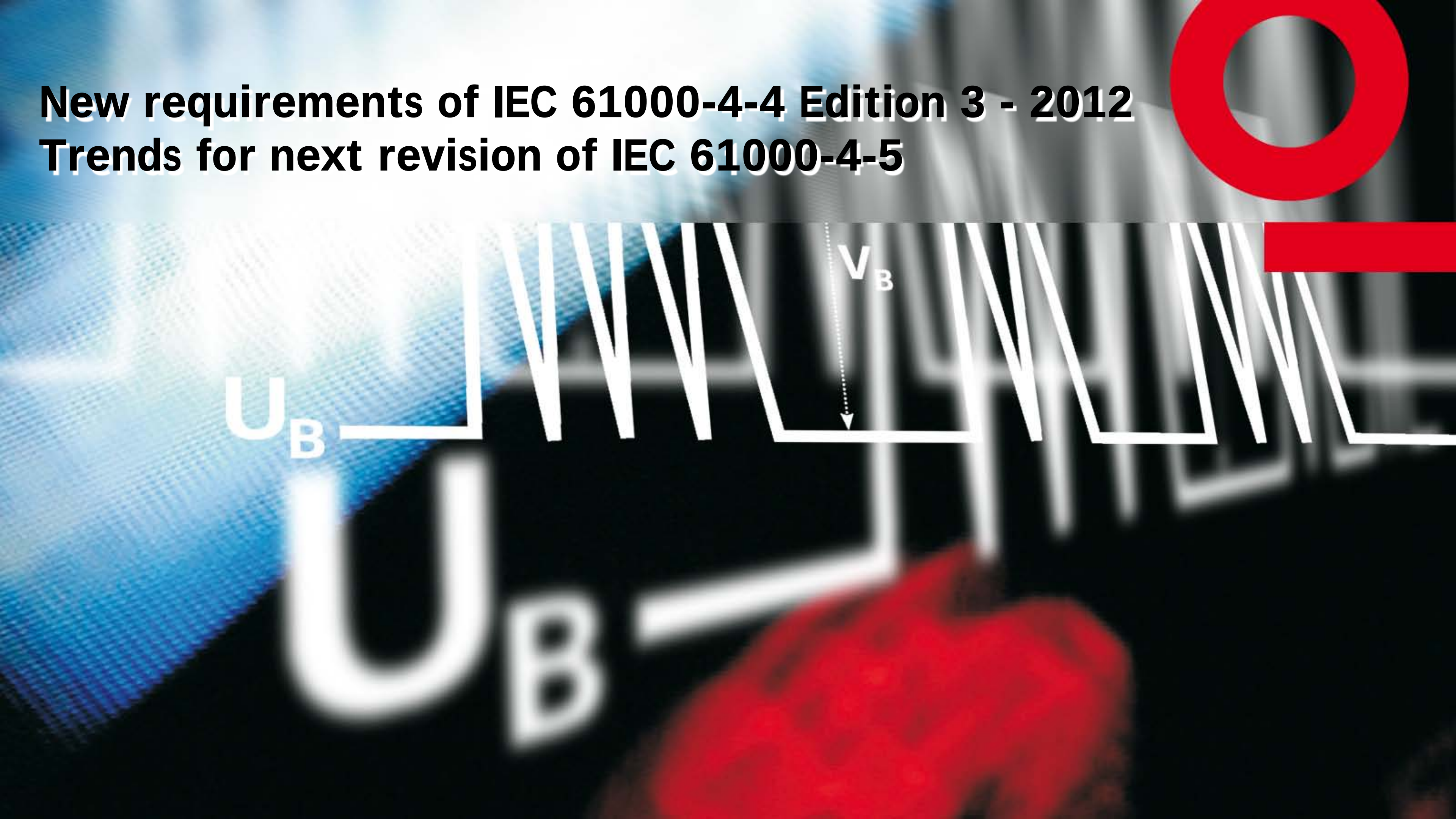
New requirements of IEC 61000-4-4 Edition 3 - 2012
Trends for next revision of IEC 61000-4-5



Eric Dudenhoeffer, TESEQ AG, Switzerland
Product Line Manager

More Application, Information, and Pricing available at:
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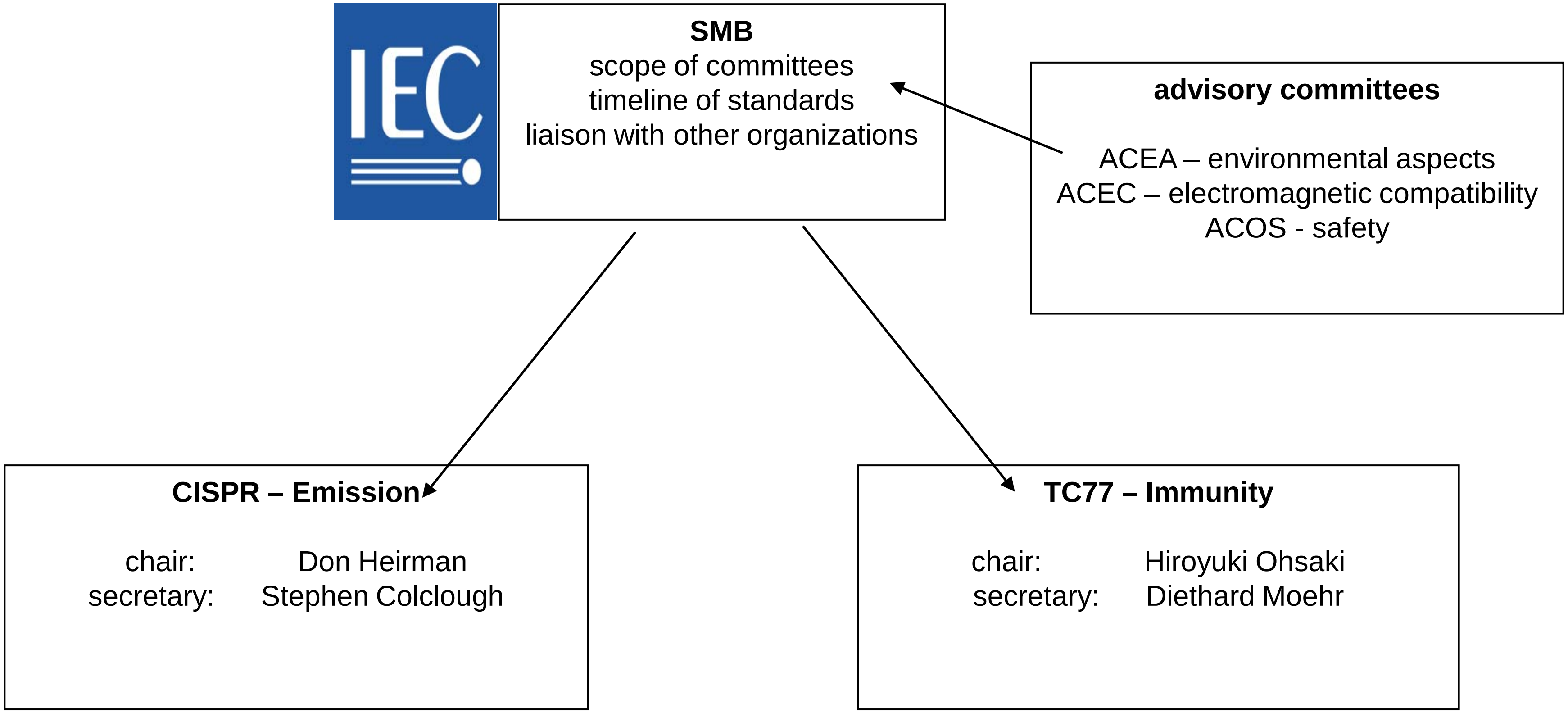
Overview IEC



