which gives immunity requirements and test procedure related to "electrical fast transient/burst".

ELECTROMAGNETIC COMPATIBILITY (EMC) -

Part 4: Testing and measurement techniques − Section 4: Electrical fast transient/burst immunity test Basic EMC publication

1 Scope

This International Standard relates to the immunity requirements and test methods for electrical and electronic equipment to repetitive electrical fast transients. It additionally defines ranges of test levels and establishes test procedures.

The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to repetitive fast transients (bursts), on supply, signal and control ports.

The test is intended to demonstrate the immunity of electrical and electronic equipment when subjected to types of transient disturbances such as those originating from switching transients (interruption of inductive loads, relay contact bounce, etc.).

The standard defines:

- test voltage waveform;
- range of test levels;
- test equipment;
- test set-up;
- test procedure.

The standard gives specifications for tests performed in "laboratories" and "post-installation tests" performed on equipment in the final installation.

This standard does not intend to specify the tests to be applied to particular apparatus or systems. Its main aim is to give a general basic reference to all concerned product committees of the IEC. The product committees (or users and manufacturers of equipment) remain responsible for the appropriate choice of the tests and the severity level to be applied to their equipment.

In order not to impede the task of coordination and standardization, the product committees or users and manufacturers are strongly recommended to consider (in their future work or revision of old standards) the adoption of the relevant immunity tests specified in this standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this section of IEC 1000-4. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this section of IEC 1000-4 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(161): 1990, *International Electrotechnical Vocabulary (IEV) − Chapter 161: Electromagnetic compatibility*

IEC 68-1: 1988, *Environmental testing − Part 1: General and guidance*

3 General

The repetitive fast transient test is a test with bursts consisting of a number of fast transients, coupled into power supply, control and signal ports of electrical and electronic equipment. Significant for the test are the short rise time, the repetition rate and the low energy of the transients.

4 Definitions

For the purpose of this section of IEC 1000-4, the following definitions and terms apply and are applicable to the restricted field of electrical fast transient/burst; not all of them are included in IEC (50)161 [IEV].

4.1 **EUT**: Equipment under test.

4.2 **port**: Particular interface of the EUT with the external electromagnetic environment.

4.3 **EFT/B**: Electrical fast transient/burst.

4.4 **coupling**: Interaction between circuits, transferring energy from one circuit to another.

4.5 **coupling network**: Electrical circuit for the purpose of transferring energy from one circuit to another.

4.6 **decoupling network**: Electrical circuit for the purpose of preventing EFT voltage applied to the EUT from affecting other devices, equipment or systems which are not under test.

4.7 **coupling clamp**: Device of defined dimensions and characteristics for common mode coupling of the disturbance signal to the circuit under test without any galvanic connection to it.

4.8 **ground (reference) plane**: A flat conductive surface whose potential is used as a common reference. [IEV 161-04-36]

4.9 **electromagnetic compatibility (EMC)**: The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. [IEV 161-01-07]

4.10 **immunity (to a disturbance)**: The ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance. [IEV 161-01-20]

4.11 **degradation (of performance)**: An undesired departure in the operational performance of any device, equipment or system from its intended performance. [IEV 161-01-19]

NOTE − The term "degradation" can apply to temporary or permanent failure.

4.12 **transient**: Pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval which is short compared with the time-scale of interest. [IEV 161-02-01]

4.13 **rise time**: The interval of time between the instants at which the instantaneous value of a pulse first reaches 10 % value and then the 90 % value. [IEV 161-02-05, modified]

4.14 **burst**: A sequence of a limited number of distinct pulses or an oscillation of limited duration. [IEV 161-02-07]

5 Test levels

The preferential range of test levels for the electrical fast transient test, applicable to power supply, protective earth (PE), signal and control ports of the equipment is given in table 1.

Table 1 - Test levels

Open-circuit output test voltage (±10 %) and repetition rate of the impulses (±20 %)				
Level	On power supply port, PE		On I/O (Input/Output) signal, data and control ports	
	Voltage peak kV	Repetition rate kHz	Voltage peak kV	Repetition rate kHz
1	0,5	5	0,25	5
2	1	5	0,5	5
3	2	5	1	5
4	4	2,5	2	5
x[1)]	Special	Special	Special	Special

[1)] "x" is an open level. The level has to be specified in the dedicated equipment specification.

These open-circuit output voltages will be displayed on the EFT/B generator. For selection of levels, see annex A.

6 Test equipment

6.1 Test generator

The simplified circuit diagram of the generator is given in figure 1.

The major elements of the test generator are:

- high-voltage source;
- charging resistor;
- energy storage capacitor;
- spark gap;
- impulse duration shaping resistor;
- impedance matching resistor;
- d.c. blocking capacitor.

6.1.1 Characteristics and performance of the fast transient/burst generator

− Open circuit output voltage range (voltage at the terminals of the energy storage capacitor): 0,25 kV −10 % to 4 kV +10 %

The generator shall be capable of operating under short-circuit conditions.

Characteristics for operation into 50 Ω load conditions:

− maximum energy:	4 mJ/pulse at 2 kV into 50 Ω load
− polarity:	positive/negative
− output type:	coaxial
− dynamic source impedance (see note)	50 Ω ± 20 % between 1 MHz and 100 MHz
− D.C.-blocking capacitor inside the generator:	10 nF
− repetition frequency of the impulses:	function of the selected test level (see 6.1.2)
− rise time of one pulse:	5 ns ± 30 % (see 6.1.2 and figure 3)
− impulse duration (50 % value):	50 ns ± 30 % (see 6.1.2 and figure 3)
− waveshape of the pulse output into 50 Ω load:	see 6.1.2 and figure 3
− relation to power supply:	asynchronous
− burst duration:	15 ms ± 20 % (see 6.1.2 and figure 2)
− burst period:	300 ms ± 20 % (see 6.1.2 and figure 2)

NOTE − The source impedance may be verified by the measurement of the peak values of the output impulse at no load and 50 Ω load conditions respectively (ratio 2:1).

6.1.2 Verification of the characteristics of the fast transient/burst generator

In order to make it possible to compare the test results from different test generators, the test generator characteristics shall be verified. For this purpose the following procedure is necessary. The test generator output is to be connected to an oscilloscope through a 50 Ω coaxial attenuator. The bandwidth of the measuring equipment shall be at least 400 MHz. The rise time, impulse duration and repetition rate of the impulses within one burst shall be monitored.

Characteristics to be verified with a 50 Ω termination of the EFT/B generator (see figure 3):

− Rise time of the pulses: 5 ns ± 30 %

− Impulse duration (50 % value): 50 ns ± 30 %

Repetition rate of the impulses and peak values of the output voltage:

5 kHz ± 20 % at 0,125 kV;
5 kHz ± 20 % at 0,25 kV;
5 kHz ± 20 % at 0,5 kV;
5 kHz ± 20 % at 1,0 kV;
2,5 kHz ± 20 % at 2,0 kV.

6.2 Coupling/decoupling network for a.c./d.c. mains supply port

This network provides the ability to apply the test voltage in a non-symmetrical condition to the power supply port of the EUT.

The circuit diagram (example for a three-phase power mains supply) is given in figure 4.

Characteristics

- frequency range: 1 MHz to 100 MHz;
- coupling capacitors: 33 nF;
- coupling attenuation: < 2 dB;
- decoupling attenuation in non-symmetrical condition: > 20 dB
- cross-talk attenuation in the network between each line to the other: > 30 dB;
- insulation withstand capability of the coupling capacitors: 5 kV (test-pulse: 1,2/50 µs).

6.3 Capacitive coupling clamp

The clamp provides the ability of coupling the fast transients/bursts to the circuit under test without any galvanic connection to the terminals of the EUT's ports, shielding of the cables or any other part of the EUT.

The coupling capacitance of the clamp depends on the diameter, material of the cables, and shielding (if any).

