EMC standards

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Types of EMC measures

- Immunity
- Emission
  - Radiated
  - Conducted
The purpose of immunity tests is to subject a product to a controlled stress that represents the likely range which is mostly dedicated by practical aspects and experience of real-world problems.
Immunity tests

1 – transient phenomena
Results of immunity tests are classified into four categories:

Performance Criteria A – ‘Performance within specification limits’

Performance Criteria B – ‘Temporary degradation which is self-recoverable’

Performance Criteria C – ‘Temporary degradation which requires operator intervention’

•Performance Criteria D – ‘Loss of function which is not recoverable’
ESD
IEC 61000-4-2
Electrostatic Discharge (ESD) – IEC 61000-4-2

- Triboelectric charging through motion
- Body capacitance maintains charge voltage
- Discharge to victim equipment
- Return current path
Electrostatic discharge (IEC 61000-4-2)

- Test purpose
- Evaluate the performance of a device submitted to human electric discharge
- Needed instruments:
  - ESD generator
  - Ground plane (horizontal and vertical)
  - Isolant surface
  - 470 kΩ loads
ESD generator
ESD Test setup

- Conducting surface
- Dielectrical material
- Isolating surface
ESD Waveform

**ESD generator equivalent circuit**

Contact discharge

Air discharge

330 Ω

150pF

330 Ω

150pF

Stray capacitance

$I_{pk} = 15A \pm 10\%$

Typical ringing waveform

Ideal calibration waveform

$t_r = 0.7 - 1\text{ ns}$

Current at indicated voltage of 4kV

Schaffner NSG 435
### Table 1 – Test levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Test voltage kV</th>
<th>1b – Air discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1a – Contact discharge</td>
<td>Level</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>x 1)</td>
<td>Special</td>
<td>x 1)</td>
</tr>
</tbody>
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1) "x" is an open level. The level has to be specified in the dedicated equipment specification. If higher voltages than those shown are specified, special test equipment may be needed.
Performance Criteria for Immunity Tests

Results of immunity tests are classified into four categories:

Performance Criteria A – ‘Performance within specification limits’

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Discharge Application

• Application of discharge:
  ✓ Direct: on the surface of the device under test
  ✓ Indirect: in the coupling planes

• Types of discharges:
  ✓ In contact: the conductive surface (head pointed gun)
  ✓ In air: on insolating surfaces (gun head rounded)

• Maximum 1 per second discharge
Choice of discharge points

- Air discharge
- Contact discharge

- Bezels
- Seams
- Keypads
- Protruding LEDs
- Connectors
- Switches
- Apertures
• The discharge return cable of the ESD generator shall be connected to the ground reference plane. The total length of this cable is in general 2 m.
In the case of air discharge testing, the climatic conditions shall be within the following ranges:

- ambient temperature: 15 °C to 35 °C;
- relative humidity: 30 % to 60 %;
- atmospheric pressure: 86 kPa (860 mbar) to 106 kPa (1 060 mbar).
The testing shall be performed by direct and indirect application of discharges to the EUT according to a test plan. This should include:

- representative operating conditions of the EUT;
- whether the EUT should be tested as table-top or floor-standing;
Contact/air discharge

• In the case of contact discharges, the tip of the discharge electrode shall touch the EUT, before the discharge switch is operated.

• In the case of air discharges, the round discharge tip of the discharge electrode shall be approached as fast as possible (without causing mechanical damage) to touch the EUT.

• Link to the standard IEC 61000-4-2
ESD design

Design to avoid ESD problems includes:

- choose circuit configurations that are unresponsive to short transients
- lay out the PCB to minimise induced voltages at critical nodes
- prevent unavoidable discharge transients from coupling into circuits and cables
- design enclosures as far as possible to prevent discharges from occurring
EFT
IEC 61000-4-4
The EFT phenomenon

- When a circuit is switched off, the current flowing through the switch is interrupted more or less instantaneously.
- At the moment of switching there is an infinite \( \frac{di}{dt} \).
- All circuits have some stray inductance associated with the wiring; some types of load, such as motors or solenoids, have considerably more inductance.
The EFT phenomenon

switch opens: arc generated while gap cannot maintain $V_L$

switch closed, current flowing

circuit switched off

$V_L = -L \cdot \frac{di}{dt}$ Limited by $C_s$
• **Purpose of test:**
  Immunity test when subjected to transient disturbances like switching transients.