SMB
scope of committees
timeline of standards
liaison with other organizations

advisory committees

ACEA – environmental aspects
ACEC – electromagnetic compatibility
ACOS - safety

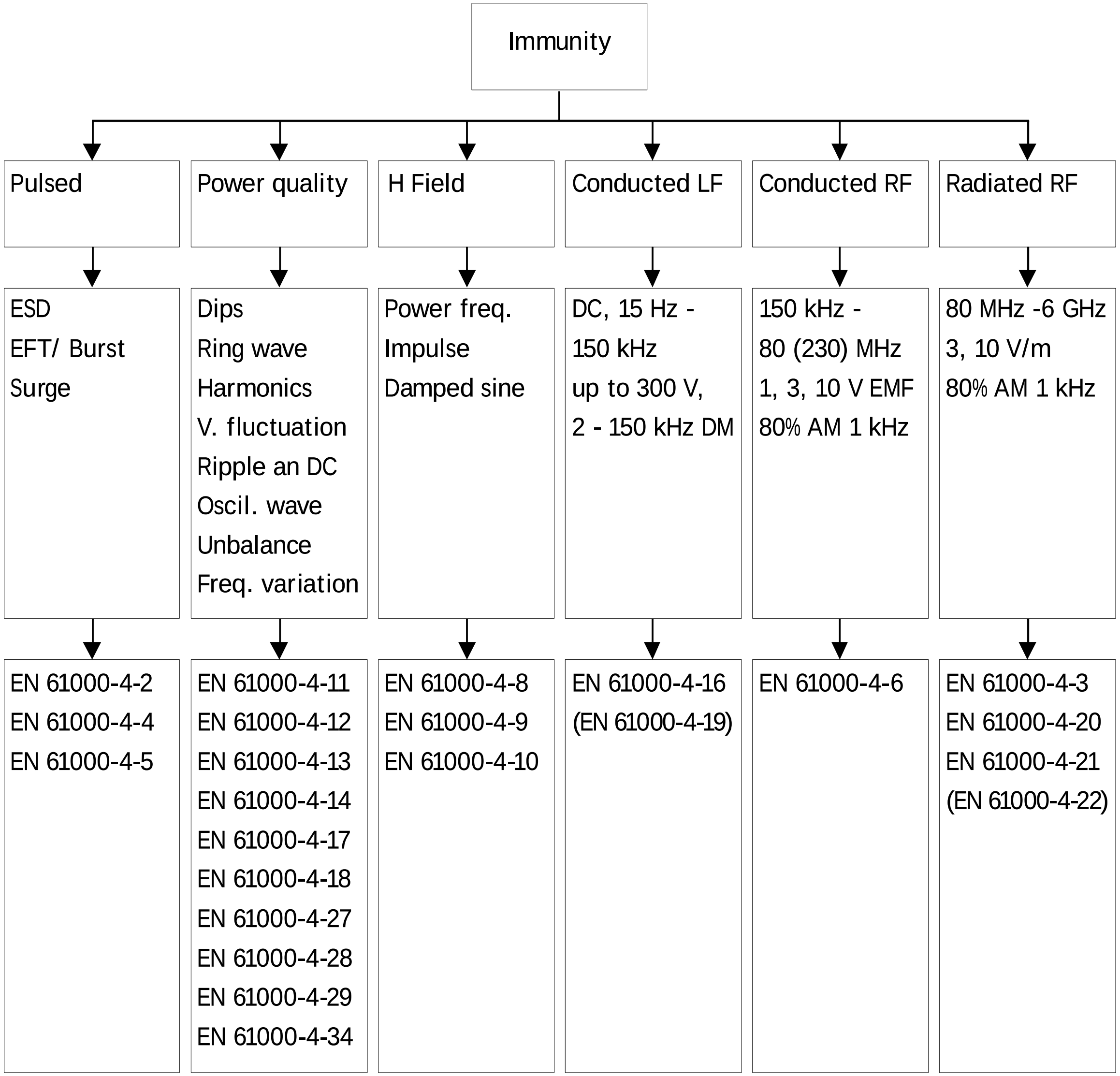
CISPR – Emission

chair: Don Heirman
secretary: Stephen Colclough

TC77 – Immunity

chair: Hiroyuki Ohsaki
secretary: Diethard Moehr

Immunity standards



Immunity

Pulsed	Power quality	H Field	Conducted LF	Conducted RF	Radiated RF
ESD EFT/ Burst Surge	Dips Ring wave Harmonics V. fluctuation Ripple an DC Oscil. wave Unbalance Freq. variation	Power freq. Impulse Damped sine	DC, 15 Hz - 150 kHz up to 300 V, 2 - 150 kHz DM	150 kHz - 80 (230) MHz 1, 3, 10 V EMF 80% AM 1 kHz	80 MHz -6 GHz 3, 10 V/m 80% AM 1 kHz
EN 61000-4-2 EN 61000-4-4 EN 61000-4-5	EN 61000-4-11 EN 61000-4-12 EN 61000-4-13 EN 61000-4-14 EN 61000-4-17 EN 61000-4-18 EN 61000-4-27 EN 61000-4-28 EN 61000-4-29 EN 61000-4-34	EN 61000-4-8 EN 61000-4-9 EN 61000-4-10	EN 61000-4-16 (EN 61000-4-19)	EN 61000-4-6	EN 61000-4-3 EN 61000-4-20 EN 61000-4-21 (EN 61000-4-22)

IEC 61000-x-x basic standards

- Terminology and safety
- Description of phenomena and levels
- Guidance values for immunity tests
- Measurement techniques
- Testing techniques
- Installation guidelines

Generic standards

- Residential, commercial and light industry
  - Houses, shops and supermarkets
  - Business premises
  - Areas of public entertainment
  - Outdoor locations, petrol stations, sport centres
  - Light industrial locattions, workshops and laboratories

- Industrial environment
  - Locations with industrial, scientific and medical apparatus
  - Heavy inductive or capacitive loads frequently switched
  - High currents and associated magnetic field

Product standards

Particular products

- Washing machines
- Electricity meters
- Monitors
- Printed boards

Product families

- LV household equipment
- Information technology equipment
- Medical equipment

Maintenance / Stability

Publication	Year	Edition	Maintenance	Responsibility
61000-4-2	2008	Ed. 2.0	2014	MT12
61000-4-3	2010	Ed. 3.2	2013	WG10
61000-4-4	2011	Ed. 2.1	2012	MT12
61000-4-5	2005	Ed. 2.0	2012	MT12
61000-4-6	2008	Ed. 3.0	2013	WG10
61000-4-9	2001	Ed. 1.1	2013	MT12
61000-4-10	2001	Ed. 1.1	2013	MT12
61000-4-12	2006	Ed. 2.0	2012	MT12
61000-4-18	2011	Ed. 1.1	2012	MT12
61000-4-20	2010	Ed. 2.0	2014	JTF TEM
61000-4-21	2011	Ed. 1.0	2015	JTF REV
61000-4-22	2010	Ed. 1.0		JTF FAR

