Insights and best practice

EMC COMPLIANCE KNOW-HOW

TECHNICAL NOTE 0107

BURST AND SURGE

SUMMARY OF CHANGES TO THE STANDARD

Author:
Frank Niechcial
Product Manager Conducted EMC
AMETEK CTS

The challenge

Staying up-to-date with EMC compliance standards is critical for product designers and test engineers.

This Technical Note summarises the recent changes to the standards that affect Burst and Surge testing. These include pulse shape, calibration/verification and even specification of coupling networks that could lead to different test results. This information is a summary of the most important changes and the possible influence in test results. It will also clarify why new test results can not be compared to those complying to the old standard.

The document is designed to accompany a video recording of a **live webinar presented by Frank Niechial**

You can view the **recording here**

AMETEK CTS GmbH Sternenhofstrasse 15 4153 Reinach, Switzerland sales.cts.eu@ametek.com

AMETEK
COMPLIANCE TEST SOLUTIONS

GO TO VIDEO 02:50

BURST:
IEC 61000-4-4 EDITION 3.0 (2012-04)

BURST - HISTORY

Date	Publication	Edition	Status
2012-04-30	IEC 61000-4-4:2012	3.0	Valid
2012-04-30	IEC 61000-4-4:2012 RLV	3.0	Valid
2011-03-30	IEC 61000-4-4:2004+AMD1:2010 CSV	2.1	Revised
2010-01-27	IEC 61000-4-4:2004/AMD1:2010	2.0	Revised
2007-06-06	IEC 61000-4-4:2004/COR2:2007	2.0	Revised
2006-08-15	IEC 61000-4-4:2004/COR1:2006	2.0	Revised
2004-07-08	IEC 61000-4-4:2004	2.0	Revised
2001-07-11	IEC 61000-4-4:1995/AMD2:2001	1.0	Revised
2000-11-09	IEC 61000-4-4:1995/AMD1:2000	1.0	Revised

IMPORTANT CHANGES IN IEC 61000-4-4

Version IEC 61000-4-4:2004 (Edition 2.0)

- The burst switch must be an electronic switch. It is not permitted to use a spark gap any longer
- Burst frequency 5 kHz at Td =15 ms or 100 kHz at Td = 0.75 ms
- Calibration at coaxial output of the simulator with 50 Ω and 1000 Ω
- Calibration at output of the coupling network in Common Mode (all lines simultaneously) with 50 Ω
- Coupling on supply lines in Common Mode (all lines simultaneously)
- Tabletop units are to be placed 0.1m above the ground reference plane
- For coupling on supply lines the length of the supply line was reduced to 0.5 m

Version IEC 61000-4-4:2004+A1:2010 (Edition 2.0)

- The characteristics of the coupling-/ decoupling network were rectified and described precisely. Also the verification described in the Corrigendum 2 of 6/2007, which was internationally released, was not acceptable

Version IEC 61000-4-4:2012 (Edition 3.0)

- New version introduces calibration of capacitive coupling clamp. Procedure as well as impulse parameters are specified.
- Changes regarding calibration values at output of the coupling network:
  - Rise time (tr): 5,5ns ± 1,5ns
  - Pulse duration (td): 45ns ± 15ns
- Distance between DUT and coupling device, both coupling network and/or coupling clamp are:
  - Devices mounted on table: 0,5m (-0/+0,1m)
  - Floor Standing devices: 1,0m (+/-0,1m)
- Test setup for rack mounted equipment.

GO TO VIDEO 02:35

TEST LEVEL SINCE IEC 61000-4-4:2004

New repetition frequency of burst pulses is introduced!

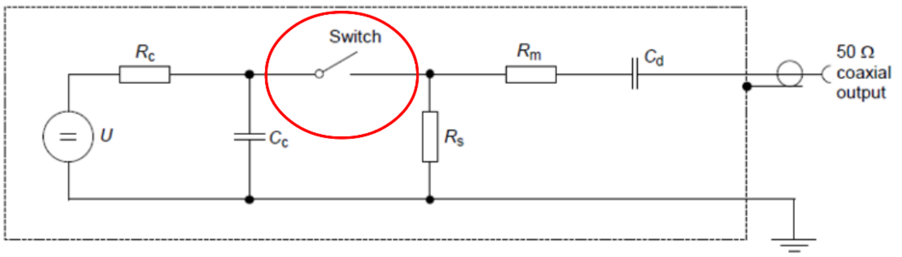
Open circuit test voltage			
Level	Power line	I/O line	
	Peak voltage in kV		Repetition rate in kHz
1	0,5	0,25	5 or **100**
2	1	0,5	5 or **100**
3	2	1	5 or **100**
4	4	2	5 or **100**
X (1)	special	special	

Table 1 – test level

The 100 kHz are merely a guideline, that could be adjusted by product committees to a more relevant variable for their product lines or products. In Annex A1 you will find representative values from real installations for your assistance.

