HV TECHNOLOGIES, Inc.

Power and I/O Line Testing Standards Updates for MIL/Aero, CE, Energy Meter Industries

Jason H. Smith
EMC Sales and Marketing Manager

Background

- 17 Years in EMC
  - 7 years Lab Manager and EMC Testing (commercial/MIL)
  - 8 years Applications Engineering EMC/RF Technical Lead
  - 2+ years EMC solutions provider
- Have been a participating member of:
  - IEC TC 77B WG10
  - IEC TC 77B
  - IEC TC 77C
- Current participating member of:
  - SAE AE2 Lighting Committee (DO 160 Sec 22/23)

Summery

- IEC Recent updates for EMC
  - IEC 61000-3-2 Ed4 Harmonic Emissions
  - IEC 61000-4-4 Ed3 EFT/Burst
  - IEC 61000-4-5 Ed3 Surge
  - IEC 61000-4-19 NEW! Differential mode
- MIL-STD-461G Proposed updates
  - CS117 Indirect lightning
  - RS106 ESD

Recently Updated Specifications

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Just Published by the IEC - Edition 05-14

Just Published [iecjustpublished@iec.ch]

An: Martin Lutz

IEC

Just Published

87 publications since **2014-05-01**

Electromagnetic compatibility

IEC 61000-3-2 ed4.0 (2014-05)
Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
ICS code 33.100.10 SC 77A CHF 190.-

IEC 61000-4-5 ed3.0 (2014-05)
Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test
ICS code 33.100.20 SC 77B CHF 290.-

IEC 61000-4-19 ed1.0 (2014-05)
Electromagnetic compatibility (EMC) - Part 4-19: Testing and measurement techniques - Test for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports
ICS code 33.100.20 SC 77A CHF 190.-

IEC 61000-3-2 Ed 4

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

IEC 61000-3-2

Edition 4.0 2014-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Supersedes and Cancels IEC 61000-3-2 Ed 3:

– published in 2005, Amendment 1:2008, Amendment 2:2009 and Corrigendum of August 2009.

colour inside

Electromagnetic compatibility (EMC) –
Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)

IEC 61000-3-2 Ed 4

- A clarification of the repeatability and reproducibility of measurements; (should have no major effect on Measurement equipment)

- Many Changes and Clarifications to test methods
  - A clarification of the requirements for Class C equipment with active input power ≤ 25 W;
  - The reclassification of refrigerators and freezers with variable-speed drives into Class D;
  - An update of the test conditions for:
    - information technology equipment;
    - information technology equipment with external power supplies or battery chargers;
    - washing machines;
    - audio amplifiers;
    - lamps;
    - vacuum cleaners;
    - high pressure cleaners;
    - refrigerators and freezers

IEC 61000-4-4 Ed3

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

IEC 61000-4-4

Edition 3.0 2012-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

- MT12 Responsibility
- Published by IEC April 2012
- Accepted in CENELEC 2012
- Date of Publication May 2013

colour inside

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test

Changes to IEC 61000-4-4 Ed3

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

1. Figures moved within the text where they are called up
2. Mathematical formula for Nominal EFT pulse
3. Defined characteristics of test load impedance
4. CDN calibration enlarged tolerances
5. Calibration of coupling clamp with a transducer plate
6. New Test setups
7. Measurement uncertainty (MU)

MATHEMATICAL FORMULA

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

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

where

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

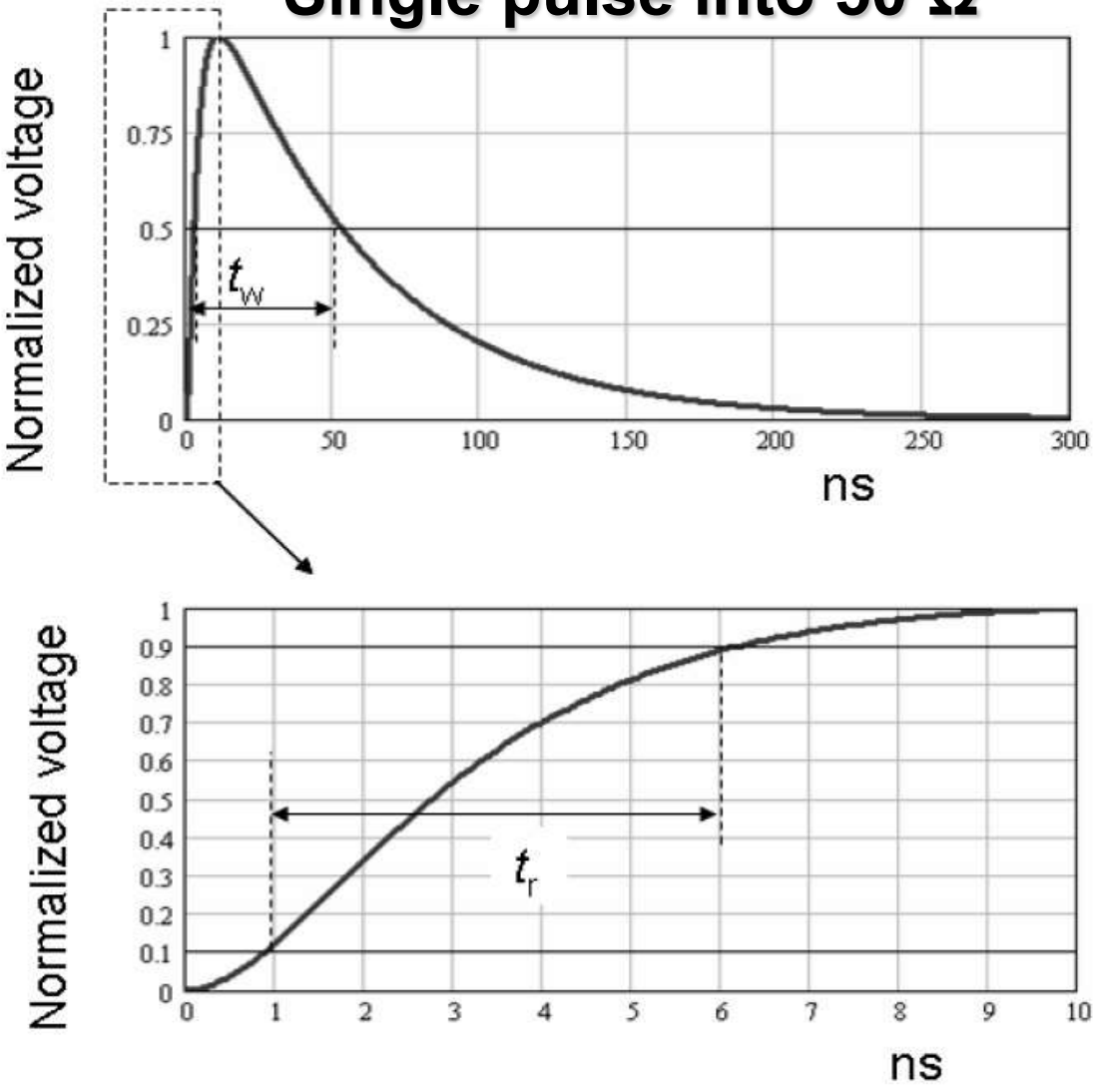
and

- *k*v is maximum or peak value of the open-circuit voltage (*k*v = 1 means normalized voltage)
- v 1 = 0,92 τ 1 = 3,7 ns τ 2 = 51 ns *n*EFT = 1,8

IDEAL WAVEFORM

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Single pulse into 50 Ω

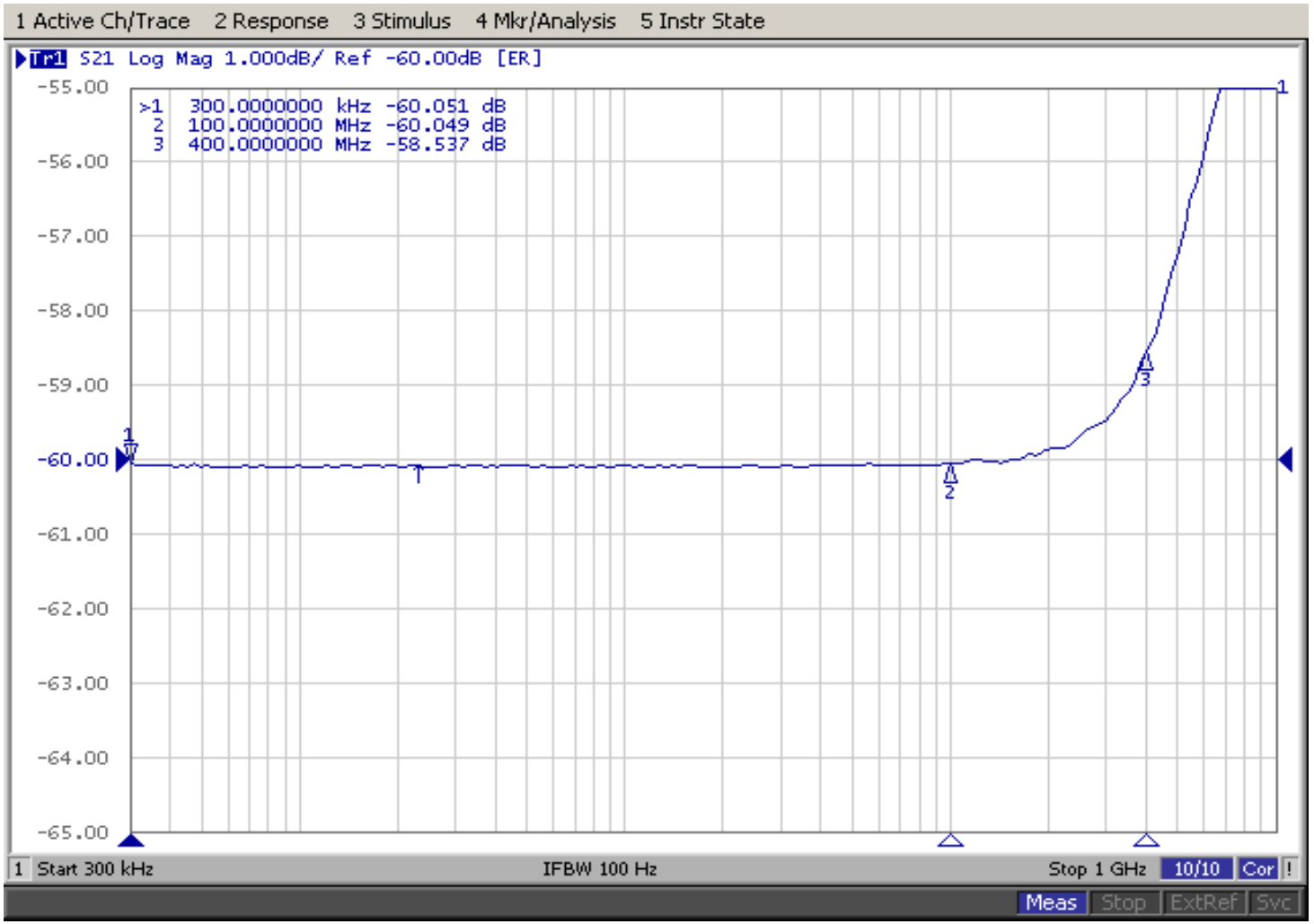


TEST LOAD IMPEDANCE

- Edition 2
  - (50 ± 1) Ω;
  - (1000 ± 20) Ω in parallel with ≤ 6 pF; the resistance measurement is made at d.c. and the capacitance measurement is made using a commercially available capacitance meter that operates at low frequencies.
- Edition 3
  - Tolerance of both load impedances shall be:
    - ± 1 dB up to 100 MHz
    - ± 3 dB from 100 MHz up to 400 MHz.

TEST LOAD IMPEDANCE

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G



CALIBRATION OF CDN

IEC updates

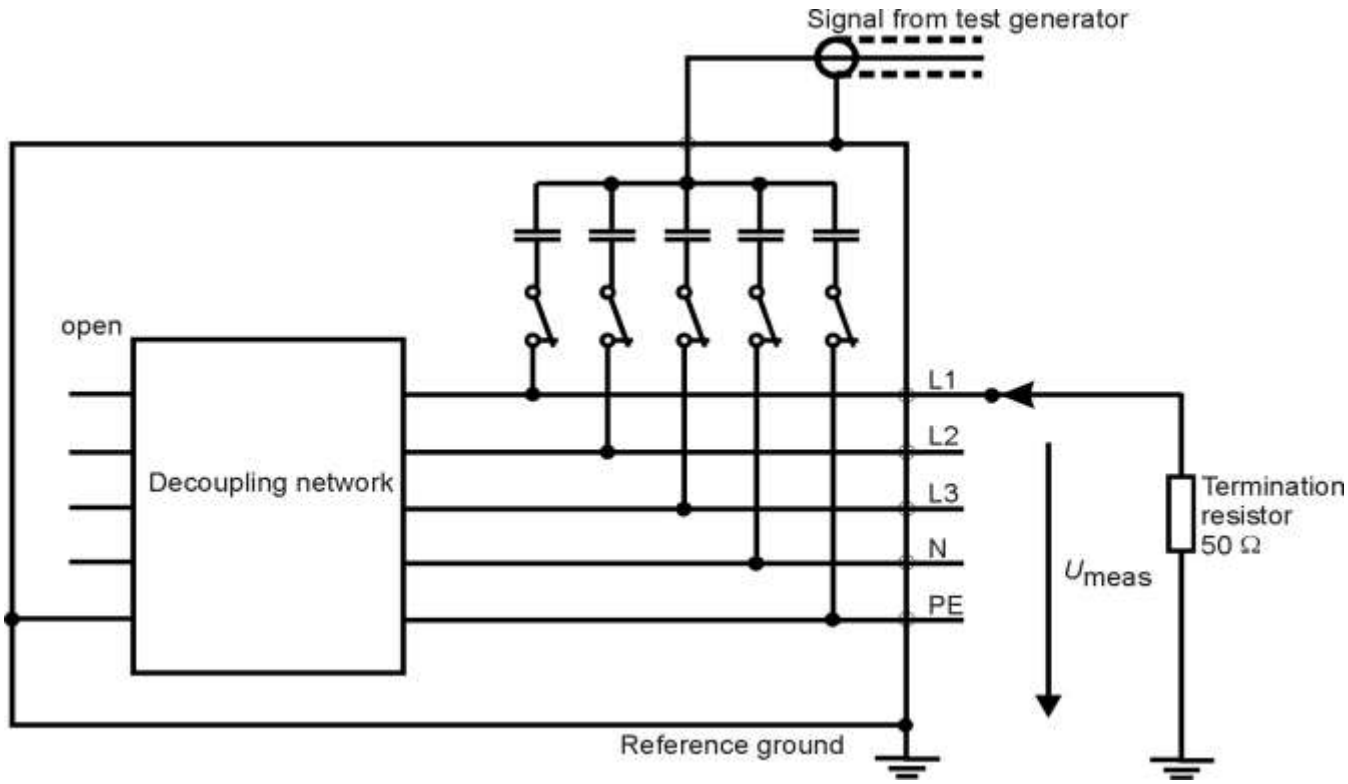
IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G



- Old standard
  - A possible disconnection of an individual line will be discovered.
  - Not all generators on the market will comply with this calibration

CALIBRATION OF CDN

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

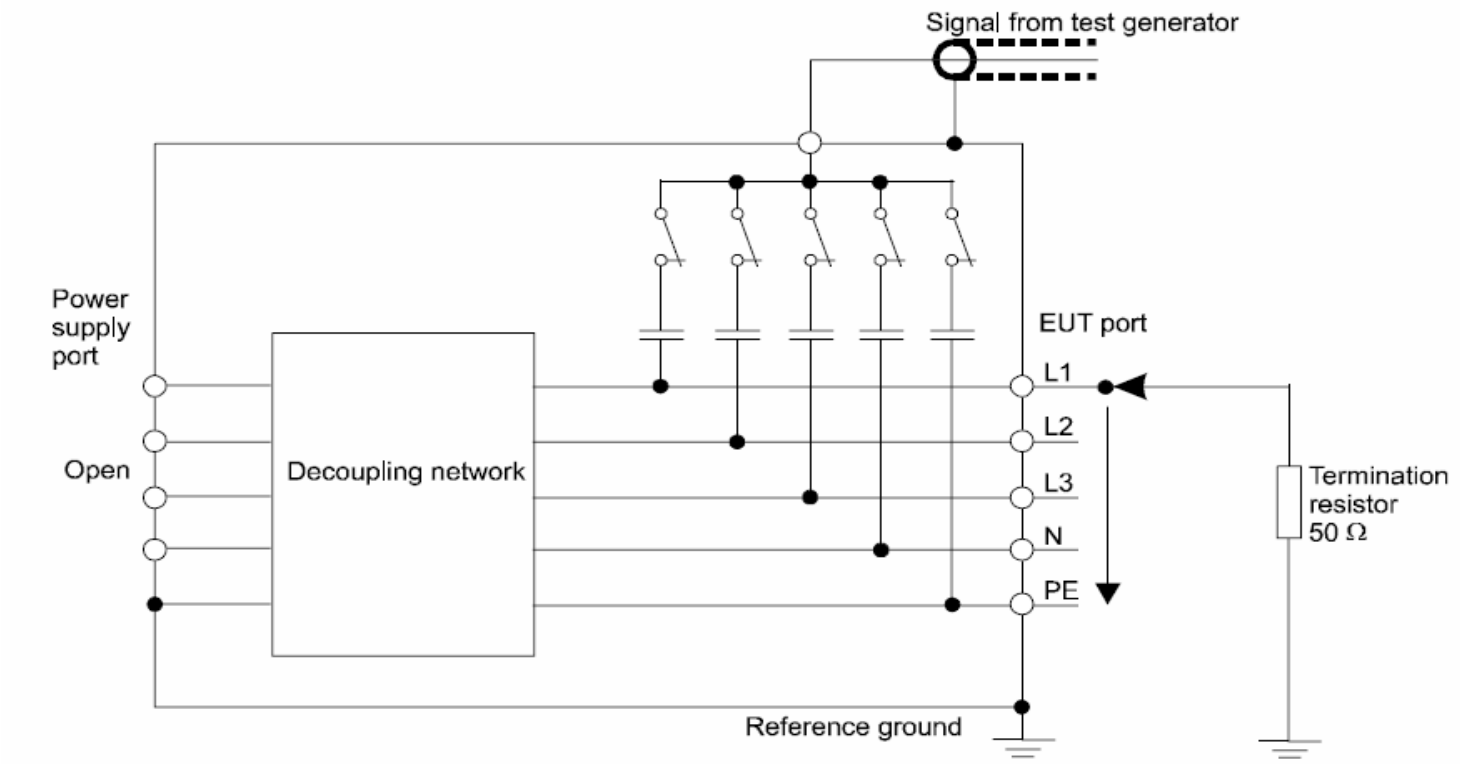
MIL-STD-461G

- The waveform shall be verified at the common output of the CDN with a single 50 Ohm termination. The verification is performed with the generator output voltage of 4 kV. (50ohm loaded produces 2kV)
- The functionality verification of each single CDN path is recommended. Now required
- Rise time of the pulse 10 to 90% shall be 5 ns +/-30% (now 2.5nS [50%])
- Impulse duration shall be 50 ns +/-30% with the 50 Ohm load.
- The residual test pulse voltage on the inputs shall not exceed 10 % of the applied test voltage.