Electrical Fast Transients - Burst

EFT

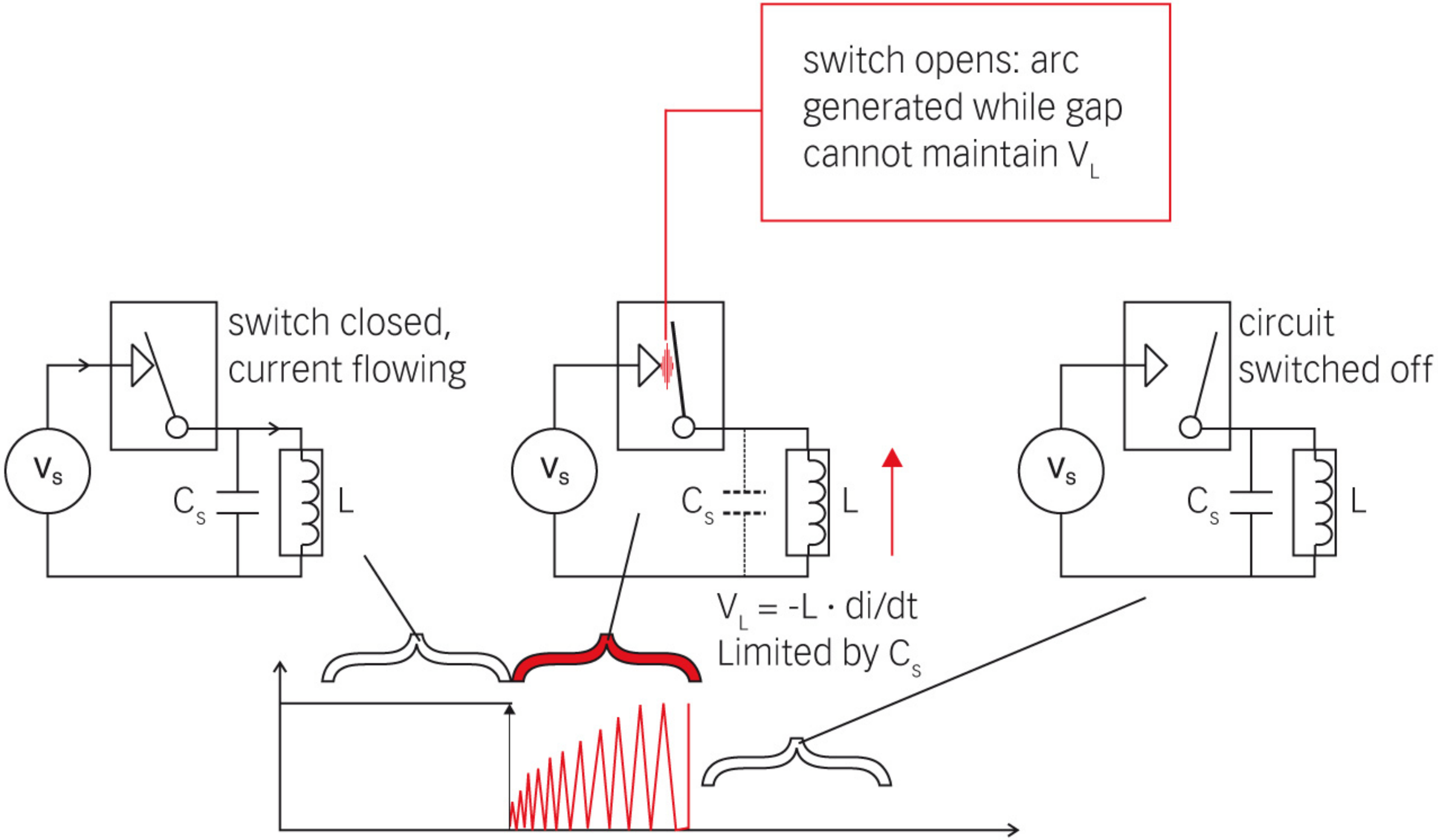
Electrical **F**ast **T**ransient

Burst Pulses

EFT/Burst – IEC/EN 61000-4-4

EF

IE



switch closed, current flowing

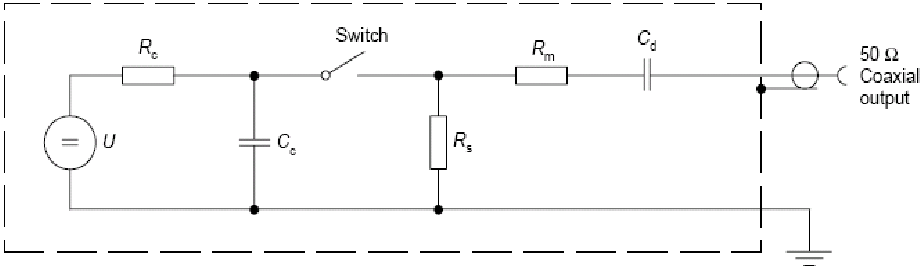
switch opens: arc generated while gap cannot maintain V_L

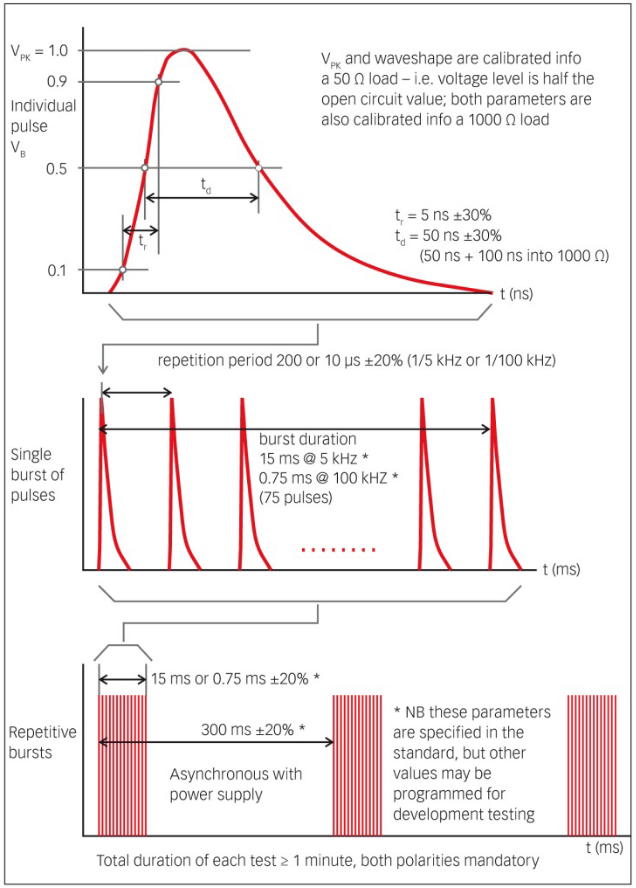
circuit switched off

$V_L = -L \cdot di/dt$

Limited by C_S

IEC 61000-4-4: Electromagnetic compatibility (EMC) - Part 4-4 : Testing and measurement techniques - Electrical fast transient/burst immunity test - Basic EMC Publication





EFT / Burst is a high frequency phenomenon with a bandwith > 100 MHz

Burst : IEC 61000-4-4

- New publication of IEC 61000-4-4:Ed 3.0 (May 2012)

Maintenance of IEC 61000-4-4

- Started Dec 2008
- Result inquiry within MT12 and observations from national comitees defined the program.

No change of:

- Test levels
- Generator specifications
- Test repetition frequency

Change (review) of:

- Test setup (i.e. rack mount, table top, AE wiring)
- Calibration of clamp
- Taking Amdt 1:2010 to main body
- Numerical model of a Burst pulse
- Measurement Uncertainty

Model of a Burst Pulse

- Informative: for Engineering and Design purposes

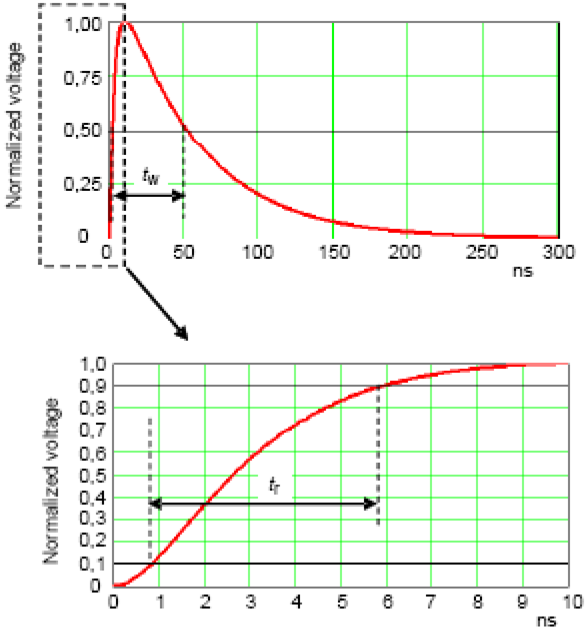


Figure 3 – Ideal waveform of a single pulse into a 50 Ω load with nominal parameters t_r = 5 ns and t_w = 50 ns