• **Materials needed:**
  ✓ EFT generator
  ✓ Coupling & decoupling device (internal or external)
  ✓ Capacitive coupling clamp for telecom line
Electric Fast Transients
EFT – Burst – EN 61000-4-4

Burst generator
With integrated CDN

Wave form generator

Coupling/decoupling Network

Ground plane

EUT

Dielectric material

0.1 m

0.1 m
# Test levels

<table>
<thead>
<tr>
<th>Level</th>
<th>On power port, PE</th>
<th>On I/O (input/output) signal, data and control ports</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Voltage peak</td>
<td>Repetition rate</td>
</tr>
<tr>
<td></td>
<td>kV</td>
<td>kHz</td>
</tr>
<tr>
<td>1</td>
<td>0,5</td>
<td>5 or 100</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>5 or 100</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>5 or 100</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>5 or 100</td>
</tr>
<tr>
<td>X</td>
<td>Special</td>
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</tr>
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</table>

**NOTE 1** Use of 5 kHz repetition rates is traditional; however, 100 kHz is closer to reality. Product committees should determine which frequencies are relevant for specific products or product types.

**NOTE 2** With some products, there may be no clear distinction between power ports and I/O ports, in which case it is up to product committees to make this determination for test purposes.

×"X" is an open level. The level has to be specified in the dedicated equipment specification.
Performance Criteria for Immunity Tests

Results of immunity tests are classified into four categories:

- **Performance Criteria A** – ‘Performance within specification limits’
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EFT wave form
EFT Application

- On each conductor
- For at least 1 min
- polarity + And –
- Test levels and intermediate levels
Test setup

- Table-top equipment: EUT located 0.1 m above the ground plane.
- The test generator and CDN placed directly on, and connected to, the ground plane.
- All cables connected to the EUT shall be placed on the insulation support 0.1 m above the ground reference plane.
Test setup

- Either a direct coupling network or a capacitive clamp shall be used for the application of the test voltages.
- Decoupling networks shall be used to protect auxiliary equipment and public networks.
The test procedure includes:

- the verification of the laboratory reference conditions;
- the preliminary verification of the correct operation of the equipment;
- the execution of the test;
- the evaluation of the test results.
Test setup

Key

/ length between clamp and the EUT to be tested (should be 0.5 m ± 0.05 m)

(A) location for supply line coupling

(B) location for signal lines coupling
Capacitive coupling clamp

The Schaffner CDN 8014 - An example of a coupling clamp

Link to the standard IEC 61000-4-4
Surge
IEC 61000-4-5
The surge phenomenon
Surge effects

- Surges impinging on electronic equipment may cause hardware damage and complete failure, or in lesser cases, operational upset.
- Below some level dependent on equipment design, no effect is observed.
- Above this level, a surge may cause the operation of the equipment to change state.
surge parameters vs equipments effects

flashover/energy boundary

DAMAGE

UPSET

cv/dt (di/dt) boundary

NO EFFECT

approximate boundary of real-world events

Transient amplitude – volts or amps

thousands

hundreds

tens

microseconds

milliseconds

Duration

seconds
Surge tests (IEC 61000-4-5)

- **Purpose of test:**
  - Evaluation the immunity of a device across shock waves caused by transient voltages induced by the residual or lightning impulse

- **Materials needed:**
  - Surge wave generator (1.2 / 50 microseconds),
  - Decoupling/coupling network (internal or external)
  - Ground plane
Surge immunity – IEC 61000-4-5