CALIBRATION OF CDN

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

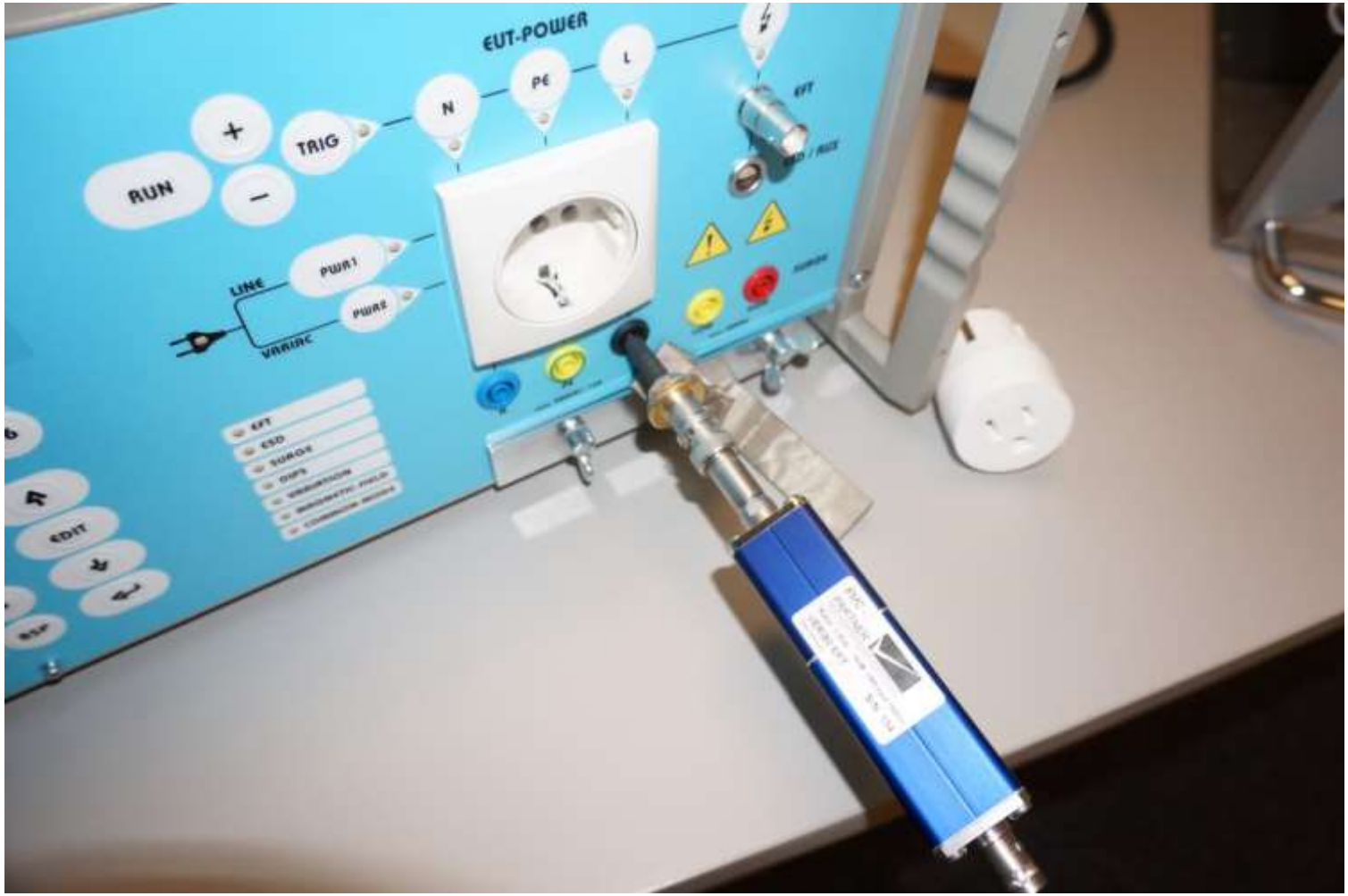
CDN calibration bigger tolerances



- Rise time of the pulses shall be (5 ± 2,5) ns.
- Pulse width shall be (50 ± 15) ns.
- Peak voltage shall be 2 kV ± 0,2 kV

CALIBRATION OF CDN

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

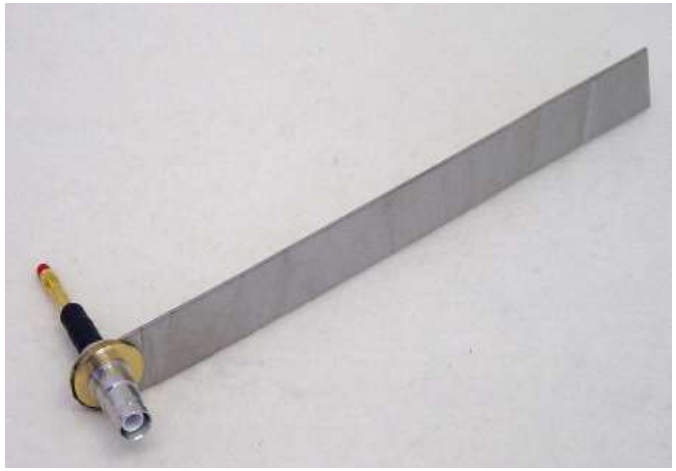


Verification Setup picture with 50Ohm load

CALIBRATION OF CDN

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

Calibration Adapter

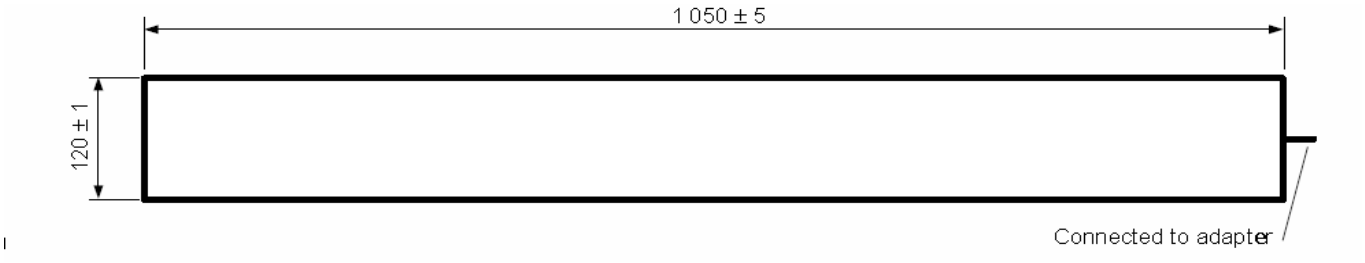


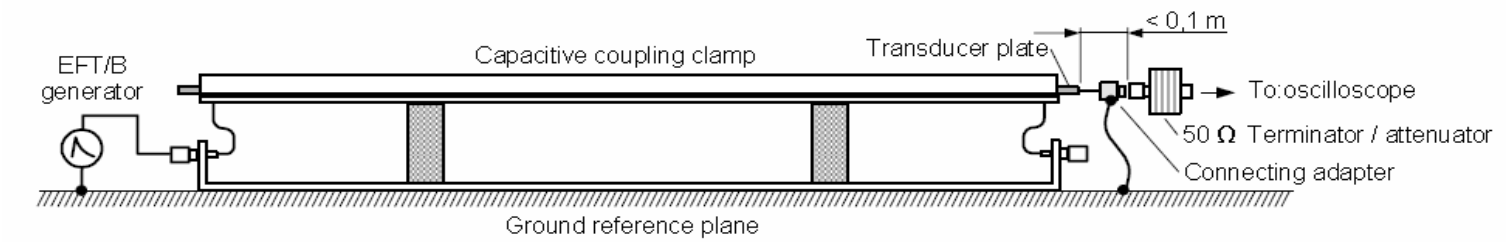
Single Phase Adapter

Three Phase Adapter

CAPACITIVE CLAMP

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G





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 5 kV on all sides must be guaranteed in order to avoid the clamp to contact the transducer plate.

CAPACITIVE CLAMP

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

Coupling Clamp Calibration Setup

Needs also 50Ω measurement load impedance

CAPACITIVE CLAMP

- Calibration Procedure
  - Calibrated using a generator, compliant with the requirements of 6.2.1 and 6.2.2.
  - Calibration is performed with the generator output voltage set to 2 kV.
  - Peak voltage and waveform parameters recorded at transducer plate output with 50Ω termination:
    - Rise time (5 ± 1,5) ns
    - Pulse width (50 ± 15) ns
    - Peak voltage (900 ± 90) V

CAPACITIVE CLAMP

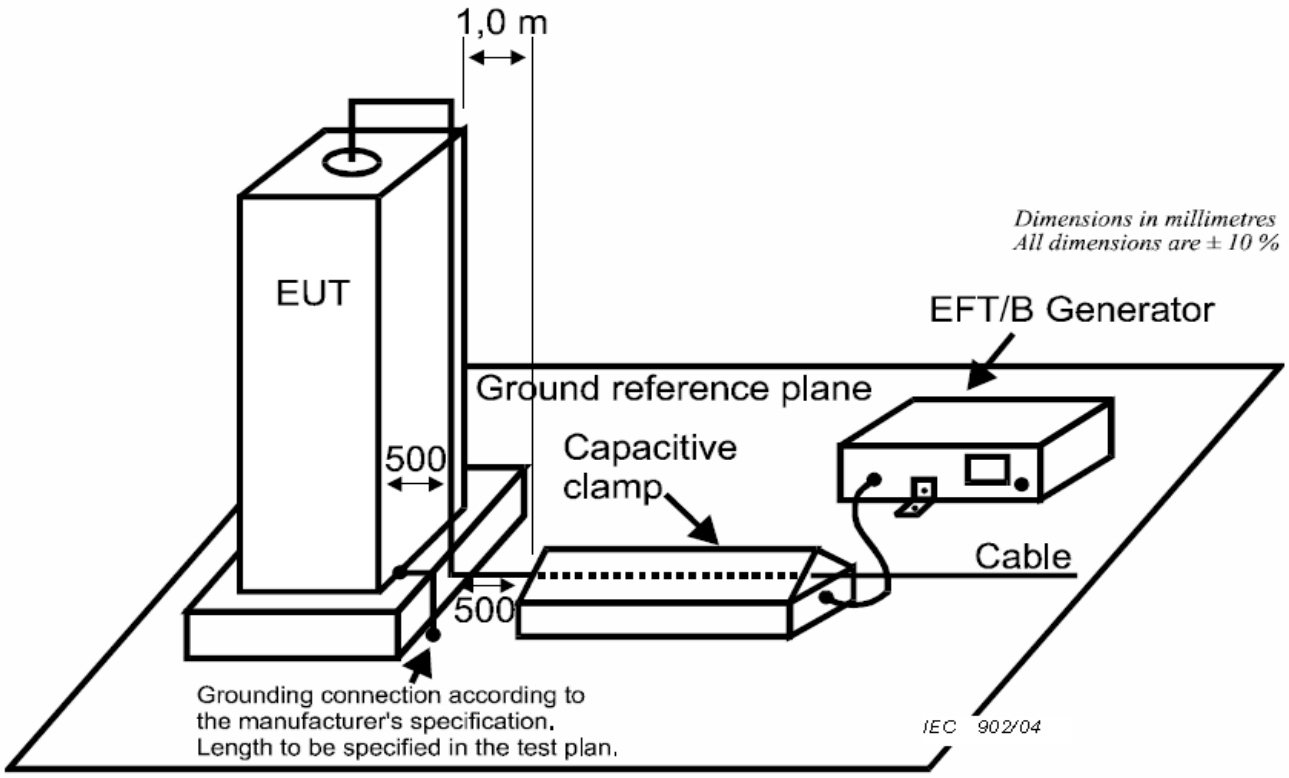
IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

- Advantages of new method
  - The complete chain: generator, cable, coupling clamp and coupling path is calibrated
  - Same waveform specification as at the generator output.
  - 50 Ohm termination as for the generator calibration can be used
  - The design of the coupling clamp can differ from the mechanical drawing example. The coupling clamp must fulfil the calibration requirements

TEST SETUPS

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Equipment with elevated cable entries



TEST SETUPS

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

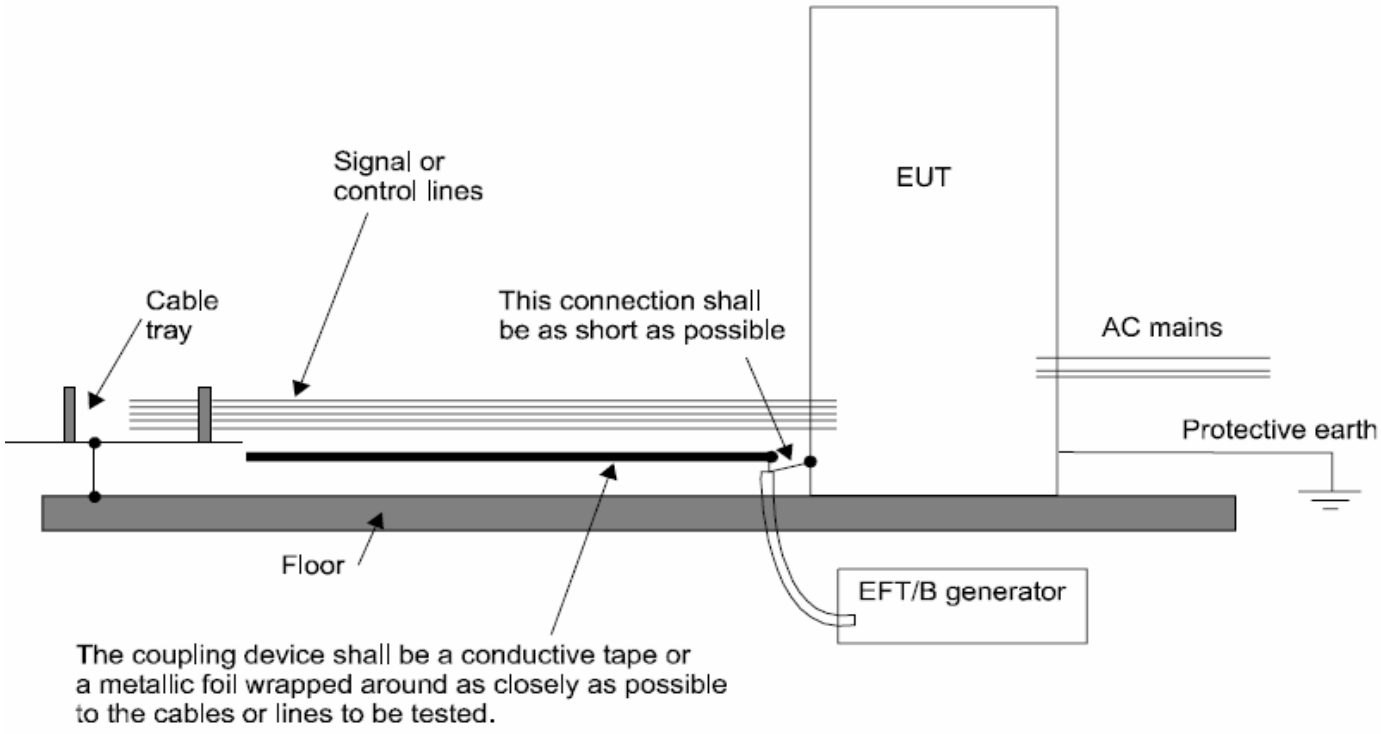
EFT coupling into mains I >100A

- If no CDN available
  - A.C. mains currents >100 A,
- Alternative methods can be used:
  - Common and unsymmetrical modes, direct injection with (33 ± 6,6) nF capacitors is preferred
  - If direct injection is not practical, the capacitive clamp is used.

TEST SETUPS

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

Insitu test without coupling clamp



An alternative method is to couple the EFT/B generator to the terminals of the lines via “real” 100pF ± 20pF capacitors instead of the distributed capacitance of the clamp or of the foil or tape arrangement.

MEASUREMENT UNCERTAINTY

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Table C.1 – Example of uncertainty budget for EFT/B rise time (t_r) and pulse width (t_w) calibration

Contributor	Distribution	Value [ns]	$u_i(y)$ [ns]	$u_i(y)^2$ [ns^2]	Comment
Reading of time by 90 % peak current	Rectangular Divisor = √3	0,05	0,029	0,000833	10 GS/s oscilloscope sampling rate
Reading of time by 10 % peak current	Rectangular Divisor = √3	0,05	0,029	0,000833	10 GS/s oscilloscope sampling rate
Equation uncertainty	Normal Divisor = 1	0,05	0,05	0,0025	Consider the rise time of all elements in the chain including the scope rise time
Repeatability	Normal Divisor = 1	0,1	0,1	0,01	Obtained from Type A evaluation using at least 5 measurements.
			Sum	0,014166	
Combined standard uncertainty u_c on rise time and pulse width.			Root	0,12 ns	
Expanded uncertainty U on rise time	Normal k = 2	0,24			Confidence level 95 %

Typical measurement uncertainty for output from EFT generator

MEASUREMENT UNCERTAINTY

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

1.3 Measurement / Calculation Results

1.3.1 Impulse Output: 50Ohm Load: Polarity Positive

Level	Name	Value Nom. Value	Deviation Tolerance	Uncertainty	
250V[1]	Vp reading	116.92 mV			✔
	Tr reading	5.083 ns			✔
	Tw reading	52.139 ns			✔
	Vpeak calc.	120.131 V 125 V	-3.895 % +10% / -10%	±3.8 %	✔
	Trise calc.	5.004 ns 5 ns	+3.752 ps 1.5 ns / -1.5 ns	±125 ps	✔
	Twidth calc.	52.123 ns 50 ns	+2.123 ns 15 ns / -15 ns	±120 ps	✔

Typical measurement uncertainty for output from EFT generator
Now required in Generator Calibration.

