

Australian/New Zealand Standard™

Electromagnetic compatibility (EMC)

Part 4.5: Testing and measurement techniques—Surge immunity test



AS/NZS 61000.4.5:2006

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Australian/New Zealand Standard™

Electromagnetic compatibility (EMC)

Part 4.5: Testing and measurement techniques—Surge immunity test

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee TE-003, Electromagnetic Interferences to supersede AS/NZS 61000.4.5:1999. It is one of a series of Standards intended to facilitate control of electromagnetic interference and the compatibility of electrical and electronic equipment.

This Standard is identical with, and has been reproduced from IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC)—Part 4-5: Testing and measuring techniques—Surge immunity test*.

The objective of this Standard is to provide designers, manufacturers, and testers of equipment incorporating electrical or electronic operation with methods of test for ascertaining immunity to electromagnetic disturbances. As this Standard is reproduced from an international standard, the following applies:

- (a) Its number appears on the cover and title page while the international standard number appears only on the cover
- (b) In the source text ‘this part of IEC 61000’ should read ‘this Australian/New Zealand Standard’.
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References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard</i>		<i>Australian/New Zealand Standard</i>
IEC		
60050	International Electrotechnical Vocabulary (IEV)	—
60050 (161)	Chapter 161: Electromagnetic compatibility	—
60060	High-voltage test techniques	—
60060-1	Part 1: General definitions and test requirements	—
60469	Pulse techniques and apparatus	—
60469-1	Part 1: Pulse terms and definitions	—

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AUSTRALIAN/NEW ZEALAND STANDARD

Electromagnetic compatibility (EMC)

Part 4.5:

Testing and measurement techniques—Surge immunity test

1 Scope and object

This part of IEC 61000 relates to the immunity requirements, test methods, and range of recommended test levels for equipment to unidirectional surges caused by overvoltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to electrical and electronic equipment.

The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to surges. The test method documented in this part of IEC 61000 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.

NOTE As described in IEC Guide 107, this is a basic EMC publication for use by product committees of the IEC. As also stated in Guide 107, the IEC product committees are responsible for determining whether this immunity test standard should be applied or not, and if applied, they are responsible for determining the appropriate test levels and performance criteria. TC 77 and its sub-committees are prepared to co-operate with product committees in the evaluation of the value of particular immunity tests for their products.

This standard defines:

- a range of test levels;
- test equipment;
- test setups;
- test procedures.

The task of the described laboratory test is to find the reaction of the EUT under specified operational conditions, to surge voltages caused by switching and lightning effects at certain threat levels.

It is not intended to test the capability of the EUT's insulation to withstand high-voltage stress. Direct injections of lightning currents, i.e, direct lightning strikes, are not considered in this standard.

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 60050(161), *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60469-1, *Pulse techniques and apparatus – Part 1: Pulse terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions in IEC 60050(161) and the following apply.

3.1

avalanche device

diode, gas tube arrestor, or other component that is designed to break down and conduct at a specified voltage

3.2

calibration

set of operations which establishes, by reference to standards, the relationship which exists, under specified conditions, between an indication and a result of a measurement

[IEV 311-01-09]

NOTE 1 This term is based on the "uncertainty" approach.

NOTE 2 The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

3.3

clamping device

diode, varistor or other component that is designed to prevent an applied voltage from exceeding a specified value

3.4

combination wave generator

generator with 1,2/50 μ s or 10/700 μ s open-circuit voltage waveform and respectively 8/20 μ s or 5/320 μ s short-circuit current waveform

3.5

coupling network

electrical circuit for the purpose of transferring energy from one circuit to another

3.6

decoupling network

electrical circuit for the purpose of preventing surges applied to the EUT from affecting other devices, equipment or systems which are not under test

3.7

duration

absolute value of the interval during which a specified waveform or feature exists or continues

[IEC 60469-1]

3.8**effective output impedance** (of a surge generator)

ratio of the peak open-circuit voltage to the peak short-circuit current

3.9**electrical installation**

assembly of associated electrical equipment having co-ordinated characteristics to fulfil purposes

[IEV 826-10-01]

3.10**EUT**

equipment under test

3.11**front time****surge voltage**

the front time T_1 of a surge voltage is a virtual parameter defined as 1,67 times the interval T between the instants when the impulse is 30 % and 90 % of the peak value (see Figures 2 and 5)

surge current

the front time T_1 of a surge current is a virtual parameter defined as 1,25 times the interval T between the instants when the impulse is 10 % and 90 % of the peak value (see Figures 3 and 6)