- Surge generator
  - With integrated CDN
- Wave form generator
- Coupling/decoupling Network
- Ground plane
- EUT
- Dielectric material 0.1 m
Surge Waveform, 1.2/50 µs

Waveform of **open-circuit voltage (1,2/50 µs)** at the output of the generator with no CDN connected (waveform definition according to IEC 60060-1)

- Front time: $T_1 = 1.07 \times T = 1.2 \, \mu s \pm 30 \%$
- Time to half-value: $T_2 = 60 \, \mu s \pm 20 \%$

Waveform of **short-circuit current (8/20 µs)** at the output of the generator with no CDN connected (waveform definition according to IEC 60060-1)

- Front time: $T_1 = 1.25 \times T = 8 \, \mu s \pm 20 \%$
- Time to half-value: $T_2 = 20 \, \mu s \pm 20 \%$
Surge Waveform, 10/700 µs

Waveform of **open-circuit voltage** (10/700 µs)
(waveform definition according to **ITU-T K series** and **IEC 60060-1**)

Front time: \( T_1 = 1,67 \times 7 = 10 \, \mu s \pm 30 \% \)
Time to half-value: \( T_2 = 700 \, \mu s \pm 20 \% \).

Waveform of the 5/320 µs **short-circuit current** waveform (definition according to **ITU-T K series** and **IEC 60060-1**)

Front time: \( T_1 = 1,25 \times T = 5 \, \mu s \pm 20 \% \)
Time to half-value: \( T_2 = 320 \, \mu s \pm 20 \% \).
Surge application

For AC lines, synchronise surges to peaks (both polarities) ...

...and zero crossings

period between surge pulses determined by EUT protection capability

surge voltage increased in level steps to maximum
Role of CDN
Results of immunity tests are classified into four categories:

Performance Criteria A – ‘Performance within specification limits’

Performance Criteria B – ‘Temporary degradation which is self-recoverable’

Performance Criteria C – ‘Temporary degradation which requires operator intervention’

Performance Criteria D – ‘Loss of function which is not recoverable’
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kV</td>
</tr>
<tr>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
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<td>4.0</td>
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NOTE  X can be any level, above, below or in between the other levels. This level can be specified in the product standard.
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Surge application

• Differential mode and common mode
• In + and – polarity
• Number of pulses: 5 (for each polarity)
• Phase angles 0 °, 90 ° and 270 °
• Test levels and intermediate levels
Surge Procedure

• Apply at least five positive and five negative surges at each coupling point
• Wait for at least a minute between applying each surge, to allow time for any protection devices to recover
• For ac mains,
  - Apply the surges line to line (three combinations for 3-phase delta, six for 3-phase star, one for single phase) and line to
Comparision between transient tests
Comparision of transient standards

- The “energy measure” of a given waveform can be described as:

\[ W = \frac{1}{R} \int_0^T \left( \frac{V(t)}{2} \right)^2 dt \]

\[ W = R \int_0^T \left( \frac{I(t)}{2} \right)^2 dt \]

- ESD: waveform magnitude in ns
- Surge test is more energetic than ESD and EFT
- EFT: waveform magnitude in ns
Immunity tests

2 – LF and RF phenomena
RF coupling phenomenon

RF emitters
Radiated immunity
IEC 61000-4-3
• Test purpose
  Evaluate the performance of a device submitted to radiated RF field

• Needed instruments:
  ✓ RF generator
  ✓ Power amplifier
  ✓ Directional coupler
  ✓ Power meter
  ✓ Antenna(s)
Overview

Radiated immunity – IEC 61000-4-3

Antenna

Power amplifier

Generator

Field meter

Optic fiber

Field uniformity
Results of immunity tests are classified into four categories:

Performance Criteria A – ‘Performance within specification limits’

Performance Criteria B – ‘Temporary degradation which is self-recoverable’

Performance Criteria C – ‘Temporary degradation which requires operator intervention’

• Performance Criteria D – ‘Loss of function which is not recoverable’
Equipments

• Anechoic chamber: of a size adequate to maintain a uniform field of sufficient dimensions with respect to the equipment under test (EUT). Additional absorbers may be used to damp reflections in chambers which are not fully lined.