MEASUREMENT UNCERTAINTY

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

EFT Setup Uncertainty

Table C. 4 – Example of uncertainty budget that use capacitive coupling clamp

Symbol	Uncertainty Source X_i	$U(x_i)$	Unit	Distribution	Divisor	$u(x_i)$	Unit	c_i	$u_i(y)$	Unit	$u_i(y)^2$
Gpc	Calibration results (pulse out)	0,12	%	normal k=2	2,00	0,06	%	1	0,06	%	0,00
Cpc	Clamp Calibration results	1,30	%	normal k=2	2,00	0,65	%	1	0,65	%	0,42
Gsr	Generator setup repeatability	1,80	%	normal k=1	1,00	1,80	%	1	1,80	%	3,24
Csr	Coupling clamp repeatability	1,60	%	normal k=1	1,00	1,60	%	1	1,60	%	2,56
Ser	EUT setup repeatability	3,40	%	normal k=1	1,00	3,40	%	1	3,40	%	11,56
SWt	SW levelling precision	1,00	%	rect	1,73	0,58	%	1	0,58	%	0,33
									$\Sigma u_i(y)^2$		**18,12**
									$\sqrt{\Sigma u_i(y)^2}$		4,26
									Expanded Uncertainty k = 2		**8,51** %

Test Result Uncertainty <9%

IEC 61000-4-5

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

IEC 61000-4-5

Edition 3.0 2014-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-5: Testing and measurement techniques – Surge immunity test

- MT12 Responsibility
- Published by IEC May 2014
- Accepted in CENELEC 2014

IEC 61000-4-5 Surge

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

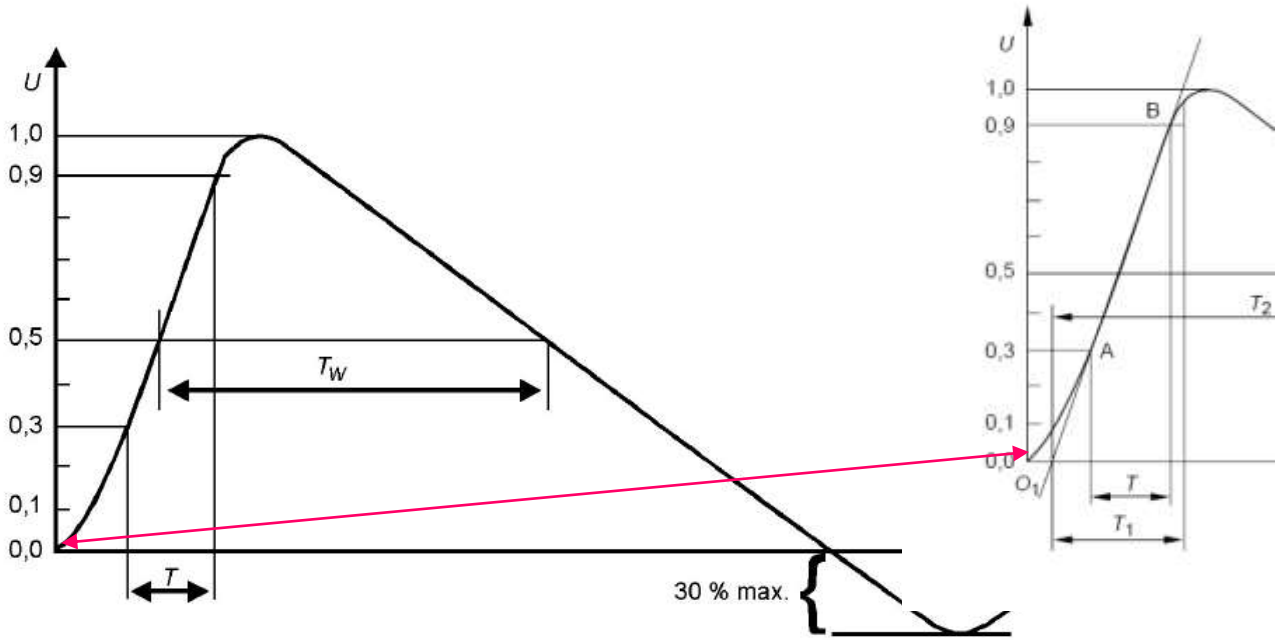
SC77B MT12 – Maintenance IEC 61000-4-5 Ed3

- Responsible for the maintenance MT12
- Points of maintenance:
  - Waveform definition (only one definition)
  - Calibration of CDN and Generator with 18 µF capacitor
  - Define a new CDN for high speed communication including calibration.
  - Define new CDN for power lines up to 200A/phase including calibration
  - Move the 10/700 µs generator to an annex and coordinate with ITU
  - MU measurement uncertainty

Waveform Clearly Defined

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

One clear Definition no longer IEC 60060 and IEC 60469



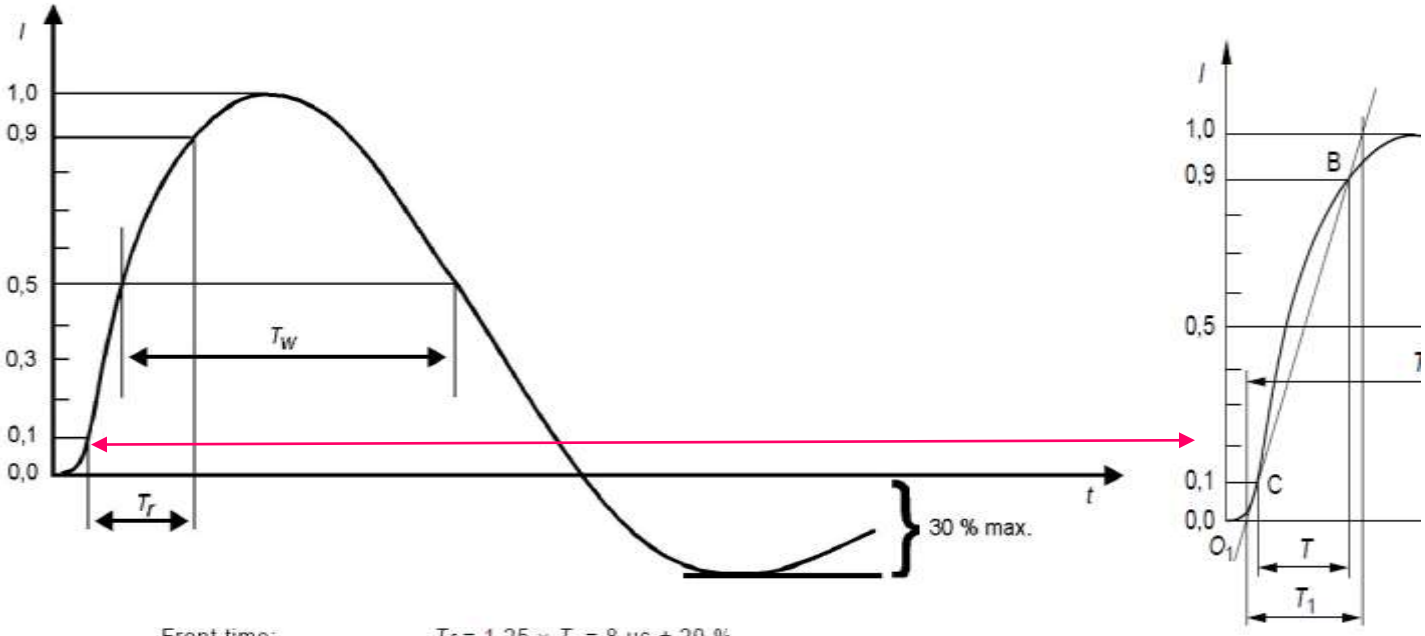
Front time: $T_f = 1{,}67 \times T = 1{,}2\ \mu s \pm 30\ \%$
Duration: $T_W = 50\ \mu s \pm 20\ \%$.

	Front time T_f µs	Duration T_d µs
Open-circuit voltage	$T_f = 1{,}67 \times T = 1{,}2 \pm 30\ \%$	$T_d = T_w = 50 \pm 20\ \%$
Short-circuit current	$T_f = 1{,}25 \times T_r = 8 \pm 20\ \%$	$T_d = 1{,}18 \times T_w = 20 \pm 20\ \%$

Waveform Clearly Defined

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

One clear Definition no longer IEC 60060 and IEC 60469



Front time: $T_f = 1{,}25 \times T_r = 8\ \mu s \pm 20\ \%$
Duration: $T_d = zz \times T_w = 20\ \mu s \pm 20\ \%$

Surge current parameters under short-circuit conditions [a]	Coupling impedance	
	18 µF (line to line)	9 µF + 10 Ω (line to ground) [b]
Front time	$T_f = 1{,}25 \times T_r = 8\ \mu s \pm 20\ \%$	$T_f = 1{,}25 \times T_r = 2{,}5\ \mu s \pm 30\ \%$
Duration	$T_d = 1{,}18 \times T_w = 20\ \mu s \pm 20\ \%$	$T_d = 1{,}04 \times T_w = 25\ \mu s \pm 30\ \%$

[a] The measurement of the surge current parameters shall be performed with the a.c./d.c. power port of the CDN open-circuit.

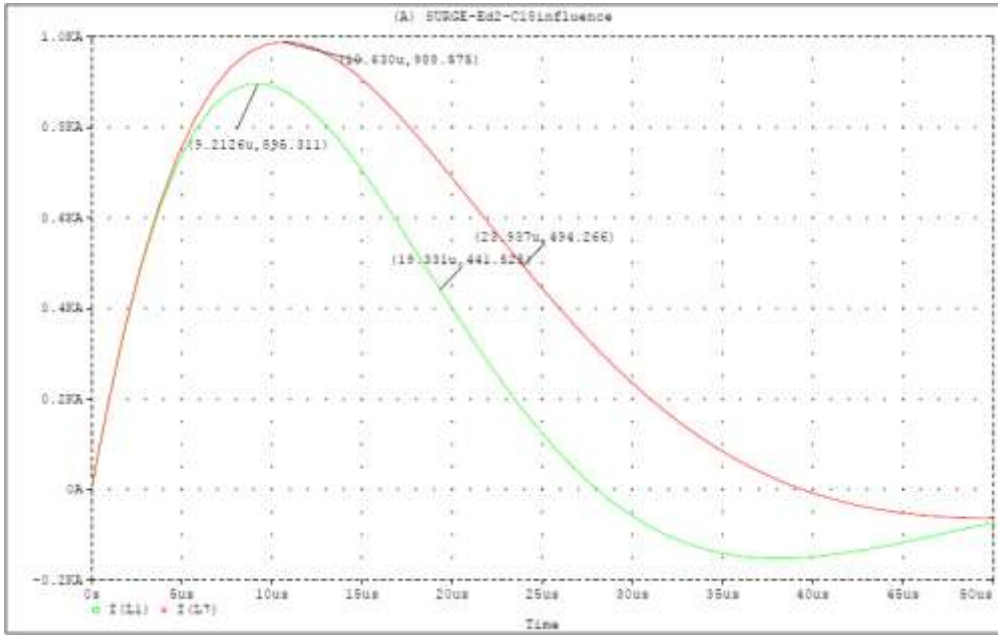
[b] The value 1,04 is derived from empirical data

CDN Calibration Defined

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

I short circuit calibration at generator and CDN output

- The characteristics of the generator shall be measured through an external capacitor of 18 µF in series with the output, both under open-circuit (load greater than or equal to 10 k Ohm) and short-circuit conditions at the same set voltage.
- **If the 18 µF capacitor is implemented in the generator, no external 18 µF capacitor is required for calibration**



CDN Calibration Defined

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Selection of coupling/decoupling method

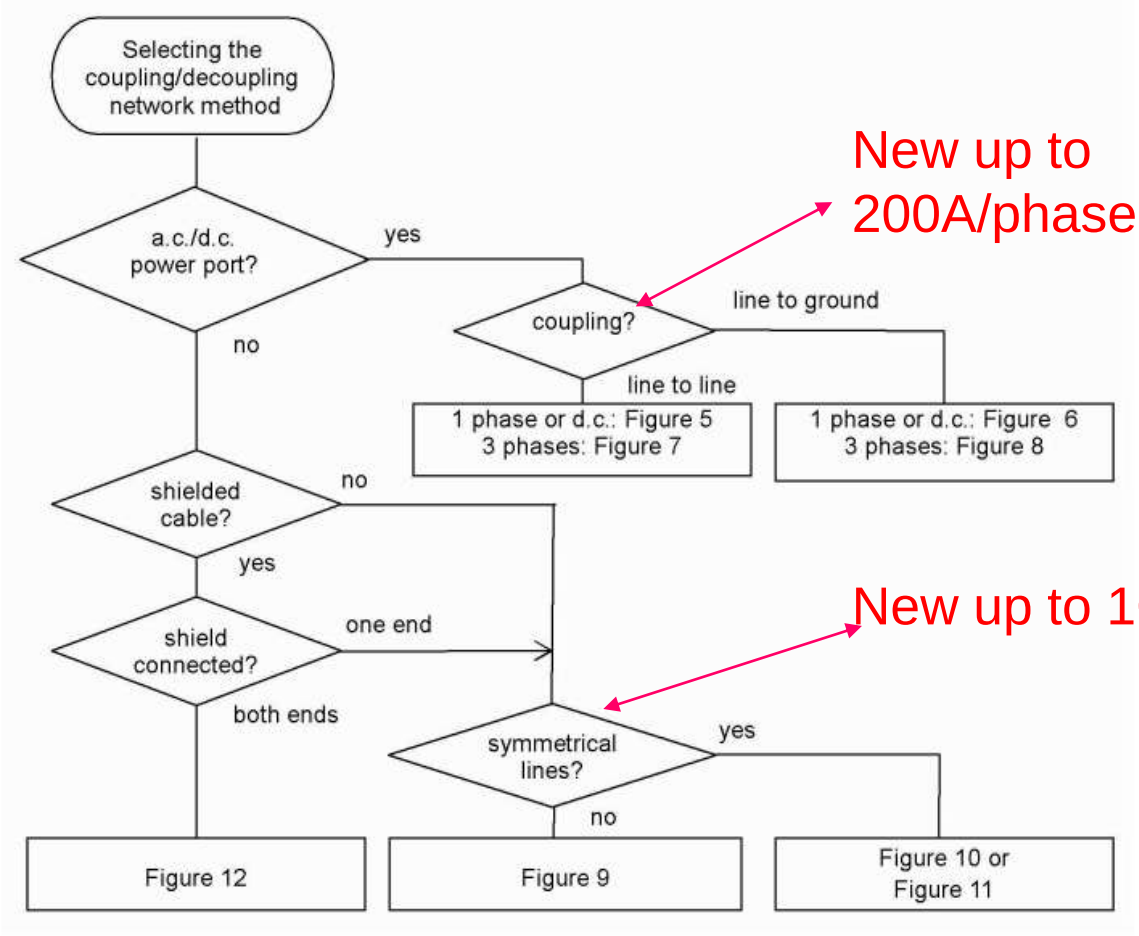


Figure 4: Selection of coupling/decoupling method

CDN Calibration Defined

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

CDN Power Rating Influence on Voltage Duration

6.3.2 Coupling/decoupling networks for a.c./d.c. power port rated up to 200 A per line

Surge voltage parameters under open-circuit conditions [a]	Coupling impedance	
	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

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

NOTE The current rating in Table 4 is the CDN rating.

CDN Calibration Defined

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

CDN Power Rating Influence on Dimensions

6.3.2 Coupling/decoupling networks for a.c./d.c. power port rated up to 200 A per line

I/O CDN Defined

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

CDN for Interconnection Lines

- 6.3.3.1 Introduction
  - This sub-clause describes the CDN for all types of interconnection lines except for unshielded outdoor symmetrical communication lines intended to interconnect to widely dispersed systems, which are described in Annex A.
    - The coupling method shall be selected as a function of interconnection cable types, the circuits, and the operational conditions supported by the product specification/standard.
    - Coupling to unshielded lines requires coupling devices (CD) that ensure sufficient insulation between the interconnection lines and the surge generator, but allow efficient transfer of the surge impulse.
    - Any CD, such as capacitors, Gas Discharge Tubes (GDT) capable of meeting the coupling and insulation functions may be used.
    - Coupling using capacitors maintains waveform integrity, but may have filtering effects on fast data transfer.
    - Avalanche devices like GDTs have a low parasitic capacitance and allow connection to most types of interconnection lines. The breakdown voltage of the coupling device shall be selected to be as low as possible, but higher than the maximum working voltage of the lines to be tested.

I/O Unsymmetrical CDN

IEC updates

IEC 61000-3-2

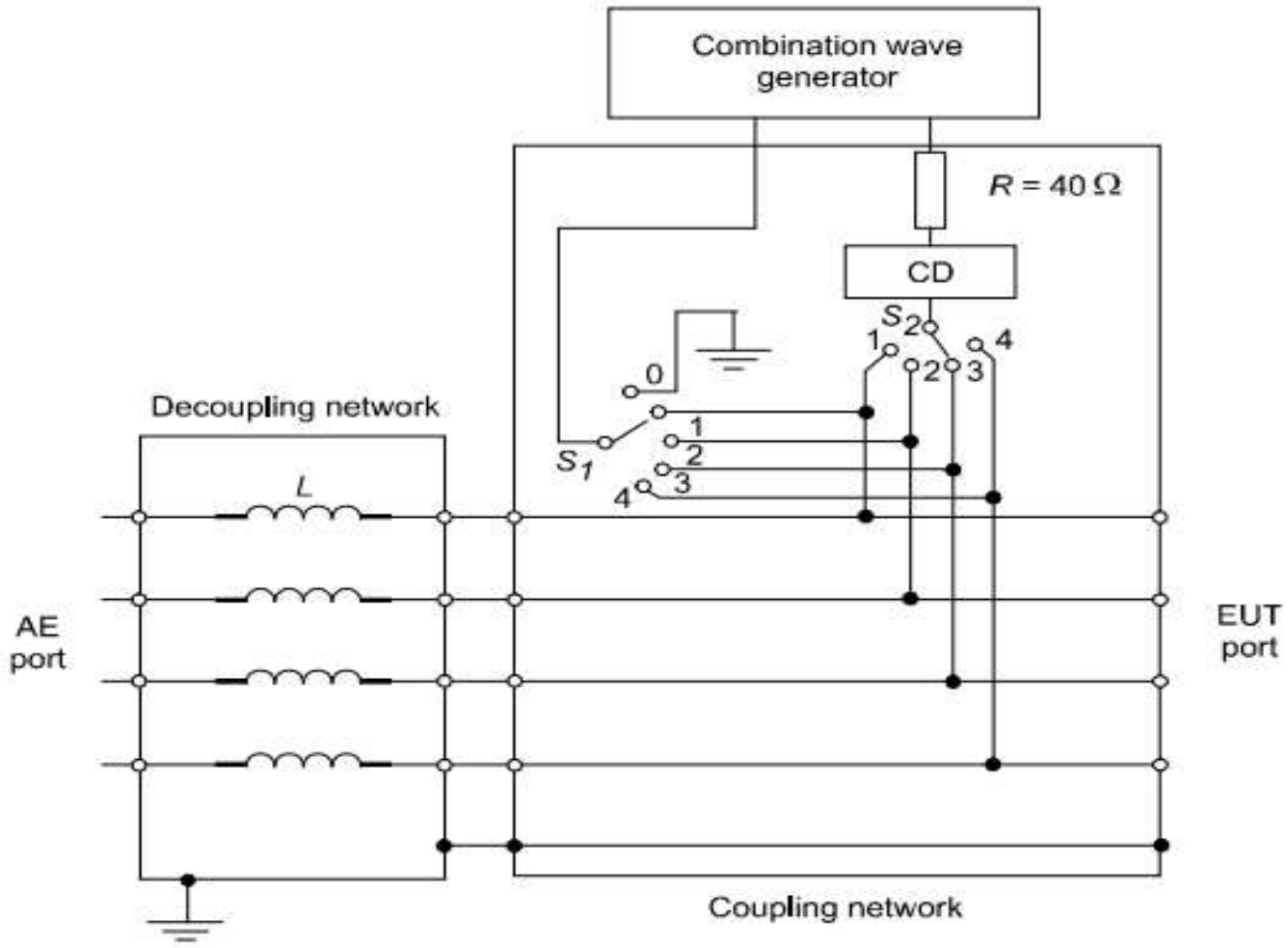
IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

CDN for Interconnection Lines, unsymmetrical operated



I/O Unsymmetrical CDN

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

Calibration values of different coupling method, unsymmetrical operated

Coupling method	CWG Output voltage [1,2,3]	Voc at CDN EUT output ± 10 %	Voltage Front time T_f $T_f = 1{,}67 \times T_r$ ± 30 %	Voltage Duration T_d $T_d = T_w$ ± 30 %	I_{sc} at CDN EUT output ± 20 %	Current Front Time T_f $T_f = 1{,}25 \times T_r$ ± 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.