The device is composed of a clamp unit (made of galvanized steel, brass, copper or aluminium) for housing the cables (flat or round) of the circuits under test and shall be placed on a ground plane of minimum area of 1 m². The reference ground plane shall extend beyond the clamp by a least 0,1 m on all sides.

The line shall be provided at both ends with a high-voltage coaxial connector for the connection of the test generator at either end. The generator shall be connected to that end of the clamp which is nearest to the EUT.

The clamp itself shall be closed as much as possible to provide maximum coupling capacitance between the cable and the clamp.

The recommended mechanical arrangement of the coupling clamp is given in figure 5 and determines its characteristics, such as frequency response, impedance, etc.

Characteristics

- typical coupling capacitance between cable and clamp: 50 pF to 200 pF;
- usable diameter range of round cables: 4 mm to 40 mm;
- insulation withstand capability: 5 kV (test-pulse: 1,2/50 µs).

The coupling method using the clamp is required for acceptance tests. It is designed to be used on lines connected to I/O and communication ports, but also on a.c./d.c. power supply ports if the coupling/decoupling network defined in 6.2 cannot be used. Other coupling methods (e.g. coupling/decoupling networks) may be used according to the product standard.

7 Test set-up

Two different types of tests can be distinguished:

- type tests performed in laboratories;
- post-installation tests performed on equipment in its final installed conditions.

The preferred test method is that of type tests performed in laboratories.

The EUT shall be arranged in accordance with the manufacturer's instructions for installation (if any).

7.1 Test equipment

The test set-up includes the following equipment (see figure 6):

- ground reference plane;
- coupling device (network or clamp);
- decoupling network;
- test generator, including the calibration or measurement means.

7.2 Test set-up for type tests performed in laboratories

7.2.1 Test conditions

The following requirements apply to tests performed in laboratories under the environmental reference conditions outlined in 8.1.

The EUT's shall be placed on a ground reference plane and shall be insulated from it by an insulating support 0,1 m ± 0,01 m thick.

In the case of table-top equipment, the EUT should be located 0,8 m ± 0,08 m above the ground plane (see figure 7).

The reference ground plane shall be a metallic sheet (copper or aluminium) of 0,25 mm minimum thickness; other metallic materials may be used but they shall have 0,65 mm minimum thickness.

The minimum size of the ground plane is 1 m x 1 m. The actual size depends on the dimensions of the EUT.

The reference ground plane shall project beyond the EUT by at least 0,1 m on all sides.

The reference ground plane shall be connected to the protective earth ("ground" in US terminology).

The EUT shall be arranged and connected to satisfy its functional requirements, according to the equipment installation specifications.

The minimum distance between the EUT and all other conductive structures (e.g. the walls of a shielded room), except the ground plane beneath the EUT, shall be more than 0,5 m.

The EUT shall be connected to the earthing system in accordance with the manufacturer's installation specifications; no additional earthing connections are allowed.

The connection of the test equipment ground cables to the ground reference plane and all bondings shall provide minimum inductance.

Coupling devices shall be used for the application of the test voltages. They shall be coupled to the lines between the EUT and the decoupling network or between two units of equipment involved in the test.

Using the coupling clamp, the minimum distance between the coupling plates and all other conductive structures, except the ground plane beneath the coupling clamp and beneath the EUT, shall be 0,5 m.

The length of the signal and power lines between the coupling device and the EUT shall be 1 m or less.

If the manufacturer provides a non-detachable supply cable more than 1 m long with the equipment, the excess length of this cable shall be gathered into a flat coil with a 0,4 m diameter and situated at a distance of 0,1 m above the ground reference plane. The distance of 1 m or less between EUT and the coupling device shall be maintained.

Examples of the test set-up for laboratory tests are given in figure 7.

7.2.2 Methods of coupling the test voltage to the EUT

The test voltage shall be applied to the following different types of lines or ports of the EUT:

Power supply ports

An example for the test set-up for direct coupling of the EFT/B disturbance voltage via a coupling/decoupling network is given in figure 8.

If the line current is higher than the specified current capability of the coupling/decoupling network, i.e. > 100 A, the test voltage shall be applied to the EUT's through a 33 nF coupling capacitor, according to figure 10.

I/O and communication ports

The examples in figure 7 and figure 9 show how to use the capacitive coupling clamp for application of the disturbance test voltage to I/O and communication ports.

Earth connections of the cabinets

The test point on the cabinet shall be the terminal for the protective earth conductor.

The test voltage shall be applied to the protective earth (PE) connection by the coupling/ decoupling network, see figure 8.

7.3 Test set-up for post-installation tests

These tests are optional, and not mandatory for certification tests; they may be applied only when agreed between manufacturer and customer. It has to be considered that other co-located equipment may be unacceptably affected.

The equipment or system shall be tested in the final installed conditions. Post-installation tests shall be performed without coupling/decoupling networks in order to simulate the actual electromagnetic environment as closely as possible.

If equipment or system other than the EUT are unduly affected during the test procedure, decoupling networks shall be used by agreement between the user and the manufacturer.

7.3.1 Test on power supply ports and on protective earth terminals

Stationary, floor-mounted equipment

The test voltage shall be applied between a reference ground plane and each of the power supply terminals, a.c. or d.c., and on the terminal for the protective or function earth on the cabinet of the EUT.

For the test set-up see figure 10.

A reference ground plane of approximately 1 m x 1 m (as described in 7.2.1) shall be mounted near the EUT and connected to the protective earth conductor at the power supply mains outlet.

The EFT/B-generator shall be located on the reference plane. The length of the "hot wire" from the coaxial output of the EFT/B-generator to the terminals on the EUT should not exceed 1 m. This connection shall be unshielded but well insulated. If a.c./d.c. blocking capacitors are necessary their capacitance shall be 33 nF. All other connections of the EUT should be in accordance with its functional requirements.

Non-stationary mounted EUT, connected to the mains supply by flexible cord and plugs

The test voltage shall be applied between each of the power supply conductors and the protective earth at the power supply outlet to which the EUT is to be connected (see figure 11).

7.3.2 Test on I/O and communication ports

As far as possible, the capacitive coupling clamp shall be used for coupling the test voltage into the lines. However, if the clamp cannot be used due to mechanical problems (size, cable routing) in the cabling, it may be replaced by a tape or a conductive foil enveloping the lines under test. The capacitance of this coupling arrangement with foil or tape should be equivalent to that of the standard coupling clamp.

In other cases, it might be useful to couple the EFT/B-generator to the terminals of the lines via discrete 100 pF capacitors instead of the distributed capacitance of the clamp or of the foil or tape arrangement.

Grounding of the coaxial cable from the test generator shall be made in the vicinity of the coupling point. Application of the test voltage to the connectors (hot wires) of coaxial or shielded communication lines is not permitted.

The test voltage should be applied in a way that the shielding protection of the equipment will not be reduced. For further explanations, see figure 12.

The test results obtained with the discrete capacitor coupling arrangement are likely to be different from those obtained with the coupling clamp or the foil coupling. Therefore, the test levels specified in clause 5 might be amended by mutual agreement between manufacturer and user in order to take significant installation characteristics into consideration.

8 Test procedure

The test procedure includes:

- the verification of the laboratory reference conditions;
- the preliminary verification of the correct operation of the equipment;
- the execution of the test;
- the evaluation of the test results.

8.1 Laboratory reference conditions

In order to minimize the effect of environmental parameters on test results, the test shall be carried out in climatic and electromagnetic reference conditions as specified in 8.1.1 and 8.1.2.

8.1.1 Climatic conditions

The tests shall be carried out in standard climatic conditions in accordance with IEC 68-1:

- ambient temperature: 15 °C to 35 °C;
- relative humidity: 25 % to 75 %;
- atmospheric pressure: 86 kPa (860 mbar) to 106 kPa (1 060 mbar).

