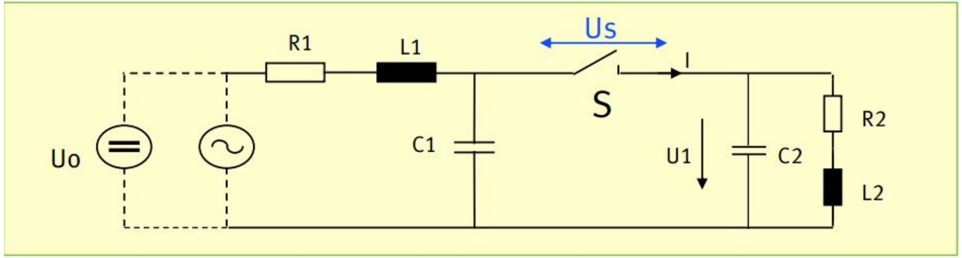
CONDUCTED | RF EQUIPMENT | POWER AMPLIFIERS

IEC 61000-4-4 Burst
Electrical fast transient / Burst immunity test

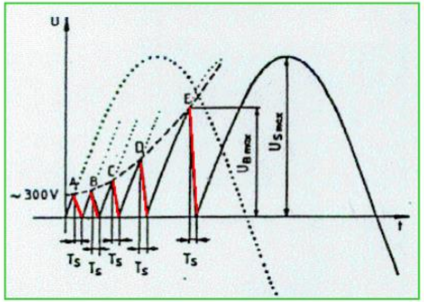
Accelonix EMC Workshop 18-6-2019

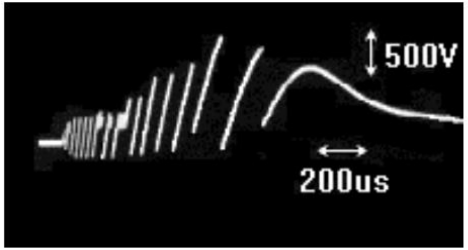
Phenomenom open a contact

Equivalent diagram of a switching circuit



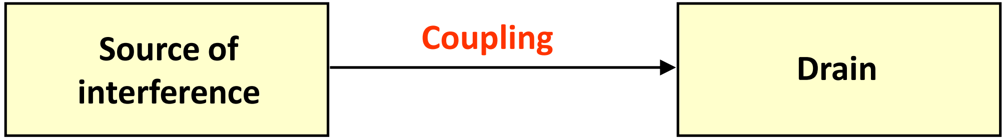
Typical voltage waveform across an opening switch





230V Power relays

EMC Model for fast transients



- **Source of interference**
  - Circuit breaker in electric circuits
  - High voltage switchgears
  - 110/230V power supply systems
  - 24V control lines
- **Characteristics**
  - Impulse with rise time in nanoseconds
  - Broadband interference spectrum up to 400 MHz
  - Amplitudes up to some kV
- **Coupling**
  - Capacitive (du/dt) to parallel lines
  - Inductive by magnetic fields (di/dt) to earth leads
  - Radiation in the near field by arcs
- **Migration**
  - Conducted in the cable system
  - Asymmetrical resp. Line to Earth

Test level IEC 61000-4-4: Ed3.0 (2012-4)

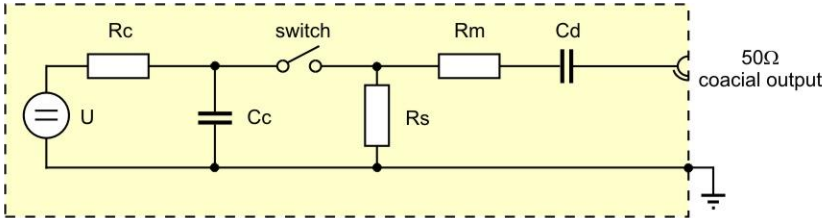
Open circuit test voltage			
Level	**Power line**	**I/O line**	
	Peak voltage [kV]		Repetition rate [kHz]
1	0,5	0,25	5 or **100**
2	1	0,5	5 or **100**
3	2	1	5 or **100**
4	4	2	5 or **100**
X (1)	special	special	

Table 1- Test levels

The use of 5 kHz repetition frequency is traditional, however, **100 kHz** is closer to reality. Product committees should determine which frequencies are relevant for specific products or product types.

In Annex B1 you will find representative values from real installations for your assistance.

Test equipment simplified circuit diagram of EFT / burst generator



50 Ώ output

Components

U	High-voltage source
Rc	Charging resistor
Cc	Energy storage capacitor
Rs	Impulse duration shaping resistor
Rm	Impedance matching resistor
Cd	DC blocking capacitor
Switch	High-voltage switch (electronic switch)

NOTE: The characteristics of the switch together with stray elements (inductance and capacitance) of the layout shape the required rise time.

Characteristic waveform

New in Edition 3

Output voltage range with 1000 Ω load:	min. **0.24 kV** up to **3.8 kV**; Test level 1 to 4
Output voltage range with 50 Ω load:	min. 0.125 kV up to 2 kV; Test level 1 to 4
Pulse repetition frequency:	5 kHz and 100 kHz ± 20 %
Burst duration (see 6.1.2 and fig. 2):	(15 ± 3) ms at 5 kHz (0.75 ± 0.15) ms at 100 kHz
Burst period	(300 ± 60) ms

Pulse shape:

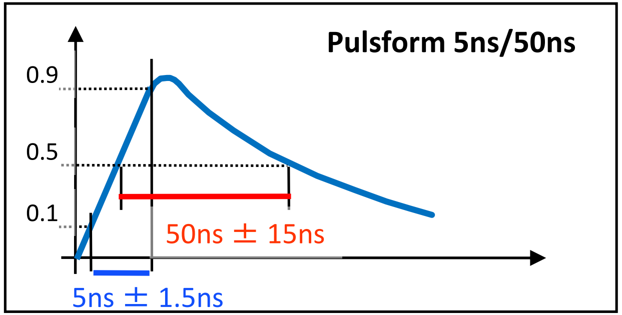
Termination at coaxial output (with 50 Ω load)	Rise time tr = (5 ± 1.5) ns Pulse duration (50 %-value) td = (50 ± 15)ns Peak value of voltage; Table 2 ± 10 %
Termination at coaxial out (with 1000 Ω load)	Rise time tr = (5 ± 1.5) ns Pulse duration (50 %-value) td = 50 ns with a tolerance of – 15 ns to + 100 ns Peak value of voltage; Table 2 ± 20 %

Parameter of the actual interferences

Single pulse

Rise time tr = 5ns

Pulse duration td = 50ns



Pulse packet (Burst)

Repetition time: **Tr = 300ms**

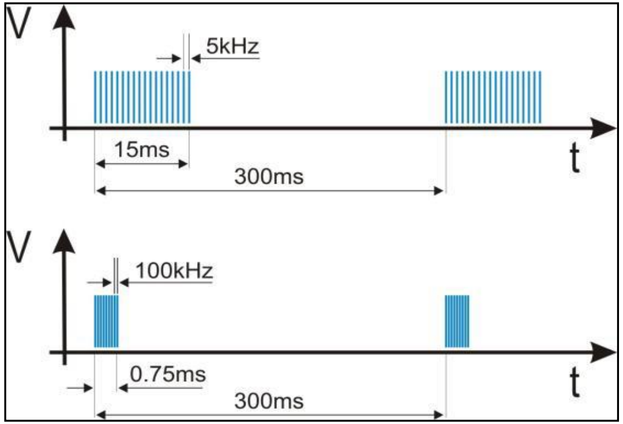
As formerly:

Duration burst packet **Td = 15ms**

at spike frequency **f = 5kHz**

Duration burst packet **Td = 0,75ms**

At spike frequency **f = 100kHz**



Mathematical modeling of Burst waveforms

new in Edition 3

Figure 3 shows the ideal waveform of a signnal pulse into a 50 Ω load with nominal parameters

tr = 5 ns and

tw = 50 ns

Formula of the ideal waveform per Figure 3, vEFT(*t*)

$$v_{\text{EFT}}(t) = k_v \left[\frac{v_1}{k_{\text{EFT}}} \cdot \frac{\left(\frac{t}{\tau_1}\right)^{n_{\text{EFT}}}}{1+\left(\frac{t}{\tau_1}\right)^{n_{\text{EFT}}}} \cdot e^{\frac{-t}{\tau_2}} \right]$$

where

$$k_{\text{EFT}} = e^{-\frac{\tau_1}{\tau_2} \cdot \left(\frac{n_{\text{EFT}} \cdot \tau_2}{\tau_1}\right)^{\frac{1}{n_{\text{EFT}}}}}$$

*k*v is max. or peak value of the open-circuit voltage (*k*v = 1 means normalized voltage)

v 1 = 0,92 τ 1 = 3,5 ns τ 2 = 51 ns *n*EFT = 1,8

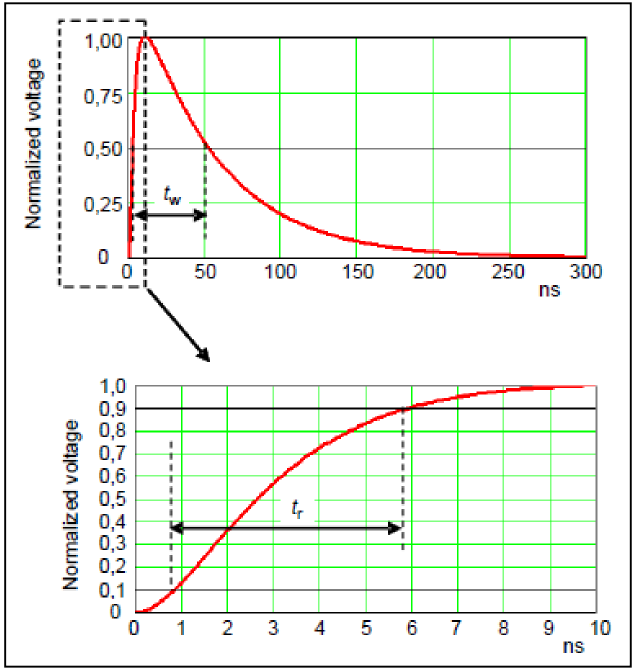


Figure 3

Characteristics - output voltage peak -

New peak voltages for 1000Ω load with respect to the voltage divider Ratio with Ri =50 Ω in table 2

Table 2 – Output voltage peak values and repetition frequencies

Set voltage kV	V_p (open circuit) kV	V_p (1 000 Ω) kV	V_p (50 Ω) kV	Repetition frequency kHz
0,25	0,25	0,24	0,125	5 or 100
0,5	0,5	0,48	0,25	5 or 100
1	1	0,95	0,5	5 or 100
2	2	1,9	1	5 or 100
4	4	3,8	2	5 or 100

Measures should be taken to ensure that stray capacitance is kept to a minimum.

NOTE 1 Use of a 1 000 Ω load resistor will automatically result in a voltage reading that is 5 % lower than the set voltage, as shown in column V_p (1 000 Ω). The reading V_p at 1 000 Ω = V_p (open circuit) multiplied times 1 000/1 050 (the ratio of the test load to the total circuit impedance of 1 000 Ω plus 50 Ω).

NOTE 2 With the 50 Ω load, the measured output voltage is 0,5 times the value of the unloaded voltage as reflected in the table above.

Calibration at the coaxial output

In order to provide a common supply basis for all test simulators, the characteristics of the test simulators have to be proved.

The verification at coaxial output has to be carried out as follows:

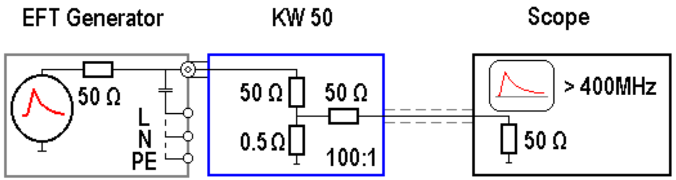
1. The demanded test voltage is set at the simulator.