• RF signal generator(s) capable of covering the frequency band of interest and of being amplitude modulated by a 1 kHz sine wave.
Equipments

• **Field generating antennas**: biconical, log periodic, horn or any other linearly polarized antenna system capable of satisfying frequency requirements.

• **An isotropic field sensor with adequate immunity of any head amplifier and optoelectronics** to the field strength to be measured, and a fibre optic link to the indicator outside the chamber.

• **Associated equipment to record the power**
Frequency range

- The tests are normally performed without gaps in the frequency range 80 MHz to 1 000 MHz.

- Test levels related to the protection against RF emissions from digital radio telephones and other RF emitting devices
  - The tests are normally performed in the frequency ranges 800 MHz to 960 MHz and 1.4 GHz to 6.0 GHz.
The purpose of field calibration is to ensure that the uniformity of the field over the test sample is sufficient to ensure the validity of the test results.

IEC 61000-4-3 uses the concept of a uniform field area, which is a hypothetical vertical plane of the field in which variations are acceptably small.

A database for setting the required field strength for the test sample is available.
Calibration of field

- A full field calibration process should be carried out annually and when changes have been made in the enclosure configuration.

- The UFA is subdivided into a grid with a grid spacing of 0.5 m (example an 1.5 m × 1.5 m UFA).

- At each frequency, a field is considered uniform if its magnitude measured at the grid points is within 0/+6 dB of the nominal value for not less than 75% of all grid points.
Calibration of field

• Calibration is performed at 1.8 times the desired field strength.
• For testing at 10V/m the calibration is run at 18V/m
• The reason of running a test at 1.8x the level is to verify the RF amplifier has the ability to reach the required field when the 80% 1KHz Amplitude Modulation is applied.
AM modulation

80% modulation gives 1.8 times peak level of unmodulated signal
Considerations for equipments choice

• Select an antenna to use.
  – Frequency range
  – Power handling
  – Beam width & gain

• Select the correct amplifier
  – Use calculated power to select the correct amplifier
  – Needs to be selected at the 1dB compression point
  – Calculate power requirements
Results of immunity tests are classified into four categories:

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## Test levels

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<tbody>
<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>x</td>
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**NOTE**  
$x$ is an open test level and the associated field strength may be any value. This level may be given in the product standard.
## Standards calls

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<td><strong>Related IEC</strong></td>
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<td>IEC 61000-6-2</td>
<td>-</td>
<td>CISPR 14-2</td>
<td>CISPR 20</td>
<td>CISPR 24</td>
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<td>Radio comms equipment: common requirements</td>
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<td>Requirements</td>
<td></td>
<td></td>
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### Radiated RF
- 3 V/m 80% AM 80-1000 MHz to EN 61000-4-3
- 10 V/m 80% AM 80-1000 MHz to IEC 61000-4-3, except broadcast bands where level is 3 V/m (2005 version adds tests up to 2.7 GHz)
- 3 V/m 80% AM 80-1000 MHz to EN 61000-4-3, with exclusion band, disregarding narrowband responses
- 3 V/m 80% AM 80-1000 MHz to EN 61000-4-3, only category IV apparatus, and ride on toys with electronics in category III
- 125 dBmV/m (1.78 V/m) 80% AM 0.15-150 MHz in open stripline, reductions at some frequencies for receivers and VTRs; plus 900 MHz 3 V/m 200 Hz keyed carrier
- 3 V/m 80% AM ≤80-1000 MHz to EN 61000-4-3, extra spot frequency functional test for TTE