NOTE − Any other values are specified in the product specification.

The EUT shall be operated within its intended climatic conditions.

8.1.2 Electromagnetic conditions

The electromagnetic conditions of the laboratory shall be such to guarantee the correct operation of the EUT in order not to influence the test results.

8.2 Execution of the test

The test shall be carried out on the basis of a test plan including verification of the performances of the EUT as defined in the technical specification.

The EUT shall be in the normal operating conditions.

The test plan shall specify:

- type of test that will be carried out;
- test level;
- polarity of the test voltage (both polarities are mandatory);
- internal or external generator drive;
- duration of the test, not less than 1 min;
- number of applications of the test voltage;
- EUT's ports to be tested;
- representative operating conditions of the EUT;
- sequence of application of the test voltage to the EUT's ports, each one after the other or to cables belonging to more than one circuit, etc.;
- auxiliary equipment.

The test plan shall be subject to agreement between manufacturer and test laboratory/ user, and under no circumstance may the test level exceed the product specification.

9 Test results and test report

This clause gives a guide for the evaluation of the test results and for the test report, related to this standard.

The variety and diversity of equipment and systems to be tested make the task of establishing the effects of this test on equipment and systems difficult.

The test results shall be classified on the basis of the operating conditions and the functional specifications of the equipment under test, as in the following, unless different specifications are given by product committees or product specifications:

1) normal performance within the specification limits;

2) temporary degradation or loss of function or performance which is self-recoverable;

3) temporary degradation or loss of function or performance which requires operator intervention or system reset;

4) degradation or loss of function which is not recoverable due to damage of equipment (components) or software, or loss of data.

Equipment shall not become dangerous or unsafe as a result of the application of the tests defined in this standard.

In the case of acceptance tests, the test program and the interpretation of the test results have to be described in the specific product standard.

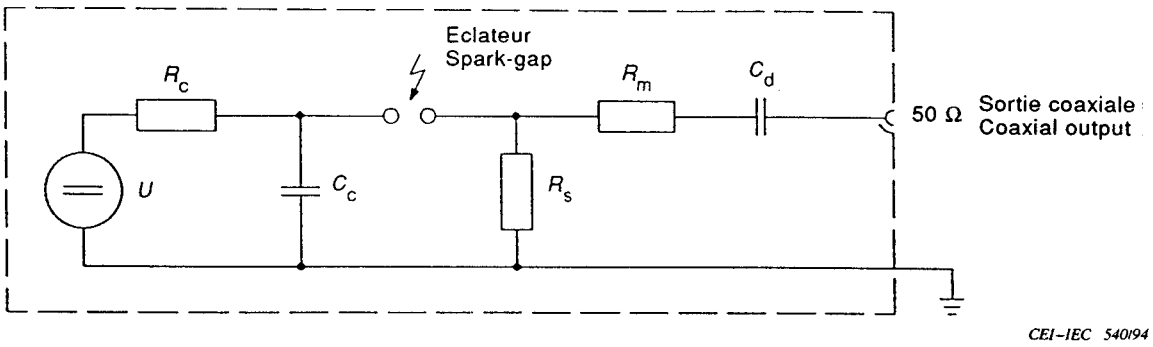
As a general rule, the test result is positive if the equipment shows its immunity, for all the period of application of the test, and at the end of the tests the EUT fulfils the functional requirements established in the technical specification.

The technical specification may define effects on the EUT that may be considered insignificant and therefore acceptable.

For these conditions it shall be verified that the equipment is able to recover its operative capabilities by itself at the end of the test; the time interval during which the equipment has lost its functional capabilities shall therefore be recorded.

These verifications are binding for the definitive evaluation of the test result.

The test report shall include the test conditions and the test results.



U = high-voltage source
R_c = charging resistor
C_c = energy storage capacitor
R_s = pulse duration shaping resistor
R_m = impedance matching resistor
C_d = d.c. blocking capacitor