2. The curve progression is measured at the coaxial output of the simulator. The Peak value of the voltage has to be 50% of the set voltage at the simulator .

3. The curve progression is measured at constant simulator settings at 1000 Ω The peak value of the voltage has to be Up (open circuit) corresponding (±20%)

Calibration routine no.: 1

Calibration at coaxial 50 Ohm output of the simulator with a 50 Ohm load

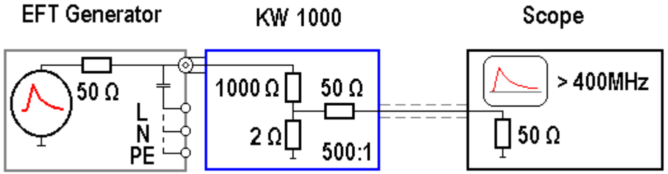


Ratio with KW50 -> 1:400

Example: 2000V Burst = 5V on scope

Calibration routine no.: 2

Calibration at coaxial 50 Ohm output of the simulator with a 1000 Ohm load

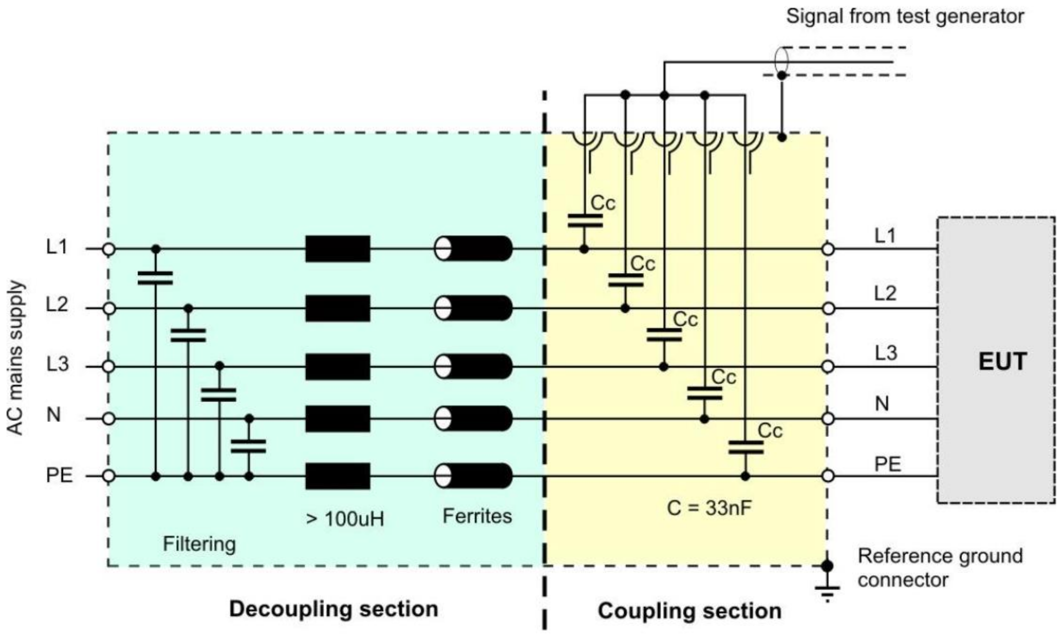


Ratio with KW1000 -> 1:1000
Example: 2000V Burst = 2V on scope

Coupling/Decoupling network for mains connectors (IEC 61000-4-4:2012)

Coupling capacitors: 33 nF

Insertion loss: asymmetric (all lines against reference earth)



Calibration of the CDN for mains supply

new in Edition 3

Proof of characteristics of coupling/decoupling network:

The pulse shape has to be proved at each output/path of coupling-/decoupling network

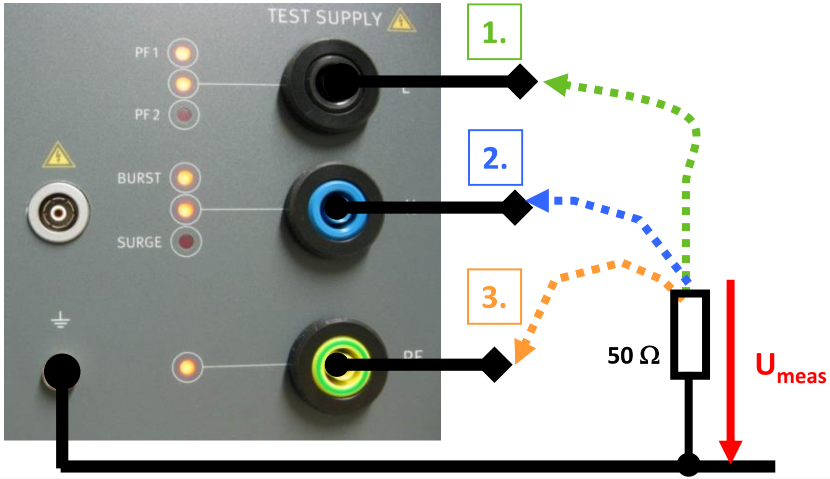
- Therefore all coupling paths are set simultaneously (Common Mode)
- The output of the coupling network is terminated with a coaxial load of 50 Ω

The calibration has to be provided with a voltage setting of **4kV** as follows:

	since EN 61000-4-4:2004	**New:** EN 61000-4-4:2012
Rise time **tr**	5 ns ± 30%	**5,5ns** ± 1,5ns
Pulse duration **td**	50 ns ± 30%	**45ns** ± 15ns
peak value of voltage	± 10% of the voltage according to table	

Calibration routine no.: 3

- The EFT transients are coupled to all CDN lines **simultaneously** (CM).
- The output of the CDN shall not be short circuited.
- The EFT transients shall be measured **at each individual output** of the CDN with 50Ω load, while the **other outputs are open**.
- Each individual output must show the transients within the tolerances as specified.



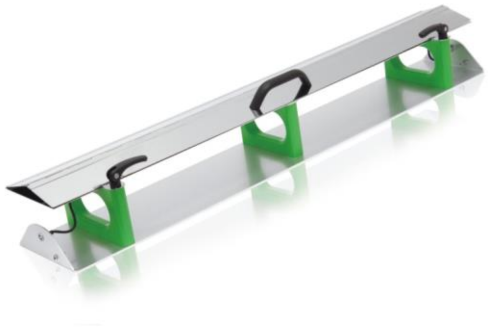
1.

2.

3.

Capacitive Coupling Clamp

new in Edition 3

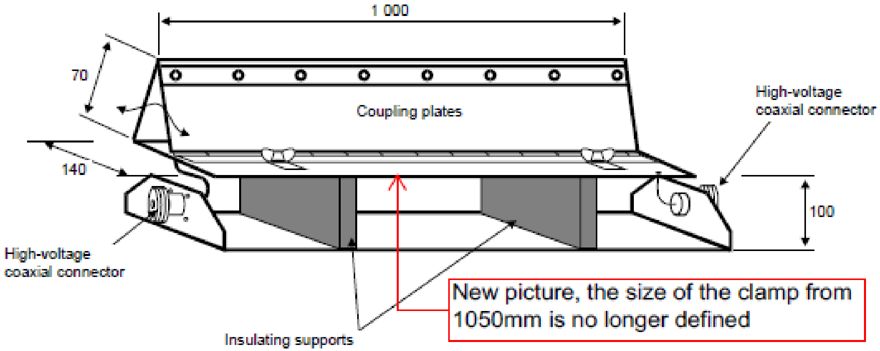


Dimensions have now tolerances

Lower coupling plate height: (100 ± 5) mm

Lower coupling plate width: (140 ± 7) mm

Lower coupling plate length: (1 000 ± 50) mm

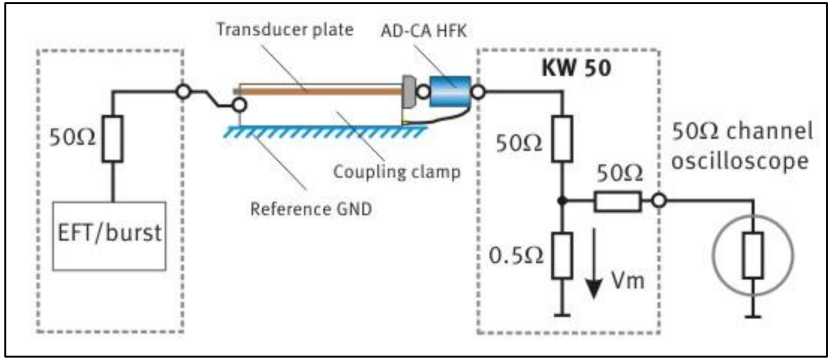


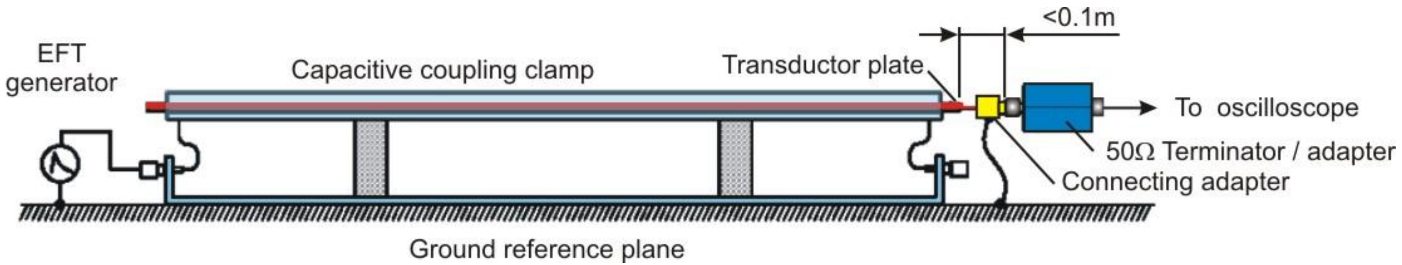
Calibration of capacitive coupling clamp

new in Edition 3

In a new chapter the edition 3 describes the calibration method of the capacitive coupling clamp with a transducer plate.

The transducer plate consists in a metallic sheet of 120 mm x 1050 mm of max 0.5 mm thickness, isolated on top and bottom by a dielectric foil of 0.5 mm. Isolation for 2.5 kV on all sides must be guaranteed in order to avoid the clamp to contact the transducer plate.





Calibration setup of capacitive coupling clamp

new in Edition 3

- The transducer plate is to be inserted into the coupling clamp and must be terminated at the opposite end of the generator connection with a coaxial load of 50 Ω.
- The calibration is performed with the generator output voltage set to **2 kV**. The calibration have to meet the following requirements:

Rise time **tr**	5ns ± 1,5ns
Pulse duration **td**	50ns ± 15ns
peak value of voltage	1kV ± 200V

Test setup and test execution

Coupling mode: „all lines against ground reference “

So, the coupling mode is a pure „Common Mode testing“. This means that the testing of single lines, line after line, is not demanded any more, but only all lines simultaneously have to be supplied with burst pulses.