SIMPLIFIED CIRCUIT DIAGRAM

Simplified circuit diagram showing major elements of a fast transient/burst generator



/12

Components

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

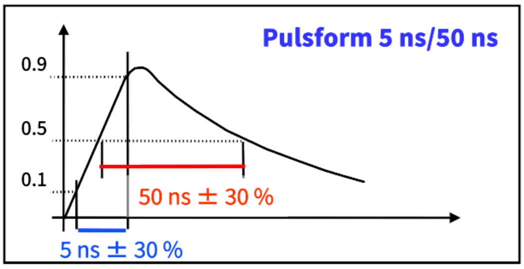
NOTE The characteristics of the switch together with stray elements (inductance and capacitance) of the layout shape the required rise time.

GO TO VIDEO 03:12

CHARACTERISTICS

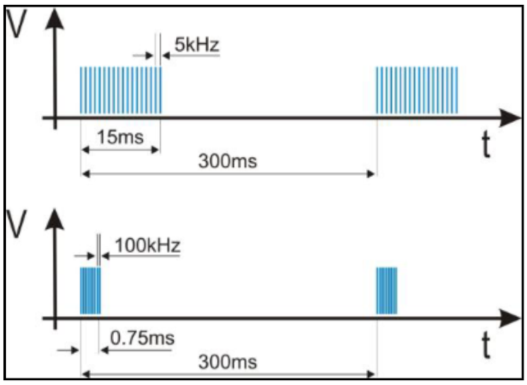
80% am (Commercial)

Single pulse
Rise time tr = 5 ns
Pulse duration td = 50 ns



Pulse packet (Burst)
Repetition time Tr = 300 ms
As formerly:
Duration burst packet Td = 15 ms
at spike frequency f = 5 kHz

Newly added:
Duration burst packet Td = 0,75 ms
At spike frequency f = 100 kHz



CHARACTERISTICS - WAVEFORM -

Output voltage range terminating with a load of 1000 Ω: min. 0.25 kV up to 4 kV;
Output voltage range terminating with a load of 50 Ω: min. 0.125 kV up to 2 kV;

Pulse repetition frequency:	5 kHz and 100 kHz ± 20 %
Burst duration (see 6.1.2 and fig. 2):	15 ms ± 20 % at 5 kHz | 0.75 ms ± 20 % at 100 kHz

Pulse shape

50 Ω Termination at coaxial output:	Rise time tr = 5 ns ± 30 % Pulse duration (50 %-value) td = 50 ns ± 30 % Peak voltage = according table 2 ± 10 %
1000 Ω Termination at coaxial out:	Rise time tr = 5 ns ± 30 % Pulse duration (50 %-value) td = 50 ns with a limiting deviation of – 15 ns bis + 100 ns Peak voltage = according table 2 ± 20 %

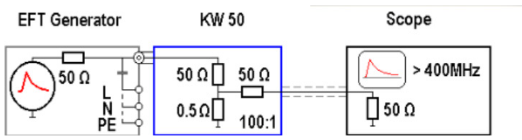
GO TO VIDEO 05:23

CHARACTERISTICS - OUTPUT VOLTAGE PEAK -

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.				

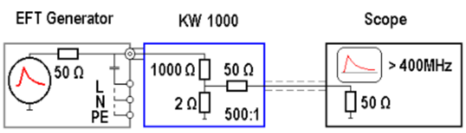
Table 2 – Output voltage peak values and repetition frequencies

CALIBRATION AT THE COAXIAL OUTPUT, 50 OHM



Ratio with KW50 -> 400:1
Example: 2000V Burst = 5V on scope

CALIBRATION AT THE COAXIAL OUTPUT, 1000 OHM



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

GO TO VIDEO 06:50

CALIBRATION AT COUPLING/DECOUPLING NETWORK

Coupling/decoupling network for mains supply connectors
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	

Remark:
The procedure is as shown in the above norm, until publication of the Amendment A1 to IEC 61000-4-4 ed.2 from 01-2010 hotly contested. In its current version, the verification is made abundantly clear.

Procedure since Amendment A1 to IEC61000-4-4 ed.2 of 01/2010
The calibration is performed with the generator output at 4 kV. The generator is connected to the input of the coupling/decoupling network. Each individual output of the CDN (normally connected to the EUT) is terminated in a sequence with a 50 Ω load while the other outputs are open. The peak voltage and waveform are recorded for each polarity.