I/O Unsymmetrical CDN

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

Port Condition during the Calibration

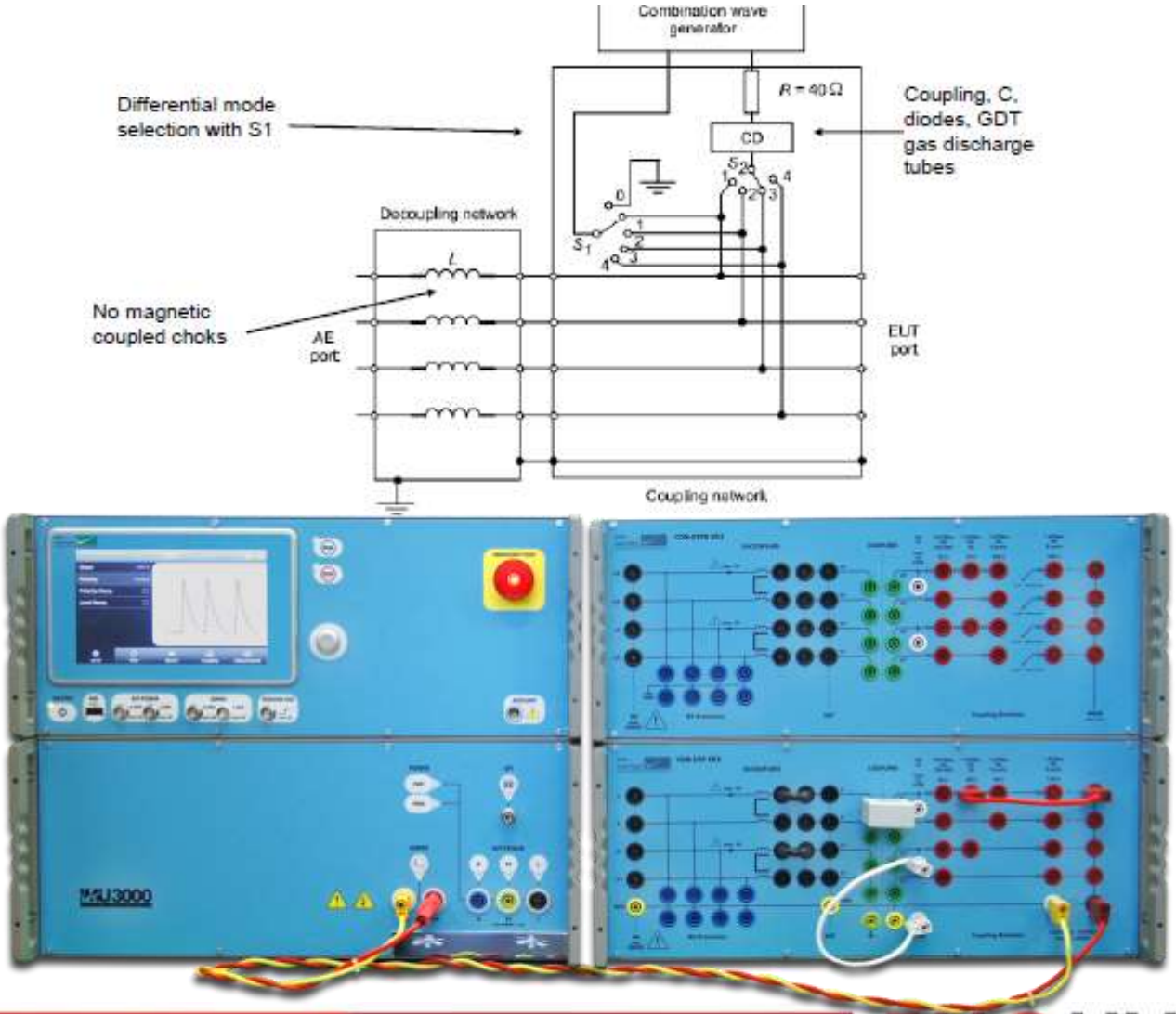
Table 7 – Summary of calibration process for CDNs for unsymmetrical interconnection lines

	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 elements)	Single line to PE	Line to PE at a time Peak voltage	Open-circuit	Open-circuit

I/O Unsymmetrical CDN

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

EMC PARTNER solution CDN-UTP8, unsymmetrical operated



I/O Symmetrical CDN

IEC updates

IEC 61000-3-2

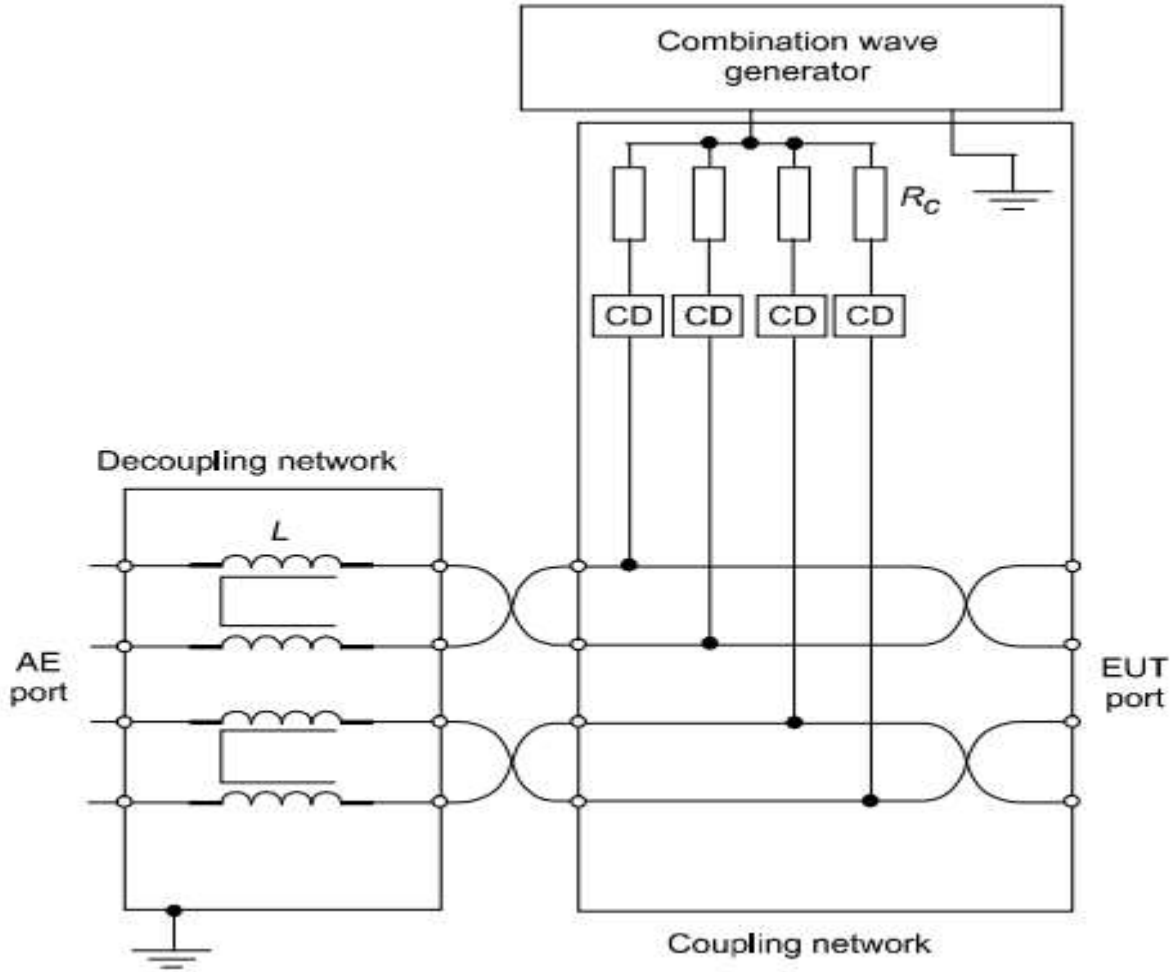
IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

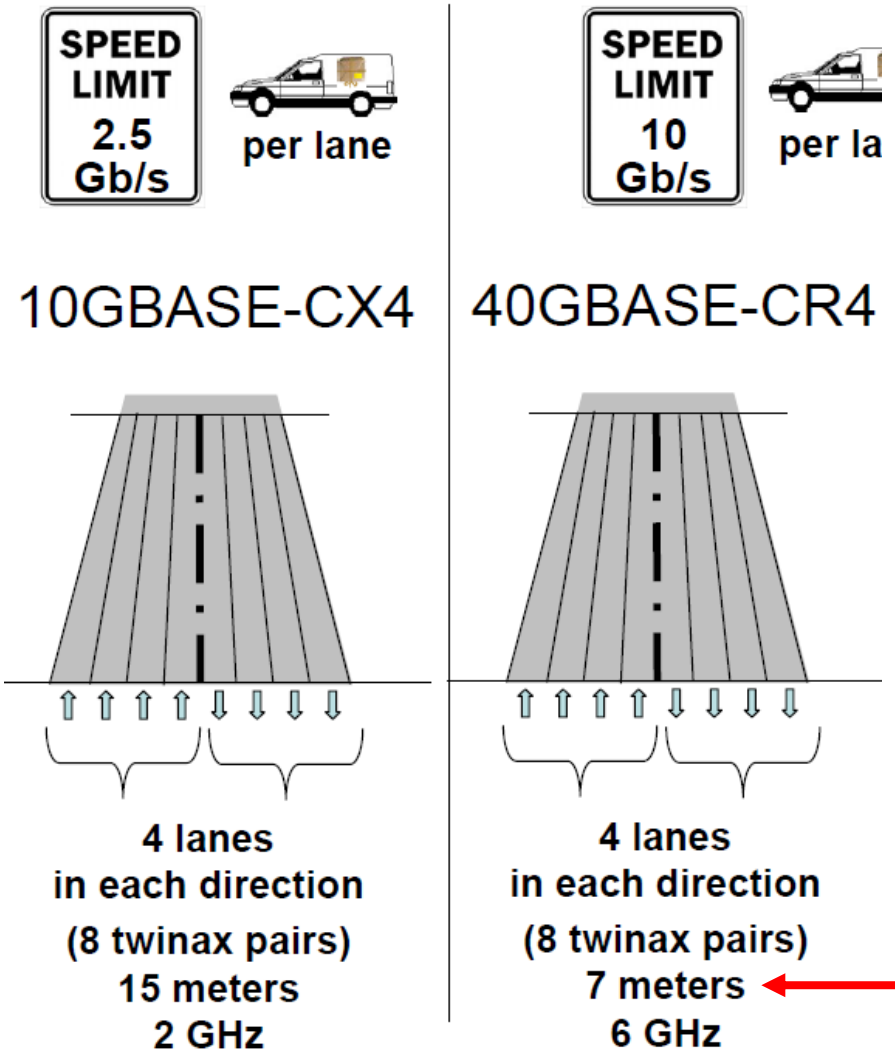
CDN for Interconnection Lines, symmetric operated 2 pairs



I/O Symmetrical CDN

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

CDN symmetric operated 4 pairs for 1Gb/s

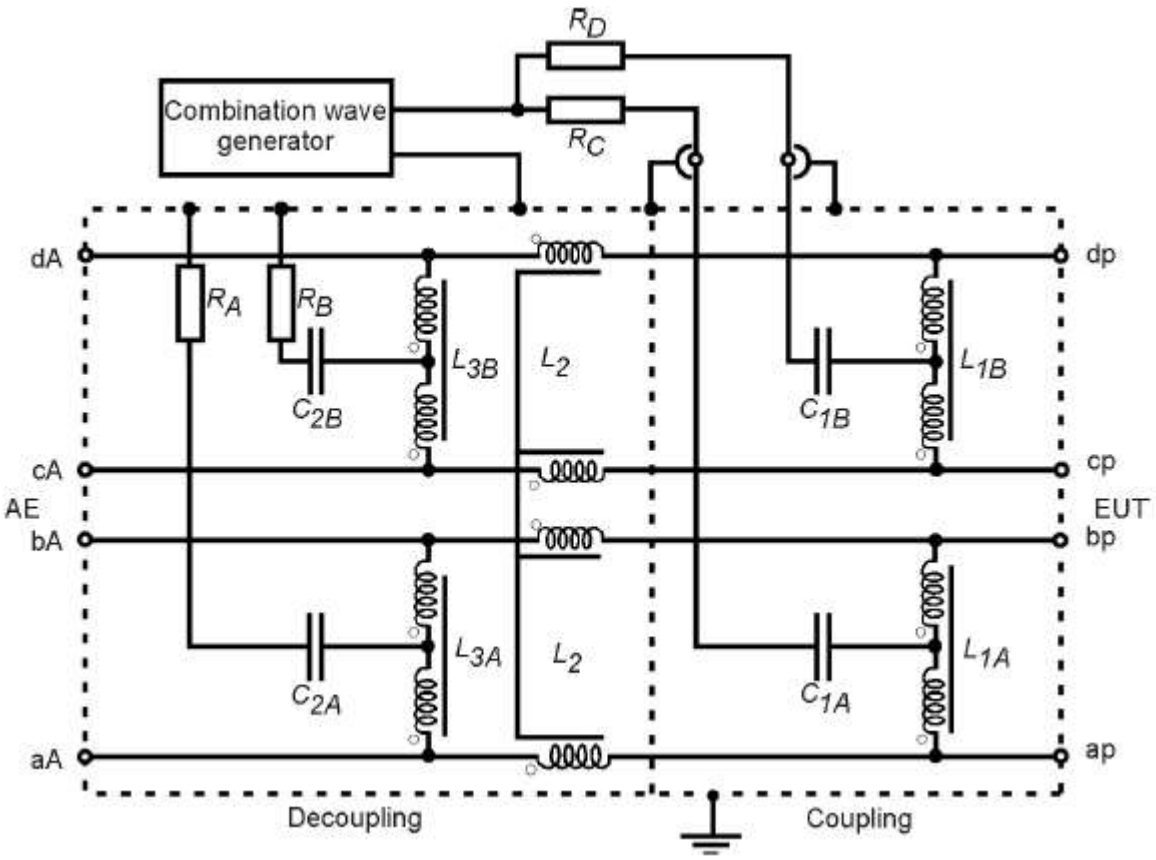


No Test cable shorter 10m is tested, no need to test

I/O Symmetrical CDN

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

NEW! CDN for Interconnection Lines
symmetric operated 2 pairs

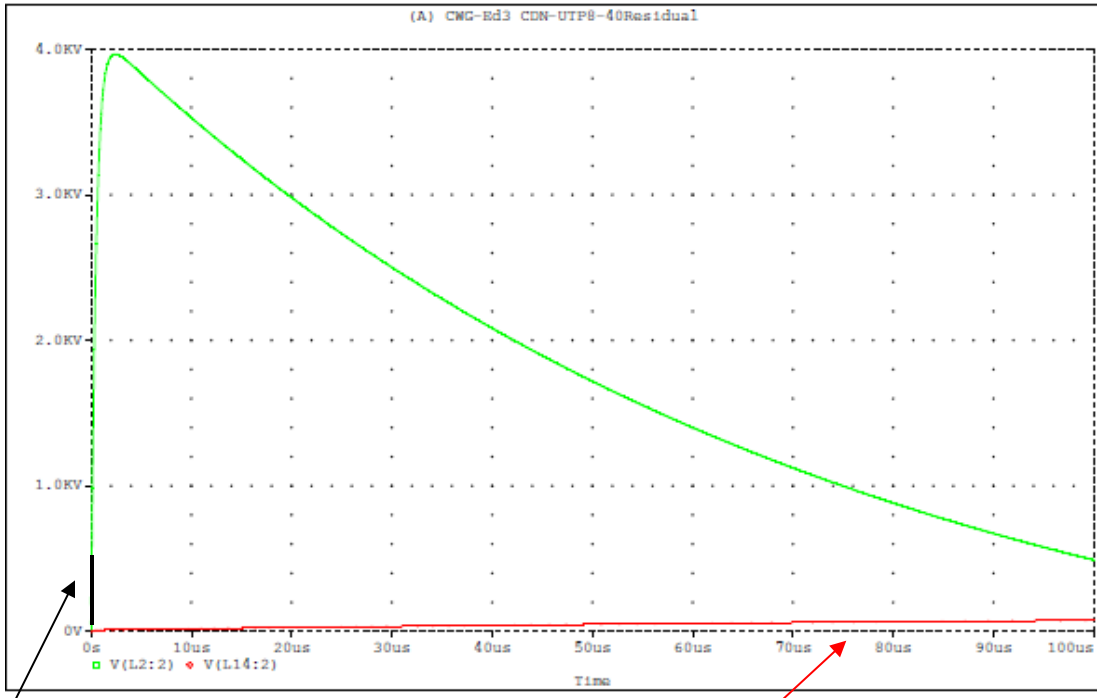


I/O Symmetrical CDN

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Residual Voltage on AE side

Residual voltage on AE side



Black curve residual voltage with GDT
Red curve residual voltage with linear circuit

I/O Symmetrical CDN

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

Calibration values of different coupling method, symmetrical operated

Table 10 – Surge waveform specifications at the EUT port of the CDN for symmetrical interconnection lines

Coupling method	CWG output voltage [a, b, c]	V_{oc} at CDN EUT output ± 10 %	Voltage front time T_f $T_f = 1{,}67 \times T_r$ ± 30 %	Voltage duration T_d $T_d = T_w$ ± 30 %	I_{sc} at CDN EUT output ± 20 %	Current front time T_f $T_f = 1{,}25 \times T_r$ ± 30 %	Current duration T_d $T_d = 1{,}18 \times T_w$ ± 30 %
Common mode CD [d], 40 Ω path	2 kV	2 kV	1,2 µs	45 µs	48 A	1,5 µs	45 µs

[a] It is recommended to calibrate the CDN at the highest rated impulse 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 2 kV. In case the CDN is rated for another maximum impulse voltage, the calibration shall be done at this maximum rated impulse voltage. The short-circuit peak current specification shall be adapted accordingly. For example, if the maximum voltage is 4 kV, the short-circuit current value shall be multiplied by 2.

[b] Coupling via gas arrestors, clamping or avalanche devices will show some switching noise on the impulse wave. Working with the highest possible impulse voltage will minimise their impact on measurements, however, it is recommended to neglect the switching noise for the peak values measurements.

[c] 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.

[d] The coupling device (CD) can be based upon capacitors, gas arrestors, clamping devices, avalanche devices or any method that allows the wanted data of the EUT to function correctly and at the same time meet the impulse waveform parameters of this table.

I/O Symmetrical CDN

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

Port Condition during the Calibration

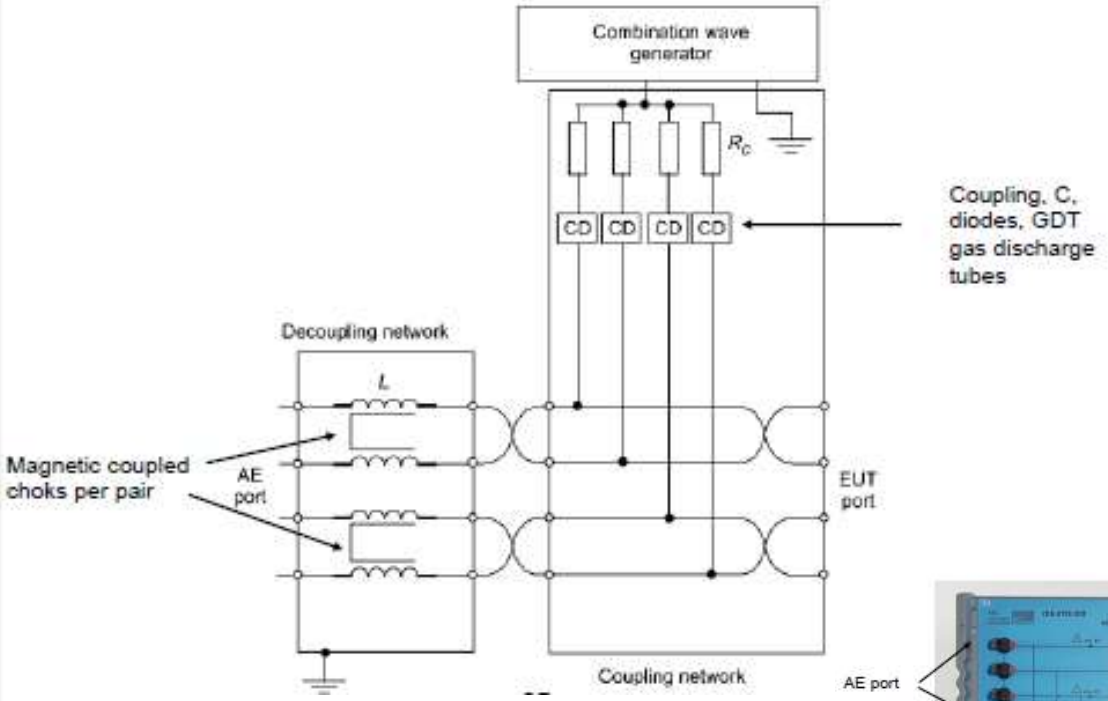
Table 9 – Summary of calibration process for CDNs for symmetrical interconnection lines

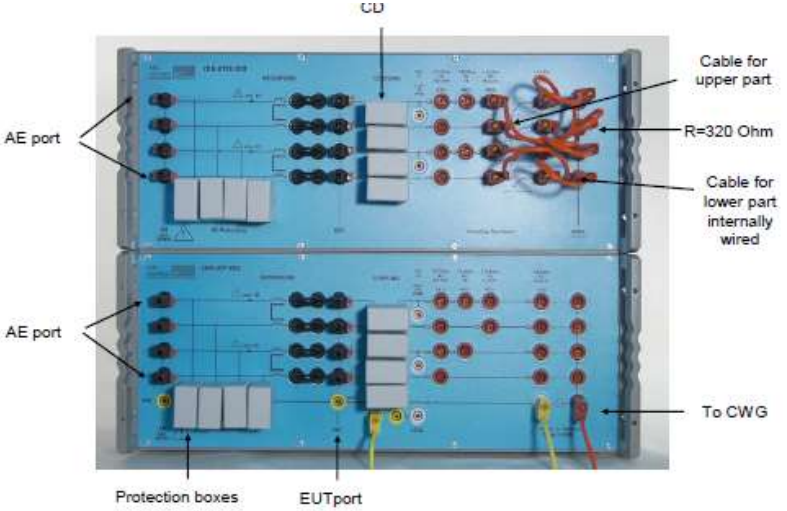
	Coupling	Measuring	AE side	EUT side
Surge voltage at EUT side	Common mode – all lines to PE *) 40 Ω path	All lines shorted together Peak voltage, front time, duration	All lines shorted to PE	Open circuit – all lines connect together
Surge current at EUT side	Common mode – all lines to PE *) 40 Ω path	All lines shorted together Peak current, front time, duration	All lines shorted to PE	All lines shorted to PE
Residual voltage on AE side (with protection elements)	Common mode – all lines to PE *) 40 Ω path	Each line to PE in turn 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.				