Figure 1 – Simplified circuit diagram of a fast transient/burst generator

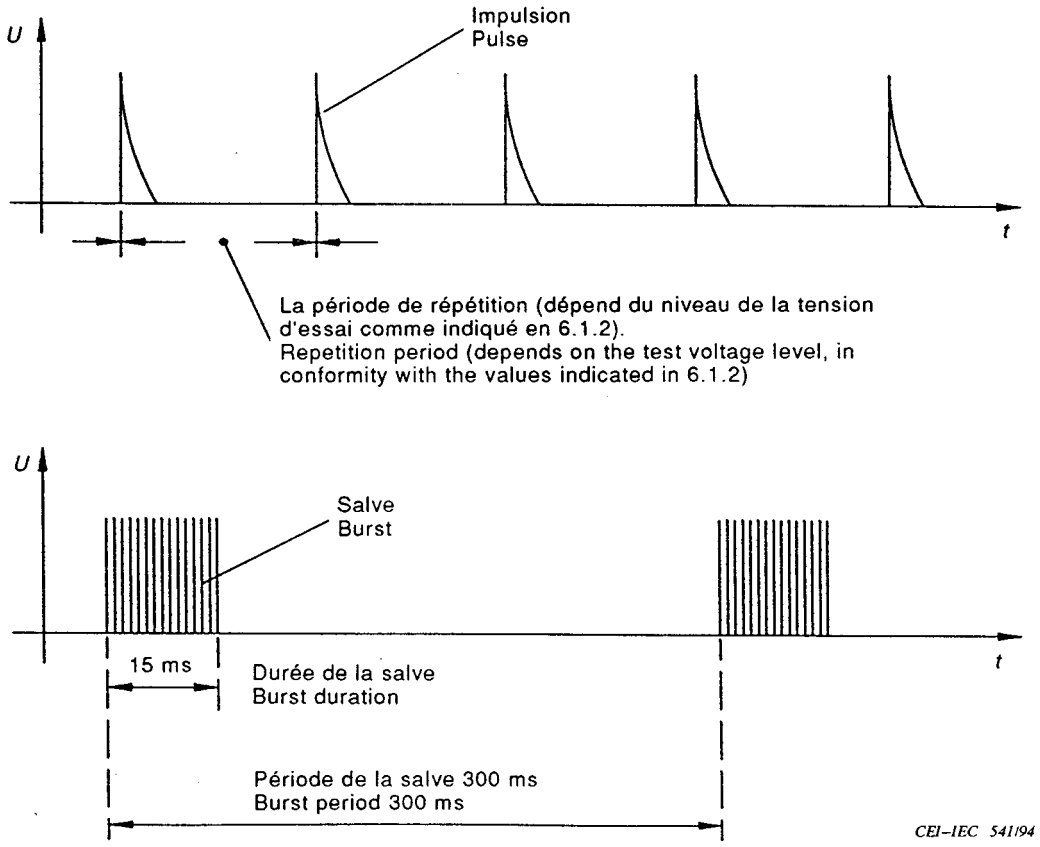


Figure 2 – General graph of a fast transient/burst

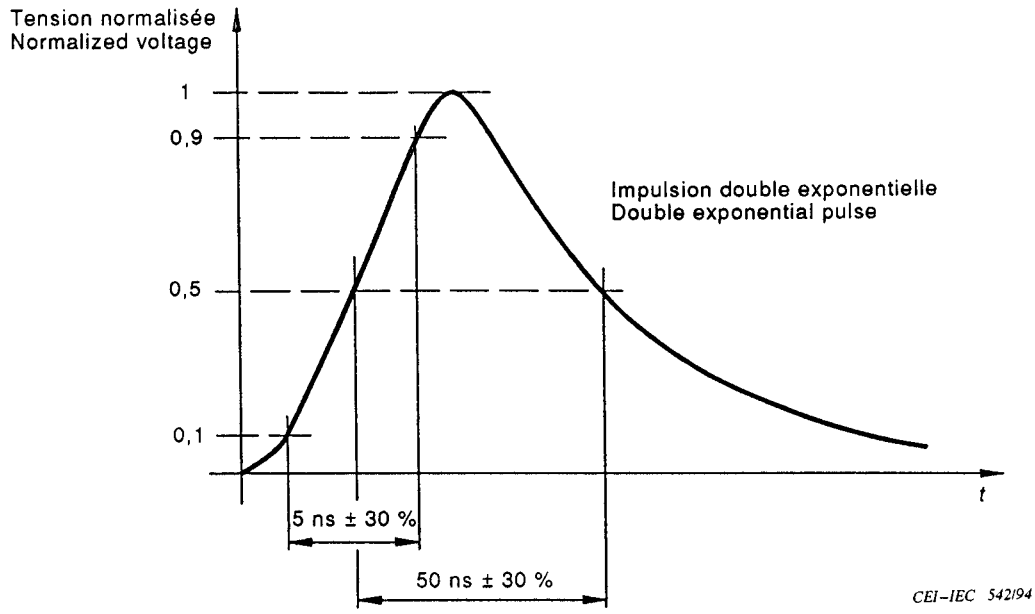
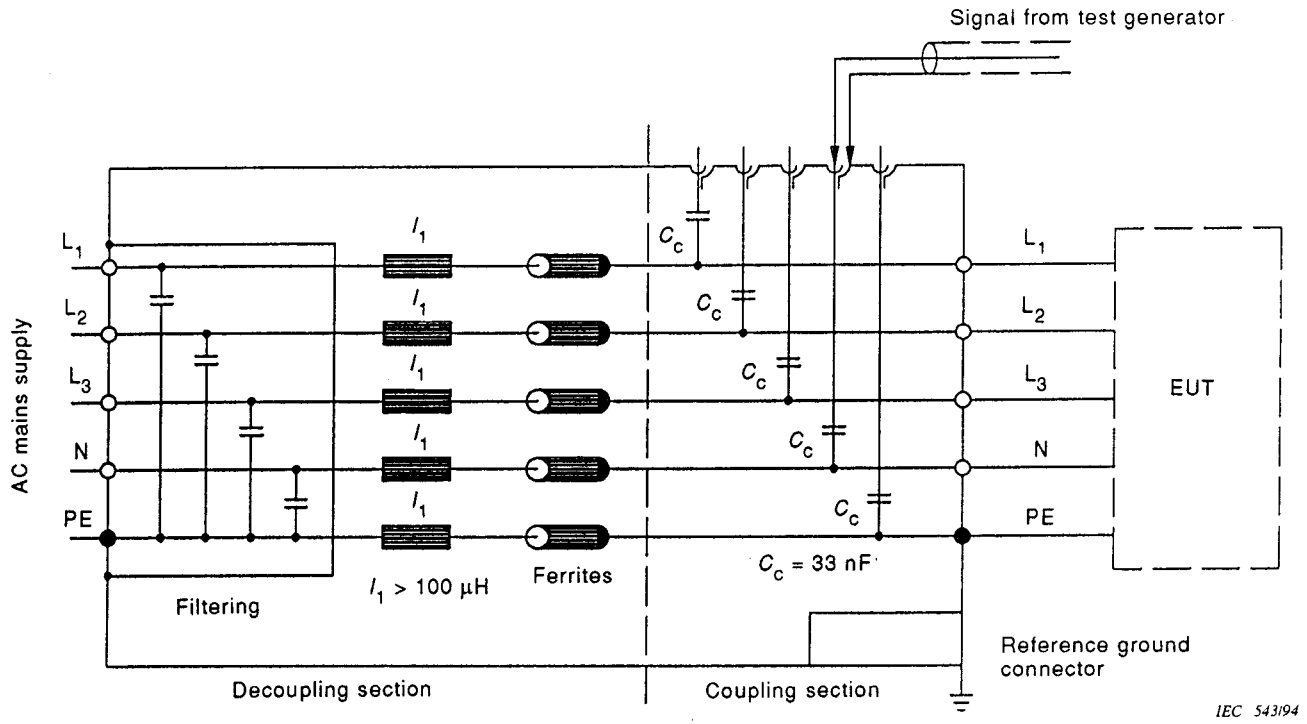


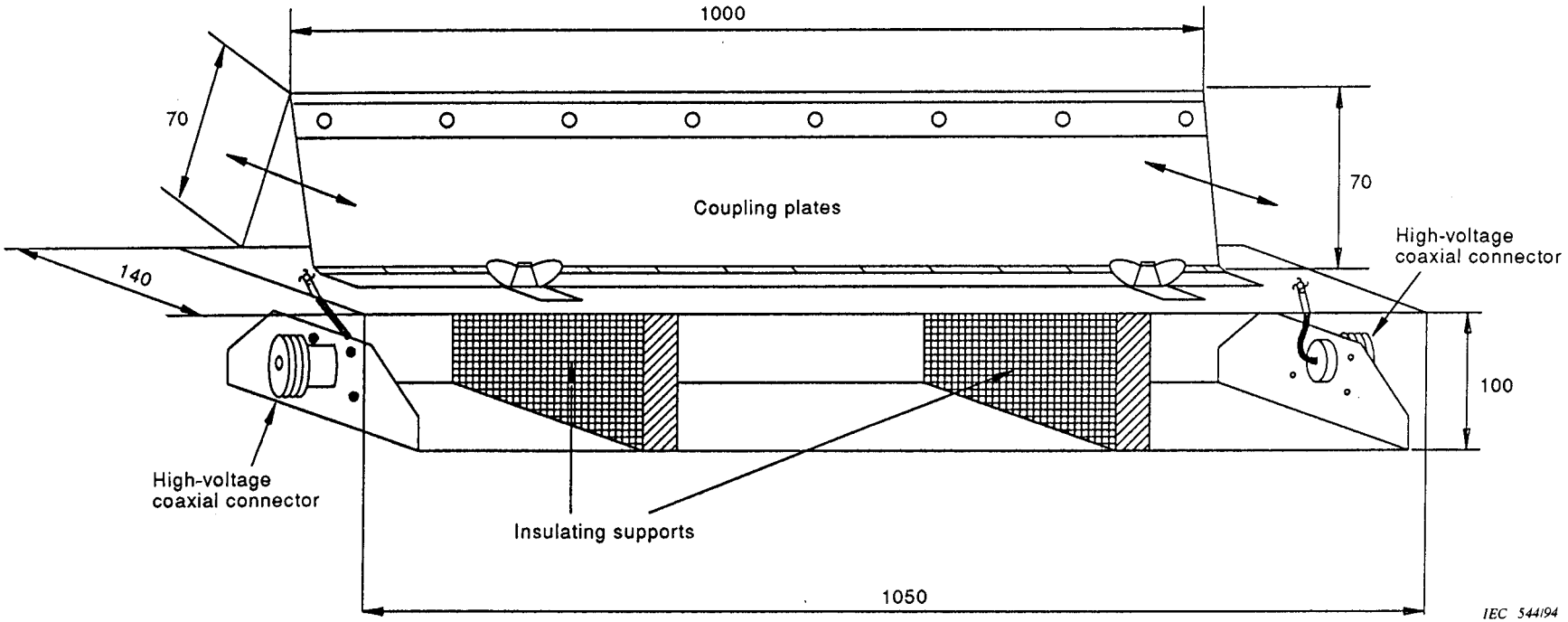
Figure 3 – Waveshape of a single pulse into a 50 Ω load



(Example: Construction for three-phase lines, d.c. lines/terminals shall be treated in a similar way.)

Warning: The construction and application of the coupling/decoupling network shall be such that existing national safety regulations will not be violated.

Figure 4 – Coupling/decoupling network for a.c./d.c. power mains supply ports/terminals



Dimensions in millimetres

Warning: The distance of the coupling section to all other conductive constructions except to the cable under test and the ground plane shall be more than 0,5 m.