### Conducted RF
- 3 V rms 80% AM 0.15-80 MHz to EN 61000-4-6 on AC power and functional earth ports, and all signal, control and DC power ports > 3 m
- 10 V rms 80% AM 0.15-80 MHz to ENV 50141, except 47-68 MHz where level is 3 V rms: all ports except signal lines < 3 m
- 3 V rms 80% AM 0.15-80 MHz to EN 61000-4-6 on AC power, and signal, telecomm, control and DC power ports > 3 m, with exclusion band, disregarding narrowband responses
- 3 V rms 80% AM 0.15-80 MHz to EN 61000-4-6 on AC power ports, 1 V rms on DC and signal ports > 3 m, category IV, extending to 230 MHz for cats. II and III
- RF common mode 126 dBmV/ermf 26-30 MHz, antenna terminal; induced voltages at mains and audio terminals, 0.15-150 MHz 80% AM up to 130 dBmV/ermf
- 3 V rms 80% AM 0.15-80 MHz to EN 61000-4-6 on power and all signal cable ports > 3 m, extra spot frequency functional test for TTE

### LF magnetic field
- 3 A/m to EN 61000-4-8, susceptible devices only
- 30 A/m to EN 61000-4-8, susceptible devices only
- Not applicable
- Not applicable
- Not applicable
- Not applicable
- 1 A/m to EN 61000-4-8, susceptible devices only
Field strength

- The resultant field is computed as follows:

\[ e = \frac{\sqrt{30p}}{d} \]

- \( p \) is the radiated power
- \( d \) is the distance between the antenna and the field measure
Conducted immunity
IEC 61000-4-6
RF coupling phenomenon

RF emitters
Radiated immunity  
(IEC 61000-4-3)

- **Test purpose**
  Evaluate the performance of a device submitted to conducted electromagnetic field

- **Needed instruments:**
  - RF generator
  - Power amplifier
  - Directional coupler
  - Dual power meter
  - Coupling device (CDN, EM clamp, Current...
Conducted immunity – IEC 61000-4-6
Coupling devices
Coupling and decoupling devices shall be used for appropriate coupling of the disturbing signal to the various cables connected to the EUT and for preventing applied test signals from affecting other devices, equipment and systems that are not under test. The coupling and decoupling devices can be combined.
Rules for selecting the injection method

1. Check the following requirements:
   I. 150 Ω AE impedance
   II. Cable 30 mm to 50 mm above GRP
   III. AE sufficiently immune

2. If all requirements are met, use clamp or current clamp injection (subclause 7.3).
3. If requirements cannot be met, use clamp or current clamp injection (subclause 7.4).
## Types of CDNs

<table>
<thead>
<tr>
<th>Typ</th>
<th>Interconnected lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1, M2, M3, M4, M5, M2+M3</td>
<td>Unscreened supply (mains)</td>
</tr>
<tr>
<td>AF2, AF4, AF6, AF8</td>
<td>Unscreened nonbalanced lines</td>
</tr>
<tr>
<td>S1, S2, S9, S25</td>
<td>Screened lines</td>
</tr>
<tr>
<td>T2, T4, T8</td>
<td>Unscreened balanced lines</td>
</tr>
<tr>
<td>RJ11, RJ45</td>
<td>Unscreened data lines</td>
</tr>
<tr>
<td>RJ11/S, RJ45/S, USB</td>
<td>Screened data lines</td>
</tr>
</tbody>
</table>
Results of immunity tests are classified into four categories:

Performance Criteria A – ‘Performance within specification limits’

Performance Criteria B – ‘Temporary degradation which is self-recoverable’

Performance Criteria C – ‘Temporary degradation which requires operator intervention’

Performance Criteria D – ‘Loss of function which is not recoverable’
Typical test levels

Table 1 – Test levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Voltage level (e.m.f.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$U_0$</td>
<td>$U_0$</td>
</tr>
<tr>
<td></td>
<td>dB(μV)</td>
<td>V</td>
</tr>
<tr>
<td>1</td>
<td>120</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>130</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>140</td>
<td>10</td>
</tr>
<tr>
<td>$X^a$</td>
<td></td>
<td>Special</td>
</tr>
</tbody>
</table>