I/O Symmetrical CDN

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

EMC PARTNER solution CDN-UTP8, symmetrical operated

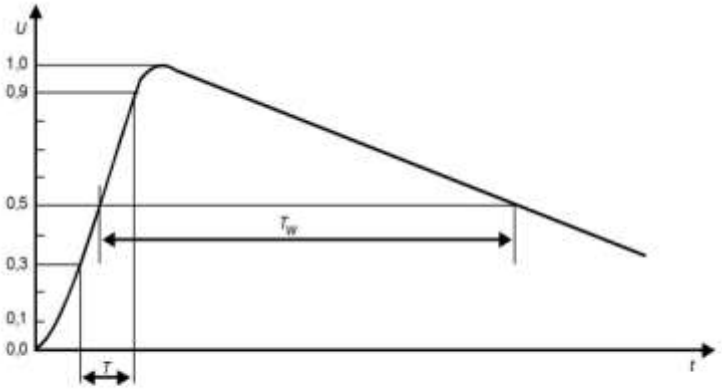




10/700 pulse

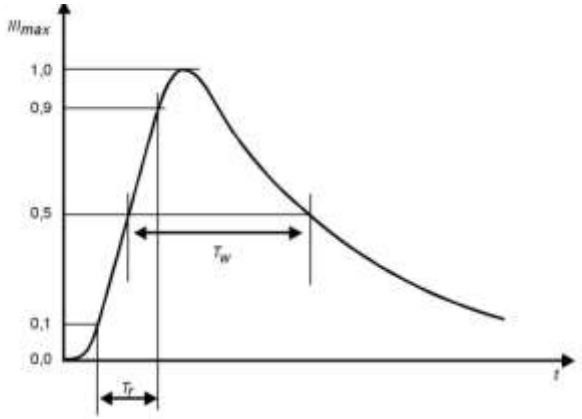
- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Annex A 10/700µs Waveform Definition



Front time: $T_f = 1{,}67 \times T = 10\ \mu s \pm 30\ \%$
Duration: $T_d = T_W = 700\ \mu s \pm 20\ \%$

Figure A.2 – Waveform of open-circuit voltage (10/700 µs)



Front time: $T_r = 1{,}25 \times T_r = 5\ \mu s \pm 20\ \%$
Duration: $T_d = T_W = 320\ \mu s \pm 20\ \%$

Figure A.3 – Waveform of the 5/320 µs short-circuit current waveform

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

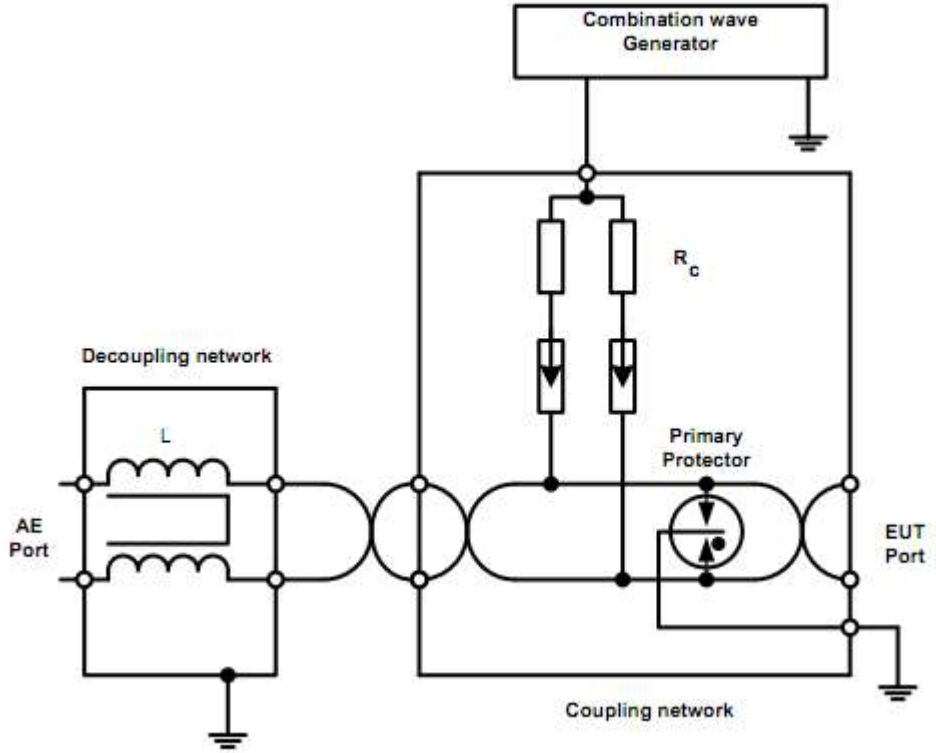
	Front time µs	Duration µs
Open-circuit voltage	10 ± 30 %	700 ± 20 %
Short-circuit current	5 ± 20 %	320 ± 20 %

Outdoor Comm lines CDN

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

CDN for Outdoor Communication Lines

A.3.2 Coupling/decoupling networks for outdoor communication lines



Outdoor Comm lines CDN

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Port Condition during the Calibration and Calibration Values

Table A.3 – Summary of calibration process for CDNs for unshielded outdoor symmetrical communication lines

	Coupling	Measuring	AE side	EUT side
Surge voltage at EUT side	Common mode – one pair to PE	Both lines from one pair shorted together: Peak voltage, front time, duration	All used lines shorted to PE	Open circuit, both lines from one pair connected together
Surge current at EUT side	Common mode – one pair to PE	Both lines from one pair shorted together: Peak current, front time, duration	All used lines shorted to PE	Both lines from one pair shorted to PE
Residual voltage on AE side (with protection elements)	Common mode – one pair to PE	Both lines from one pair shorted together: Peak voltage	Open circuit	Open circuit

he intention of this calibration process is to check the proper function of the components, the saturation f decoupling chokes, the decoupling effect of the DN part, the current capability and the coupling effect f the CN part. The coupling method described in the above paragraphs has an influence on the voltage nd current wave forms. The parameters for the calibration are defined in the Table A.4.

Table A.4 – Surge waveform specifications at the EUT port of the CDN for unshielded outdoor symmetrical communication lines

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 1 pair 27,5 Ω	4 kV	4 kV	8 µs	250 µs	145 A	3,2 µs	250 µs

[1]) For CDN with more than one pair, each pair has to be calibrated separately , as described in the table A.3.

[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 minimize 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.

Measurment Uncertainty

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

•IEC/TR 61000-1-6:2012, "Electromagnetic Compatibility (EMC) – Part 1-6: General – Guide to the assessment of measurement uncertainty" F1

Pulse shape	relevant frequency-range	centre frequency f_0
ESD 61000-4-2:2008	0 Hz – 4 GHz	≈ 100 MHz
Burst pulse 61000-4-4:2004	0 Hz - 1 GHz	≈ 15 MHz
Surge voltage and current 61000-4-5:2005	0 Hz - 5 MHz	≈ 15 kHz for 6.4 µs pulses ≈ 100 kHz for 1 µs pulses

F.3.2 Application of uncertainties in the surge generator compliance criterion

Generally, in order to be sure the generator is within its specifications, the calibration results should be within the specified limits of this standard (tolerances are not reduced by MU).

F.5 Application of uncertainties in the surge generator compliance criterion
Generally, in order to be sure the generator is within its specification, the calibration results should be within the specified limits of this standard (tolerances are not reduced by MU). Further guidance is given in clause 6 of [F1].

MATHEMATICAL FORMULA

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Annex E Mathematical modeling of surge waveforms

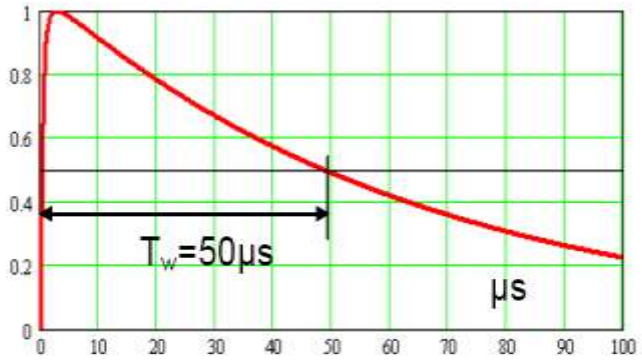


Figure E. 1: Voltage surge (1,2/50µs): Late time response

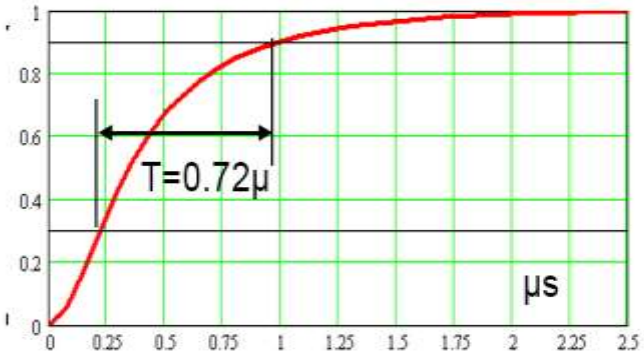


Figure E. 2: Voltage surge (1,2/50µs): Early time response

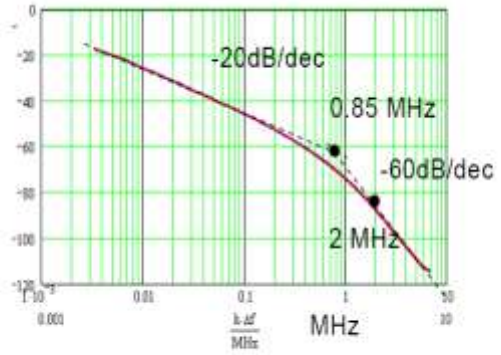


Figure E. 3: Voltage surge (1,2/50µs): Spectral response with Δf = 3,333 kHz

>200Amp coupling

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

Coupling/decoupling surges to lines rated above 200 A

To test high current EUTs for which no commercial CDNs are available, the following setup can be used:

- The coupling network as shown in Figures 7 and 8 shall be used.
- The decoupling network may consist of single chokes or a long enough supply cable to provide sufficient inductance; assuming that a straight 1 m length of wire represents about 1 µH. The recommended inductance values are given in table H.1. A single choke or wire should be used per line in order to ensure proper differential mode decoupling.

Decoupling elements like capacitors or MOVs or combinations of both may not be necessary in the decoupling network.

Table H. 1 – Recommended inductance values for decoupling lines (> 200 A)

EUT rated current	Recommended decoupling inductance
200 A < Current rating ≤ 400 A	200 to 100 µH
400 A < Current rating ≤ 800 A	100 to 50 µH
800 A < Current rating ≤ 1600 A	50 to 25 µH
N [Ampere] < Current rating ≤ 2 x N	Inductance reduces by a factor of 2

H.3 Additional precautions

When testing on 3-phase power systems, where the EUT has a rated voltage of more than 415 V per phase, the supply voltage may damage the surge generator.

IEC 61000-4-19

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

IEC 61000-4-19

Edition 1.0 2014-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-19: Testing and measurement techniques – Test for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports

IEC 61000-4-19

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

TC77A WG6 Differential Mode Coupling in the Frequency Range 2 to 150kHzIEC 61000-4-19

- Actual problems in the range of 2 to 150kHz
- Disturbance Sources
- Influenced products
- Standard gap in this range
- Needed a New Standard
- Content of the new standard
- The solution

Why is there a need?

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Energy in the 21st Century

Energy Usage is growing 25% per year

- More electrical goods
- Increasing number of Computers

-Can be solved by implementation of smart grid and:

Why is there a need?

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

Smart Grid – New Technology

Installing new Energy sources:
- Solar installation
- Wind mills
- Geothermic
- Etc.

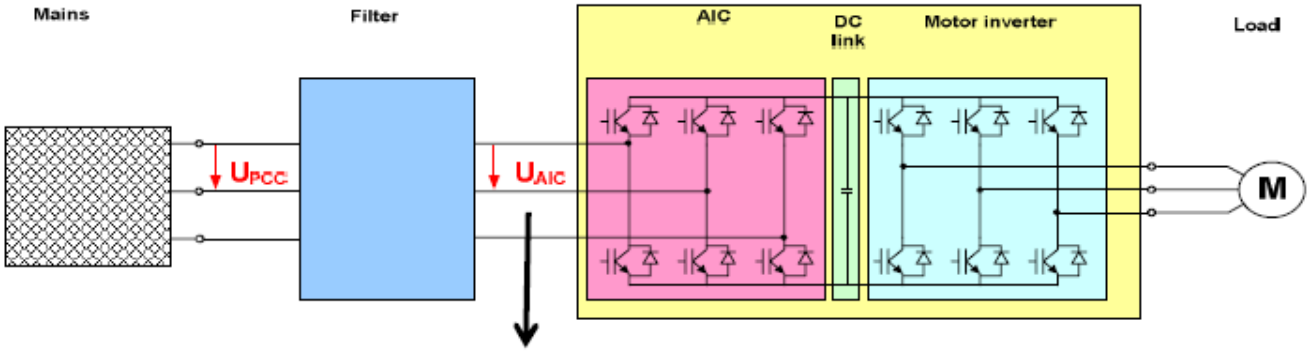
Energy saving with power electronic 30%:
- Variable speed drive
- Regenerative breaking (trains, elevators, conveyor system, cranes, etc.
- Switched mode power supplies

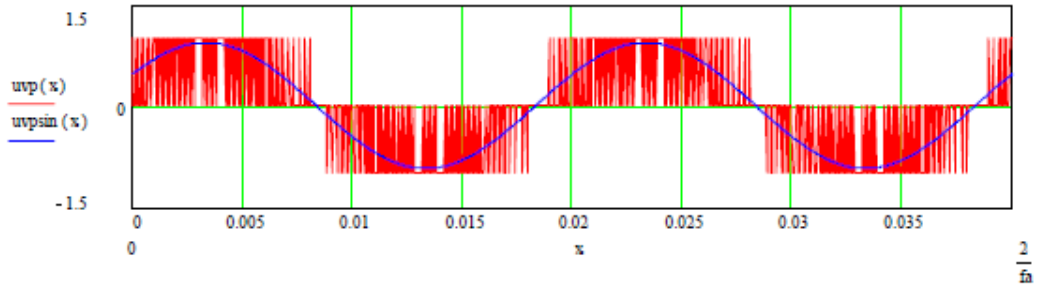
Why is there a need?

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Smart Grid – New Technology

Example: Variable Speed Drives





U_{AIC} is a pulsed voltage with a 50Hz fundamental in it

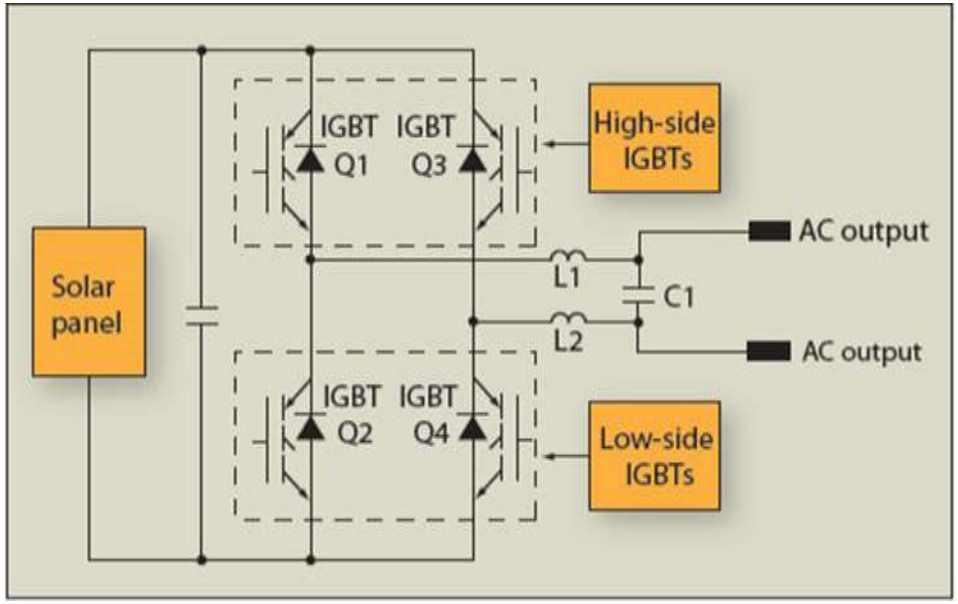
It is the target of the filter to reduce the HF components to the grid

Current Flow →

Why is there a need?

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Example: Power Inverters



Why is there a need?

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

TC77A WG6 Differential Mode Coupling in the Frequency Range 2 to 150kHzIEC 61000-4-19

EMI sources & victims

See Study Report II, 205A/Sec0339/R

see also Draft IEC 61000-4-19, 205A/Sec0260/R:2010)

Sources:

- Lighting equipment (Energy saving lamps, Fluorescent lamps, LEDs)
- Inverters / Power drives (household / commercial / industrial equipment)
- Power supplies (consumer electronics, IT equipment, telco systems, UPS)
- ELB, Circuit breaker operation
- Household equipment (e.g. induction cooking hobs, washing machines)
- MCS

Victims:

- Lighting / lighting control systems
- Control circuits, e.g. heat control (disturbed DCF77)
- Remote control
- Magnetic card reader
- Traffic control system
- Solid state electricity meters
- Radio clocks / standard time-signal system
- Medical equipment
- MCS

Why is there a need?