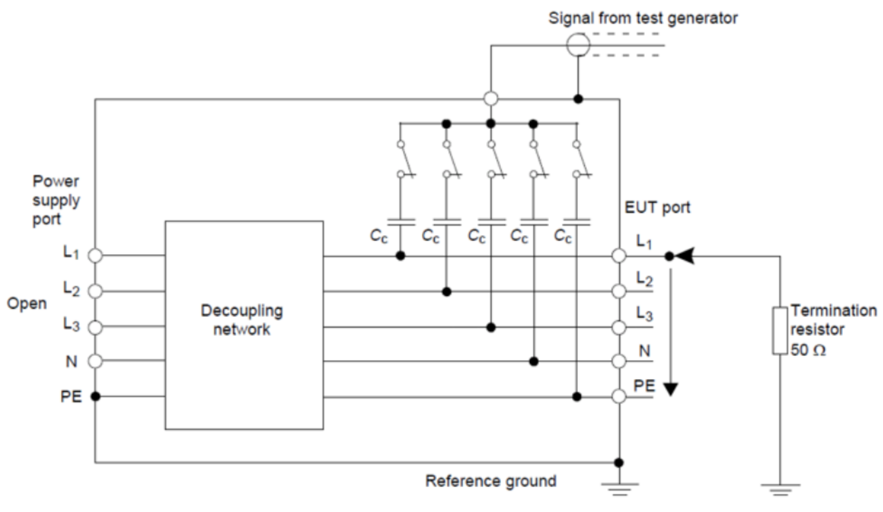
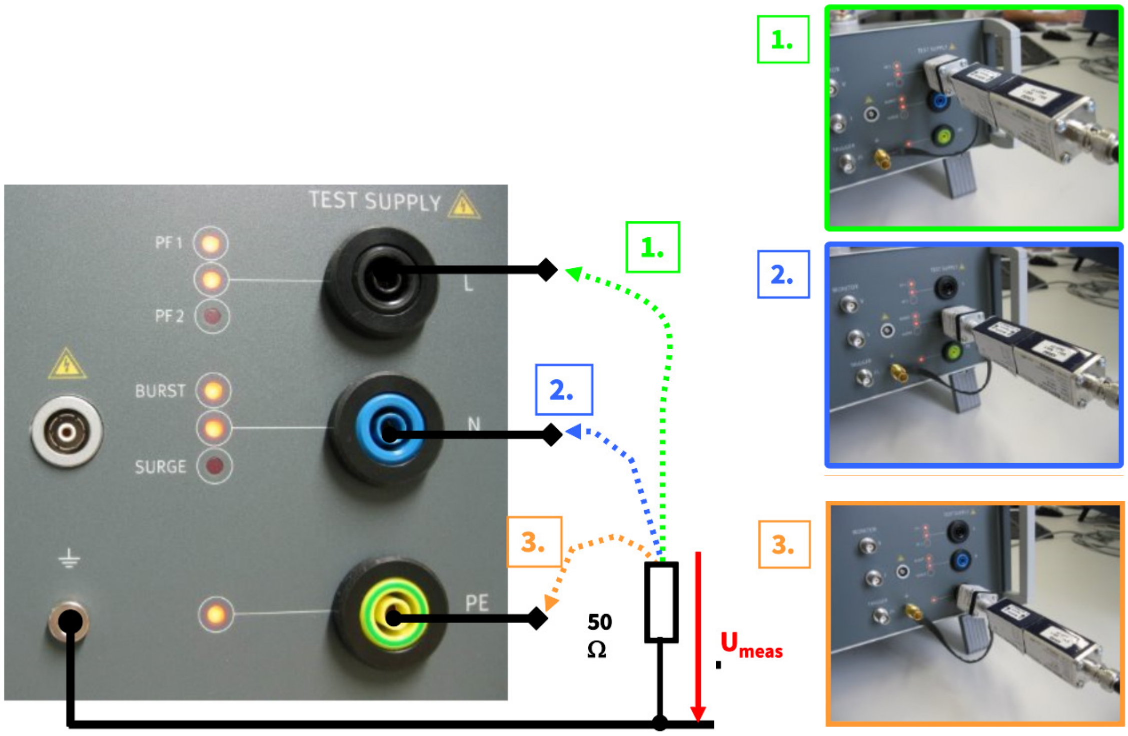


Figure 5 – Calibration of the waveform at the output of the coupling/decoupling network

GO TO VIDEO 09:06

CALIBRATION AT COUPLING/DECOUPLING NETWORK (continued...)

