Differential mode disturbances across power supply networks,
2 kHz – 150 kHz

- IEC 61000-4-19 -

Adrian Matoi, EMC Partner

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EMC PARTNER AG

- Founded in 1994
- Swiss private company, headquarters in Laufen (CH)
- Largest choice of impulse generators
- Market leader, reputed worldwide
- Development, production and testing in house
- Global representative network

Largest range of impulse test equipment up to 100 kV and 100 kA
EMC Partner provides conducted immunity test solutions for a broad range of sectors:

- Industry & Household
- Components
- Renewable energy
- Avionics
- Military
- Telecom
Full compliance differential mode testing

- Frequency domain overview
- Disturbance sources and victims
- Voltage test and current test
- Comparison: emission and immunity levels
- Comparison: different immunity tests
- Conclusion
Frequency range overview: emissions

Product norms, ex. IEC/TS 62578
- IEC 61000-4-7
- CISPR 16-1-2 method

IEC 61000-3-2

IEC 61000-4-30 (power quality norm)
- IEC 61000-4-7
- CISPR 16-1-2 method

CISPR 11, 14, 15 (16) ...

DC 2 kHz 9 kHz 150 kHz f [kHz]
Frequency range overview: immunity

IEC 61000-4-19 Differential mode
IEC 61000-4-16 Common mode

DC  2 kHz  9 kHz  150 kHz
Disturbance sources

- In the norm, published 7.05.2014:
  Inverters, Smart meters with PLC comm., Switched power supplies, Variable speed drives, UPS systems, DVD players

- New investigations are carried out for:
  EV charging stations
  Compact fluorescent lamps
  CNC machines
Victims

✓ In the norm, published 7.05.2014:

Solid state meters, Notebooks, Alarm systems, Electronic controls, Card readers

✓ New investigations are carried out for:

Heating systems
Washing machines
Electronic clocks / time circuits (faster)
DC link capacitors in rectifying circuits (thermal stress)
Differential mode as per IEC 61000-4-19

**IEC 61000-4-19**

- **Voltage test**, 2-150 kHz, 20V, \(Z_o = 10\ \Omega\)
- **Current test**, 2-150 kHz, 4A, \(Z_o = 1\ \Omega\)

**Application**
- **Voltage test**: all equipment connected to grid, except current measurement equipment
- **Current test**: equipment with a.c. current measurement port

**EUT**
- Up to 280 V, P – N or P – PE
- 50 Hz or 60 Hz
Waveforms for voltage and current tests

5.1.1 Test wave profile with CW pulses with pause

5.1.2 Test wave profile with rectangular modulated pulses
Waveforms for voltage and current tests

Modulation frequencies:

- 50 Hz: 3 Hz, 101 Hz, 301 Hz, 601 Hz (given in standard)
- 60 Hz: 4 Hz, 121 Hz, 361 Hz, 721 Hz (given in standard)
- Selectable: 1 Hz – 1 kHz
Setup voltage test - IEC 61000-4-19
Calibration of the CDN- voltage test

CDN attenuation

IEC 61000-4-19 voltage test

-80
-70
-60
-50
-40
-30
-20
-10
0
1
10
100
1000

Measured att
Normative limit

frequency [kHz]
attenuation [dB]

CDN
IEC 61000-4-19
voltage test

Measured att
Normative limit

frequency [kHz]
attenuation [dB]

CDN
IEC 61000-4-19
voltage test

Measured att
Normative limit

frequency [kHz]
attenuation [dB]
## Voltage test levels

<table>
<thead>
<tr>
<th>Level</th>
<th>2 kHz [V]</th>
<th>9 kHz [V]</th>
<th>95 kHz [V]</th>
<th>150 kHz [V]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>12</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>x</td>
<td>Special</td>
<td>Special</td>
<td>Special</td>
<td>Special</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voltage test levels</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

The table above shows the voltage test levels for different frequencies. The graph visualizes the relationship between voltage and frequency for each level.
Voltage test setup with IMU SLAVE SMART
EMC Partner provides built-in, adjustable current source 1 – 25 A
Built-in, adjustable current source 1 – 25 A, built-in decoupling Z
## Current test levels

<table>
<thead>
<tr>
<th>Level</th>
<th>2 to 30 kHz</th>
<th>30 to 150 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>x</td>
<td>Special</td>
<td>Special</td>
</tr>
</tbody>
</table>

### Diagram

The diagram illustrates the current test levels across different frequency bands, showing the current intensity (I [A]) at specific frequencies (f [kHz]).
Current test setup 1p with IMU SLAVE SMART
Electricity meters – no reference meter
Current test setup 1p with IMU SLAVE SMART
Electricity meters – with reference meter
Current test setup 1p with IMU SLAVE SMART Electric meters – with reference meter, ext. CT
Current test setup 3p with IMU SLAVE SMART
Electricity meters – no reference meter
Current test setup 3p with IMU SLAVE SMART
Electricity meters – with reference meter
Comparison: emission and immunity levels