Components

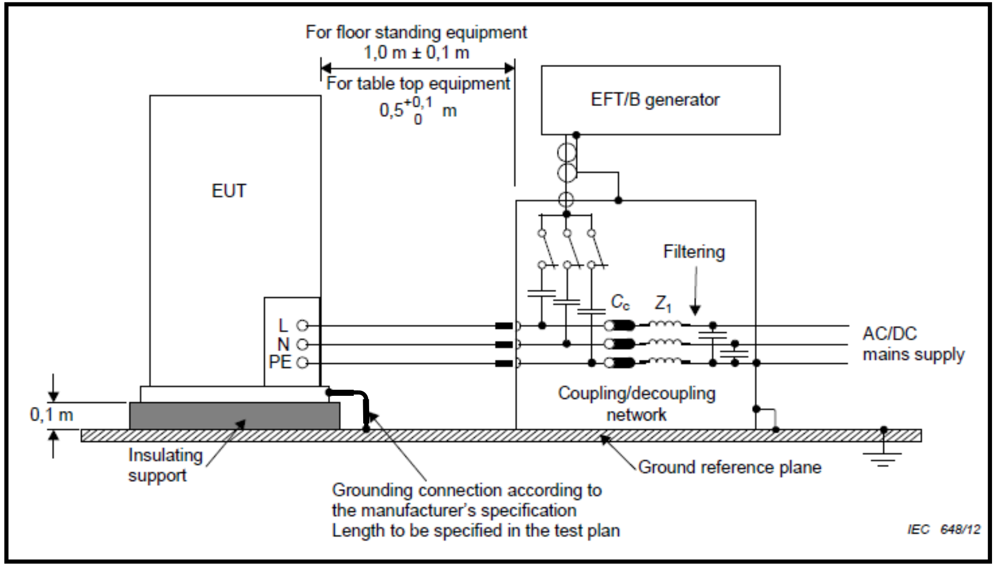
PE protective earth

N neutral

L phase

*Z*1 decoupling inductive

*C*c coupling capacitor



General tests set-up acc. to EN 61000-4-4:2012

new in Edition 3

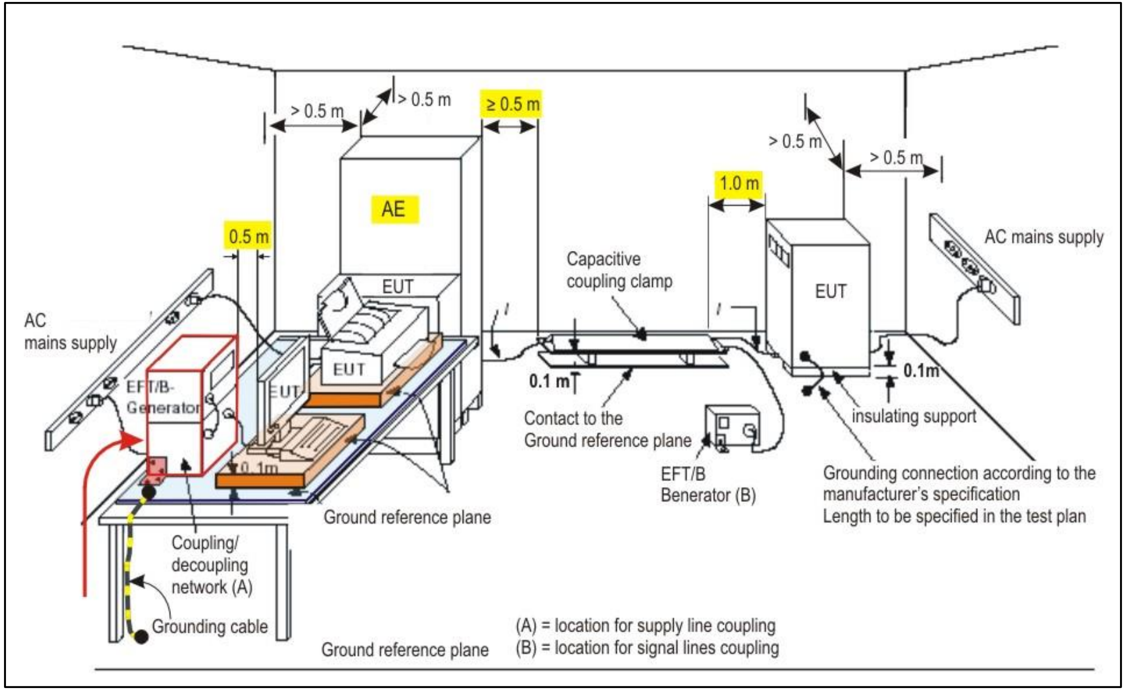
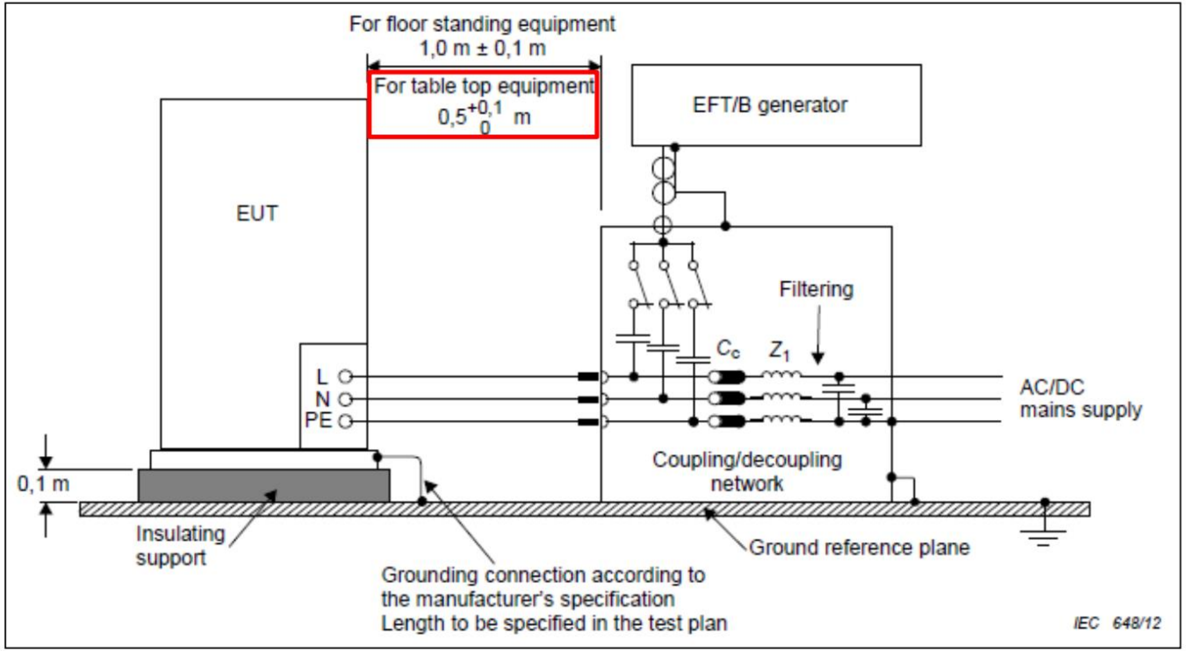


Figure 11: Example of a test setup for laboratory type tests (marked new in Ed3)

Test Setup coupling on lines



Coupling mode : Common mode “all lines to reference ground

Test setup: Connection of coupling network

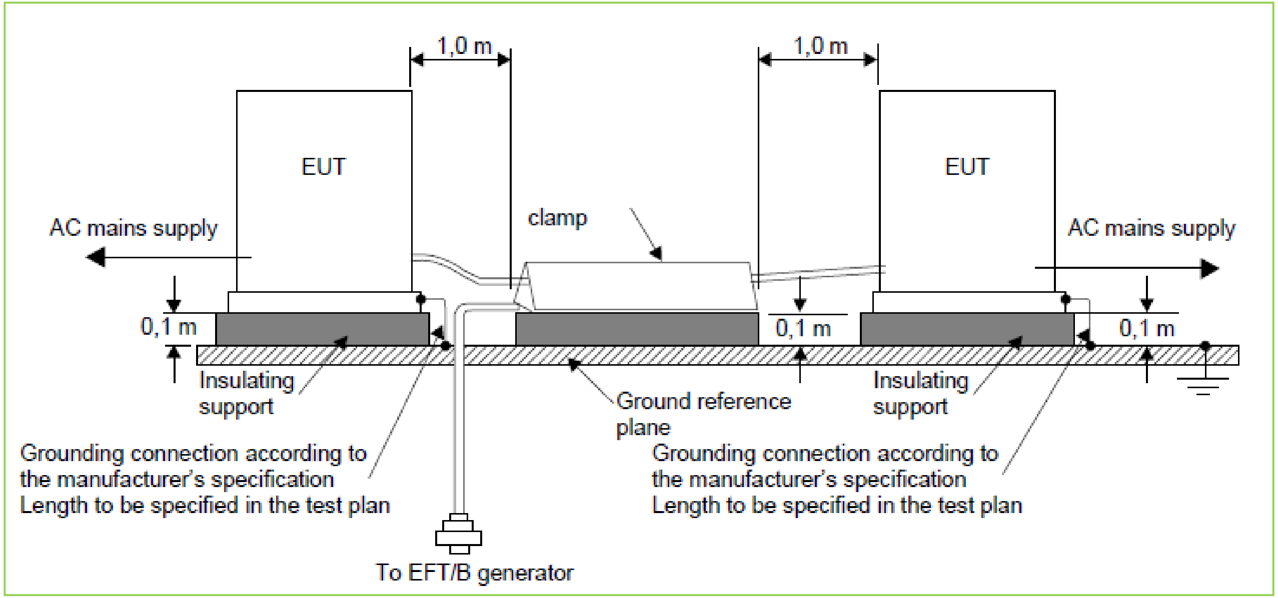
The coupling network has to be connected with the reference ground in low impedance manner!

Test setup: Coupling on supply lines

Burst to AC supply lines EUT on insulated support distance generator to EUT =0.5m

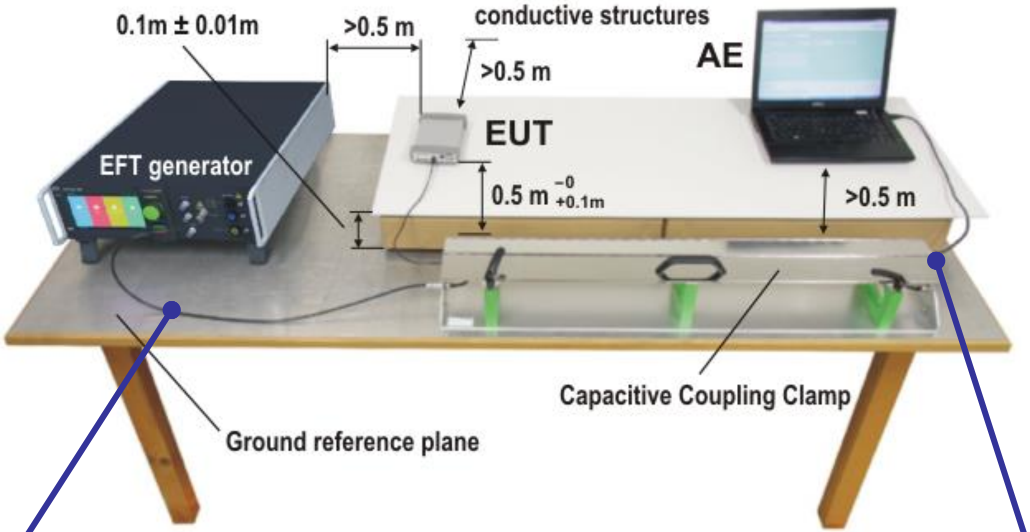
Test setup: Coupling on supply lines (floor standing device)

