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
s(q_k) = \sqrt{\frac{1}{n-1} \sum_{k=1}^{n} (q_k - Q)^2}

Became

SCHAFFNER
Test Systems

TESEQ
Advanced Test Solutions for EMC
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**
  - ESD
  - EFT/ Burst
  - Surge

- **Power quality**
  - Dips
  - Ring wave
  - Harmonics
  - V. fluctuation
  - Ripple an DC
  - Oscil. wave
  - Unbalance
  - Freq. variation

- **H Field**
  - Power freq.
  - Impulse
  - Damped sine

- **Conducted LF**
  - DC, 15 Hz -
  - 150 kHz
  - up to 300 V,
  - 2 - 150 kHz DM

- **Conducted RF**
  - 150 kHz -
  - 80 (230) MHz
  - 1, 3, 10 V EMF
  - 80% AM 1 kHz

- **Radiated RF**
  - 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 61000-4-19)**

- **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 locations, 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
<table>
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<th>Maintenance</th>
<th>Responsibility</th>
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EFT

Electrical Fast Transient

Burst Pulses
EFT / Bursts – IEC/EN 61000-4-4


text under the diagram:
s \left( q_k \right) = \frac{1}{n-1} \sum_{k=1}^{n} \left( q_k - Q \right)

Diagram:
- Switch closed, current flowing
- Switch opens: arc generated while gap cannot maintain $V_L$
- Circuit switched off

Mathematical equation:

\[ V_L = -L \cdot \frac{di}{dt} \]

Limited by $C_s$
EFT / Burst is a high frequency phenomenon with a bandwidth \( > 100 \text{ MHz} \).
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 committees 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
The formula of the ideal waveform of Figure 3, $v_{EFT}(t)$, is as follows:

$$v_{EFT}(t) = \frac{v_1}{k_{EFT}} \left( \frac{t}{\tau_1} \right)^{\eta_{EFT}} \cdot e^{-\frac{t}{\tau_2}}$$

where

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

and

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

$v_1 = 0.92 \quad \tau_1 = 3.5 \text{ ns} \quad \tau_2 = 51 \text{ ns} \quad n_{EFT} = 1.3$

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:
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
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.dudenhoeﬀen@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].
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 – Lead voltage obtained by measurements and MWS model in calibration setup configuration [2].
IEC 61000-4-4 Amdt 1:2010 has been taken in the main body of Ed 3.0
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 $5.5 \pm 1.5$ ns.

Pulse width shall be $45 \pm 15$ ns.

Peak voltage shall be $2 \pm 0.2$ 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).
High energy transients → Effect of lightning strokes or switching of major power systems like capacitor bank switching.
Lightning strokes

- Direct strike to primary supply
- Direct strike to LV supply (esp. in rural areas)
- Ground strike

fault clearance
Lightning Protection Zone 0
LPZ2
Standardized pulse

High energy pulse with low bandwidth: < 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)
Numerical model

\[
    s(q_k) = \frac{1}{n-1} \sum_{k=1}^{n} (q_k - \bar{q})^2
\]

\[
    t_w = 50 \mu s
\]

**Figure E. 1: Voltage surge (1,2/50\mu s): Late time response**

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

\[
    T = 0.72 \mu s
\]

**Figure E. 2: Voltage surge (1,2/50\mu s): Early time response**
Maintenance of IEC 61000-4-5

- Only one calibration method

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

<table>
<thead>
<tr>
<th></th>
<th>Front time $T_f$ μs</th>
<th>Duration $T_d$ μs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-circuit voltage</td>
<td>$1.2 \pm 30 %$</td>
<td>$50 \pm 20 %$</td>
</tr>
<tr>
<td>Short-circuit current</td>
<td>$8 \pm 20 %$</td>
<td>$20 \pm 20 %$</td>
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### 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

<table>
<thead>
<tr>
<th>Surge voltage parameters under open-circuit conditions</th>
<th>Coupling impedance</th>
<th>18 µF</th>
<th>9 µF + 10 Ω</th>
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<tbody>
<tr>
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<td>1,2 µs ± 30 %</td>
<td>1,2 µs ± 30 %</td>
<td></td>
</tr>
<tr>
<td>Current rating ≤ 32 A</td>
<td>1,2 µs ± 30 %</td>
<td>1,2 µs ± 30 %</td>
<td></td>
</tr>
<tr>
<td>Current rating ≤ 63 A</td>
<td>1,2 µs ± 30 %</td>
<td>1,2 µs ± 30 %</td>
<td></td>
</tr>
<tr>
<td>Current rating ≤ 125 A</td>
<td>1,2 µs ± 30 %</td>
<td>1,2 µs ± 30 %</td>
<td></td>
</tr>
<tr>
<td>Current rating ≤ 200 A</td>
<td>1,2 µs ± 30 %</td>
<td>1,2 µs ± 30 %</td>
<td></td>
</tr>
</tbody>
</table>

#### 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 ondatalines
- 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
Existing specifications date 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.