[IEC 60060-1, 24.3 modified]

3.12**ground (reference)**

part of the Earth considered as conductive, the electrical potential of which is conventionally taken as zero, being outside the zone of influence of any earthing (grounding) arrangement

[IEV 195-01-01]

3.13**high-speed communication lines**

input/output lines which operate at transmission frequencies above 100 kHz

3.14**immunity**

ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01 -20]

3.15**interconnection lines**

I/O lines (input/output lines) and communication lines

3.16**primary protection**

means by which the majority of stressful energy is prevented from propagating beyond a designated interface

3.17**rise time**

interval of time between the instants at which the instantaneous value of a pulse first reaches the specified lower and upper limits.

[IEV 161-02-05]

NOTE Unless otherwise specified, the lower and upper values are fixed at 10 % and 90 % of the pulse magnitude.

3.18**secondary protection**

means by which the let-through energy from primary protection is suppressed. It may be a special device or an inherent characteristic of the EUT

3.19**surge**

transient wave of electrical current, voltage, or power propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease

[IEV 161-08-11 modified]

3.20**symmetrical lines**

pair of symmetrically driven conductors with a conversion loss from differential to common mode of greater than 20 dB

3.21**system**

set of interdependent elements constituted to achieve a given objective by performing a specified function

[IEV 351-11-01 modified]

NOTE The system is considered to be separated from the environment and other external systems by an imaginary surface which cuts the links between them and the considered system. Through these links, the system is affected by the environment, is acted upon by the external systems, or acts itself on the environment or the external systems.

3.22**time to half-value**

T_2

interval of time between the instant of virtual origin O_1 and the instant when the voltage or current has decreased to half the peak value

[IEC 60060-1, 18.1.6 modified]

NOTE The time to half-value T_2 of a surge is a virtual parameter.

3.23**transient**

pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval short compared to the time scale of interest

[IEV 161-02-01]

3.24**verification**

set of operations which is used to check the test equipment system (e.g. the test generator and the interconnecting cables) to demonstrate that the test system is functioning within the specifications given in Clause 6

NOTE 1 The methods used for verification may be different from those used for calibration.

NOTE 2 The procedure of 6.1.2 and 6.2.2 is meant to ensure the correct operation of the test generator, and other items making up the test setup so that the intended waveform is delivered to the EUT.

NOTE 3 For the purposes of this basic EMC standard this definition is different of the definition given in IEC 311-01-13.

3.25

virtual Origin

O_1

for the surge voltage waveform, it is the instant at which a straight line drawn through the 30 % and 90 % amplitude values crosses the time axis. For the surge current waveform, it is the instant at which a straight line drawn through the 10 % and 90 % amplitude values crosses the time axis

4 General

4.1 Power system switching transients

Power system switching transients can be separated into transients associated with

- a) major power system switching disturbances, such as capacitor bank switching;
- b) minor local switching activity or load changes in the power distribution system;
- c) resonating circuits associated with switching devices, such as thyristors;
- d) various system faults, such as short circuits and arcing faults to the grounding system of the installation.

4.2 Lightning transients

The major mechanisms by which lightning produces surge voltages are the following:

- a) direct lightning stroke to an external (outdoor) circuit injecting high currents producing voltages by either flowing through ground resistance or flowing through the impedance of the external circuit;
- b) an indirect lightning stroke (i.e. a stroke between or within clouds or to nearby objects which produces electromagnetic fields) that induces voltages/currents on the conductors outside and/or inside a building;
- c) lightning ground current flow resulting from nearby direct-to-earth discharges coupling into the common ground paths of the grounding system of the installation.

The rapid change of voltage and flow of current which can occur as a result of the operation of a lightning protection device can induce electromagnetic disturbances into adjacent equipment.

4.3 Simulation of the transients

The characteristics of the test generator are such that it simulates the above-mentioned phenomena as closely as possible.

If the source of interference is in the same circuit, for example in the power supply network (direct coupling), the generator may simulate a low impedance source at the ports of the equipment under test.

If the source of interference is not in the same circuit as the victim equipment (indirect coupling), then the generator may simulate a higher impedance source.

5 Test levels

The preferred range of test levels is given in Table 1.

Table 1 – Test levels

Level	Open-circuit test voltage $\pm 10\%$ kV
1	0,5
2	1,0
3	2,0
4	4,0
X	Special
NOTE X can be any level, above, below or in between the other levels. This level can be specified in the product standard.	