Test setup: signal lines with capacitive coupling clamp



Example: Floor standing system of two EUTs

Test setup: capacitive coupling clamp



EUT must placed on the same side as the burst simulator is connected

Decoupling network to the AE port if required

Test setup: Capacitive coupling clamp

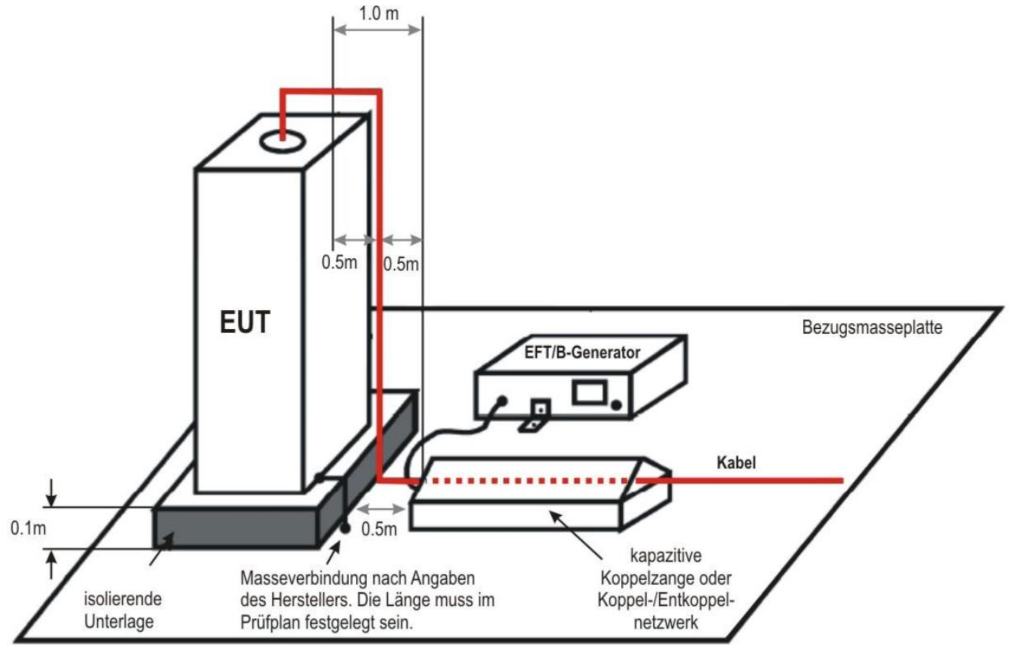


Figure 13 Example of a test setup for equipment with elevated cable entries

Example for in situ test on a.c./d.c. Power ports and PE

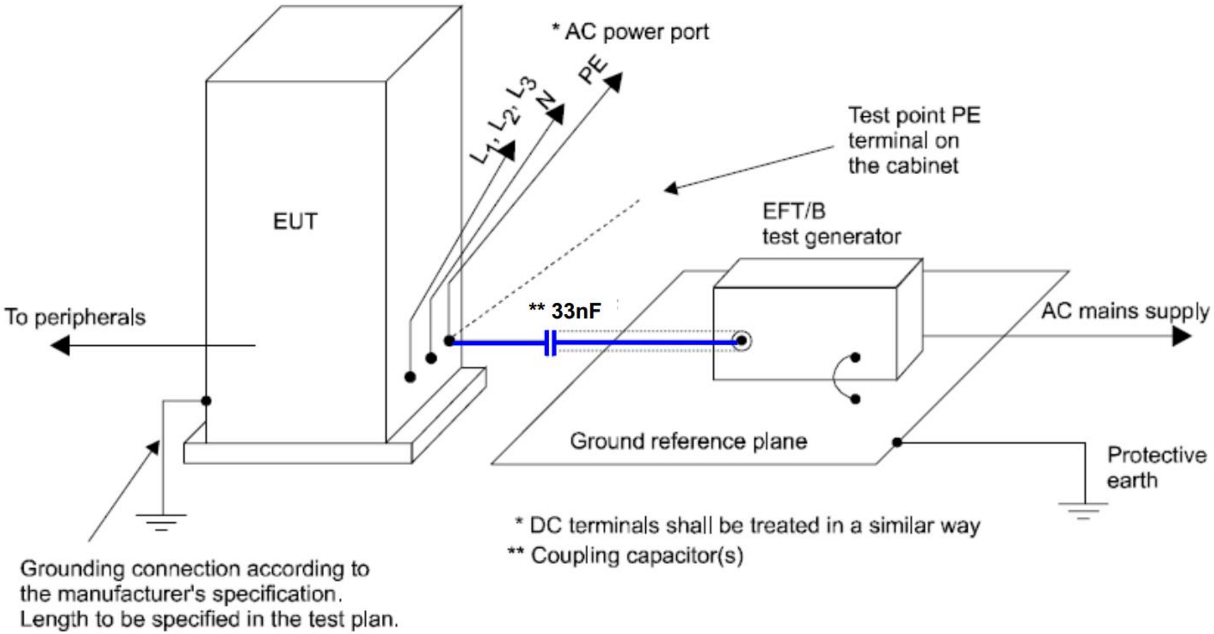


Figure 13 Example of a test setup for equipment with elevated cable entries

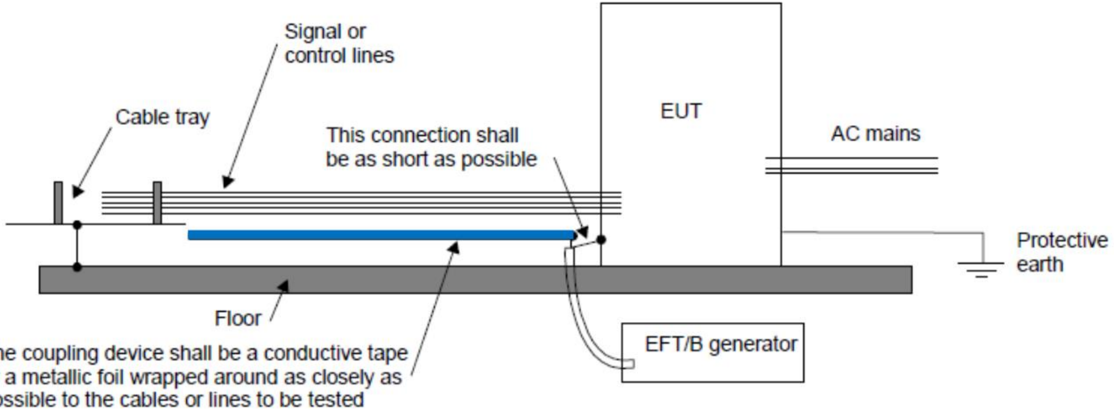
Alternative method for coupling to signal lines without a CCC

The capacitive coupling clamp is the preferred method for coupling the test voltage into signal and control ports. If the clamp cannot be used due to mechanical reasons (e.g. size, cable routing) in the cabling, it shall be replaced by,

a. a tape or a conductive foil enveloping the lines under test.

or alternatively

b. via discrete (100 ± 20) pF capacitors



EFT Burst generators

Current EFT Burst generators from the AMETEK CTS product lines

emtest



Compact NX5
Compact NX7
EFT 500N8

TESEQ


NSG 3040A
NSG 3060A

Coffee break

emtest MILMEGA TESEQ

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IEC 61000-4-5 Surge

Inventory of revision of IEC 61000-4-5 Ed.3 :(2014)

Accelonix EMC workshop 18-6-2019

> IEC 61000-4-5 PHENOMENON

- **Atmospheric discharges**
  - Max current peak value
  - Rise of the current di/dt,
  - Rise of dU/dt caused the tripping of arrestors in the primary loop who are transformed to the secondary part.

- **Switching events electromechanical events**
  - Switching of capacitive loads in high voltage circuits. Cables, capacitor banks etc.
  - Switching of loads in low voltage systems.
  - Switching of resonance circuits with thyristors.
  - Short circuits and flash-overs in installations.
  - Tripping of protection devices as varistors and fuses.

- **Coupling**
  - Capacitive to parallel lines (du/dt)
  - Induction in loops (di/dt)
  - Radiation in the near field
  - Direct coupling in case of direct impact

- **Propagation**
  - Conducted to supply-, signal-, data- and control lines
  - Symmetrical (line to line) or unsymmetrical to PE

> IEC 61000-4-5 Edition 3 (2014)

No Change of:

- Test levels
- Generator specifications
- Phase angle
- Separation of pulse 1.2/50 and 10/700

Question: Can the old device still be used?
Answer: It depends…

Changes to Ed 3 :2014 :

- Impulsform definition (only one definition)
- Add mathematical formula for wave shape
- Calibration for CDN and generator with a capacitor of 15 µF
- New definition for CDN up to 200A / phase with calibration
- New specification for CDN for signal and data-lines with calibration
- New specification for high speed communication CDN
- Move of 10/700 µs generator to Annex and Harmonization with ITU-TK series
- Measurement Uncertainty MU in annex D

> One Waveshape definition in the IEC 61000-4-5 Edition 3 (2014)

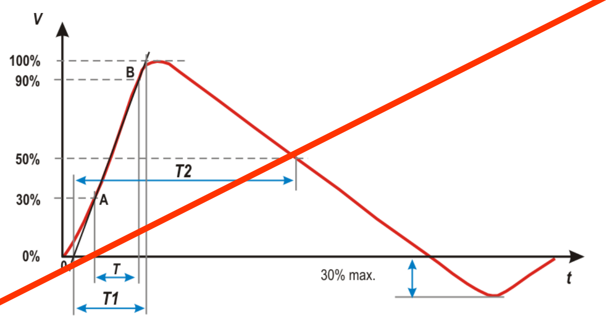
Previous edition 2 offers two methods for waveshape measurement

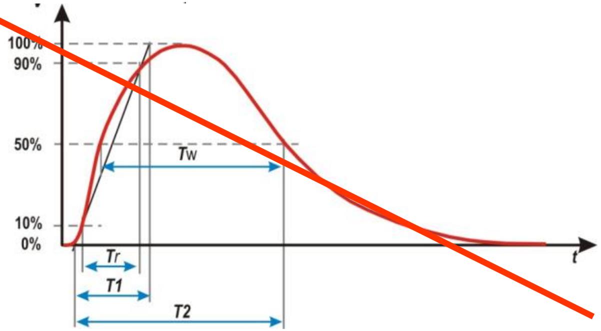
Table 2 – Definitions of the waveform parameters 1,2/50 µs – 8/20 µs

Definitions	In accordance with IEC 60060-1		In accordance with IEC 60469-1	
	Front time µs T1	Time to half value µs T2	Rise time (10 % – 90 %) µs	Duration time (50 % – 50 %) µs
Open-circuit voltage	1,2 ± 30 %	50 ± 20 %	1 ± 30 %	50 ± 20 %
Short-circuit current	8 ± 20 %	20 ± 20 %	6,4 ± 20 %	16 ± 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.



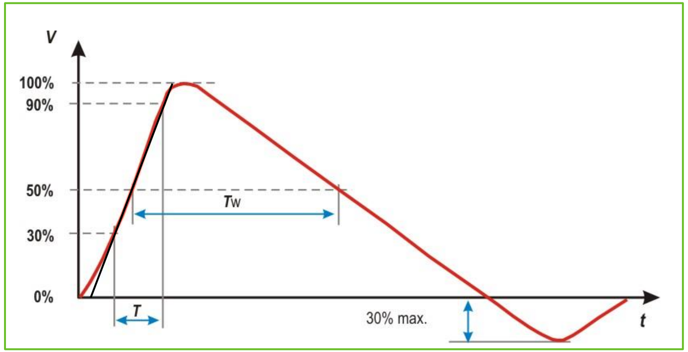


> IEC 61000-4-5 IMPULSE DEFINITION

- **Open circuit voltage :** 1.2/50µs

Front Time: T_f = 1.67 x T= 1.2µs ± 30%
Duration: T_d = Tw = 50µs ± 20%

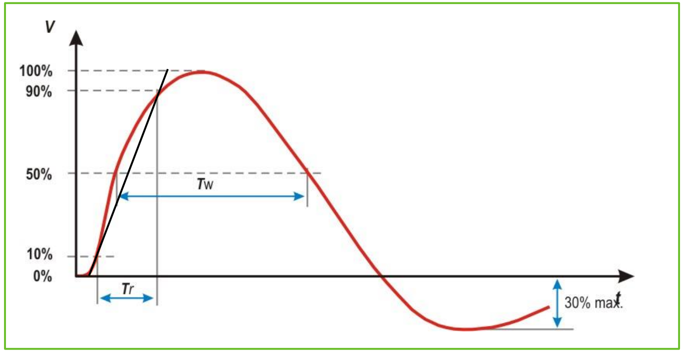
NOTE: The open circuit voltage waveform at the output of the coupling/decoupling network may have a considerable undershoot, in principle as the curve shown in Figure



- **Short circuit current:** 8/20µs

Front Time : T_f = 1.25xTr = 8µs ± 20%
Duration: T_d = 1.18 x Tw =20µs ± 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.