- The EFT transients are coupled to all lines of the CDN 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



GO TO VIDEO 10:21

CALIBRATION OF CAPACITIVE COUPLING CLAMP

- The transducer plate consists of 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.
- 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**	5 ns ± 1,5 ns
Pulse duration **td**	50 ns ± 15 ns
peak value of voltage	1 kV ± 200 V

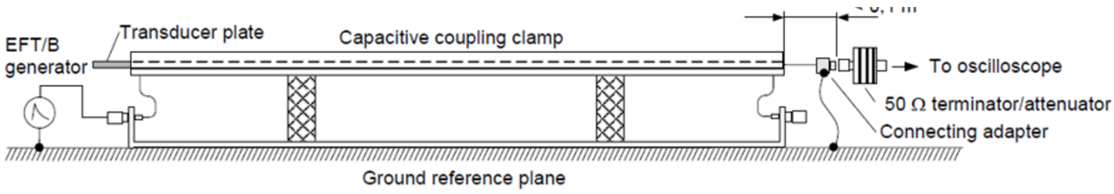


Figure 8 – Calibration of capacitive coupling clamp using the transducer plate

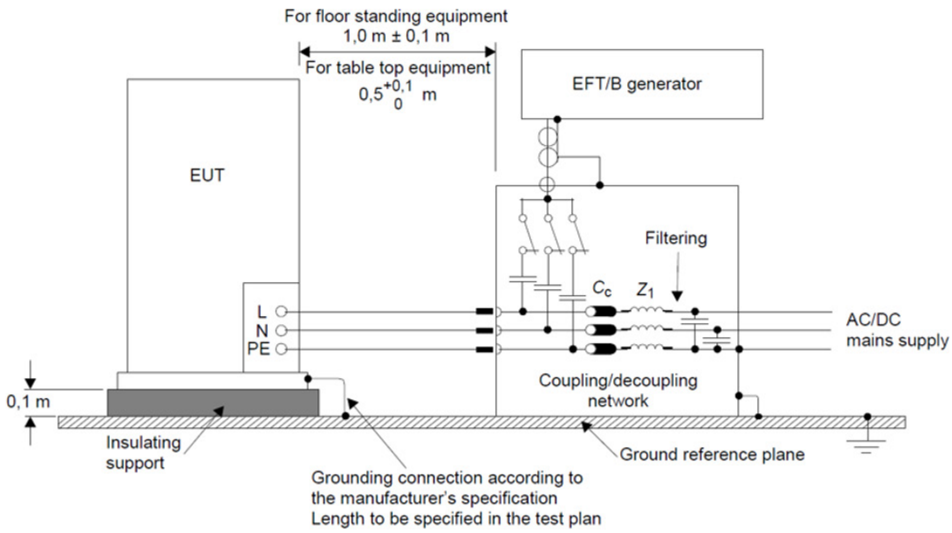
Calibration setup
of a capacitive coupling clamp using the transducer plate
acc. to figure 8 of IEC 61000-4-4:2012

GO TO VIDEO 12:35

COMMON MODE COUPLING

Coupling mode: „all lines against ground reference "

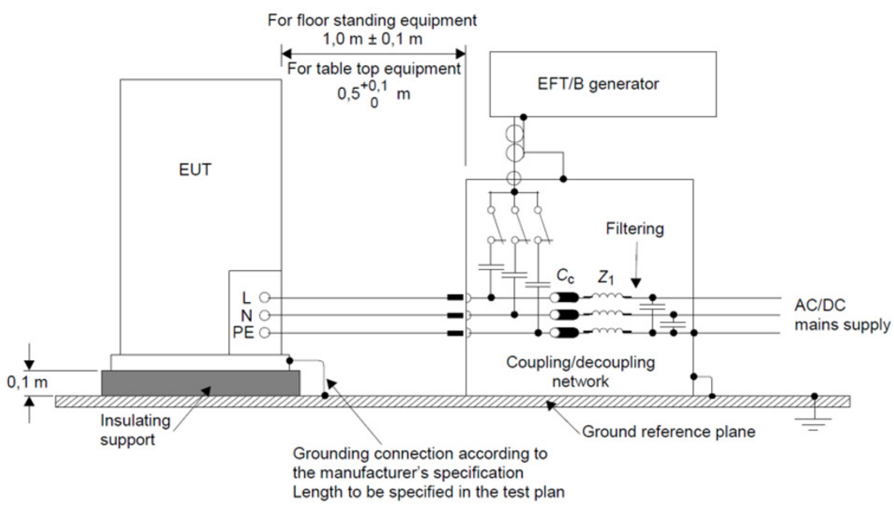
So, the coupling mode is a pure „Common Mode testing". This means that the testing of single lines, line after line, is not demanded any more, but only all lines simultaneously must be supplied with burst pulses.