Figure 5 – Construction of the capacitive coupling clamp

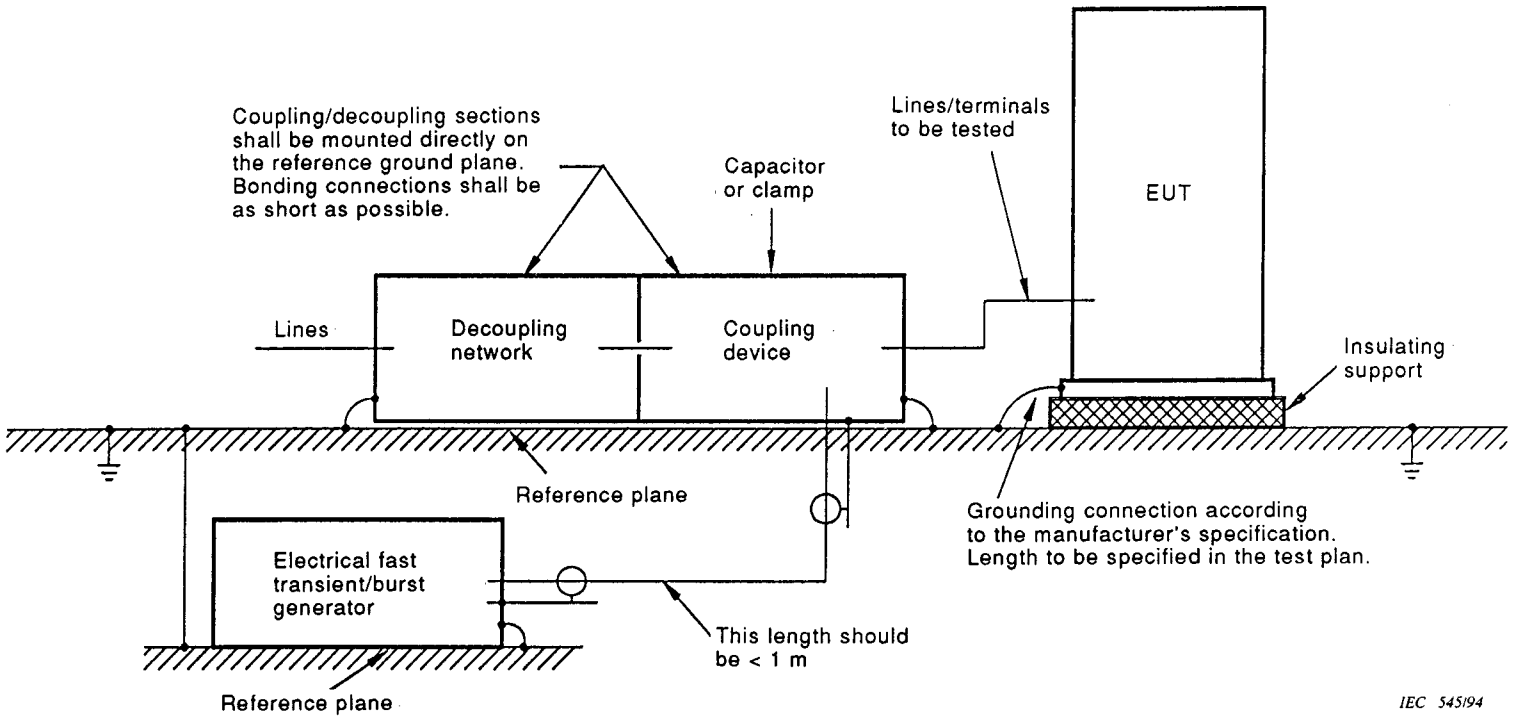


Figure 6 – Block-diagram for electrical fast transient/burst immunity test

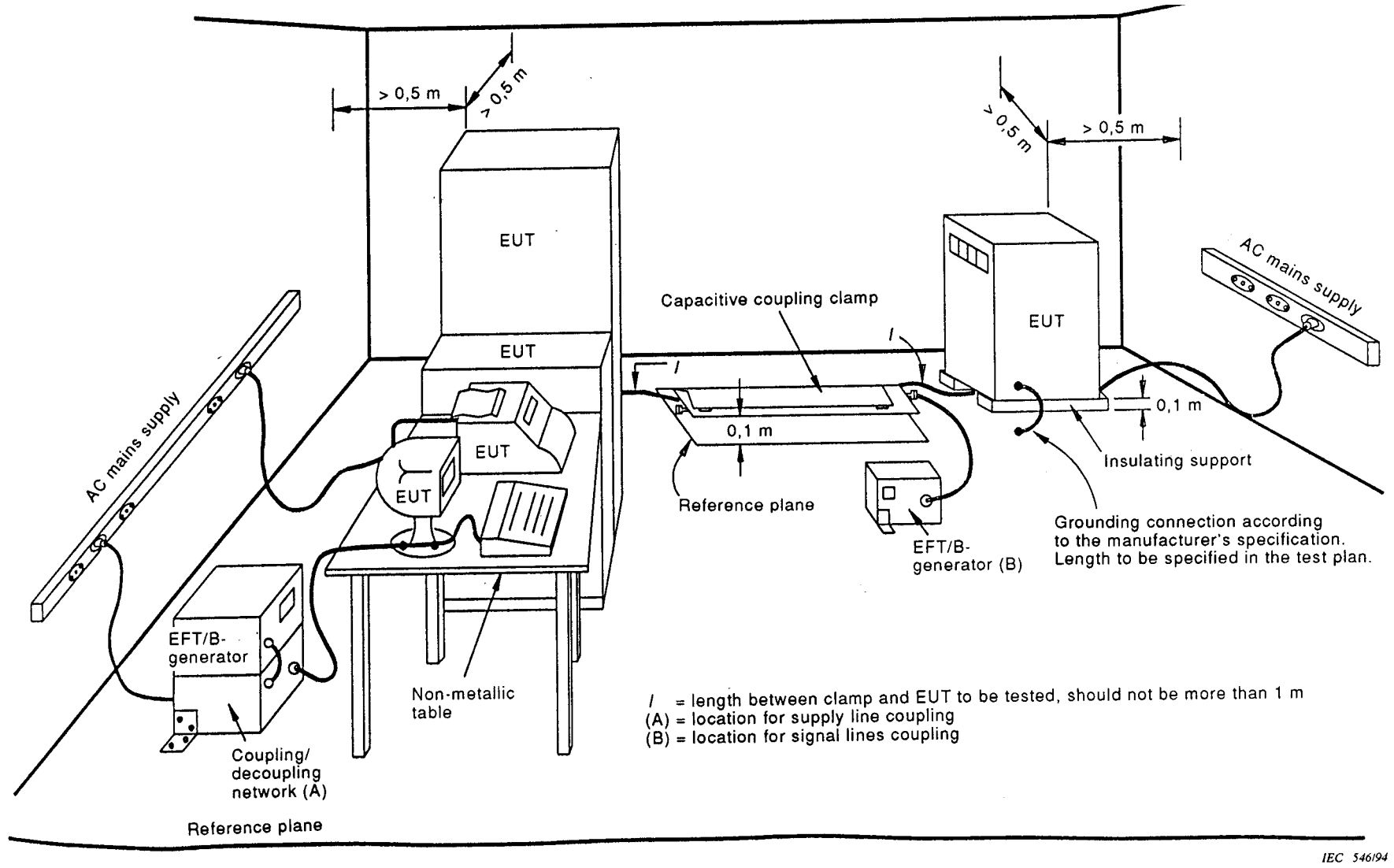


Figure 7 – General test set-up for laboratory type tests

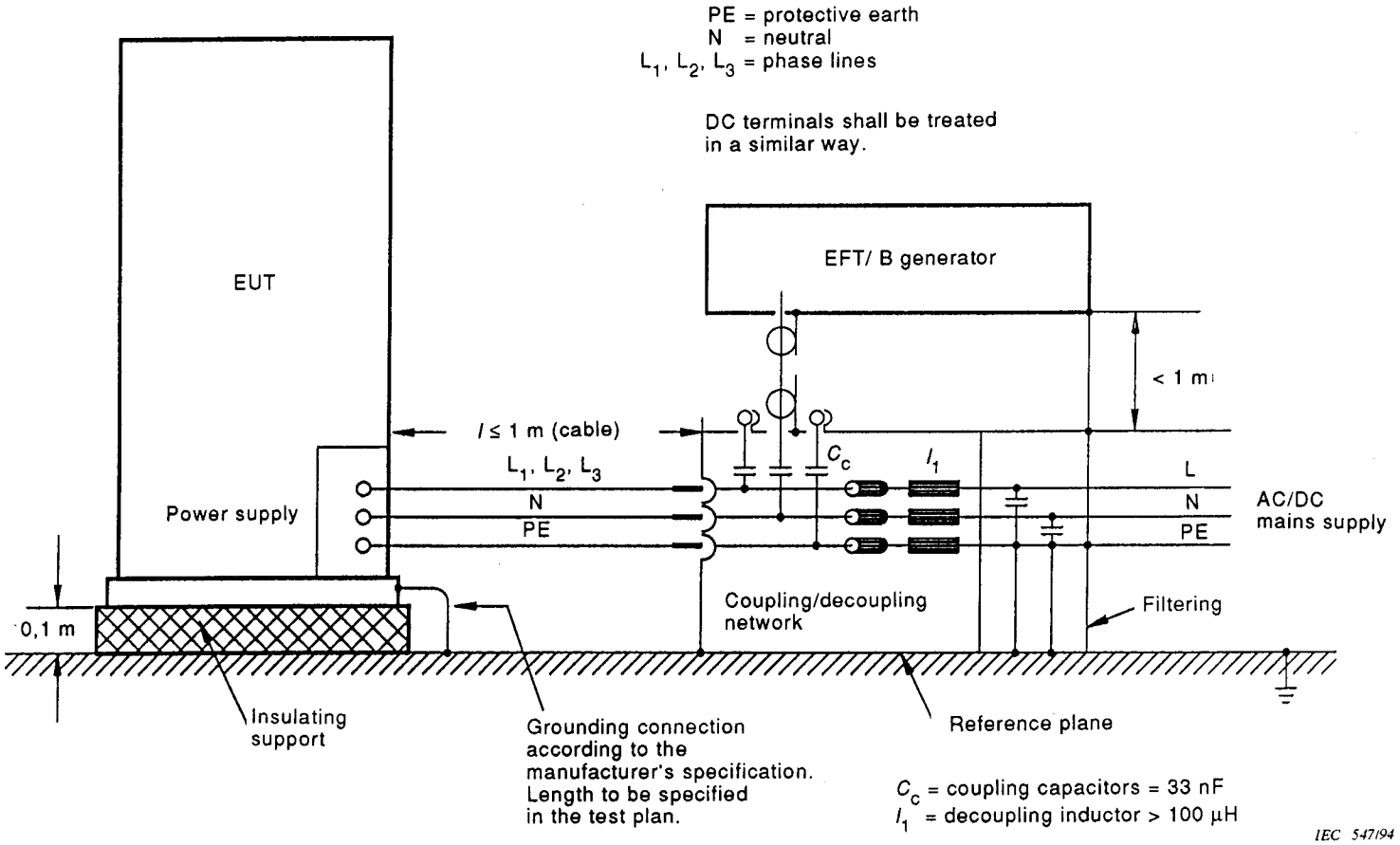