The calculation as per IEC 60469-1 (10% - 90%) is deleted

Test Levels

Table 1 specifies in detail the test levels for the open circuit voltages for testing Line to Line and Line to ground

Table 1 Test Levels

Level	Open circuit test voltage kV	
	Line to Line	Line to ground
1	---	0,5
2	0,5	1
3	1	2
4	2	4
X [a]	Special	Special

[a] "X" can be any level, above, below or in between the others. The level shall be specified in the dedicated equipment specification.

- All voltages of the lower test levels shall be satisfied
- For selection of the test levels for the different interfaces, refer to Annex A.

> Generator Source Impedance

The characteristics of the test generator shall simulate the phenomena as closely as possible. Depend of the different arise and coupling mechanism of the sources, the standard define different source impedance's for surge testing.

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.
If the source of interference is **in other circuit** as the victim equipment (indirect coupling) as the ports of the victim-equipment, then the generator may simulate a higher impedance source.

2 Ohm	**12 Ohm** (2 Ohm + 10 Ohm)	**42 Ohm** (2 Ohm + 40 Ohm)
Power lines (acc. to IEC61000-4-5: low-voltage power supply)		All other Lines
symmetrical (L-N, L-L) Source in the same circuit unsymmetrical Switching direct lightning	unsymmetrical (L- PE, N-PE) Source in the other circuit indirect lightning	Unsymmetrical (symmetrical) only indirect influences

IEC 61000-4-5 Edition 3 (2014)

Changes to Ed 3 :2014

Characteristics and performance of the generator:

The output impedance is controlled with the relationship between the open circuit peak voltage and the short circuit current.

New values for the 12 Ω output (10Ω + 2 Ω) impedance have been defined.

NOTE The time parameters are valid for the short circuit current at the generator output without 10Ω resistor. **(New additional note)**

Open-circuit peak voltage ± 10 % at EUT port of the CDN	Short-circuit peak current ± 10 % at EUT port of the CDN (18 µF)	Short-circuit peak current ± 10 % at EUT port of the CDN (9 µF + 10 Ω)
0,5 kV	0,25 kA	41,7 A
1,0 kV	0,5 kA	83,3 A
2,0 kV	1,0 kA	166,7 A
4,0 kV	2,0 kA	333,3 A

Calibration of CDNs for a.c./d.c. mains supply rated up to 200 A per line (6.4.2)

The characteristics of the CDN shall be measured under *open-circuit* conditions (load greater than or equal to 10 k⍰) and under *short-circuit* conditions at the same set voltage.

All performance characteristics stated in 6.3.2 **Tables 4** and 5 shall be met at the CDN output.

Surge voltage parameters under open-circuit conditions [a]	Coupling impedance	
Load > 10kΩ	18 µF (Line to Line)	9 µF + 10 Ω (Line to ground)
Peak voltage		
Current rating ≤ 16 A	Set voltage +10 %/-10 %	Set voltage +10 %/-10 %
16 A < Current rating ≤ 32 A	Set voltage +10 %/-10 %	Set voltage +10 %/-10 %
32 A < Current rating ≤ 63 A	Set voltage +10 %/-10 %	Set voltage +10 %/-15 %
63 A < Current rating ≤ 125 A	Set voltage +10 %/-10 %	Set voltage +10 %/- 20 %
125 A < Current rating ≤ 200 A	Set voltage +10 %/-10 %	Set voltage +10 %/- 25 %
Front time	1,2 µs ± 30 %	1,2 µs ± 30 %
Duration		
Current rating ≤ 16 A	50 µs +10 µs/-10 µs	50 µs +10 µs/-25 µs
16 A < Current rating ≤ 32 A	50 µs +10 µs/-15 µs	50 µs +10 µs/-30 µs
32 A < Current rating ≤ 63 A	50 µs +10 µs/-20 µs	50 µs +10 µs/-35 µs
63 A < Current rating ≤ 125 A	50 µs +10 µs/-25 µs	50 µs +10 µs/-40 µs
125 A < Current rating ≤ 200 A	50 µs +10 µs/-30 µs	50 µs +10 µs/-45 µs

New in Ed. 3

- Waveshape defined for common mode coupling to PE
- Tolerances are increased at higher current in the coupling network.

Decoupling inductivity:

- Maximum 1.5 mH
- Voltage Drop CDN < 10%

> Calibration of CDNs for unsymmetrical interconnection lines (6.4.3.2)

Measurements shall be performed with the impulse applied to one coupling path at a time.
The peak amplitude, the front time and impulse duration shall be measured for the CDN rated impulse voltage under open-circuit conditions.

The inputs of the DN at the auxiliary equipment (AE) side shall be short circuited to PE for the impulse voltage and impulse current measurement at the EUT output port.

The residual voltage value depends on the protection requirements of the AE. Therefore no limits are given in this standard.

Changes to Ed 3 :2014

Calibration process for unsymmetrical interconnection lines

	Coupling	Measuring	AE side	EUT side
Surge voltage at EUT side	Single Line to PE	Single Line Peak voltage, front time, duration	All lines shorted to PE	Open Circuit
Surge Current at EUT side	Single Line to PE	Single Line Peak current, front time, duration	All lines shorted to PE	Short Circuit
Surge voltage at EUT side	Single Line to Line	Single Line Peak voltage, front time, duration	All lines shorted to PE	Open Circuit
Surge Current at EUT side	Single Line to Line	Single Line Peak current, front time, duration	All lines shorted to PE	Short Circuit
Residual voltage on AE Side (with protection)	Single Line to PE	Line to PE at a time Peak voltage	Open Circuit	Open Circuit

> Waveform specification for unsymmetrical interconnection lines

Changes to Ed 3 :2014

Table 8 : Surge waveform specs. at the EUT port of the CDN

Coupling method	CWG Output voltage [1,2,3]	Voc at CDN EUT output ± 10 %	Voltage Front time T_r $T_f = 1{,}67 \times T_r$ ± 30 %	Voltage Duration T_d $T_d = T_w$ ± 30 %	I_{sc} at CDN EUT output ± 20 %	Current Front Time T_r $T_f = 1{,}25 \times T_r$ ± 30 %	Current Duration T_d $T_d = 1{,}18 \times T_w$ ± 30 %
Line to PE R = 40 Ω CD = 0,5 µF	4 kV	4 kV	1,2 µs	38 µs	87 A	1,3 µs	13 µs
Line to PE R = 40 Ω CD = GDT	4 kV	4 kV	1,2 µs	42 µs	95 A	1.5 µs	48 µs
Line to Line R = 40 Ω CD = 0,5 µF	4 kV	4 kV	1,2 µs	42 µs	87 A	1,3 µs	13 µs
Line to Line R = 40 Ω CD = GDT	4 kV	4 kV	1,2 µs	47 µs	95 A	1,5 µs	48 µs

[1]) It is recommended to calibrate the CDN at the highest rated pulse voltage, as this will minimise the effects of the switching noise generated by CLDs and GDTs. The value shown in the table is for a generator setting of 4kV. In case the CDN is rated for another maximum pulse voltage, the calibration shall be done at this maximum rated pulse voltage. The short circuit peak current specification shall be adapted accordingly. e.g. If the Maximum voltage is 1kV the short circuit current value shown in this table shall be multiplied by 1/4

[2]) Coupling via gas arrestors, clamping or avalanche devices will show some switching noise on the pulse waveform. Working with the highest possible pulse voltage will minimise their impact on measurements; it is recommended to neglect the switching noise for the front times and duration values measurements.

[3]) The values shown in this table are for a CWG with ideal values. In case the CWG generates parameter values close to the tolerances, the additional tolerances of the CDN may generate values out of tolerances for the CWG-CDN combination.

> Calibration process for symmetrical interconnection lines (6.4.3.3)

Measurements shall be performed with the impulse applied to one coupling path at a time.
The peak amplitude, the front time and impulse duration shall be measured for the CDN rated impulse voltage under open-circuit conditions.
The inputs of the CDN at the auxiliary equipment (AE) side shall be short circuited to PE for the impulse voltage and impulse current measurement at the EUT output port.
The maximum allowed residual voltage value depends on application specific elements, which are not specified in this standard.

Changes to Ed 3 :2014

Table 9: Calibration process

	Coupling	Measuring	AE side	EUT side
Surge voltage at EUT side	Common mode – all lines to PE *) 40 Ω path	All lines shorted together Peak voltage, front time, duration	All lines shorted to PE	Open circuit – all lines connect together
Surge current at EUT side	Common mode – all lines to PE *) 40 Ω path	All lines shorted together Peak current, front time, duration	All lines shorted to PE	All lines shorted to PE
Residual voltage on AE side	Common mode – all lines to PE *) 40 Ω path	Line to PE at a time Peak voltage	Open circuit	Open circuit

*) 40 Ω path means that the transfer impedance is always 40 Ω, this means that for coupling to 1 pair 80 Ω per line or 40 Ω per pair are used, for coupling to 2 pairs 160 Ω per line or 80 Ω per pair are used, for coupling to 4 pairs 320 Ω per line or 160 Ω per pair are used.

Table 10: Waveform specification

Coupling method	CWG Output voltage [1], [2], [3]	Voc at CDN EUT output ± 10 %	Voltage Front time T_f ± 30 %	Voltage Duration T_d ± 30 %	I_{sc} at CDN EUT output ± 20 %	Current Front Time T_f ± 30 %	Current Duration T_d ± 30 %
Common mode CD, 40 Ω path	2 kV	2 kV	1,2 µs	42 µs	48 A	1,5 µs	45 µs

> Calibration coupling network

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. The characteristics of the generator shall be measured under:

Open circuit voltage with HV-Probe

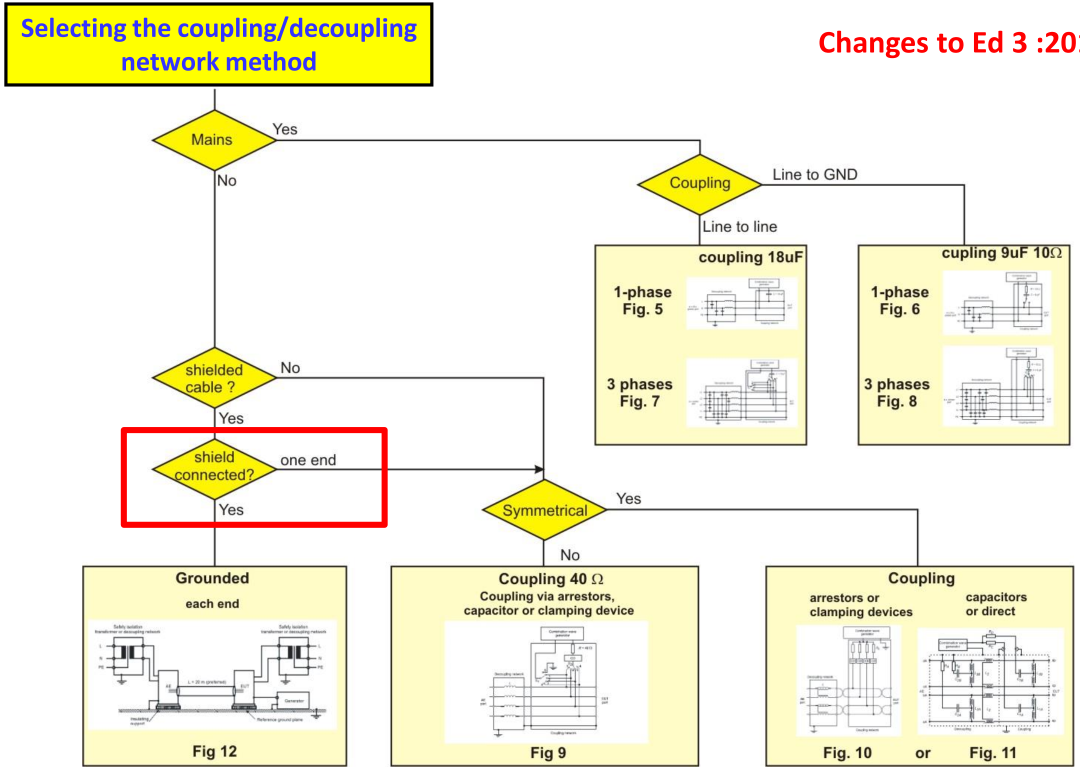
each:
DM: L-N
CM: L-PE
CM: N-PE

Short circuit current with current probe

each:
DM: L-N
CM: L-PE
CM: N-PE

> Coupling Network selection

Changes to Ed 3 :2014



> Example of test setup for capacitive coupling on a.c./d.c. lines

New measurements method is defined including residual voltages at AE ports of data lines CDN. The inductance values for the decoupling inductance is removed from each figure.