The test levels shall be selected according to the installation conditions; classes of installation are given in Clause B.3.

All voltages of the lower test levels shall be satisfied (see 8.2).

For selection of the test levels for the different interfaces, refer to Annex A.

6 Test instrumentation

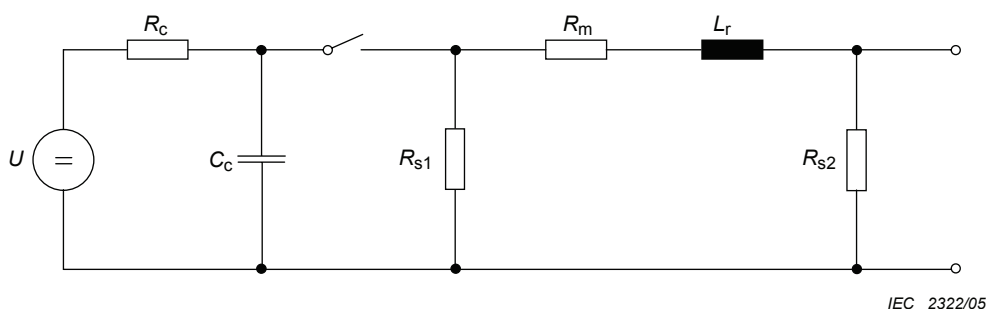
Two types of combination wave generator are specified. Each has its own particular applications, depending on the type of port to be tested (see Clause 7). The 10/700 μs combination wave generator is used to test ports intended for connection to symmetrical communication lines. The 1,2/50 μs combination wave generator is used in all other cases, and in particular, for testing ports intended for power lines and short-distance signal connections.

6.1 1,2/50 μs combination wave generator

It is the intention of this standard that the output waveforms meet specifications at the point where they are to be applied to the EUT. Waveforms are specified as open-circuit voltage and short-circuit current and therefore are measured without the EUT connected. In the case of an a.c. or d.c. powered product where the surge is applied to the a.c. or d.c. supply lines, the output must be as specified in Tables 6 and 7. In the case where the surge is to be applied directly from the generator output terminals, the waveforms shall be as specified in Table 2. It is not intended that the waveforms meet specifications both at the generator output and at the output of coupling/decoupling networks simultaneously, but only as applied to the EUT. The waveform specifications are to be met without an EUT connected.

This generator is intended to generate a surge having: an open-circuit voltage front time of 1,2 μs ; an open-circuit voltage time to half value of 50 μs ; a short-circuit current front time of 8 μs ; and a short-circuit current time to half value of 20 μs .

A simplified circuit diagram of the generator is given in Figure 1. The values for the different components R_{S1} , R_{S2} , R_m , L_r , and C_c are selected so that the generator delivers a 1,2/50 μs voltage surge (at open-circuit conditions) and a 8/20 μs current surge into a short circuit.



U	High-voltage source
R_c	Charging resistor
C_c	Energy storage capacitor
R_s	Pulse duration shaping resistors
R_m	Impedance matching resistor
L_r	Rise time shaping inductor

Figure 1 – Simplified circuit diagram of the combination wave generator (1,2/50 μs – 8/20 μs)

For convenience, the ratio of peak open-circuit output voltage to peak short-circuit current of a combination wave generator may be considered the effective output impedance. For this generator, the ratio defines an effective output impedance of 2 Ω .

NOTE The waveform of the voltage and current is a function of the EUT input impedance. This impedance may change during surges to equipment due either to proper operation of the installed protection devices, or to flash over or component breakdown if the protection devices are absent or inoperative. Therefore, the 1,2/50 μs voltage and the 8/20 μs current waves have to be available from the same generator output as required by the load.

6.1.1 Characteristics and performance of the generator

Polarity	positive and negative
Phase shifting	in a range between 0° to 360° relative to the phase angle of the a.c. line voltage to the equipment under test, with a tolerance of $\pm 10^\circ$
Repetition rate	1 per minute or faster
Open-circuit peak output voltage	adjustable from 0,5 kV to the required test level
Waveform of the surge voltage	see Table 2 and Figure 2
Output voltage setting tolerance	see Table 3
Short-circuit peak output current	depends on peak voltage setting (see Tables 2 and 3)
Waveform of the surge current	see Table 2 and Figure 3
Short-circuit output current tolerance	see Table 3
Effective output impedance	2 $\Omega \pm 10\%$