The formula of the ideal waveform of Figure 3, $v_{EFT}(t)$, is as follows:

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

where

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

and

k_v is maximum or peak value of the open-circuit voltage (k_v = 1 means normalized voltage)

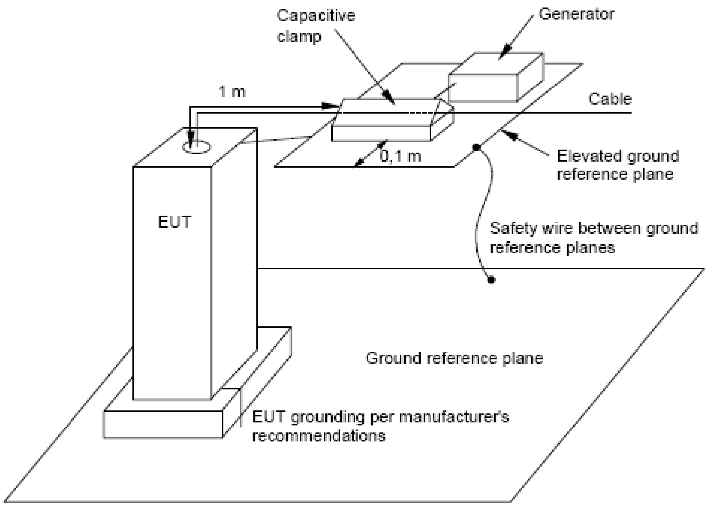
$v_1 = 0{,}92$ $\tau_1 = 3{,}5$ ns $\tau_2 = 51$ ns $n_{EFT} = 1{,}8$

NOTE The origin of this formula is given in IEC 62305-1:2010, Annex B.

Test Setups

For EUTs with cable inputs on the top

- This method is difficult to meet
- This has been investigated
- Numerical simulations have been made for alternative setups
- Measurement campaigns have been run
- An easier alternative has been found, validated and will be published in Ed 3.0



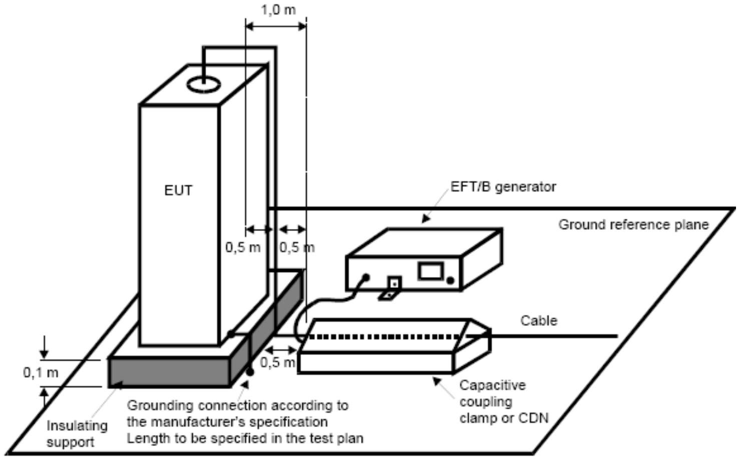
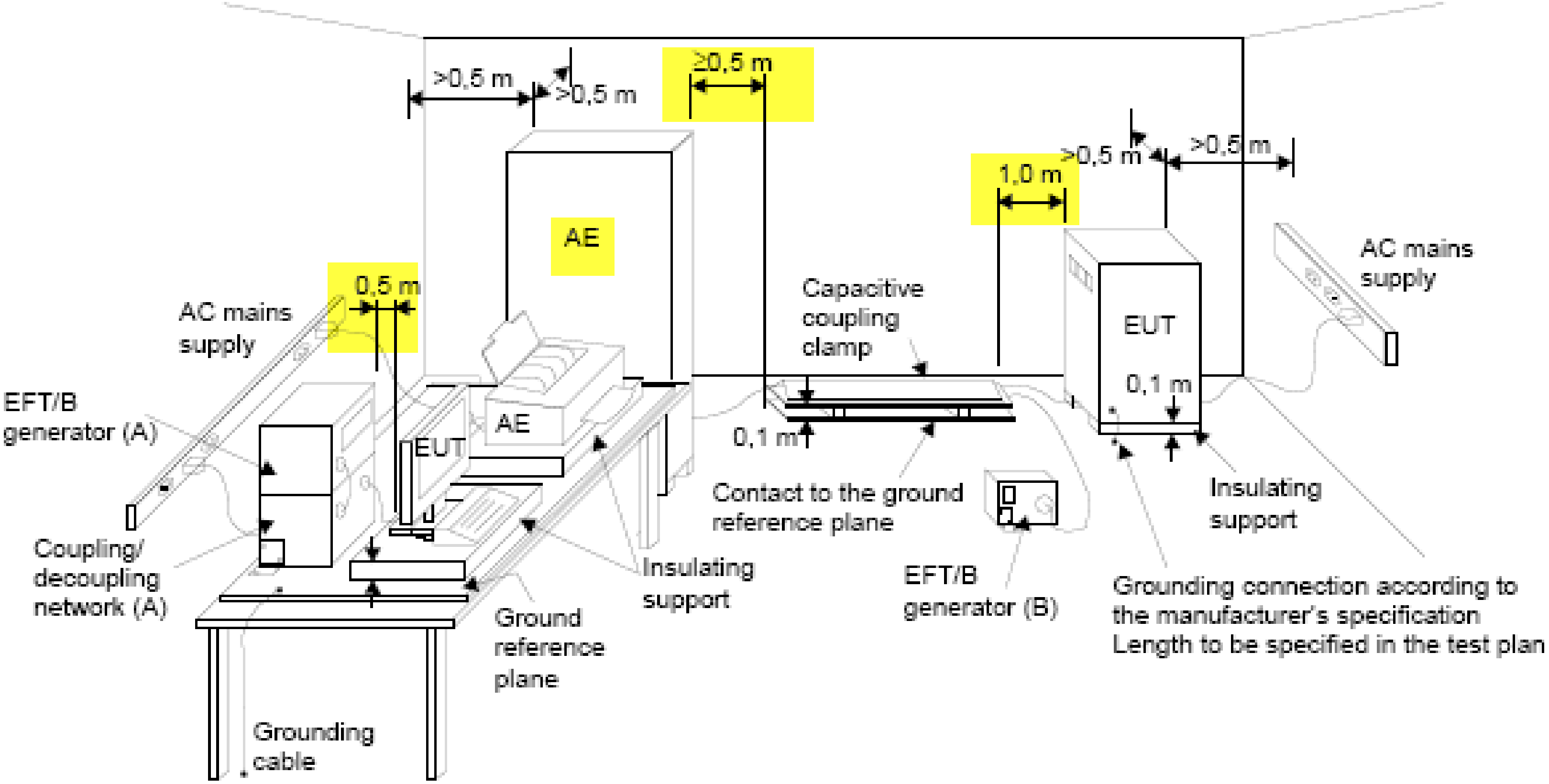


Figure 13 – Example of a test setup for equipment with elevated cable entries

Other Changes in Test Setups

- Some of the changes are shown in yellow:

61000-4-4/FDIS © IEC



Calibration of Coupling Clamp

Various methods have been proposed and investigated

- Using network analysers
- Using RLC bridges
- Using same equipment (attenuators and scope) as for generator calibration

Finally the best method has been selected:

- Using same equipment (attenuators and scope) as for generator calibration

Calibration of Coupling Clamp

- IEEE publication about the new method

Full-wave Investigation
of EFT Injection Clamp Calibration Setup

Spartaco Caniggia
EMC Consultant
Viale Moranti 7,
20010 Bareggio (MI), Italy
spartaco.caniggia@ieee.org

Eric Dudenhoeffen
TESEQ AG
Nordstrasse 11F, CH-4542 Luterbach
Switzerland
eric.dudenhoeffer@teseq.com

Francescaromana Maradei
Dept. of Electrical Eng.,
Sapienza Univ. of Rome
Via Eudossiana 18, 00184 Rome, Italy
fr.maradei@ieee.org

The validity of the method has been investigated through numerical simulations and validated by a measurement campaign.