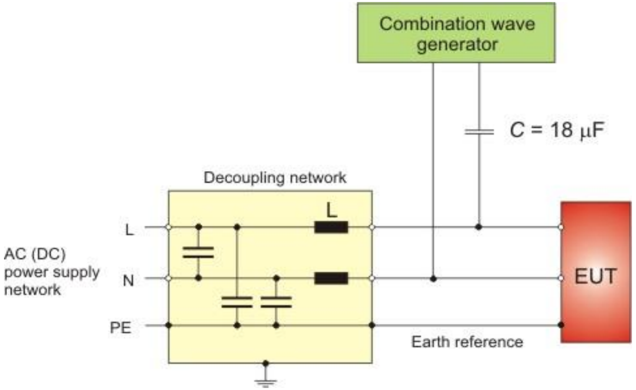


Fig. 5: Coupling Line to Neutral

Decoupling: L= 1.5mH

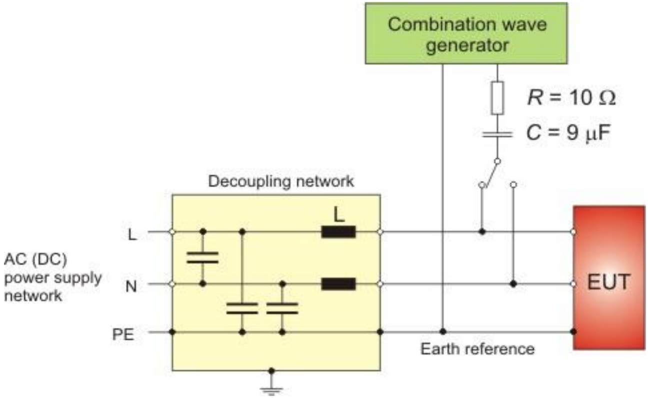


Fig. 6: Coupling L - PE and N – PE

Decoupling: L= 1.5mH

Example of test setup for capacitive coupling on 3-phase a.c. lines.

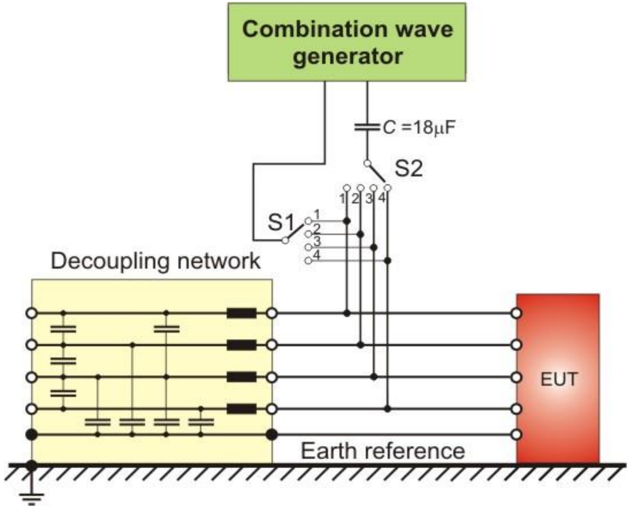


Fig. 7: Coupling Line to Line / Neutral

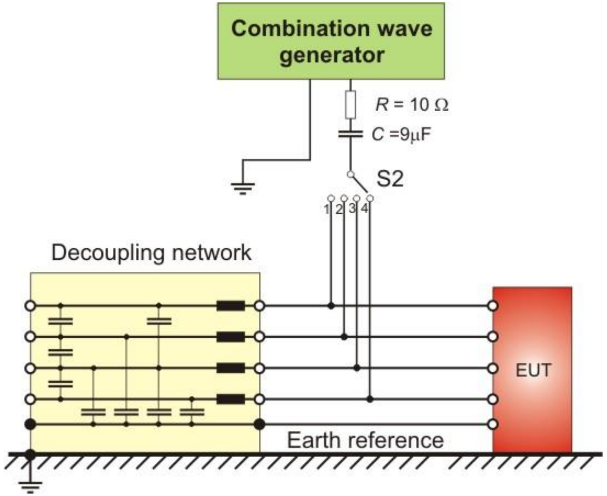


Fig. 8: Coupling Line - PE and Neutral - PE

> Coupling to unshielded unsymmetrical interconnections lines

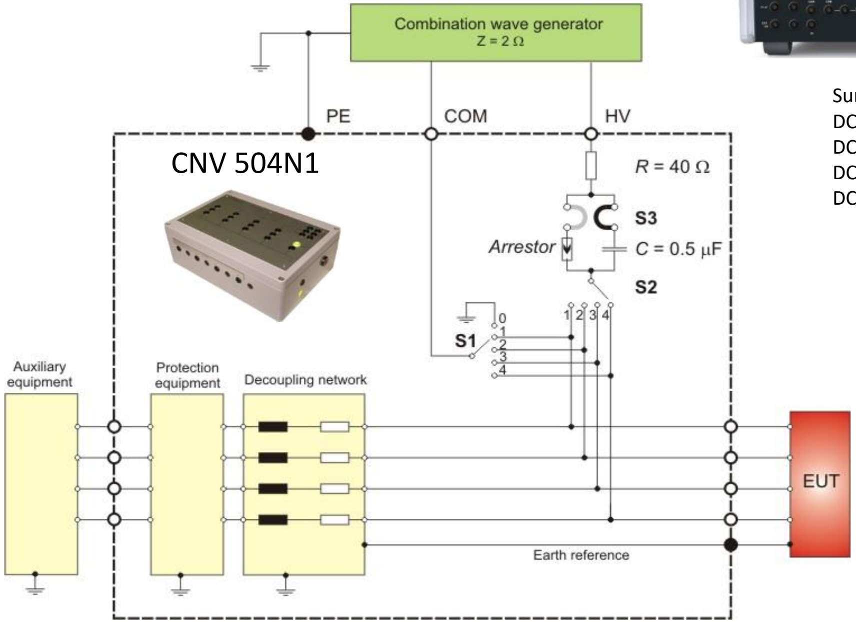
NEW

Surge & Ringwave
DCD5 SR-4-1
DCD5 SR-4-4
DCD5 SR-8-1
DCD5 SR-8-4

Switch S1 :
- Line to Earth : Position 0
- Line to Line : Position 1 to 4

Switch S2 :
- during the test : Positions 1 to 4 *but not in same position as switch S1*

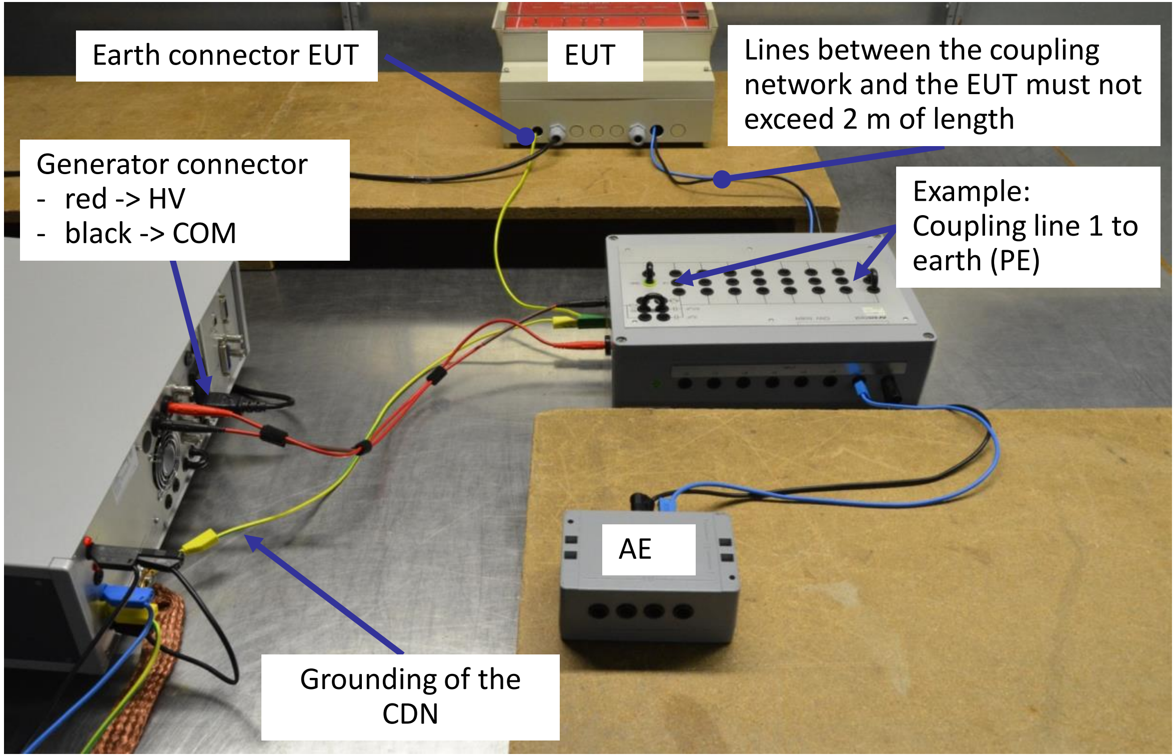
Switch S3 :
- Position coupling with gas arrestor to symmetrical I/O lines
- Position capacitive coupling 0.5uF asymmetrical I/O lines
- Position capacitive coupling 3.0uF Ringwave



Alternative coupling via clamping circuit

> Coupling on I/O lines via CNV508N1 unshielded unsymmetrical

Example

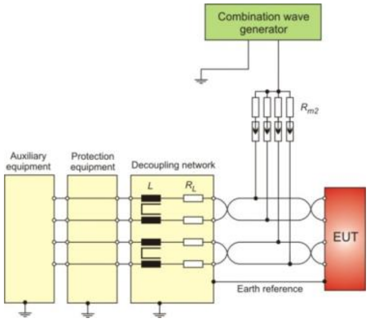


> Unshielded symmetrical interconnection lines

Line to Ground coupling

Changes to Ed 3 :2014

IEC 61000-4-5 Ed2, Figure 14



1.2/50us Generator
R_{m2}= n x 40 Ω, max. 250 Ω

10/700us Generator
R_{m2}= n x 25 Ω, max. 250 Ω

IEC 61000-4-5 Ed3, Figure 10 and Figure A4

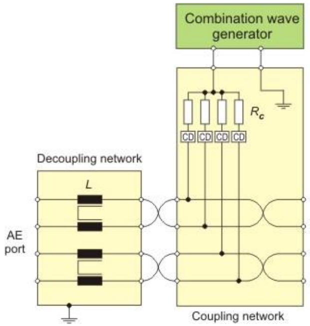


Figure 10

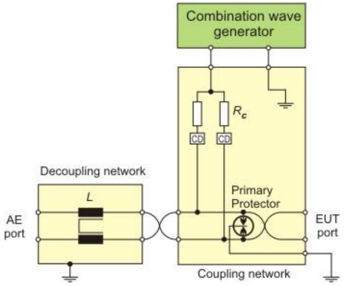


Figure A4

1.2/50us Generator
R_c= 40 Ω

10/700us Generator
R_c= **25 Ω**

Other coupling devices than gas arrestors (GDT) are allowed.