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

TC77A WG6 Differential Mode Coupling in the Frequency Range 2 to 150kHzIEC 61000-4-19

Wrong metering values

Disturbance to smart meters, displaying wrong metering values

Malfunction of controls

Heating system, remote control, traffic control systems, lighting systems, household equipment)

Malfunction of standard time-signal systems

Disturbance to reception of time information, Malfunction of control circuits, e.g. of a heating system,Radio clocks being fast

Magnetic card-readers

malfunction Temporary loss of function

IT components

malfunction of modems, routers

Loss of communication

(Temporary) Loss of communication in MCS / AMR-PLC systems (some tens to some hundreds/substation (up to 92%))

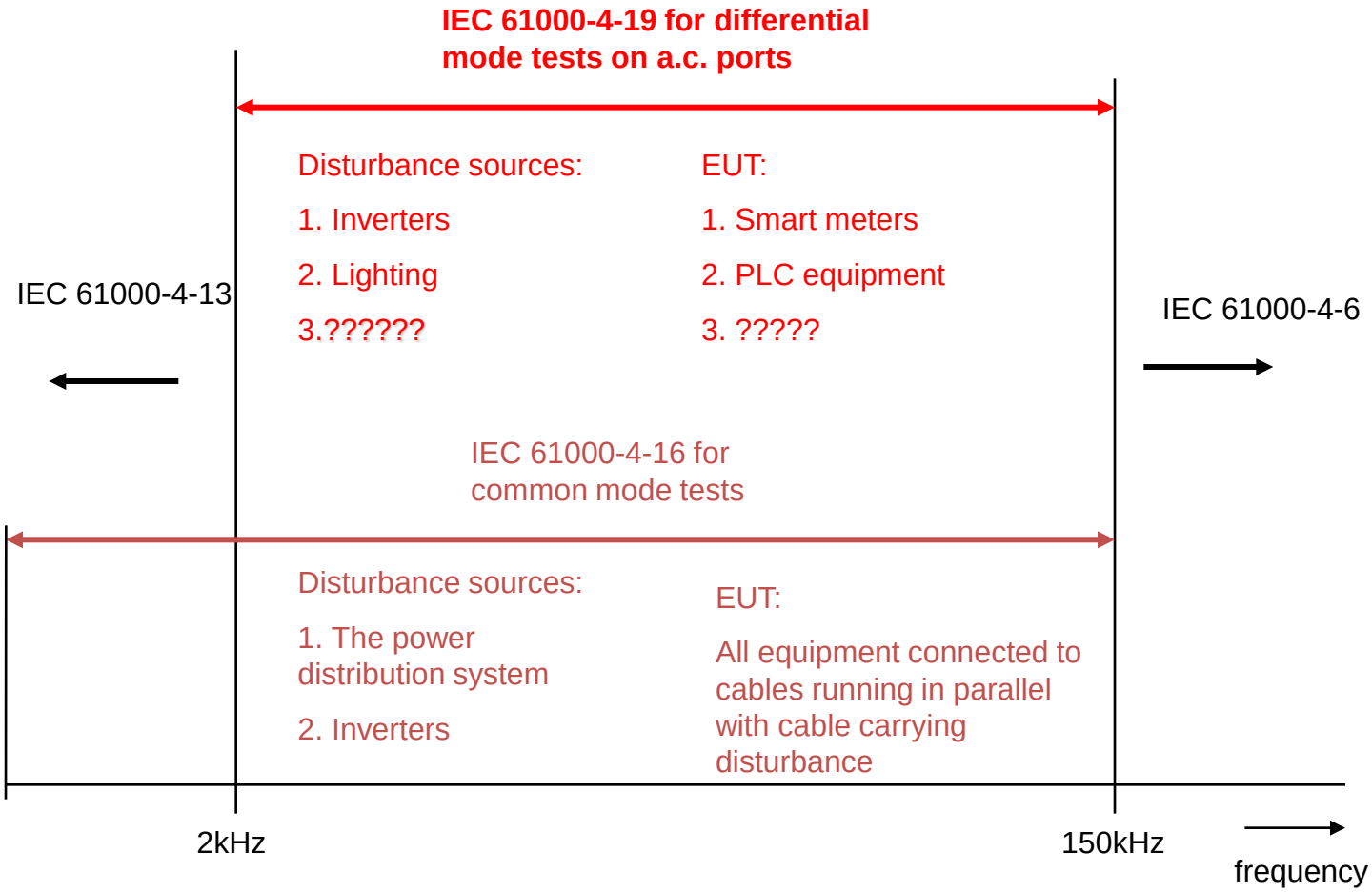
Gap in the standards

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

Standard Overview in the Frequency Range up to 150kHz

Missing Standards in the frequency range 2kHz to 150kHz:

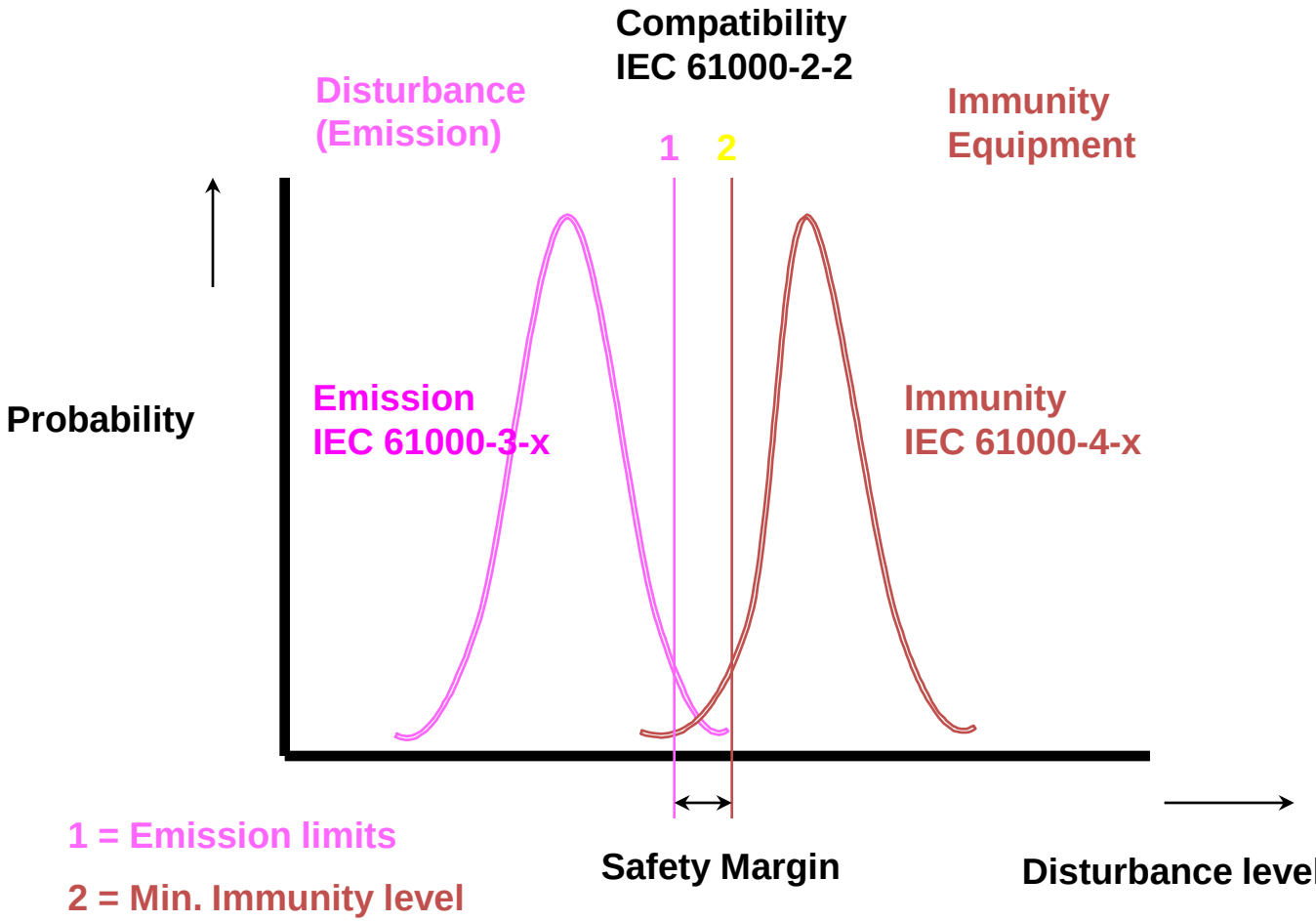
Compatibility IEC 61000-2-?, Emission IEC 61000-3-?, Immunity IEC 61000-4-19



Creating a Standard

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

The Standard are necessary to reach Compatibility



Creating a Standard

Content of Basic Standard

- The content of the basic standard:
  - Definition and description of one phenomenon
  - Test and measurement methods specification
  - Test instrumentation
  - Basic test set up
  - Range of test levels
  - MU for the calibration measurement equipment (partly)

  - Basic standards are modules for generic or product standards

- Not included
  - Prescribed limits
  - Performance criteria for a specific product
  - Product specific test arrangements
  - Test sequences

Creating a Standard

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

General Test Procedure in accordance with Basic Standards

- Calibrate the generator in accordance with the calibration procedure defined in Basic standard
  - Generator must pass calibration
  - Goal: reproducible test results, test time as short as possible, no discussion about influence of the EUT onto the waveforms, amplitude, rise fall time, etc .
- Connect the EUT to the calibrated generator as a black box. No additional measurement of waveform required.
- Carry out the EMC test

Its out

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

IEC 61000-4-19

Edition 1.0 2014-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

BASIC EMC PUBLICATION

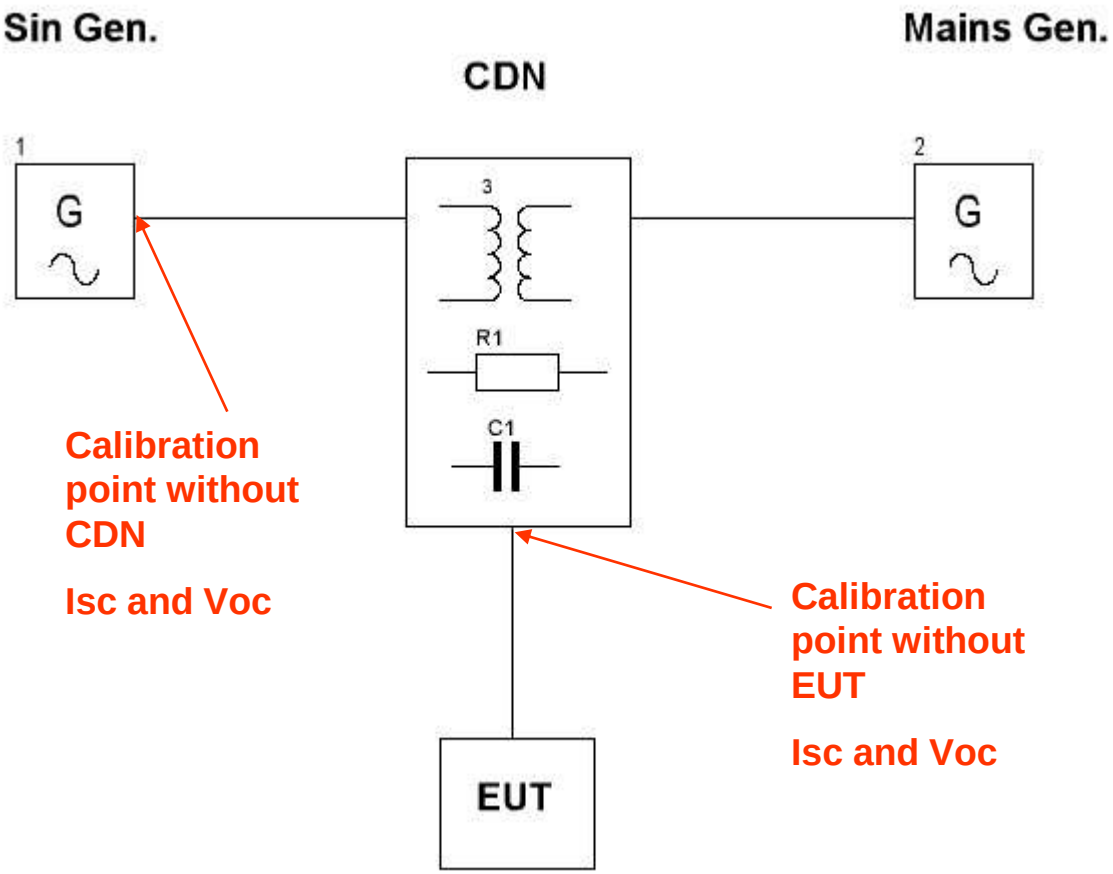
PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-19: Testing and measurement techniques – Test for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports

Requirements

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Example Test equipment



Requirements

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

General Information: IEC 61000-4-19

➢Emissions in the frequency range 2 kHz - 150 kHz often have both differential mode and common mode components. This standard provides immunity tests only for differential mode disturbances and signaling. It is recommended to perform common mode tests as well, which are covered by IEC 61000-4-16.

➢To verify such immunity, two tests for voltage and current are defined in this standard, both in the frequency range from 2 kHz to 150 kHz:

- ➢• a sweep test performed with CW (continuous wave) pulses with pauses between each pulse;
- ➢• a test performed with blocks of rectangular modulated pulses with four different modulation frequencies.

➢Typically, voltage tests apply to all PLC equipment, while current tests are intended for equipment with an a.c. current measurement port, such as an electricity meter.

Levels

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Test Levels: voltage, current IEC 61000-4-19

Level	Open circuit unmodulated test voltage V (r.m.s.)		
	2 kHz-9 kHz	9 kHz-95 kHz	95 kHz-150 kHz
1	0,5	0,5—0,1	0,1
2	3	3—0,6	0,6
3	12	12—2,4	2,4
4	20	20—10	10
X[a]	Special	Special	Special

[a] "X" can be any level, above, below or in between the others. The level shall be specified by product standard.

Table 2 – Test levels in the 2-150 kHz frequency range for differential current testing

Level	Unmodulated current in A (r.m.s.)	
	2 kHz—30 kHz	30 kHz—150 kHz
1	1	0,5
2	2	1
3	3	1,5
4	4	2
X	Special	Special

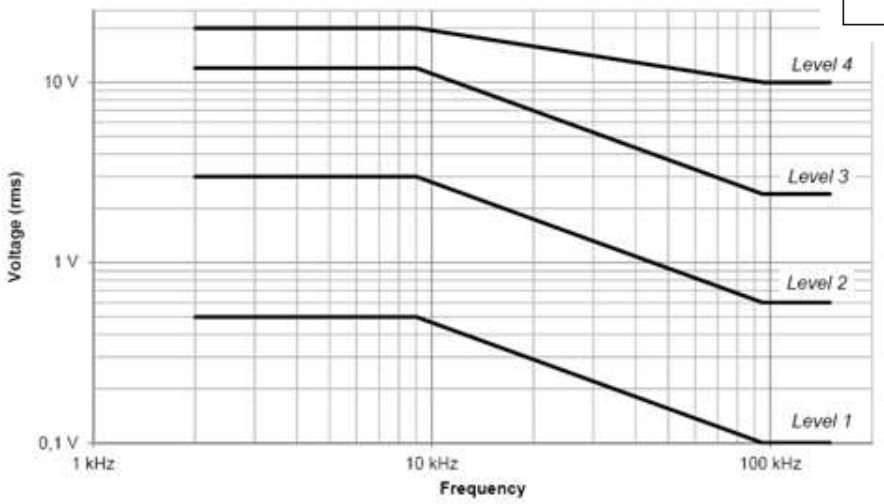


Figure 1 – Frequency vs. amplitude profile for differential voltage testing

Levels

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Test Wave Profile Pause and Modulated IEC 61000-4-19

5.1.1 Test wave profile with CW pulses with pauseVoltage

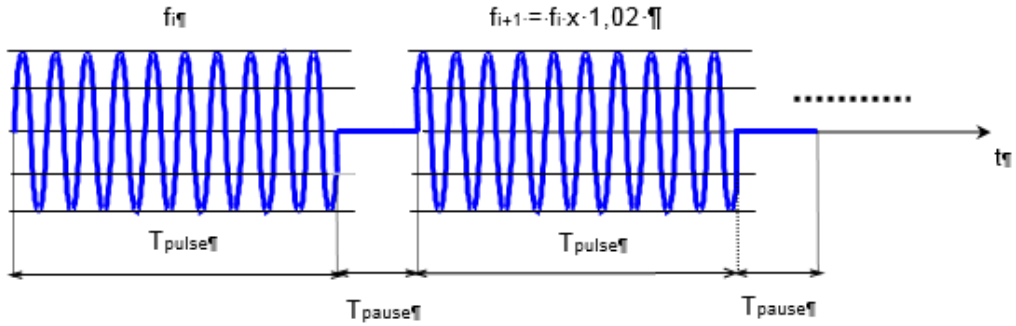


Figure 2 — Test wave profile with CW pulses with pause

5.1.2 Test wave profile with rectangular modulated pulses

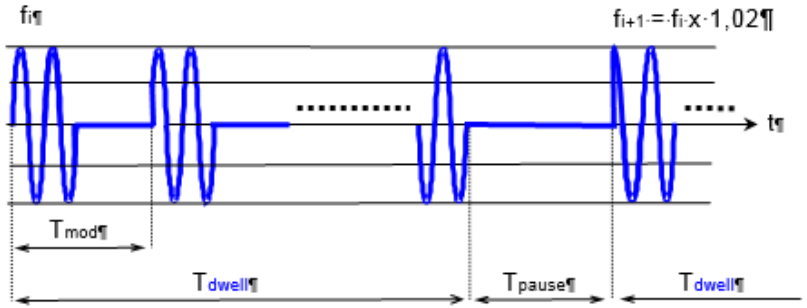


Figure 3 — Test wave profile with rectangularly modulated pulses for differential voltage testing

Calibration

Calibration of the Generators

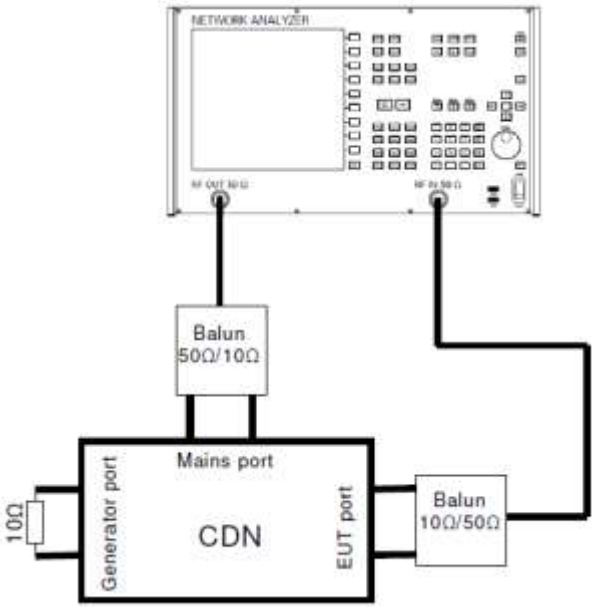
- The verification of the generators shall be carried out in open circuit for the differential voltage generator with a differential probe of minimum 1 MΩ and in short circuit for the differential current generator with a shunt of maximum 0,01 Ω using an oscilloscope or other equivalent measurement instrumentation with 10 MHz minimum bandwidth.
  - For differential voltage verification, the open circuit voltage at the EUT port of the CDN shall be measured with the voltage differential probe.
  - For differential current verification, the short circuit current at the EUT port shall be measured using the shunt.
  - The impedance shall be verified measuring the values of the open circuit voltage divided by the short circuit output current at 2 kHz and 150 kHz.