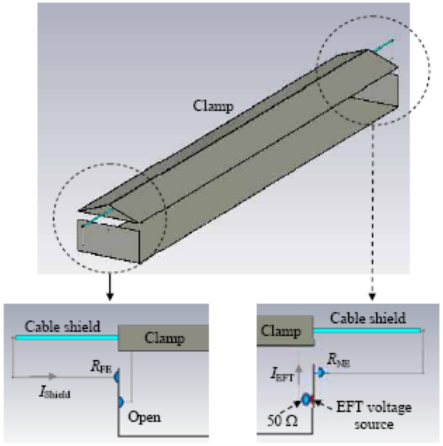


Fig. 3 – MWS model of capacitive coupling clamp housing a coaxial cable.

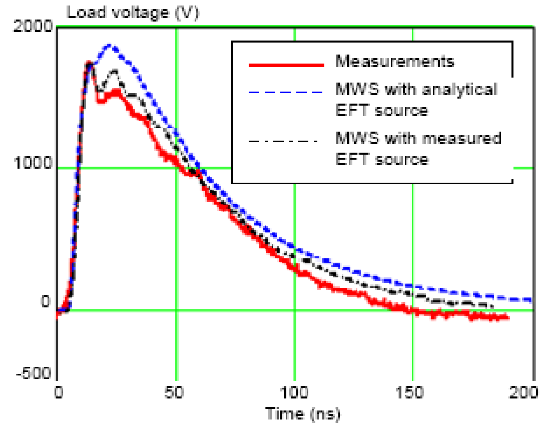


Fig. 15 – Load voltage obtained by measurements and MWS model in calibration setup configuration [2].

Calibration of Coupling Clamp

- Need of a transducer plate and adapter

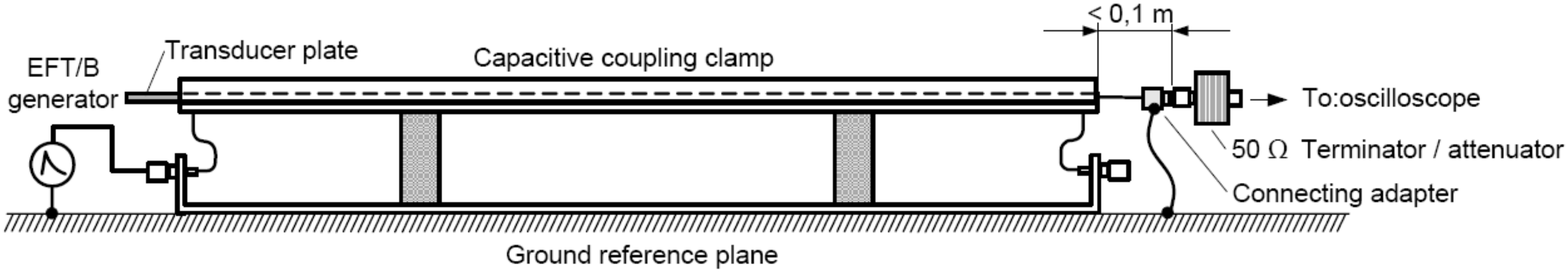


Figure 8 – Calibration of a capacitive coupling clamp using the transducer plate

The waveform shall be calibrated with a single 50 Ω termination.

The clamp shall be calibrated with a generator, which has been shown to be compliant with the requirements of 6.2.2 and 6.2.3.

The calibration is performed with the generator output voltage set to 2 kV.

The waveform characteristics shall meet the following requirements:

- rise time (5 ± 1,5) ns;
- pulse width (50 ± 15) ns;
- peak voltage (1 000 ± 200) V.

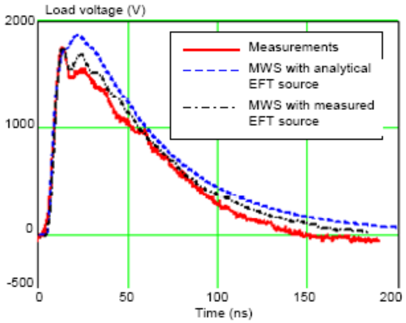


Fig. 15 – Load voltage obtained by measurements and MWS model in calibration setup configuration [2].

Generator Calibration

- IEC 61000-4-4 Amdt 1:2010 has been taken in the main body of Ed 3.0

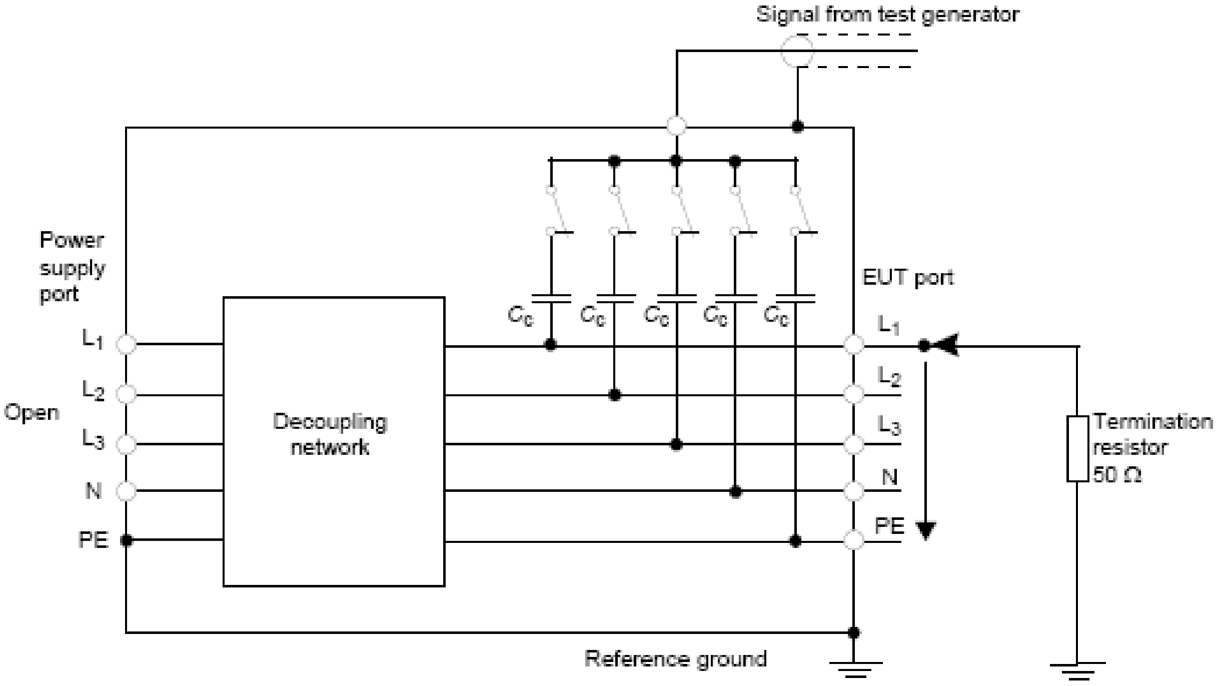
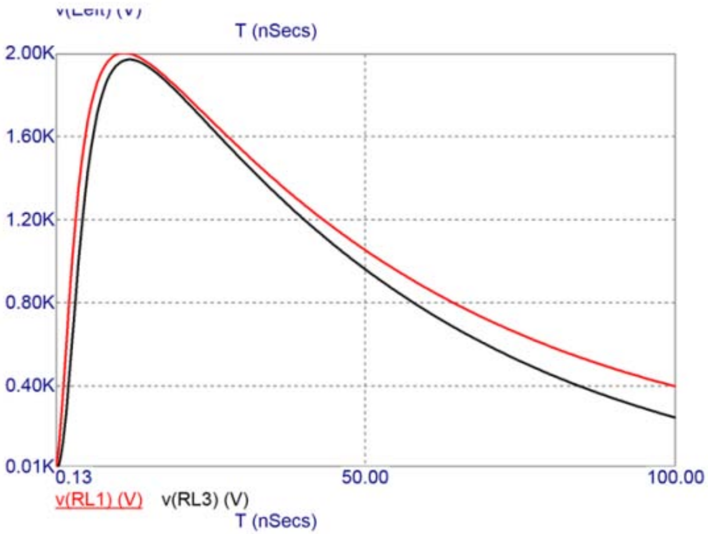