Test set-up for shielded lines ground at both sides

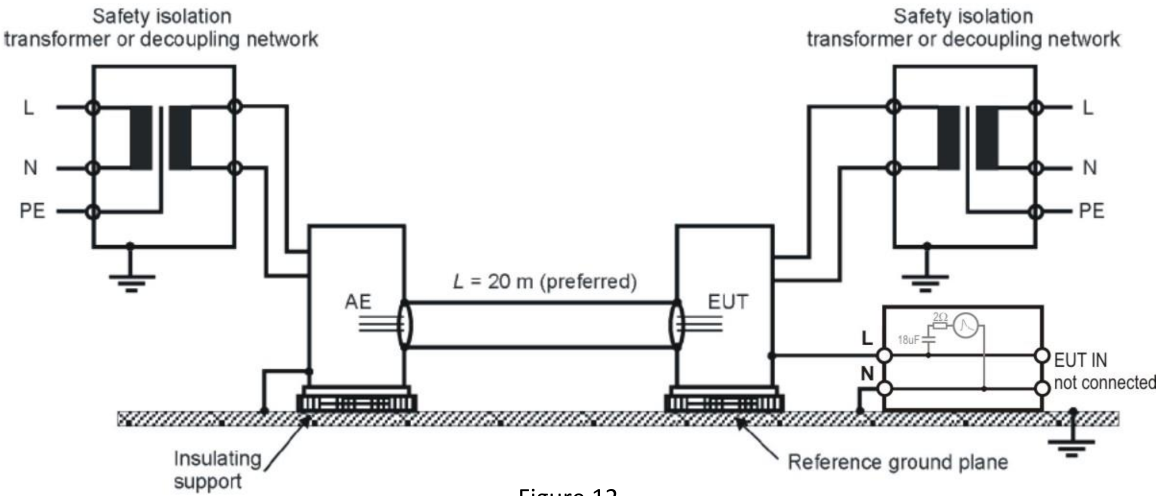


Figure 12

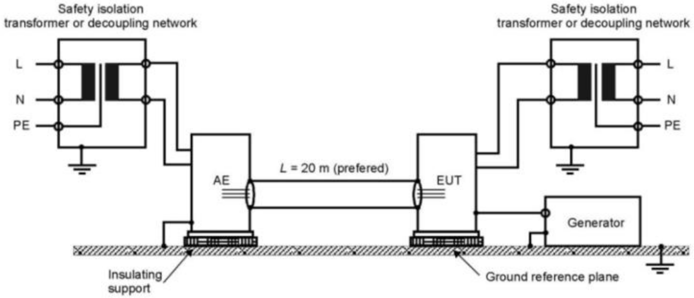
NOTE 1 It is permissible for the power to the EUT and/or the AE to be provided via a decoupling network, rather than via the isolating transformer shown. In this case, the EUT's protective earth connection should not be connected to the decoupling network.

NOTE 2 D.C. supplied EUT and/or AE should be powered through the decoupling networks.

IEC 61000-4-5 Edition 3 (2014)

Changes to Ed 3 :2014

Figure 12 Test setup for shielded lines



The EUT is isolated from ground and the surge (2Ω) is applied to its metallic enclosure; the termination (or auxiliary equipment) at the port(s) under test is grounded.

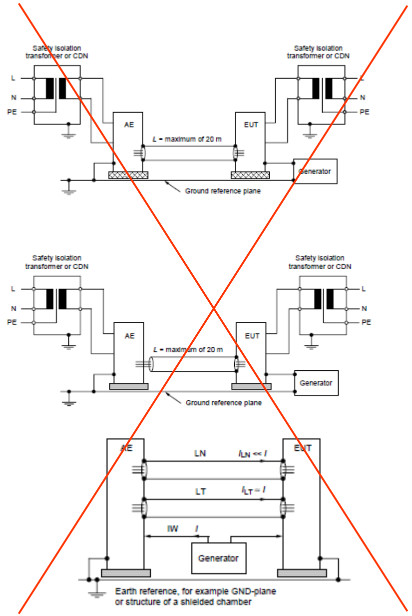
Cable length:

– 20 m (preferred length) or

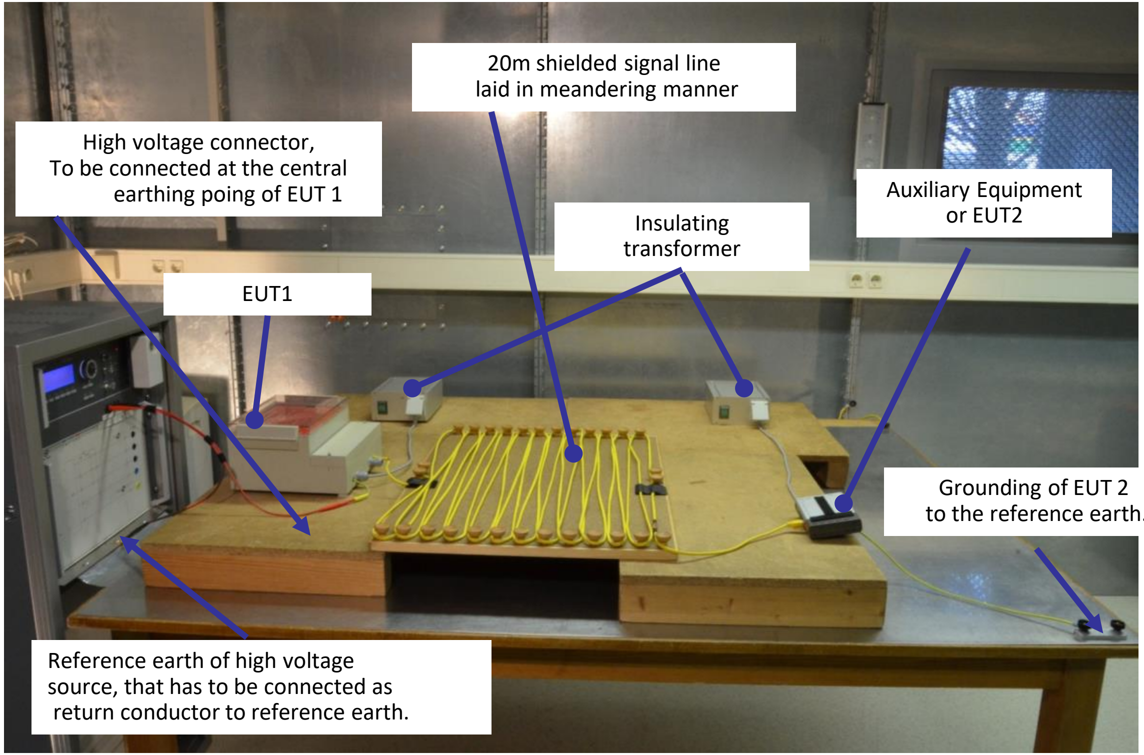
– the shortest length over 10 m, where the manufacturer provides pre-assembled cables used in actual installations

→ No test shall be required for cables which according to the manufacturer's specification are ≤ 10 m.

Figures in Ed.2 are replaced by



Test set-up for shielded cables

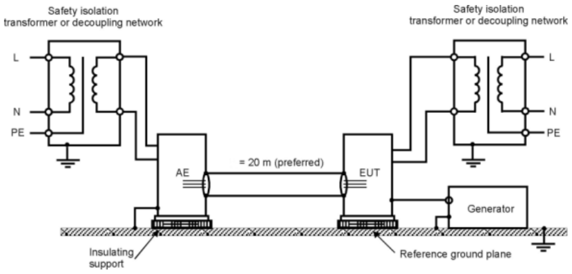


> Test set-up for shielded lines grounded only at both and one end

Rules for application of the surge to shielded lines:

a) Shields grounded at both ends:
– the test shall be carried out according to Figure 12.

The test level is applied on shields with a 2 Ω generator source impedance and with the 18 µF capacitor



b) Shields grounded at one end:
– the test shall be carried out according to 7.4 or 7.5 (see Figure 4) because the shield does not provide any protection against surges induced by magnetic fields.

NOTE 2:
In this case, surge testing is not applied to the shield.

Changes to Ed 3 :2014

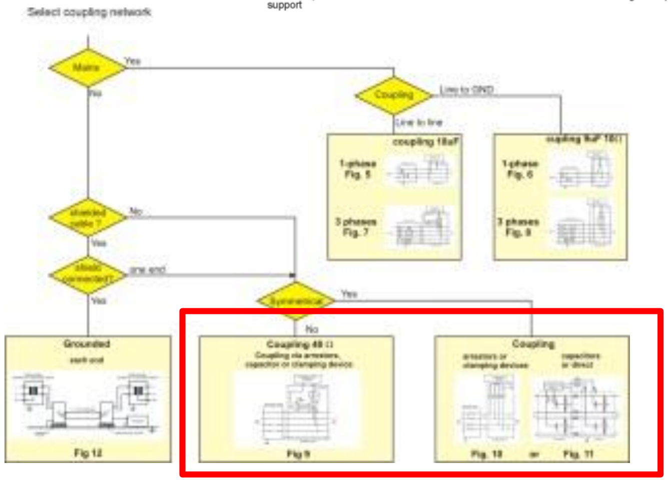
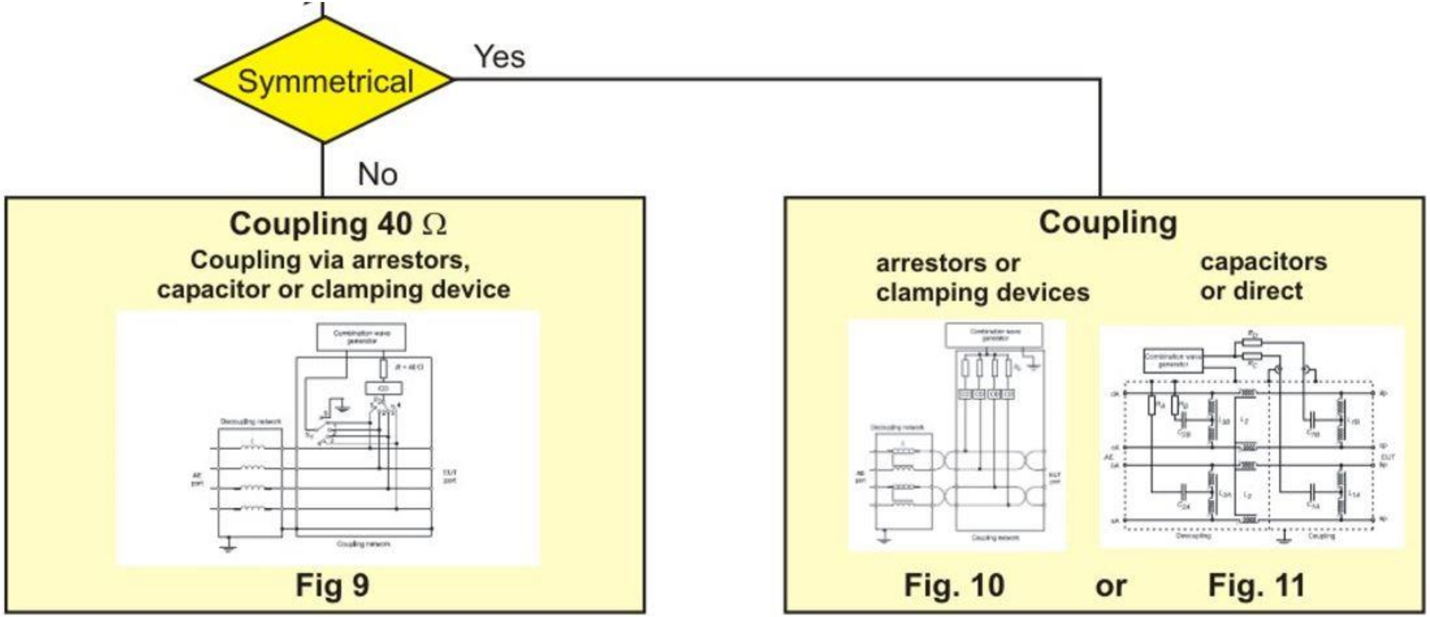