CABLE LENGTH EUT-CDN: ACC. IEC 61000-4-4:2012

Test set-up for type tests in laboratory on main supply lines

- The new standard defines the distance and not the cable length.
- There is a distinction between floor standing equipment and table top equipment



GO TO VIDEO 13:22

SURGE:
IEC 61000-4-5 EDITION 3.1 (2017-08)

SURGE - HISTORY

Date	Publication	Edition	Status
2017-08-04	IEC 61000-4-5:2014/AMD1:2017	3.0	Valid
2017-08-04	IEC 61000-4-5:2014+AMD1:2017 CSV	3.1	Valid
2009-10-20	IEC 61000-4-5:2005/COR1:2009	2.0	Revised
2005-11-29	IEC 61000-4-5:2005	2.0	Revised
2001-04-26	IEC 61000-4-5:1995+AMD1:2000 CSV	1.1	Revised
2000-11-09	IEC 61000-4-5:1995/AMD1:2000	1.0	Revised
1995-03-01	IEC 61000-4-5:1995/COR1:1995	1.0	Revised
1995-02-01	IEC 61000-4-5:1995	1.0	Revised

GO TO VIDEO 14:04

IMPORTANT CHANGES IN IEC 61000-4-5 ED. 3

- Pulse parameters changed , now it is only one-time definition of pulse shapes (front time Tf and pulse duration Td)
- Verification of the Waveforms have to be made at the generator output (with 18µF in serial), and at the output of the coupling/decoupling networks.
- Harmonization of CDN up to 200 A
- New verification procedure for data line CDN´s, new calibration table. For verification the open-circuit voltage and the short-circuit current will measured. Additionally the AE-port should be open and not connected.
- The impedance for tests on shielded lines are 2 Ohm + 18 µF.
- New test setup for shielded control lines which are grounded only at one end. In this case the lines will be tested like unshielded lines.
- No line-to-ground surges are applied for double-insulated products (i.e. products without any dedicated earth terminal). This applies to the power supply lines as well as for signal and data lines.
- The coupling network for symmetrical operated telecommunication lines which will be used for tests with the T-Surge waveform (10/700 µs) is changed. The effective impedance of the coupling path has been changed.
- Measurement Uncertainty MU in annex D.

TEST LEVELS

IEC 61000-4-5:2005 (Ed. 2)

Table 1 – Test levels

Level	**Open-circuit test voltage ±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.

IEC 61000-4-5:2017 (Ed. 3)

Table 1 – Test levels

Level	**Open-circuit test voltage** kV	
	Line-to-line	**Line-to-ground** [b]
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.

[b] For symmetrical interconnection lines the test can be applied to multiple lines simultaneously with respect to ground, i.e. "lines to ground".

GO TO VIDEO 17:16

SURGE PULSE DEFINITION IEC 61000-4-5:2005 ED. 2

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

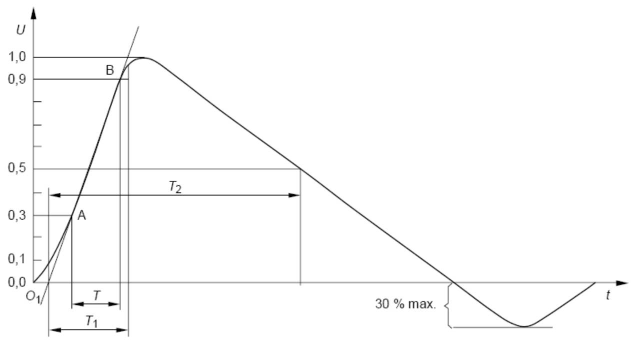
Definitions	In accordance with IEC 60060-1		In accordance with IEC 60469-1	
	Front time µs	Time to half value µs	Rise time (10 % – 90 %) µs	Duration time (50 % – 50 %) µs
Open-circuit voltage	1,2 ± 30 %	50 ± 20 %	1 ± 30 %	50 ± 20 %
Short-circuit current	8 ± 20 %	20 ± 20 %	6,4 ± 20 %	16 ± 20 %

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.

Definition according IEC 60060-1:

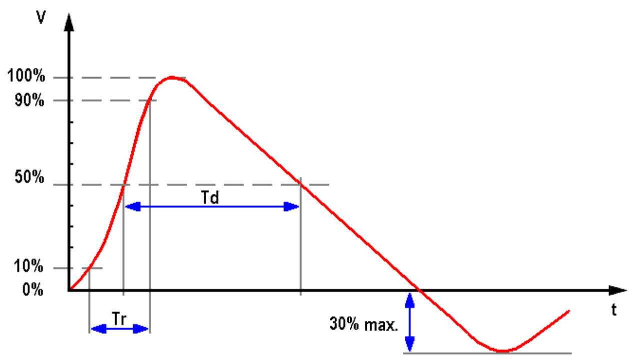
Front time: T1 = 1.67xT=1.2 µs ± 30 %
Time to half value: T2 = 50 µs ± 20 %



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

Definition according IEC 60469-1:

Rise time (10% - 90%): tr=1 µs ± 30 %
Duration time (50% - 50%): td=50 µs ± 30 %

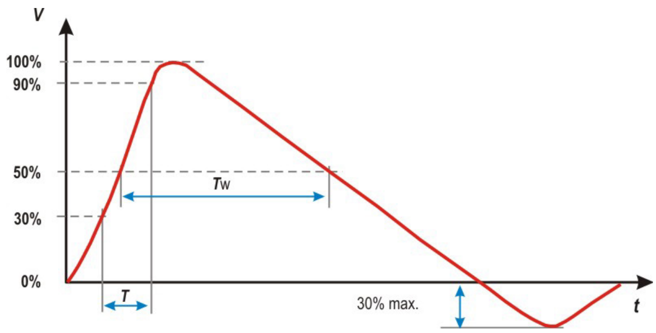


SURGE PULSE DEFINITION IEC 61000-4-5:2017 ED. 3

Open circuit voltage : 1.2/50 s

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

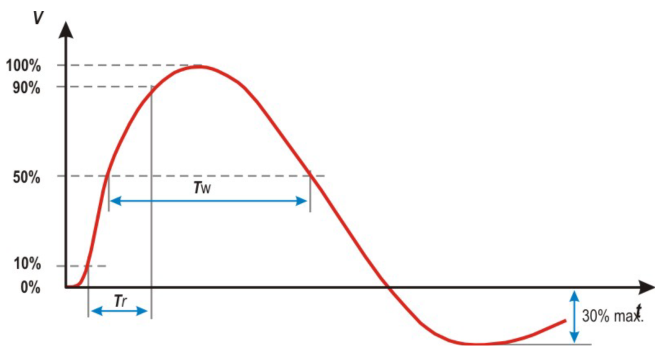
NOTE: The open circuit voltage waveform at the output of the coupling/decoupling network may have a considerable undershoot, in principle as the curve shown in Figure



Short circuit current: 8/20 s

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



GO TO VIDEO 20:14

CALIBRATION COUPLING NETWORK IEC 61000-4-5:2017 ED. 3

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

The characteristics of the CDN shall be measured under open-circuit conditions (load greater than or equal to 10 kOhm) 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	
	18 µF	9 µF + 10 Ω
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

[a] The measurement of the surge voltage parameters shall be done with the a.c./d.c. mains supply port of the CDN open-circuit.

New in Ed. 3

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

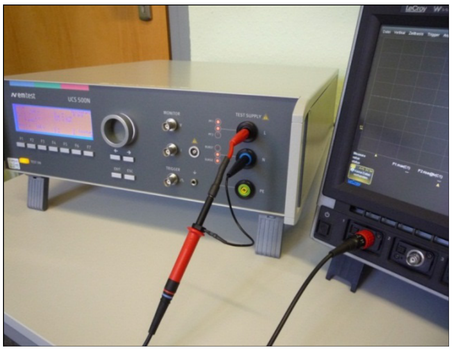
Decoupling inductivity:

- Maximum 1.5 mH
- Voltage Drop CDN < 10%

GO TO VIDEO 21:32

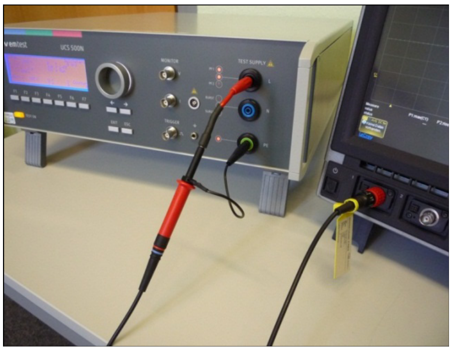
CALIBRATION COUPLING NETWORK
IEC 61000-4-5:2017 ED. 3 (continued)

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

GO TO VIDEO 21:52

CALIBRATION OF CDNS FOR UNSYMMETRICAL INTERCONNECTION LINES

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=1,18xT_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.

New in Ed. 3:

Waveform specification for unsymmetrical interconnection lines – was NOT specified in Ed. 2

CALIBRATION PROCESS FOR SYMMETRICAL INTERCONNECTION LINES

New in Ed. 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.

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.