Example: IEC/TS 62578 Ed. 2.0/2013: Active infeed converters

2 – 9 kHz IEC 61000-4-7 method and LISN (source impedance problematic)
9 – 150 kHz CISPR 16 method and LISN
Comparison: emission and immunity levels

Example: IEC/TS 62578 Ed. 2.0/2013: Active infeed converters
Emissions 9 – 150 kHz CISPR 16 method and LISN

<table>
<thead>
<tr>
<th></th>
<th>C1 Quasi Peak dB(μV)</th>
<th>C2 Quasi Peak dB(μV)</th>
<th>C3 ( I_{equ} &lt; 100 \text{ A} ) Quasi Peak dB(μV)</th>
<th>C3 ( I_{equ} &gt; 100 \text{ A} ) Quasi Peak dB(μV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 kHz</td>
<td>120,5</td>
<td>128</td>
<td>138</td>
<td>148</td>
</tr>
<tr>
<td>50 kHz</td>
<td>110</td>
<td>117,5</td>
<td>126</td>
<td>135</td>
</tr>
<tr>
<td>150 kHz</td>
<td>82,5</td>
<td>90</td>
<td>100</td>
<td>130</td>
</tr>
</tbody>
</table>
Comparison: emission and immunity levels

Example: IEC/TS 62578 Ed. 2.0/2013: Active infeed converters
QP measurement 200 Hz BW, input 20V@10 kHz from IMU SLAVE SMART

1.7 V ≈ 125 dBµV  
Limit @10 kHz = 145 dBµV
Comparison: emission and immunity levels

Example: IEC/TS 62578 Ed. 2.0/2013: Active infeed converters
QP measurement 200 Hz BW, input 20V@10 kHz from IMU SLAVE SMART

LISN Impedance at 10 kHz ≈ 15 Ω
Comparison: emission and immunity levels

Are the measurement method and LISN from CISPR fully applicable for measuring emissions in frequency domain 9 kHz to 150 kHz?

LISN Impedance: ideal 50 Ω
LISN Impedance at 10 kHz: 15 Ω

Time constant of QP detector: steady state reached > 1 s
Dwell time of signals from IEC 61000-4-19: ~1ms – 3 s
Comparison: emission and immunity levels

IEC 61000-4-30: “…methods of CISPR 16 may not accurately record the characteristics of some immunity test waveforms in IEC 61000-4-19…”

Emission and immunity levels: quo vadis

Current situation:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Normative</th>
<th>Informative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Immunity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEC 61000-4-19</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>IEC 61000-4-16</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Emission</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IEC 61000-4-30</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>IEC 61000-4-7 (2 – 9 kHz)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>IEC 62758 (under consideration)</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
Comparison: different immunity tests

Surge test: frequency spectrum up to 2 MHz (voltage) and 0.15 MHz (current), as described in Annex E of IEC 61000-4-5/2014.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>IEC 61000-4-5</th>
<th>IEC 61000-4-16</th>
<th>IEC 61000-4-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated disturbance</td>
<td>CW surge</td>
<td>Cont/short CM</td>
<td>Cont DM</td>
</tr>
<tr>
<td>Duration</td>
<td>~ 50 µs</td>
<td>100 s / decade</td>
<td>3 s / freq. step</td>
</tr>
<tr>
<td>Output impedance</td>
<td>2 Ω and 12Ω</td>
<td>50 Ω</td>
<td>11 Ω / V 10 Ω</td>
</tr>
<tr>
<td>Coupling</td>
<td>L-N, L/N-PE</td>
<td>L+N - PE</td>
<td>L-N</td>
</tr>
<tr>
<td>SPD activated</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
Can DM and CM be replaced with Surge?
## Test equipment

<table>
<thead>
<tr>
<th>Article Nr.</th>
<th>Voltage Tester</th>
</tr>
</thead>
<tbody>
<tr>
<td>106996</td>
<td>IMU4000 SMART</td>
</tr>
<tr>
<td>*or 106997</td>
<td>IMU3000 SMART</td>
</tr>
<tr>
<td>*Generator Model depends on additional customer requirements</td>
<td></td>
</tr>
<tr>
<td>105685</td>
<td>IMU SLAVE SMART I1V1</td>
</tr>
<tr>
<td>107128</td>
<td>IMU SLAVE SMART I1</td>
</tr>
<tr>
<td>107129</td>
<td>IMU SLAVE SMART V1</td>
</tr>
</tbody>
</table>
Conclusions

✓ Common mode and differential mode tests and test setups are different, and anyway different from surge test

✓ Different generators with different parameters like output impedance, current and voltage range are required to perform the two tests

✓ Additional efforts are required in order to provide adequate emission measurement methods

✓ Immunity test as per IEC 61000-4-19 are mandatory, not informative

✓ As first company in the world to offer a complete test system for IEC 61000-4-19, EMC Partner is ready to meet optimally your testing demands.
Thank you,

www.emc-partner.com