Figure 4

> Test set-up for shielded lines grounded only at both and one end



> Coupling on fast symmetrically operated I/O lines

Surge tests to high speed data-lines
Coupling as per figure 11 of IEC 61000-4-5 Ed. 3 :2014

Changes to Ed 3 :2014

AE Port
max. 40V

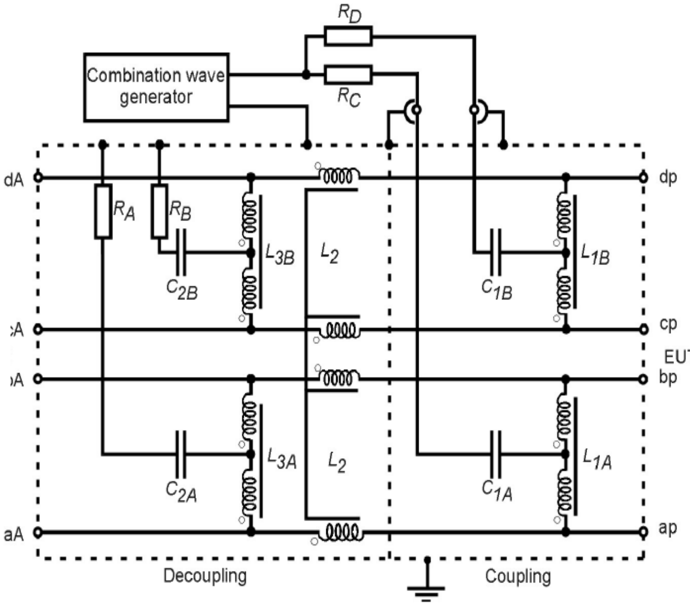
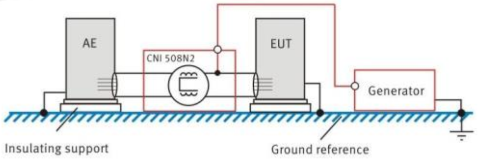


Figure 11

EM Test up to 1GBit/s

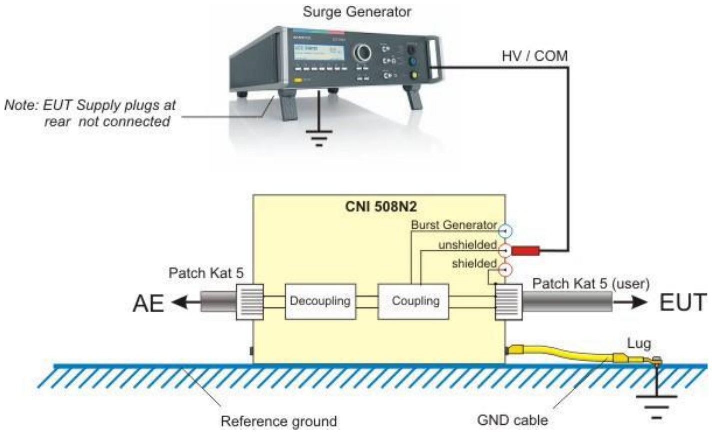
CNI 508N2
Surge 1.2/50µ up to 3kV
Burst 5/50n up to 4kV
POE, POE+ compatible

HSC 4-8
Surge 1.2/50µ up to 3kV
Burst 5/50n up to 4kV
Ringwave (0.5µ/100kHz) up to 4kV
POE, POE+ compatible

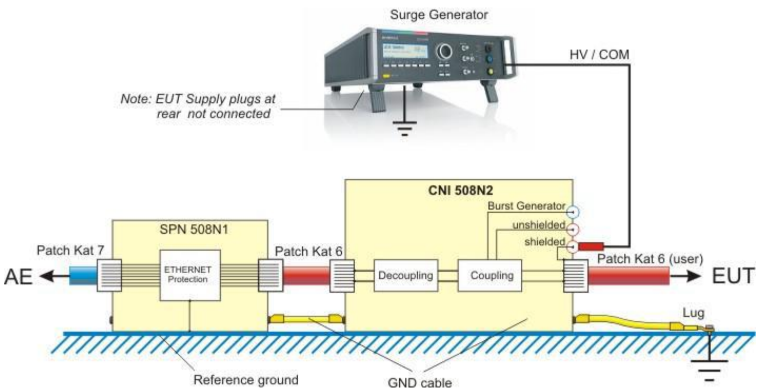


Coupling on fast symmetrically operated I/O lines

Example for coupling as per figure 11 of IEC 61000-4-5 Ed. 3.0:2012



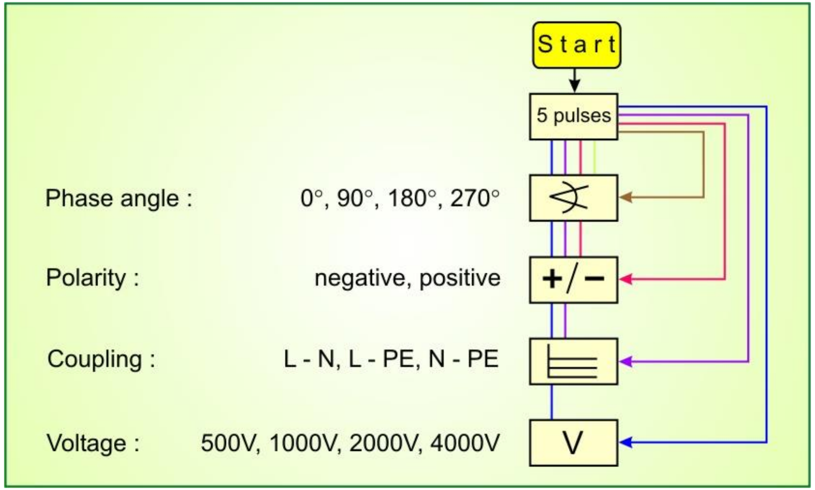
Coupling to unshielded lines

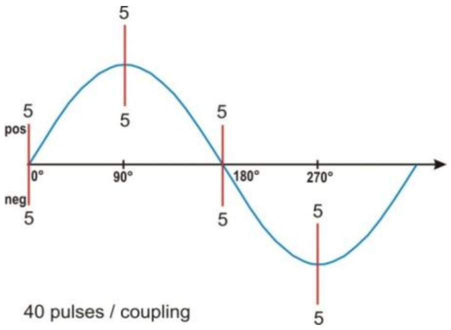


Coupling to shield with additional AE protection with SPN 508N1

Test procedure for Surge with 1-phase EUT

The test procedure includes:
– the verification of the test instrumentation according to 7.2.
– the establishment of the laboratory reference conditions;
– the confirmation of the correct operation of the EUT;
– the execution of the test;
– the evaluation of the test results (see Clause 9 ;Criteria A,B,C,D)





- 5 test-pulses for every setting (Level, Coupling, Angle, Polarity).
- Time between successive pulses: 1 min or less.

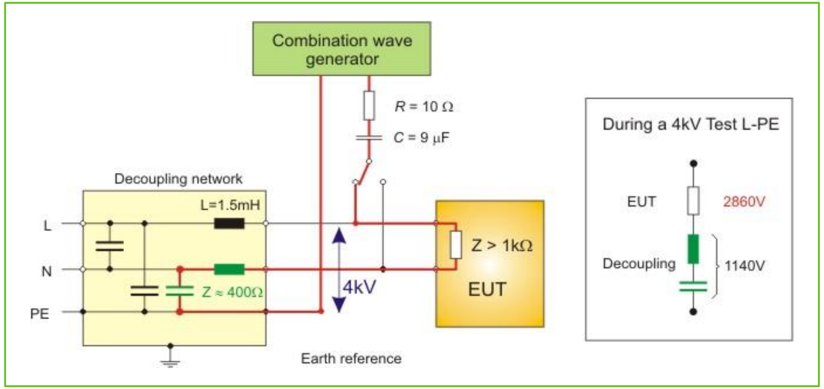
> TOPICS FOR EDITION 3 (maintenance results)

Testing of double-insulated products

Changes to Ed 3 :2014

No line to ground surges are applied for double-insulated products (i.e. products without any dedicated earth terminal).

NOTE 2 Product committees may decide if line to ground surge testing is applicable to double-insulated products with earthed connections other than PE.



Example: A product standard requires 4kV common mode and 2kV differential mode. For a single phase EUT it must be tested with 1kV between L and N and with 2kV between L and PE as well as between N and PE. According to the requirement for the coupling/decoupling network, the EUT may ‘see’ 1,5kV between L and N during the common mode tests. In the past some equipment failed the common mode tests with damages in the path between L and N, although the differential mode tests have been passed.

Annex A (Telecom Surge)

The surge testing for outdoor communication lines (telecom part) is moved to Annex A.
The waveform definition is seen in the table blow.

Table A.1 – Definitions of the waveform parameters 10/700 µs – 5/320 µs

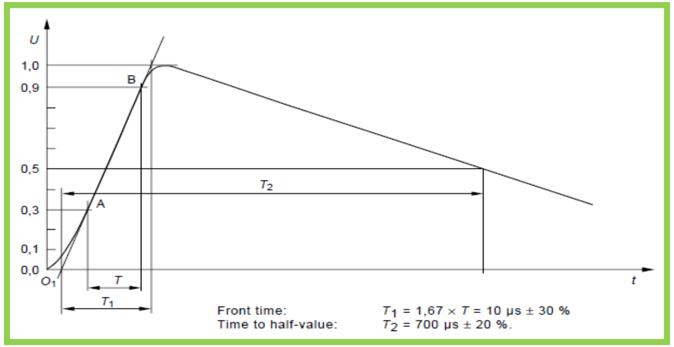
	Front time µs	Duration µs
Open-circuit voltage	10 ± 30 %	700 ± 20 %
Short-circuit current	5 ± 20 %	320 ± 20 %

Source impedance 40 Ohm

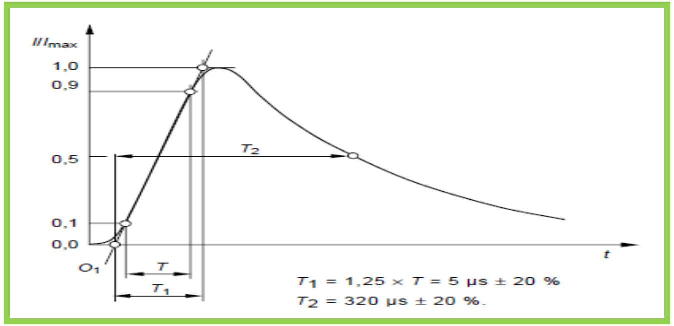
Table A.2 – Relationship between peak open-circuit voltage and peak short-circuit current

Open-circuit peak voltage ± 10 % at generator output	Short-circuit peak current ± 10 % at generator output
0,5 kV	12,5 A
1,0 kV	25 A
2,0 kV	50 A
4,0 kV	100 A

Waveform of open-circuit voltage (10/700 µs)



Waveform of short-circuit current (5/320 µs)



Surge generators

Current Surge generators from the AMETEK CTS product lines

emtest

Compact NX5

Compact NX7

VCS 500Nx 8

VCS 500N12 + CDN 100 A

TESEQ

NSG 3040A

NSG 3060A

NSG 3150 (15 kV)

emtest MILMEGA TESEQ

CONDUCTED

RF EQUIPMENT

POWER AMPLIFIERS

Thank you!

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T: +31 40 750 1650 E: sales@accelonix.nl

Coffee break

Demo NX5