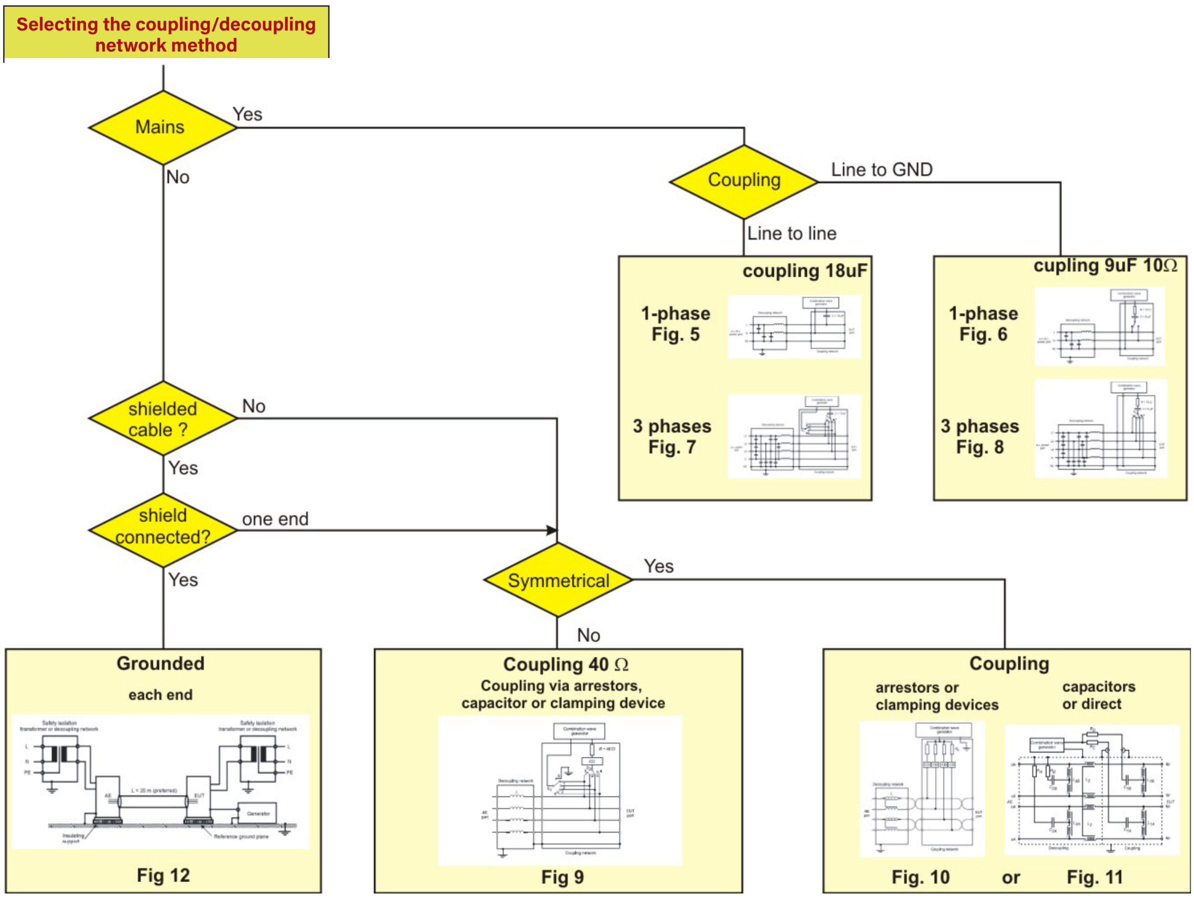
Table 10: Waveform specification

Coupling method	CWG Output voltage [1]), [2]), [3])	Voc at CDN EUT output ± 10 %	Voltage Front time T_r ± 30 %	Voltage Duration T_d ± 30 %	I_{sc} at CDN EUT output ± 20 %	Current Front Time T_r ± 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

GO TO VIDEO 23:23

FLOW CHART FOR COUPLING METHOD

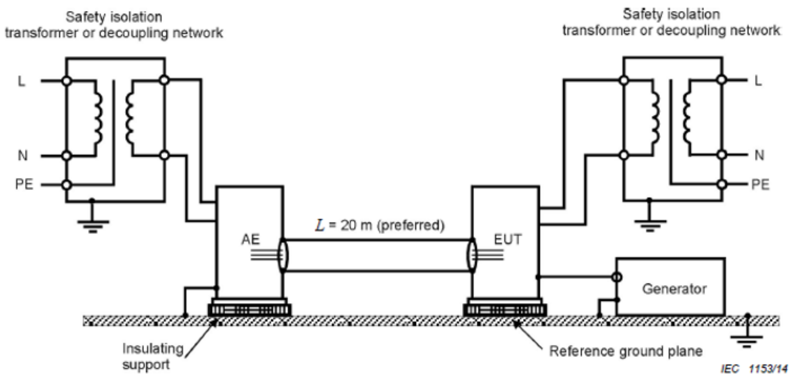
New in Ed.3



GO TO VIDEO 24:08

TEST SET-UP FOR SHIELDED LINES GROUNDED AT BOTH SIDES

For EUTs that do not have metallic enclosures, the surge is applied directly to the shielded cable at the EUT side.



Generator impedance for tests on shielded lines:

IEC 61000-4-5 Ed. 2

- 2 Ohm

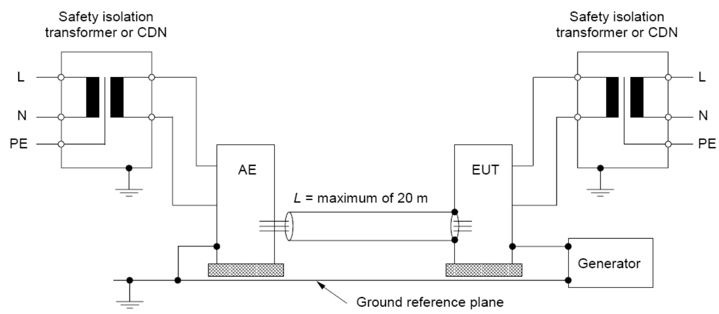
New: IEC 61000-4-5 Ed. 3

- 2 Ohm + 18 µF

TEST SET-UP FOR SHIELDED LINES GROUNDED ONLY AT ONE END

According to
IEC 61000-4-5:2004:

The test is done with an open end at the AE side.