Figure 5 – Calibration of the waveform at the output of the coupling/decoupling network

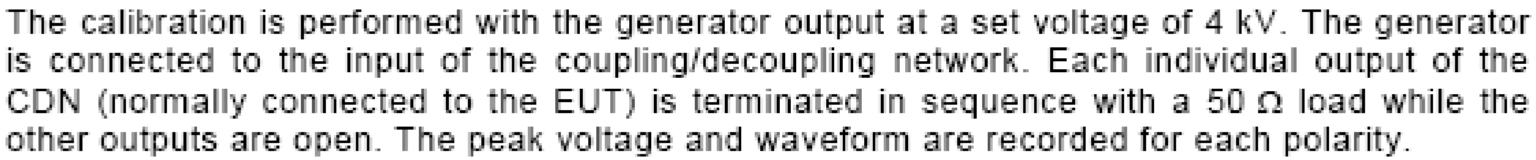
Generator Calibration

- The introduction of Measurement Uncertainty considerations pushed to look at things closer
- The use of numerical simulation tools allowed better visibility
- The introduction of the Amdt 1:2010 calibration method generates results drifts which were neglected

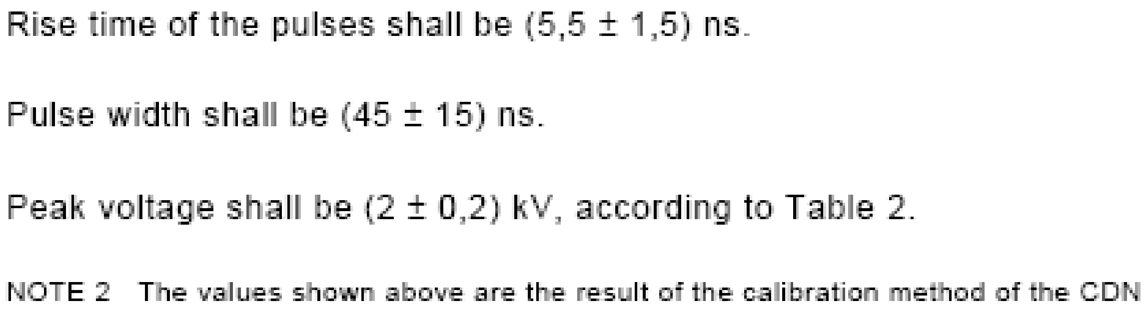


Generator Calibration

- To make things right, specifications have been re-adjusted for parameter values when measured with new method (full common mode) at CDN output
- Note that there is no change for generator or CDN specification, the new calibration method generates slight changes in the parameter definition at CDN output
- Using the new definition from Ed 3.0 for calibration will give results which are better centered in the tolerance range



The calibration is performed with the generator output at a set voltage of 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 sequence with a 50 Ω load while the other outputs are open. The peak voltage and waveform are recorded for each polarity.

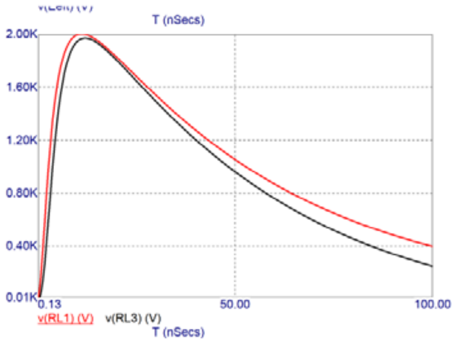


Rise time of the pulses shall be (5,5 ± 1,5) ns.

Pulse width shall be (45 ± 15) ns.

Peak voltage shall be (2 ± 0,2) kV, according to Table 2.

NOTE 2 The values shown above are the result of the calibration method of the CDN



Annex C: Measurement Uncertainty (MU) Considerations

- Informative (not mandatory)
- Will be implemented in each new immunity standard
- Is in line with IEC 61000-1-6

Title:
IEC/TR 61000-1-6 Ed.1: ELECTROMAGNETIC COMPATIBILITY (EMC) – Part 1-6: General – Guide to the assessment of measurement uncertainty

- Concerns only the test equipment calibration uncertainty, not the uncertainty of the burst test
- Dedicated to the calibration laboratories
- Ends with an important statement about compliance of test equipment:

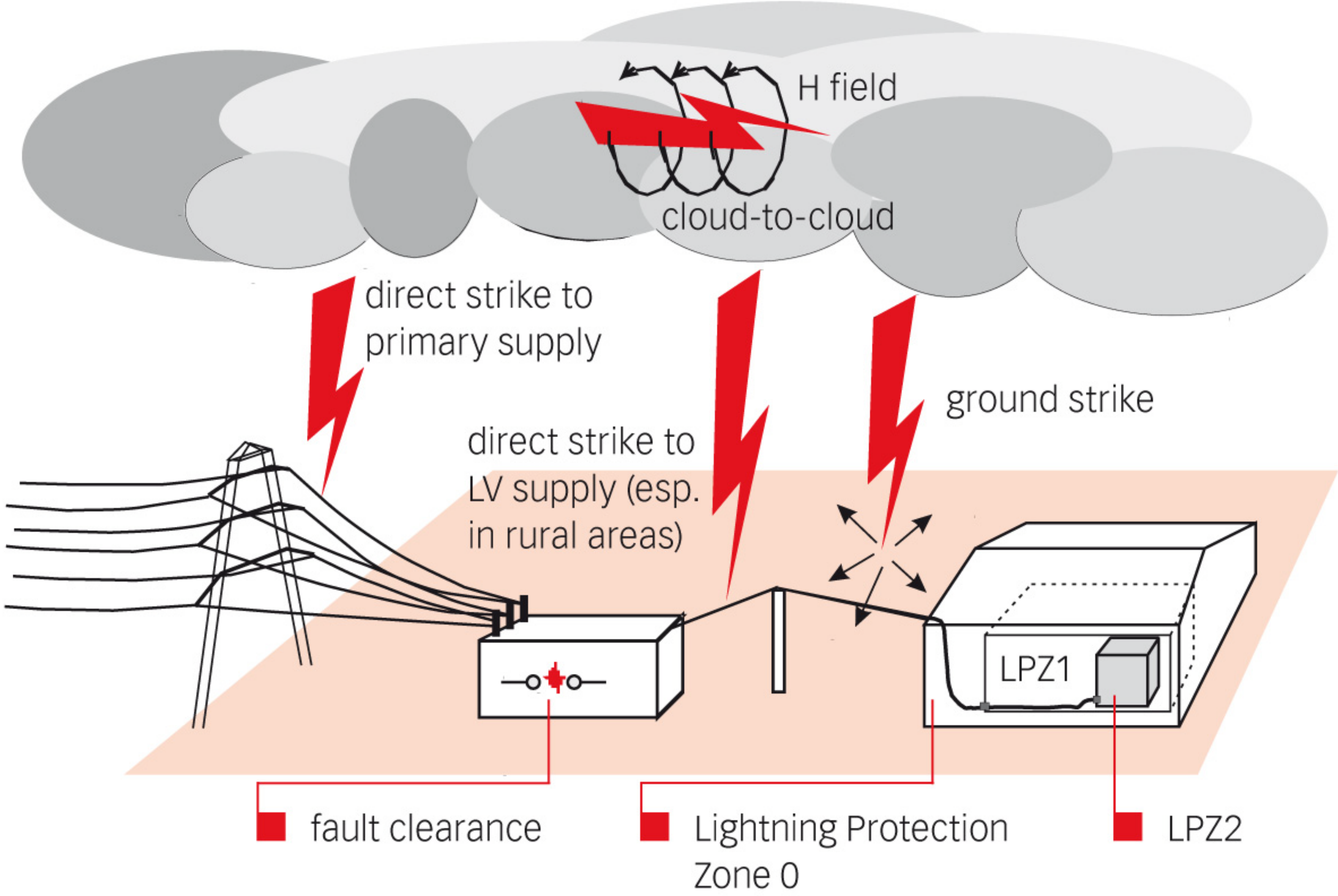
C.5 Application of uncertainties in the EFT/B generator compliance criterion