Table 2 – Definitions of the waveform parameters 1,2/50 μ s – 8/20 μ s

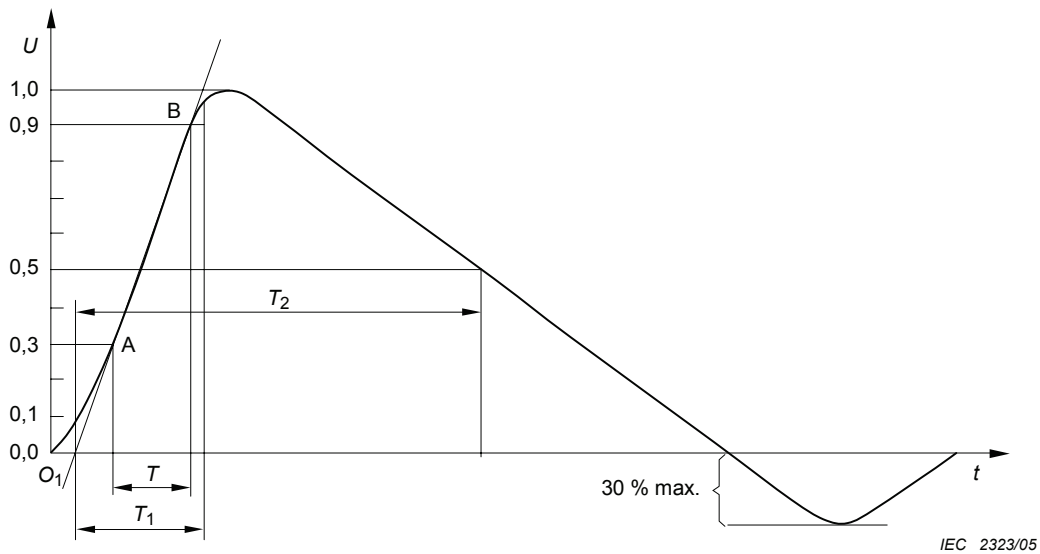
Definitions	In accordance with IEC 60060-1		In accordance with IEC 60469-1	
	Front time μ s	Time to half value μ s	Rise time (10 % – 90 %) μ s	Duration time (50 % – 50 %) μ s
Open-circuit voltage	1,2 $\pm$ 30 %	50 $\pm$ 20 %	1 $\pm$ 30 %	50 $\pm$ 20 %
Short-circuit current	8 $\pm$ 20 %	20 $\pm$ 20 %	6,4 $\pm$ 20 %	16 $\pm$ 20 %
NOTE In existing IEC publications, the waveforms 1,2/50 μs and 8/20 μs are generally defined according to IEC 60060-1 as shown in Figures 2 and 3. Other IEC recommendations are based on waveform definitions according to IEC 60469-1 as shown in Table 2. Both definitions are valid for this part of IEC 61000 and describe just one single generator.				

Table 3 – Relationship between peak open-circuit voltage and peak short-circuit current

Open-circuit peak voltage $\pm$ 10 %	Short-circuit peak current $\pm$ 10 %
0,5 kV	0,25 kA
1,0 kV	0,5 kA
2,0 kV	1,0 kA
4,0 kV	2,0 kA

The peak short-circuit current shall be as shown in Table 3 when the peak open circuit voltage is as specified.

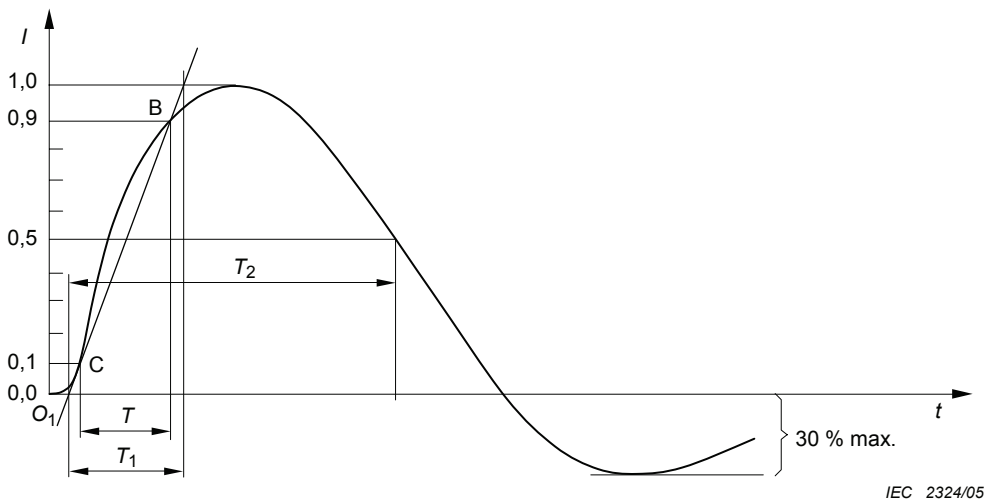
A generator with floating output shall be used.