Figure 8 – Example of test set-up for direct coupling of the test voltage to a.c./d.c. power supply ports/terminals for laboratory test purposes

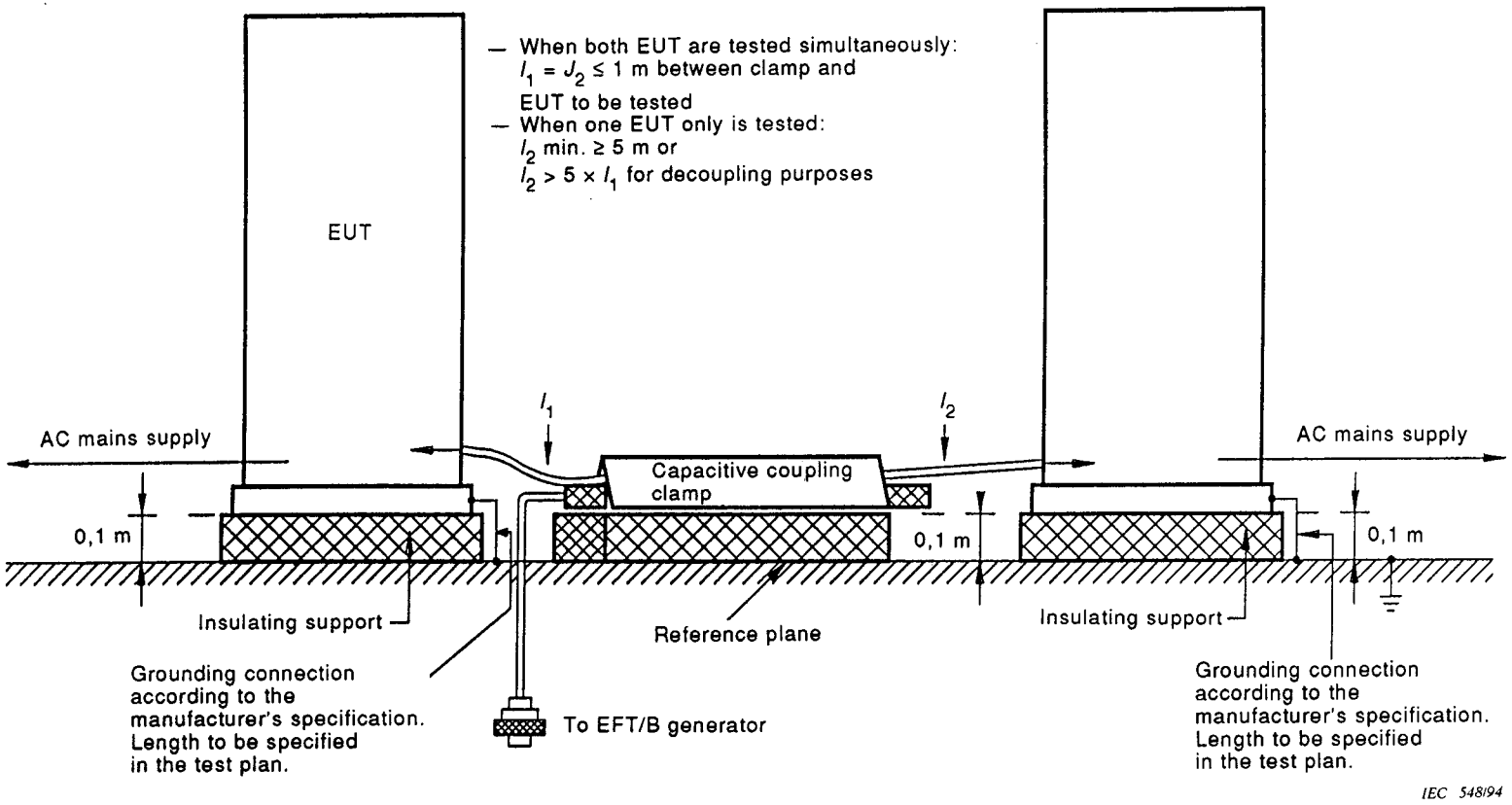


Figure 9 – Example of test set-up for application of the test voltage by the capacitive coupling clamp for laboratory test purposes