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).

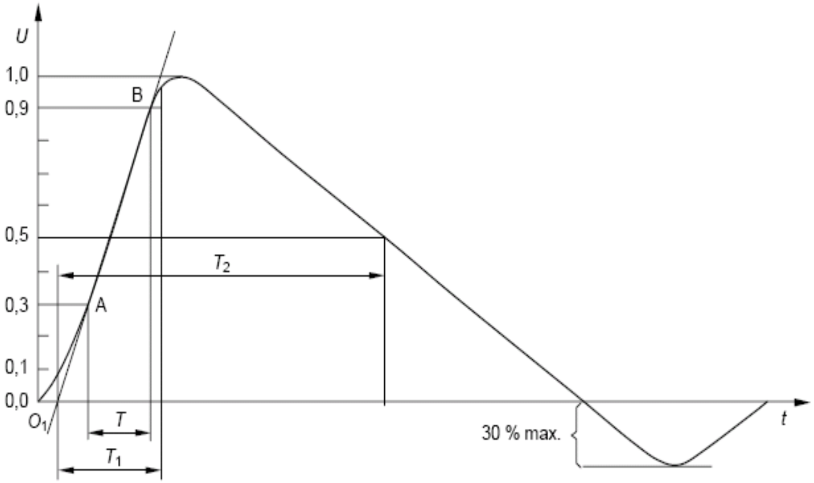
Lightning transients – SURGE – IEC 61000-4-5

High energy transients → Effect of lightning strokes or switching of major power systems like capacitor bank switching.

Lightning strokes



Standardized pulse



High energy pulse

with low bandwith: < 100 kHz

1,2/50 us 8/20us

Voltage amplitude up to 4 kV

Current amplitude up to 2 kA

- Trends for next revision of IEC 61000-4-5

Maintenance of IEC 61000-4-5

- Started Dec 2010
- Result inquiry within MT12 and observations from national committees defined the program.

No change of:

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

Change (review) of:

- Add mathematical formula for wave shape
- Harmonization of CDN up to 200 A
- Specify High Speed dataline CDN
- Phase synchronization in 3 phase systems
- New calibration table for 10 Ohm
- Test setup for class II equipment
- Test setup for shielded control lines
- Harmonization with ITU-T.K series
- Clear statement about 2 methods 60060-1, 60469-1
- Development of MU (annex D)

Maintenance of IEC 61000-4-5

- Numerical model

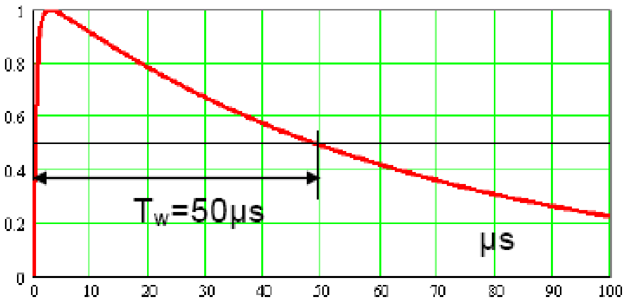


Figure E. 1: Voltage surge (1,2/50µs): Late time response

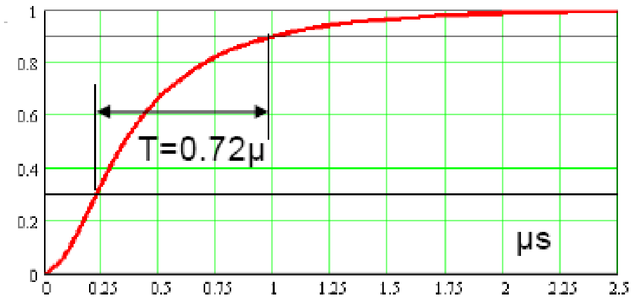
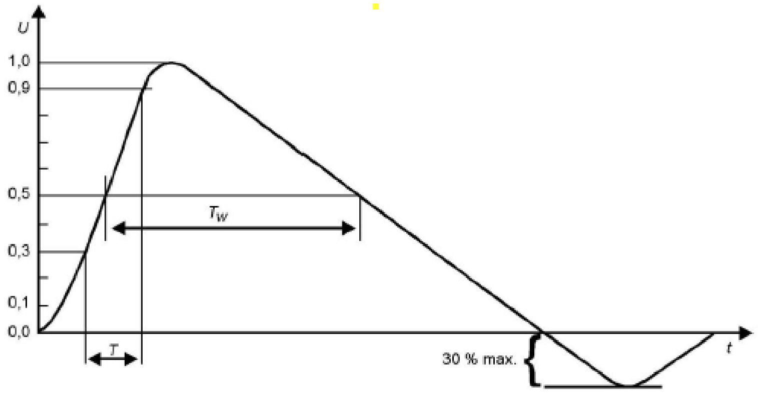


Figure E. 2: Voltage surge (1,2/50µs): Early time response

$$v_{SURGE}\ t = k_v \cdot \left[\frac{v}{k_{SURGE}} \cdot \frac{\left(\frac{t}{\tau}\right)^{\eta_{SURGE}}}{+\left(\frac{t}{\tau}\right)^{\eta_{SURGE}}} \cdot e^{\frac{-t}{\tau}} \right]$$

Maintenance of IEC 61000-4-5

- Only one calibration method

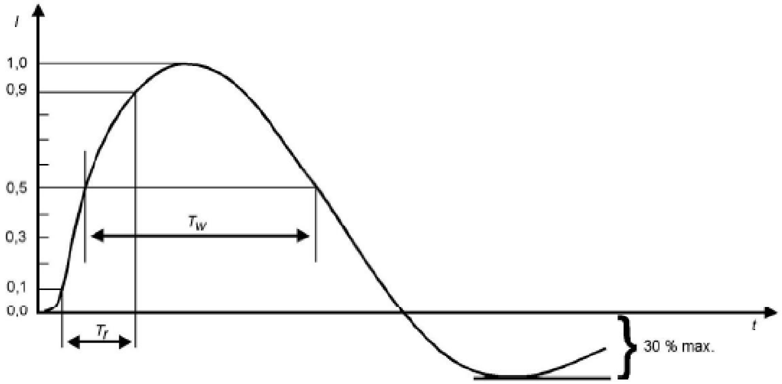


Front time: T_f = 1,67 × T = 1,2 µs ± 30 %
Duration: T_d = T_W = 50 µs ± 20 %.