Front time: $T_1 = 1,67 \times T = 1,2 \mu\text{s} \pm 30 \%$
 Time to half-value: $T_2 = 50 \mu\text{s} \pm 20 \%$.

NOTE The open circuit voltage waveform at the output of the coupling/decoupling network may have a considerable undershoot, in principle as the curve shown in Figure 3.

Figure 2 – Waveform of open-circuit voltage (1,2/50 μs) at the output of the generator with no CDN connected (waveform definition according to IEC 60060-1)



Front time: $T_1 = 1,25 \times T = 8 \mu\text{s} \pm 20 \%$
 Time to half-value: $T_2 = 20 \mu\text{s} \pm 20 \%$

NOTE The 30 % undershoot specification applies only at the generator output. At the output of the coupling/decoupling network there is no limitation on undershoot or overshoot.

Figure 3 – Waveform of short-circuit current (8/20 μs) at the output of the generator with no CDN connected (waveform definition according to IEC 60060-1)

6.1.2 Calibration of the generator

In order to compare the test results from different generators, the generator shall be calibrated periodically. For this purpose, the following procedure is necessary to measure the most essential characteristics of the generator.

The generator output shall be connected to a measuring system with a sufficient bandwidth and voltage capability to monitor the characteristics of the waveforms.

The characteristics of the generator shall be measured under *open-circuit* conditions (load greater than or equal to 10 k Ω) and under *short-circuit* conditions (load smaller than or equal to 0,1 Ω) at the same charge voltage.

All waveform definitions as well as the performance parameters stated in 6.1.1 and 6.1.2 respectively shall be met at the output of the generator.

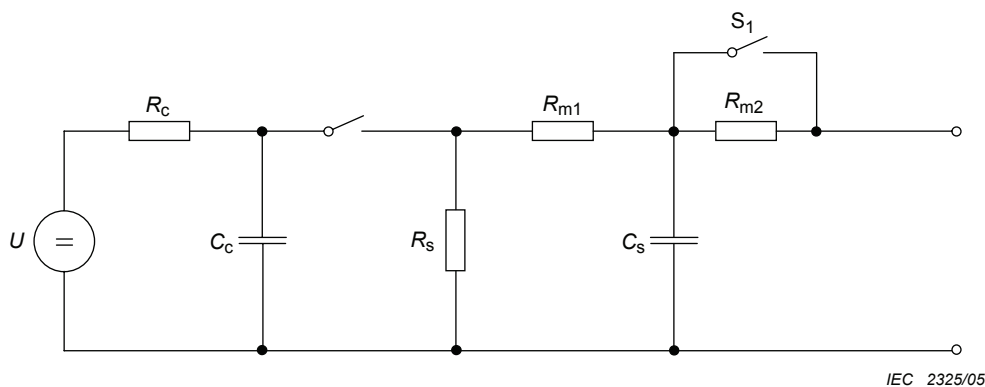
NOTE 1 When an additional internal or external resistor is added to the generator output to increase the effective source impedance from 2 Ω to e.g. 42 Ω according to the requirements of the test setup, the front time and the time to half value of test pulses at the output of the coupling network may be significantly changed.

NOTE 2 The characteristics of the combination wave generator in this clause can be used for verification.

6.2 10/700 μ s combination wave generator

This generator is intended to generate a surge having: an open-circuit voltage front time of 10 μ s; and an open-circuit voltage time to half value of 700 μ s.

The simplified circuit diagram of the generator is given in Figure 4. The values for the different components are selected so that the generator delivers a 10/700 μ s surge.



U	High-voltage source
R_C	Charging resistor
C_C	Energy storage capacitor
R_S	Pulse duration shaping resistor
R_m	Impedance matching resistors
C_S	Rise time shaping capacitor
S_1	Switch closed when using external matching resistors

Figure 4 – Simplified circuit diagram of the combination wave generator (10/700 μ s – 5/320 μ s) according to ITU K series standards