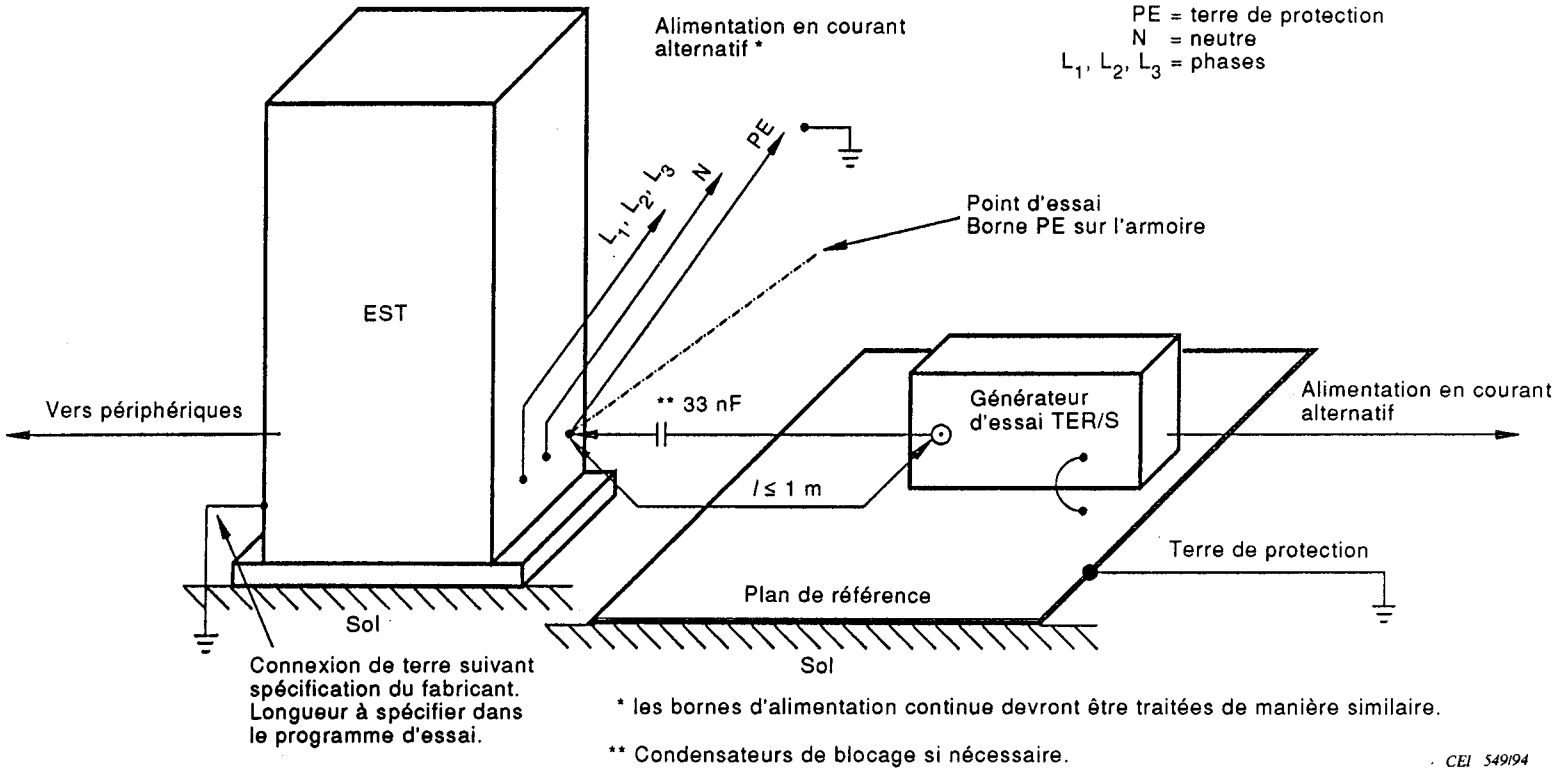


Figure 10 – Example for post-installation test on a.c./d.c. power supply ports and protective earth terminals for stationary, floor-mounted EUT

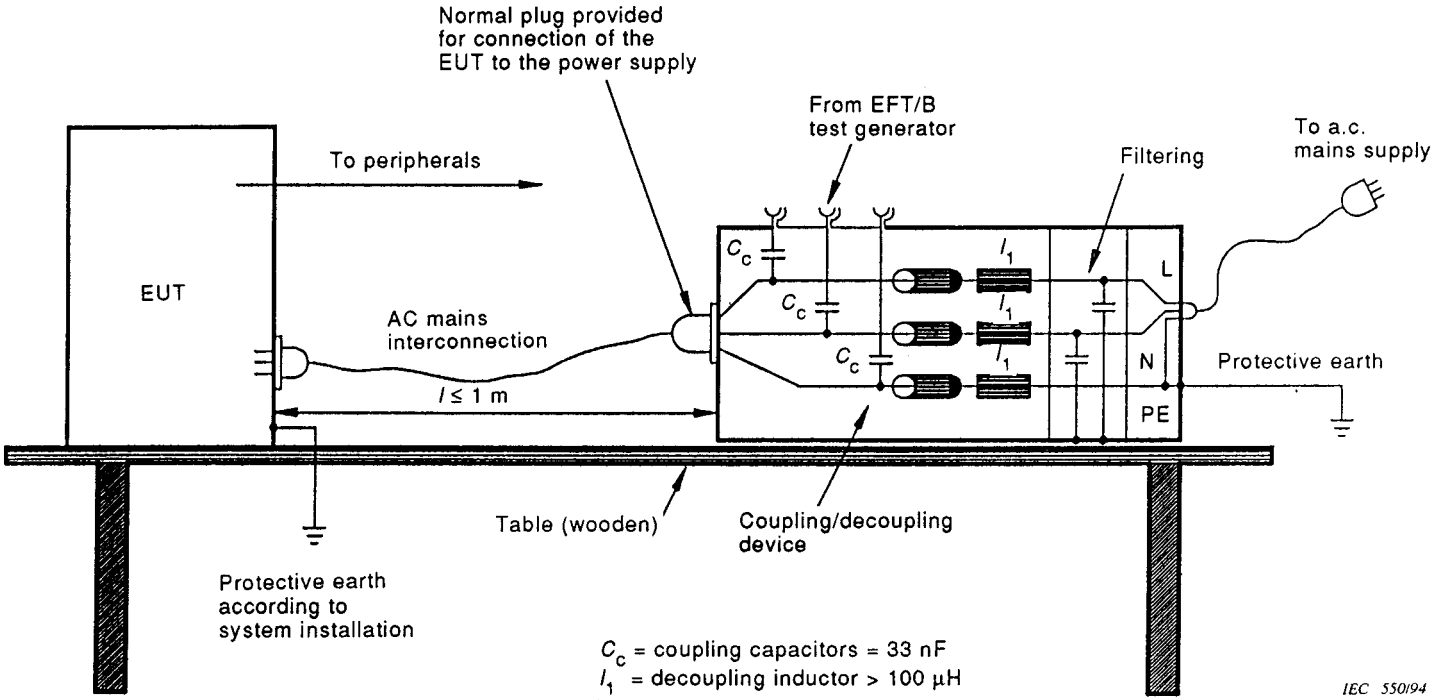


Figure 11 – Example for post-installation test on a.c. mains supply port and protective earth terminals for non-stationary mounted EUT