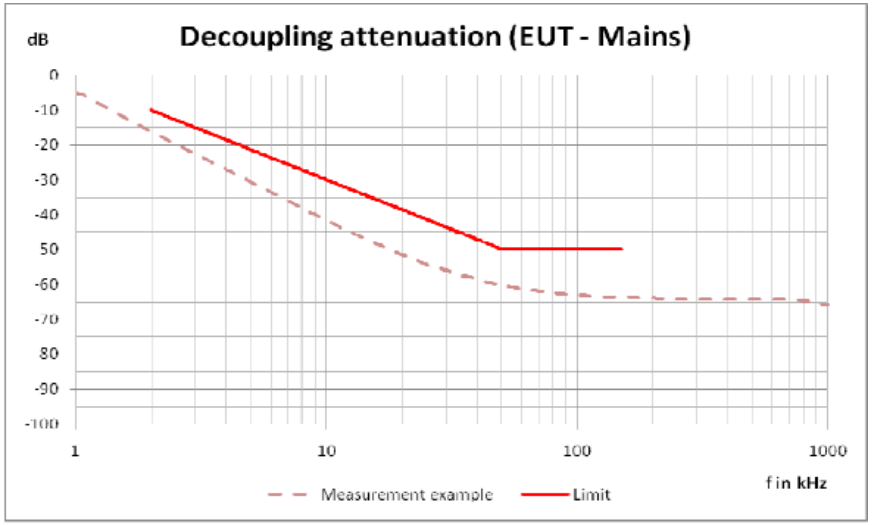
Calibration

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

Calibration of the CDN

- The damping characteristics (mains to EUT) of the CDN shown in Figure 4 shall be verified in a 10 Ω measurement system using impedance matching baluns and a network analyser. The generator port should be terminated by 10 Ω or by the generator having 10 Ω output impedance.

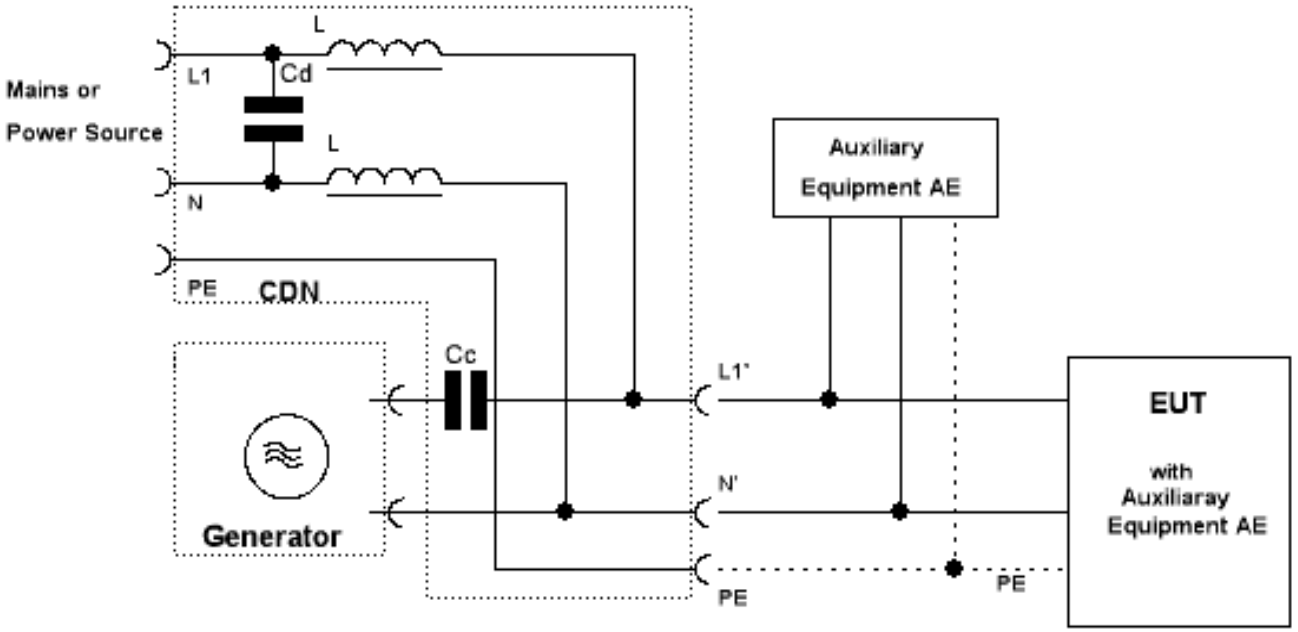




Setup Voltage

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Test set up Voltage Test



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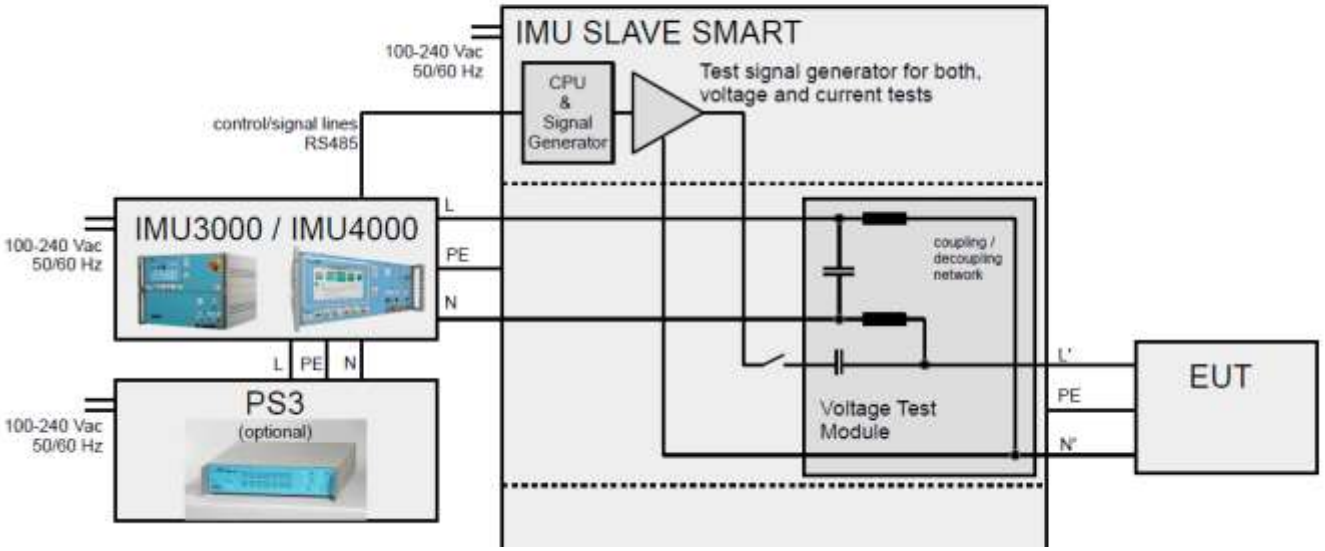
Setup Voltage

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

IMU SLAVE SMART – voltage test block diagram



Setup Current

IEC updates

IEC 61000-3-2

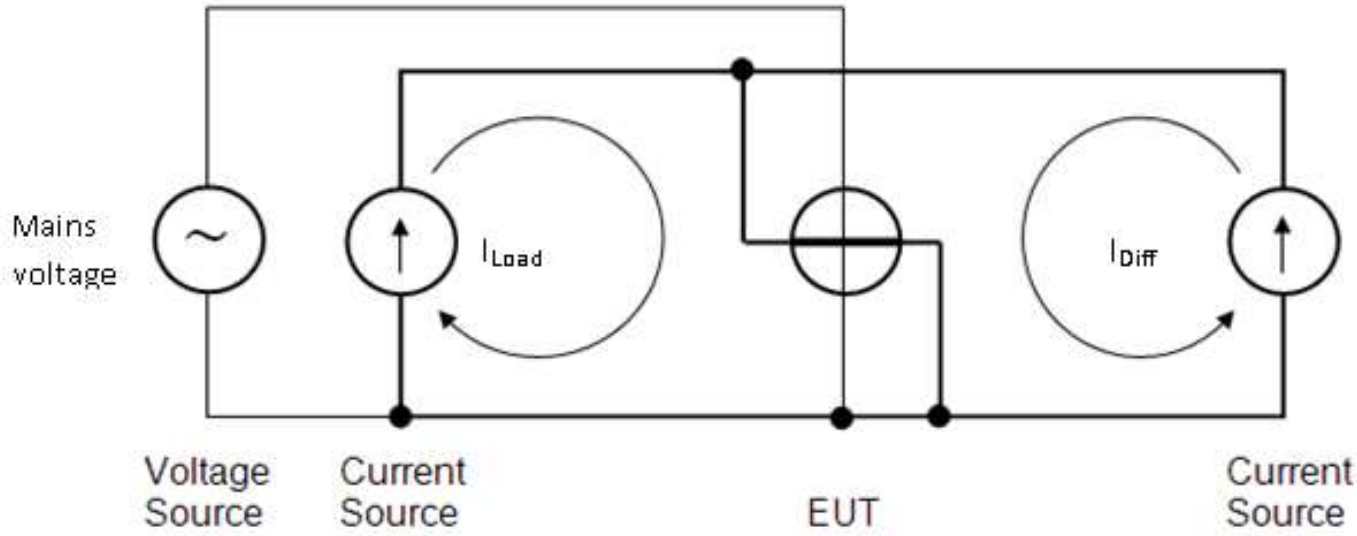
IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

Test set up Current Test



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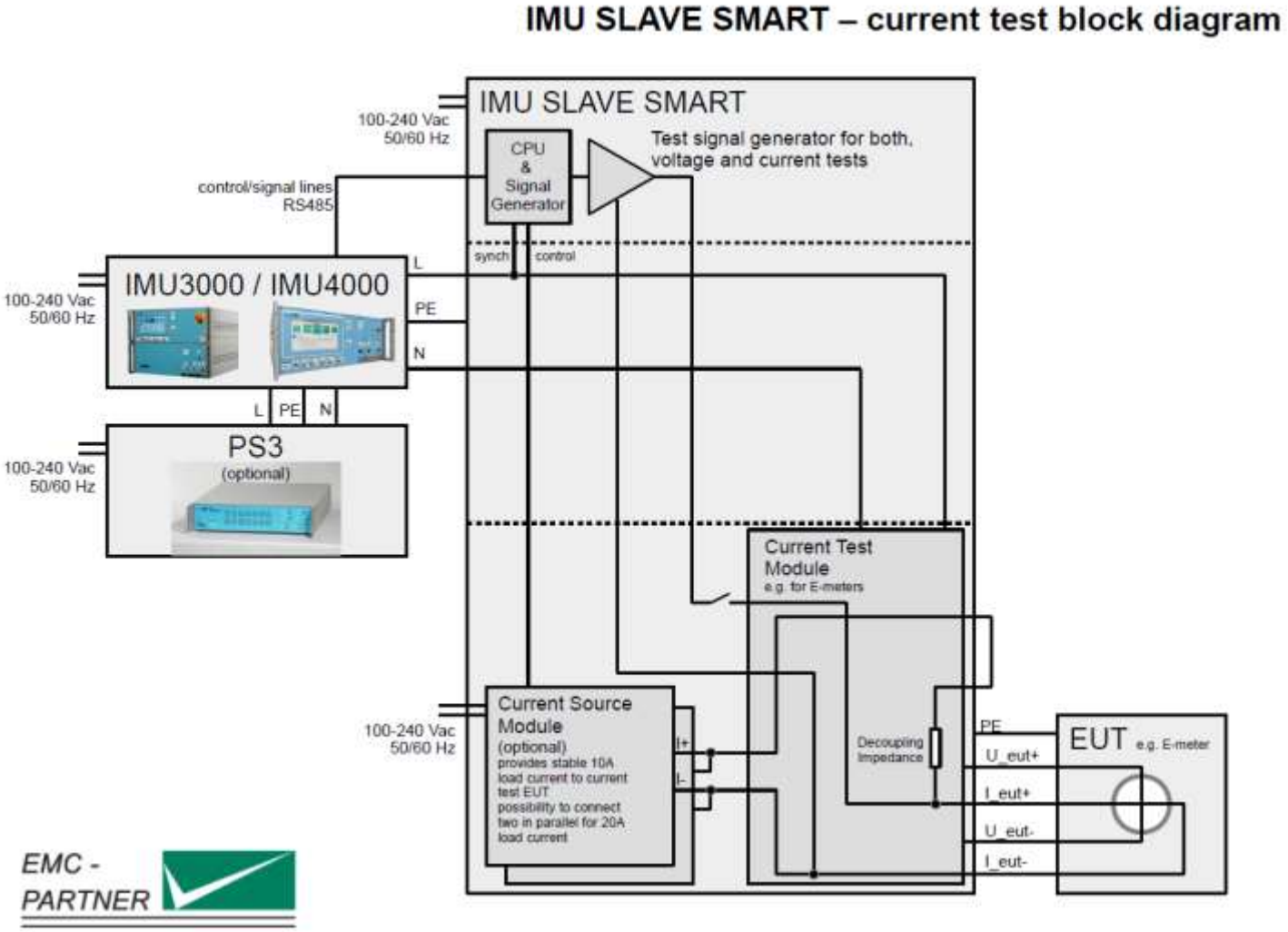
Figure·8·—·Test·set·up·for·differential·current·testing·¶

Setup Current

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G



MIL-STD-461 Power & I/O

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

MIL-STD-461F

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

- Superseding
  - MIL-STD-461E (1999)
    - Test Methods and Limits
  - MIL-STD-461D (1993)
    - Test Limits
  - MIL-STD-462D (1993)
    - Test Methods

Current Requirements

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

MIL-STD-461G

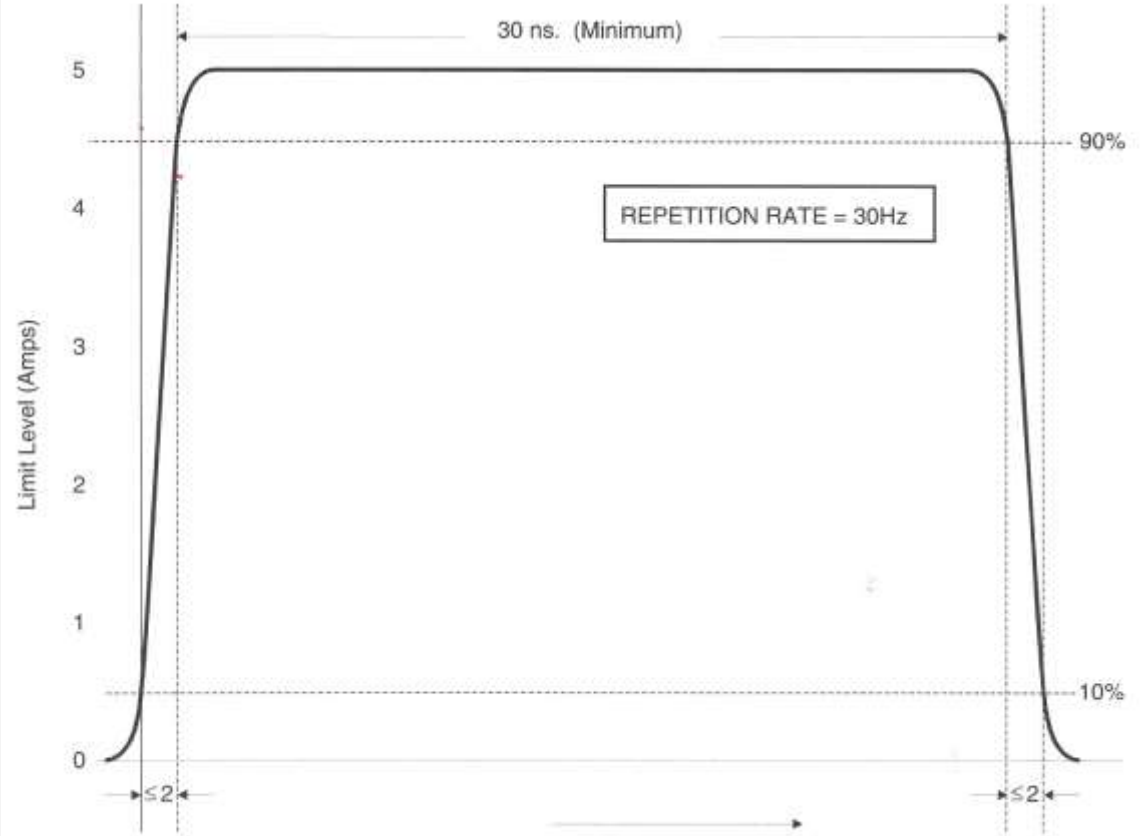
Requirement	Description
CE101	Conducted Emissions, Power Leads, 30 Hz to 10 kHz
CE102	Conducted Emissions, Power Leads, 10 kHz to 10 MHz
CE106	Conducted Emissions, Antenna Terminal, 10 kHz to 40 GHz
CS101	Conducted Susceptibility, Power Leads, 30 Hz to 150 kHz
CS103	Conducted Susceptibility, Antenna Port, Intermodulation, 15 kHz to 10 GHz
CS104	Conducted Susceptibility, Antenna Port, Rejection of Undesired Signals, 30 Hz to 20 GHz
CS105	Conducted Susceptibility, Antenna Port, Cross-Modulation, 30 Hz to 20 GHz
CS106	Conducted Susceptibility, Transients, Power Leads
CS109	Conducted Susceptibility, Structure Current, 60 Hz to 100 kHz
CS114	Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 200 MHz
CS115	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation
CS116	Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads, 10 kHz to 100 MHz
RE101	Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz
RE103	Radiated Emissions, Antenna Spurious and Harmonic Outputs, 10 kHz to 40 GHz
RS101	Radiated Susceptibility, Magnetic Field, 30 Hz to 100 kHz
RS103	Radiated Susceptibility, Electric Field, 2 MHz to 40 GHz
RS105	Radiated Susceptibility, Transient Electromagnetic Field

CS115

- Unique to MIL-STD-461
- Replaces RS06 „chattering relay“ test in MIL-STD-461C
- Excites natural resonances in EUT cabling
- Waveform defined at system interface