According to
IEC61000-4-5 Ed. 3:

The test is done as for unshielded asymmetrically operated I/O lines

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.

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

For EUTs which do not have metallic enclosures, the surge is applied directly to the shielded cable at the EUT side.

GO TO VIDEO 25:23

COUPLING ON HIGH-SPEED I/O LINES

Figure 11 shows an example of a coupling and decoupling network for symmetrical interconnection lines allowing tests with interconnection speed up to 1 000 Mbit/s.

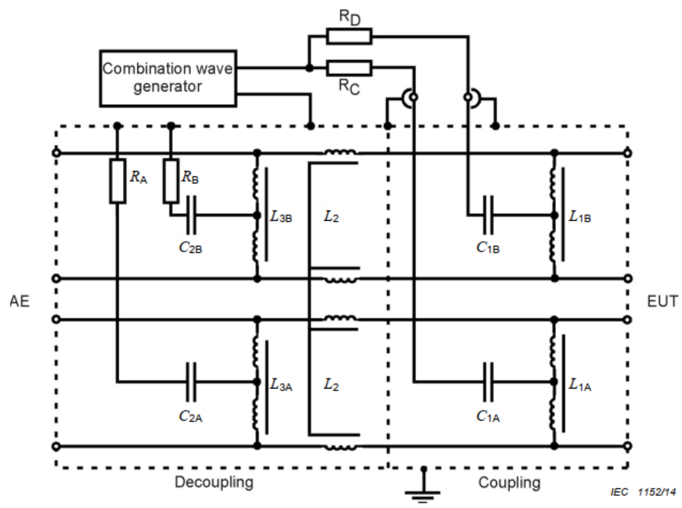
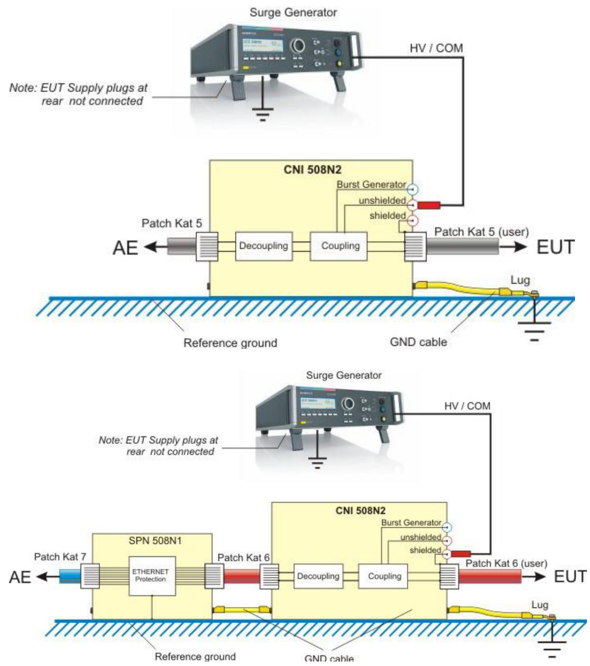


Figure 11 – Example of CDN for unshielded symmetrical interconnection lines



About Frank Niechcial

Frank Niechcial is a Product Manager at AMETEK CTS in Switzerland. He started his EMC-career in 1996 at the EMC-test house of EM TEST, which was acquired 2011 by AMETEK. Frank worked in the commercial team for over 20 years assisting customers with their individual EMC compliance requirements across many industries.

In his current role he is responsible for the industrial conducted test-equipment product portfolio, and is a member of the UK 767.3 committee which is engaged in high-frequency phenomena.

His educational background includes a Master in telecommunication engineering and a QM-degree for quality management systems.

About AMETEK CTS

AMETEK CTS is a global leader in EMC compliance testing and RF power amplifiers. AMETEK has been designing and manufacturing precision instruments for more than 30 years. Under the brand names of EM Test, Teseq, IFI and Milmega the company produce a wide range of specialist solutions aligned to the individual needs of equipment manufacturers across a variety of industries. These include:

Automotive
Aerospace and Defense
Consumer electronics
Household appliances
Medical devices
Renewable energy

From its design and manufacturing facilities in Switzerland, Germany, the United States and the UK, AMETEK CTS provides customers with innovative solutions to the complex requirements of EMC compliance standards.