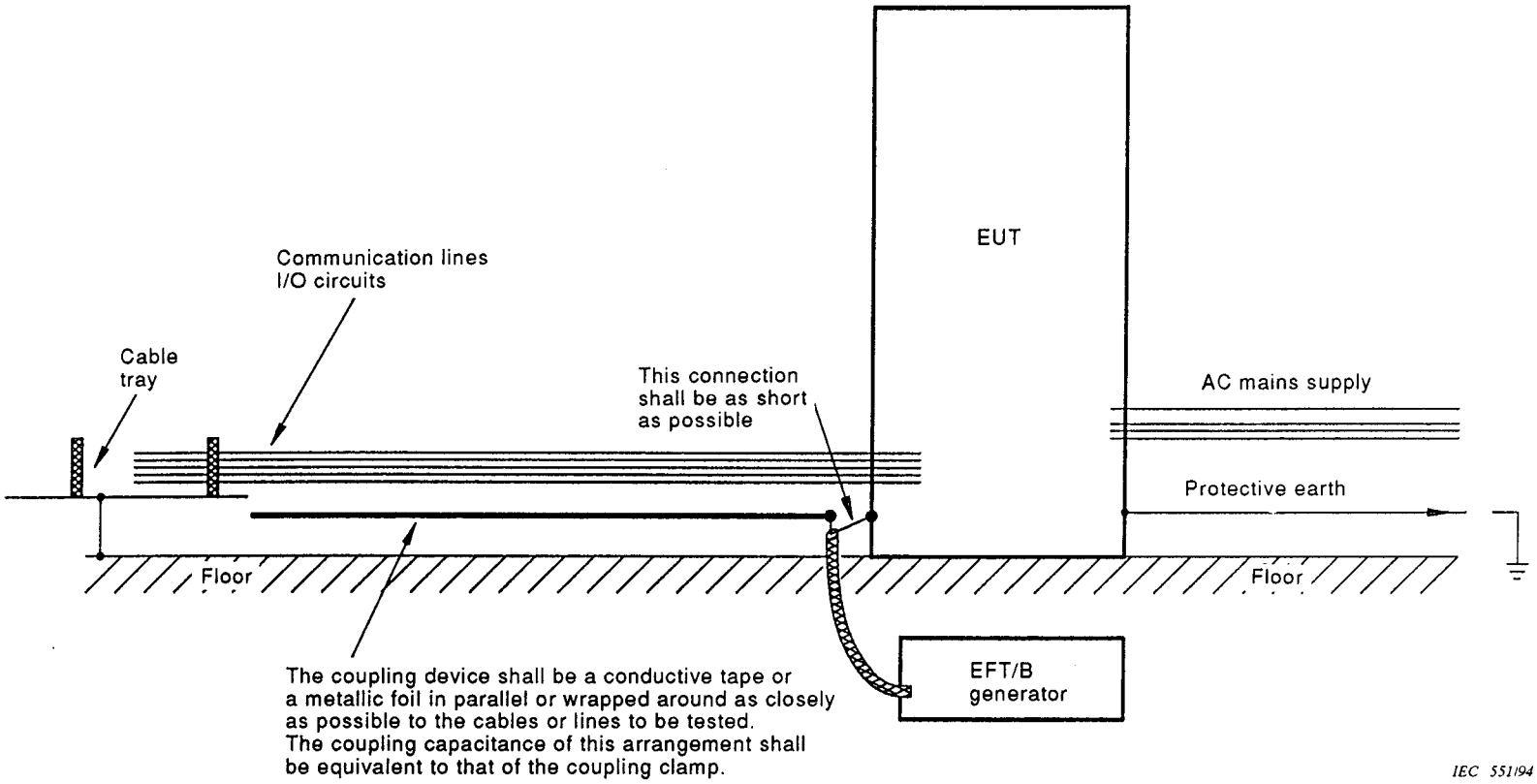


Figure 12 – Example for post-installation test on communications and I/O ports without the capacitive coupling clamp

Annex A
(informative)

Explanatory notes on transient/burst generator and selection of the test levels

Experience collected over a long period of immunity testing of electrical and electronic equipment has shown that to cover sufficiently the wide range of electric and electromagnetic disturbances, a test that simulates fast transients with high repetition frequency is necessary. The knowledge of this fact is commonplace among EMC experts and many companies have developed such fast transient testing.

The problem is that relevant parameters of the test generator and the test set-up differ widely and the test results cannot be related to each other. This situation is bound to create problems if equipment with different immunity levels and from different manufacturers is integrated into one system in a given electromagnetic environment.

These concerns were among the principal considerations which have led to the preparation of this standard.

A.1 Fast transient/burst generator

To eliminate ambiguities which may arise from diverging characteristics of various test generators a standardized calibration or testing procedure is necessary. During the application of fast transients/bursts into a 50 Ω resistive load (frequency response flat up to 400 MHz) the relevant characteristics of the test generator should be measured (see 6.1.2).

Due to the mechanical and electrical instability of the spark gap below 1 kV, the test voltages below 2 kV may be derived by voltage dividers.

The actual phenomenon of a burst occurs with repetition rates of the individual pulses from 10 kHz to 1 MHz. However, extensive investigations have indicated that this relatively high repetition rate is difficult to duplicate with a generator using a fixed adjusted spark gap. Therefore lower repetition rates (but of representative individual pulses) have been specified in 6.1.2.

The pulse repetition rate according to the selected test level will take into account the special behaviour of this spark gap circuitry.

A.2 Selection of the test levels

The test levels should be selected in accordance with the most realistic installation and environmental conditions. These levels are outlined in clause 5 of this standard.

The immunity tests are correlated with these levels in order to establish a performance level for the environment in which the equipment is expected to operate.

For testing I/O, control, signal and data EUT’s ports use half the test voltage values applied on power supply ports.

Based on common installation practices, the recommended selection of test levels for EFT/B testing according to the requirements of the electromagnetic environment, is the following:

Level 1: Well-protected environment

The installation is characterized by the following attributes:

- suppression of all EFT/B in the switched power supply and control circuits;
- separation between power supply lines (a.c. and d.c.) and control and measurement circuits coming from other environments belonging to higher severity levels:
- shielded power supply cables with the screens earthed at both ends on the reference ground of the installation, and power supply protection by filtering.

The computer room may be representative of this environment.

The applicability of this level to testing of equipment is limited to the power supply circuits for type tests, and to the earthing circuits and equipment cabinets for post-installation tests.

Level 2: Protected environment

The installation is characterized by the following attributes:

- partial suppression of EFT/B in the power supply and control circuits which are switched only by relays (no contactors);
- separation of all the circuits from other circuits associated with environments of higher severity levels;
- physical separation of unshielded power supply and control cables from signal and communication cables.

The control room or terminal room of industrial and electrical plants may be representative of this environment.

Level 3: Typical industrial environment

The installation is characterized by the following attributes:

- no suppression of EFT/B in the power supply and control circuits which are switched only by relays (no contactors);
- poor separation of the industrial circuits from other circuits associated with environments of higher severity levels;
- dedicated cables for power supply, control, signal and communication lines;
- poor separation between power supply, control, signal and communication cables;
- availability of earthing system represented by conductive pipes, ground conductors in the cable trays (connected to the protective earth system) and by a ground mesh.

The area of industrial process equipment, the power plants and the relay room of open-air H.V. substations may be representative of this environment.

Level 4: Severe industrial environment

The installation is characterized by the following attributes:

− no suppression of EFT/B in the power supply and control and power circuits which are switched by relays and contactors;

− no separation of the industrial circuits from other circuits associated with environments of higher severity levels;

− no separation between power supply, control, signal and communication cables;

− use of multicore cables in common for control and signal lines.

The outdoor area of industrial process equipment, where no specific installation practice has been adopted, of power stations, open-air H.V. substation switchyards and gas insulated switchgear of up to 500 kV operating voltage (with typical installation practice) may be representative of this environment.

Level 5: Special situations to be analysed

The minor or major electromagnetic separation of disturbance sources from equipment circuits, cables, lines etc., and the quality of the installations may require the use of a higher or lower environmental level than those described above. It should be noted that equipment lines of a higher environmental level can penetrate a lower severity environment.

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