NOTE 1 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 this figure.

NOTE 2 The value 1,67 is the reciprocal of the difference between the 0,9 and 0,3 thresholds.

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



Front time: T_f = 1,25 × T_r = 8 µs ± 20 %
Duration: T_d = 1,18 x T_w = 20 µs ± 20 %

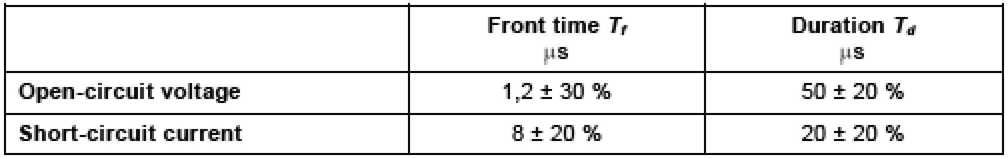
NOTE 1 The 30 % undershoot specification applies only at the generator output. At the output of the coupling/decoupling network there is no limitation on undershoot or overshoot.

NOTE 2 The value 1,25 is the reciprocal of the difference between the 0,9 and 0,1 thresholds.

NOTE 3 The value 1,18 is derived from empirical data.

Figure 3 – Waveform of short-circuit current (8/20 µs) at the output of the generator

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



	Front time T_f µs	Duration T_d µs
Open-circuit voltage	1,2 ± 30 %	50 ± 20 %
Short-circuit current	8 ± 20 %	20 ± 20 %

Maintenance of IEC 61000-4-5

- CDN specification up to 200 A

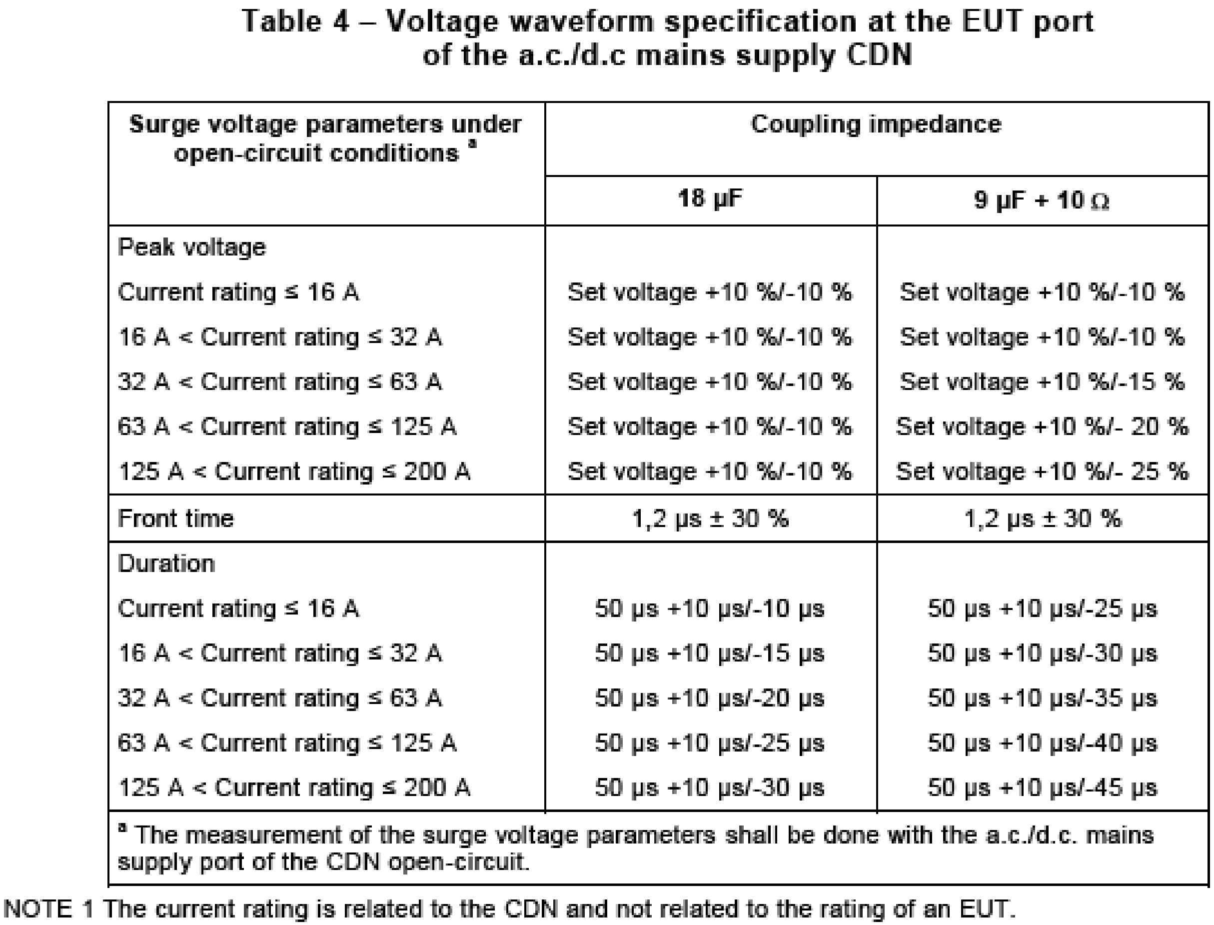


Table 4 – Voltage waveform specification at the EUT port of the a.c./d.c mains supply CDN

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

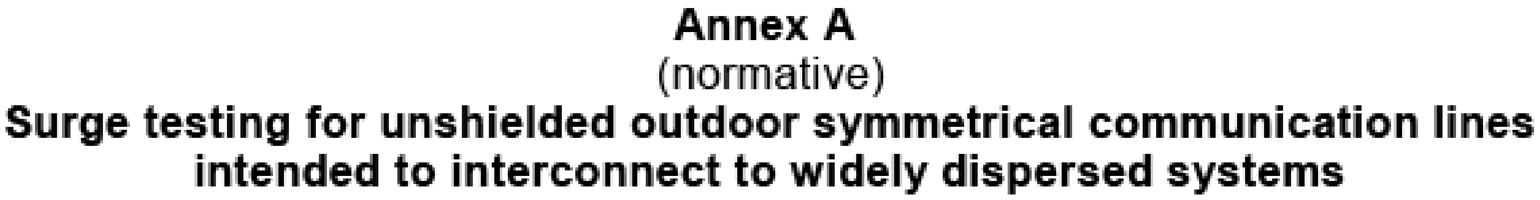
[a] The measurement of the surge voltage parameters shall be done with the a.c./d.c. mains supply port of the CDN open-circuit.

NOTE 1 The current rating is related to the CDN and not related to the rating of an EUT.

- Technical background published in TESEQ newsletter 02/2009: Pulse integrity vs. Voltage drop

Maintenance of IEC 61000-4-5

- Surge coupling on datalines
- Clear split between indoor and outdoor lines
- 10/700 pulse applies only to outdoor lines, so it has been moved to an annex



Annex A
(normative)
Surge testing for unshielded outdoor symmetrical communication lines intended to interconnect to widely dispersed systems

A.2 10/700 µs combination wave generator

Maintenance of IEC 61000-4-5

- Existing specifications dates from times where high speed data transfer was 150 kHz… now up to 10Gbit/s for Ethernet
- Section about dataline coupling has been reviewed
- Calibration specification for dataline CDNs
- Harmonisation with specification from ITU-T.K series and several other telecom standards

Maintenance of IEC 61000-4-5

- IEC 61000-4-5 Ed 3.0
- Publication earliest end 2013

Thank you for your attention.

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