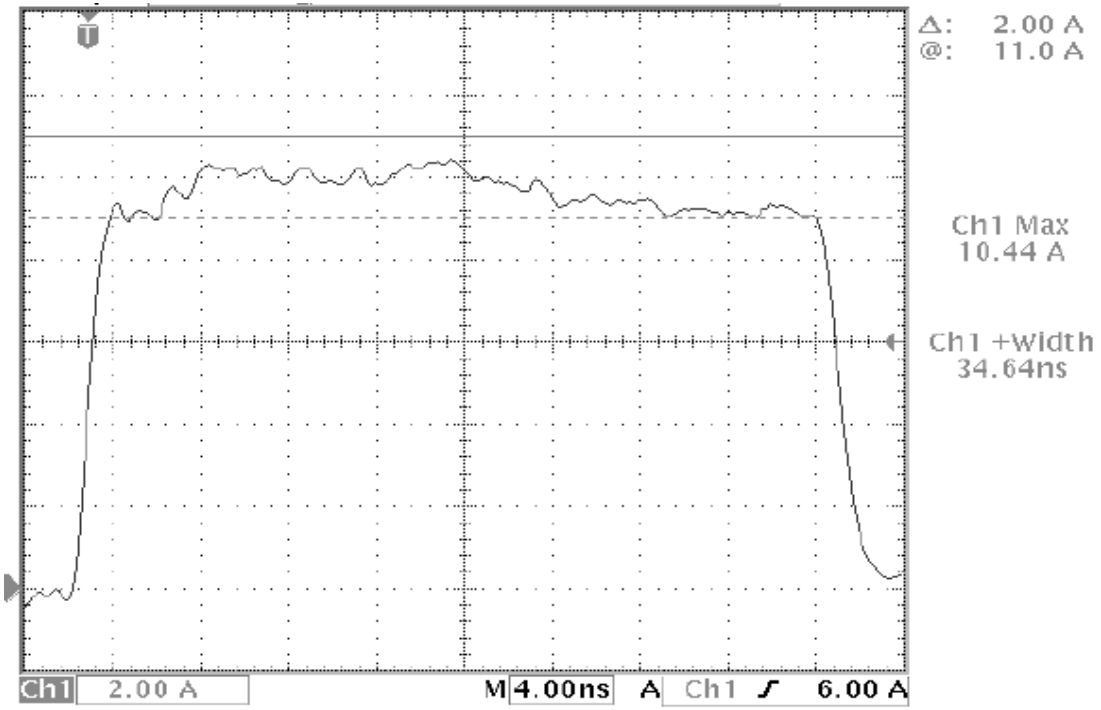
CS115

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G



CS115 Output

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G



Sample Waveform in calibration jig

CS116

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

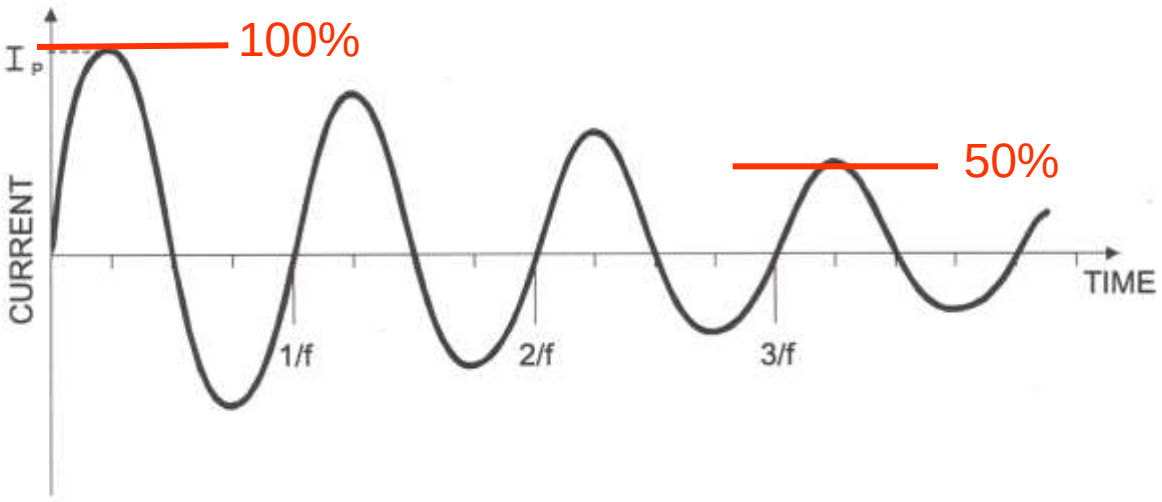
- Previously CS 10, 11, 12 , 13
- EMP exictation of cable bundles
- Waveform defined at system interface
- Frequencies fixed

CS116

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Damping Rate or Q

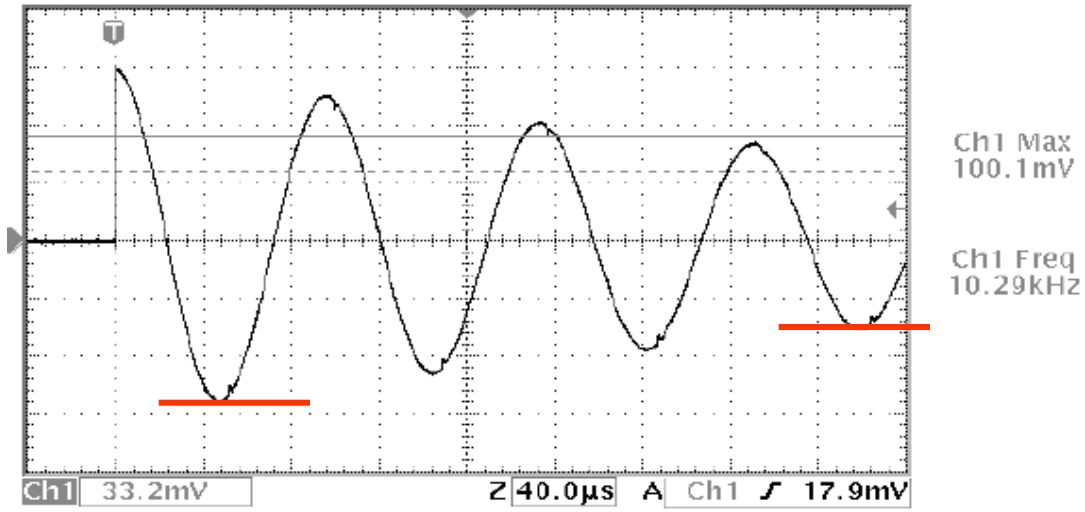
$$Q = \frac{\pi(N - 1)}{\ln(I_P/I_N)}$$



Test Frequencies : 10kHz, 100kHz, 1MHz, 10MHz, 30MHz, 100MHz

CS116 Output

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

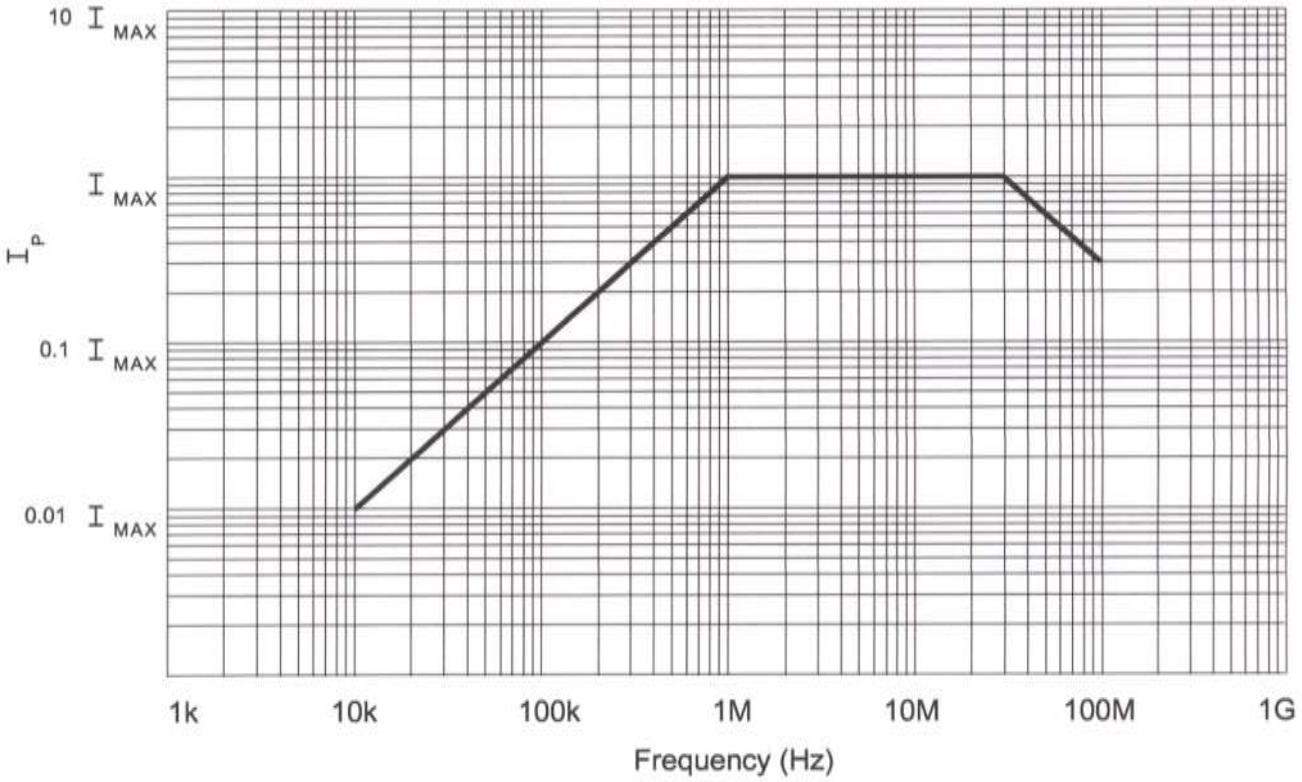


Cosine wave is allowed.

In this case Q is calculated from the first full sine wave (NEGATIVE)

CS116 Test levels

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G



NOTES:

1. For Army and Navy procurements, I_{MAX} = 10 amperes
2. For Air Force procurements, I_{MAX} = 5 amperes

CS106, CS115, & CS116

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

Test equipment Example MIG2000-6

MIL-STD-461G

MIL-STD-461G

- **Is still a work in process**
- **All information listed here is subject to change before release**

For informational purposes only

MIL-STD-461G

What may come in the update

- Addition of lightning tests
  - Based on DO-160 Sec22
- Addition of ESD tests
  - Based on IEC 61000-4-2
- Text to clarify use of FFT based receiver

MIL-STD-461G

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G

CS114	Conducted Susceptibility, Bulk Cable Injection, 10 kHz to 200 MHz
CS115	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation
CS116	Conducted Susceptibility, Damped Sinusoidal Transients, Cables and Power Leads, 10 kHz to 100 MHz
CS117	Conducted Susceptibility, Lightning Induced Transients, Cables and Power Leads
RE101	Radiated Emissions, Magnetic Field, 30 Hz to 100 kHz
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz
RE103	Radiated Emissions, Antenna Spurious and Harmonic Outputs, 10 kHz to 40 GHz
RS101	Radiated Susceptibility, Magnetic Field, 30 Hz to 100 kHz
RS103	Radiated Susceptibility, Electric Field, 2 MHz to 40 GHz
RS105	Radiated Susceptibility, Transient Electromagnetic Field
RS106	Radiated Susceptibility, Electrostatic Discharge

MIL-STD-461G

CS117 Conducted Susceptibility

- Lightning Induced Transients, Cables and Power Leads
  - Applicable for Army, Navy, Airforce
    - Aircraft
    - Space Vehicles (limited)

MIL-STD-461G

- CS117 Indirect Lightning
  - Still a work in progress!
    - Provisionally
    - Most waveforms as in DO-160 section 22
    - Multiple stroke
    - Multiple Burst
    - Specific Test Levels

CS117 Proposed Levels

IEC updates

IEC 61000-3-2

IEC 61000-4-4

IEC 61000-4-5

IEC 61000-4-19

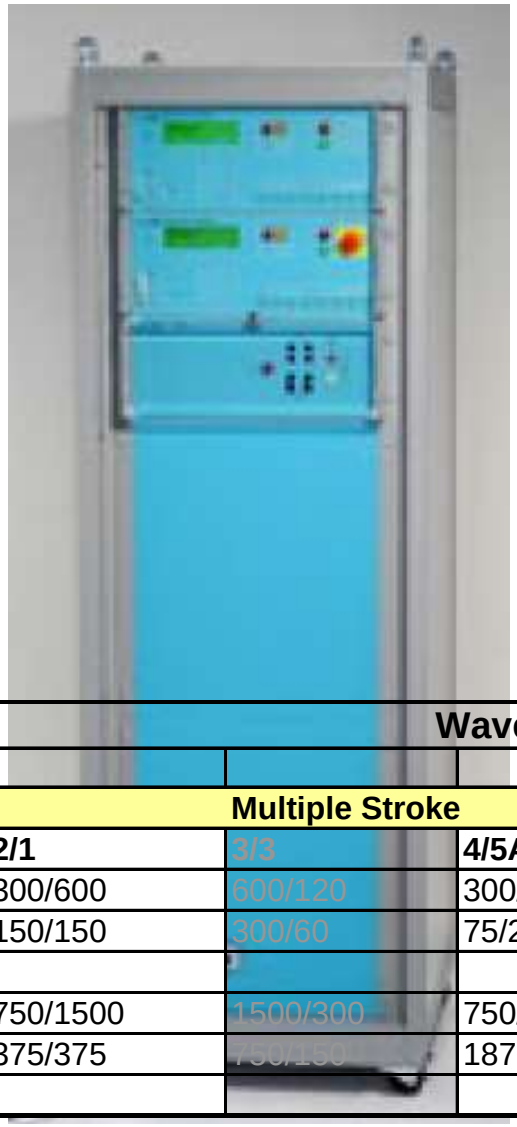
MIL-STD-461G

CRITICALITY	WAVEFORMS					
	MULTIPLE STROKE[1]				MULTIPLE BURST[2]	
		2/1	3/3[4]	4/5A[5]	3[4]	6[6]
		V_L/I_T[3]	V_T/I_L[3]	V_L/I_T[3]	V_T/I_L[3]	V_L/I_T[3]
Internal	First Stroke[1]	300/600(60)	600/120(24)	300/1000(300)	360/6	600/30
	Subsequent Stroke[1]	150/150(30)	300/60(12)	75/200(150)		
External	First Stroke[1]	750/1500(150)	1500/300(60)	750/2000(750)	900/15	1500/75
	Subsequent Stroke[1]	375/375(75)	750/150(30)	187.5/400(375)		

1. Amplitude Tolerance is +20%,-0% for the First Stroke. Amplitude Tolerance is +50%,-0% for the Subsequent Stroke.
2. Amplitude Tolerance is +20%,-0%.
3. V_T represents the test voltage level in Volts and I_T represents the test current level in Amperes. V_L (Volts) and I_L (Amperes) represent limits intended to prevent over-stressing the EUT beyond the requirements. Current test or limit levels (I_T or I_L) specified in parenthesis should be used for testing individual power leads. When the power lines are tested together this current shall be increased to the number of power lines multiplied by the appropriate individual current test or limit level.
4. Apply Waveform 3 at 1 MHz and 10 MHz.
5. Waveform Set 4/5A is not applicable to equipment installations contained entirely within an all metallic skin (no composites).
6. Waveform 6 is only applicable to EUTs that utilize low impedance cable bundle installations (for example, engines).

CS117 Proposed Levels

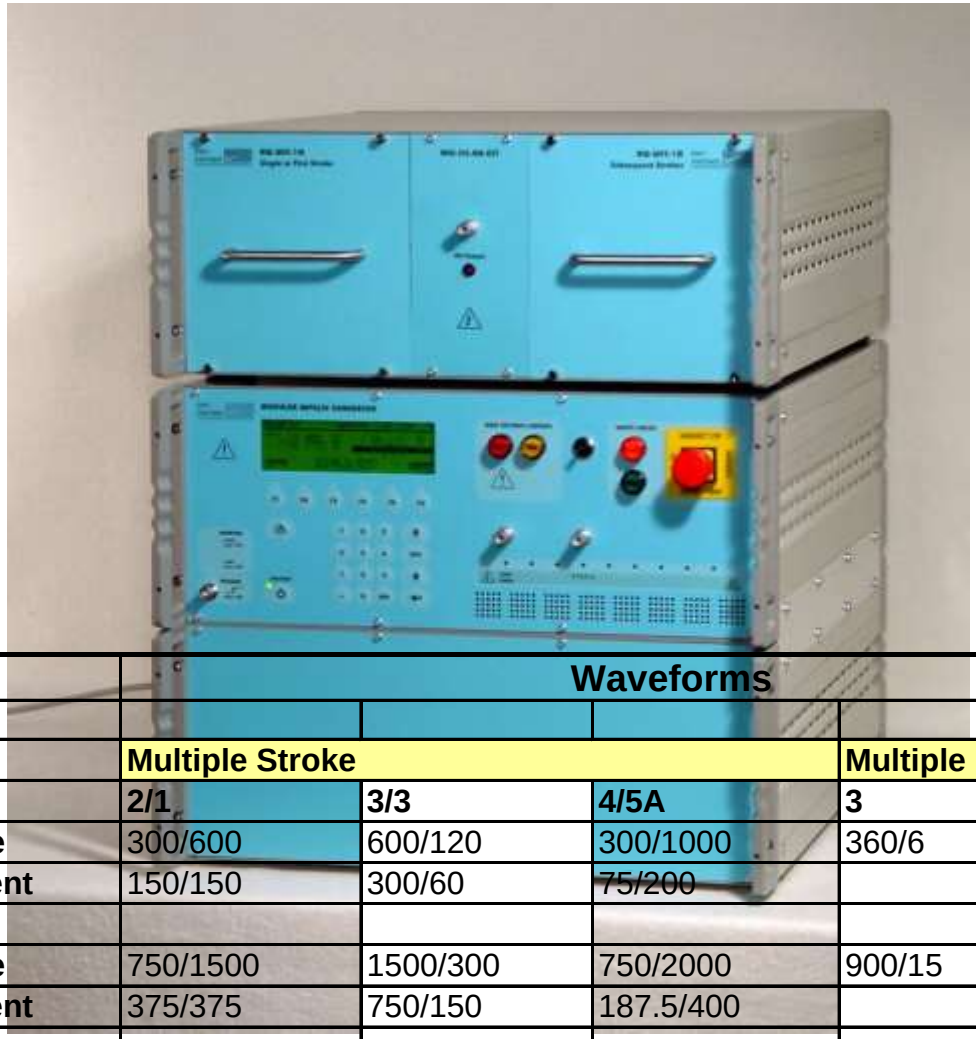
- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G



Criticality		Waveforms				
		Multiple Stroke			Multiple Burst	
		2/1	3/3	4/5A	3	6
Internal	1st Stroke	300/600	600/120	300/1000	360/6	600/30
	Subsequent	150/150	300/60	75/200		
External	1st Stroke	750/1500	1500/300	750/2000	900/15	1500/75
	Subsequent	375/375	750/150	187.5/400		

CS117 Proposed Levels

- IEC updates
- IEC 61000-3-2
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-19
- MIL-STD-461G



Criticality		Waveforms				
		Multiple Stroke			Multiple Burst	
		2/1	3/3	4/5A	3	6
Internal	1st Stroke	300/600	600/120	300/1000	360/6	600/30
	Subsequent	150/150	300/60	75/200		
External	1st Stroke	750/1500	1500/300	750/2000	900/15	1500/75
	Subsequent	375/375	750/150	187.5/400		

RS106 Proposed Levels

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

- **RS106 Electrostatic Discharge**
  - **Test equipment from IEC61000-4-2**
  - **±2kV up to ±25kV (± 15kV)**
  - **150pF & 330ohm**
  - **EMCP equipment**
    - **ESD3000**
    - **ESD3000DN1**
    - **ESD3000RM32**

RS106 Verification

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

- RS106 Electrostatic Discharge
  - Pre-Test Verification
  - Measure voltage at ESD Tip
  - At each new test level
  - EMCP equipment
    - ESD-VERI-V

RS106 Verification

IEC updates
IEC 61000-3-2
IEC 61000-4-4
IEC 61000-4-5
IEC 61000-4-19
MIL-STD-461G

- RS106 Electrostatic Discharge
  - Calibration Contact up to 8kV
  - DSO bandwidth ≥1GHz
    - -4-2 requires ≥ 2GHz (We sugest ≥ 4GHz)
  - Target from IEC61000-4-2
  - EMCP equipment
    - ESD-TARGET2

MIL-STD-461G Process

- **Next Steps (tenative)**
  - **Final Draft to be distributed early 2015**
  - **Open for public comment**
  - **Plan for final release late 2015**

Thank You

Thank You,
Jason Smith
EMC Sales & Marketing Manager

HV TECHNOLOGIES, Inc.
8526 Virginia Meadows Drive
Manassas, VA 20109

HVT - "Partners for HV and EMC Solutions"
www.hvtechnologies.com

(T) +1-703-365-2330, ext. 1829
(F) +1-703-365-2331
(M) +1-703-980-4330
smith@hvtechnologies.com

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www.emclive2014.com