$^a$ X is an open level.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Related IEC</td>
<td>IEC 61000-6-1</td>
<td>IEC 61000-6-2</td>
<td>-</td>
<td>CISPR 14-2</td>
<td>CISPR 20</td>
<td>CISPR 24</td>
</tr>
<tr>
<td>Scope</td>
<td>Residential, commercial, light industry generic</td>
<td>Industrial generic</td>
<td>Radio comms equipment: common requirements</td>
<td>Household appliances, electric tools and similar</td>
<td>Broadcast receivers and associated equipment</td>
<td>Information technology equipment</td>
</tr>
<tr>
<td>Test</td>
<td>Requirements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Radiated RF</strong></td>
<td>3 V/m 80% AM 80-1000 MHz to EN 61000-4-3</td>
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<td>3 V rms 80% AM 0.15-80 MHz to EN 61000-4-6 on AC power and functional earth ports, and all signal, control and DC power ports &gt; 3 m</td>
<td>10 V rms 80% AM 0.15-80 MHz to ENV 50141, except 47-68 MHz where level is 3 V rms: all ports except signal lines &lt; 3 m</td>
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<td>RF common mode 126 dBmV/εm 26-30 MHz, antenna terminal; induced voltages at mains and audio terminals, 0.15-150 MHz 80% AM up to 130 dBmV emf</td>
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<td>Not applicable</td>
<td>Not applicable</td>
<td>1 A/m to EN 61000-4-8, susceptible devices only</td>
</tr>
</tbody>
</table>
Calibrating the injected level

- substitution method

- The power required to give this same stress level is repeated in the actual test.

- For the 150 ohms systems, the required power: \( \frac{v_{\text{stress}}}{6} \) or \( V_{\text{stress}} - 15.6 \text{ dB (resistive divider)} \)

- For the 50 ohms systems, the required power: ...
Immunity to magnetic fields
IEC 61000-4-8
Magnetic field immunity – IEC 61000-4-8

50 Hz

EUT

MC 2630

UCS 500M

MV2616
Performance Criteria for Immunity Tests

Results of immunity tests are classified into four categories:

- **Performance Criteria A** – ‘Performance within specification limits’
- **Performance Criteria B** – ‘Temporary degradation which is self-recoverable’
- **Performance Criteria C** – ‘Temporary degradation which requires operator intervention’
- **Performance Criteria D** – ‘Loss of function which is not recoverable’
<table>
<thead>
<tr>
<th>Test</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radiated RF</strong></td>
<td>3 V/m 80% AM 80-1000 MHz to EN 61000-4-3 10 V/m 80% AM 80-1000 MHz to IEC 61000-4-3, except broadcast bands where level is 3 V/m (2005 version adds tests up to 2.7 GHz) 3 V/m 80% AM 80-1000 MHz to EN 61000-4-3, with exclusion band, disregarding narrowband responses 3 V/m 80% AM 80-1000 MHz to EN 61000-4-3, only category IV apparatus, and ride on toys with electronics in category III 125 dBmV/m (1.78 V/m) 80% AM 0.15-150 MHz in open stripline, reductions at some frequencies for receivers and VTRs; plus 900 MHz 3 V/m 200 Hz keyed carrier 3 V/m 80% AM ≤80-1000 MHz to EN 61000-4-3, extra spot frequency functional test for TTE</td>
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</tbody>
</table>
Immunity to voltage dips and short interruptions
IEC 61000-4-11
Voltage dips and short interruptions
IEC 61000-4-11

Power fail generator

Variac
Results of immunity tests are classified into four categories:

Performance Criteria A – ‘Performance within specification limits’

Performance Criteria B – ‘Temporary degradation which is self-recoverable’

Performance Criteria C – ‘Temporary degradation which requires operator intervention’

• Performance Criteria D – ‘Loss of function which is not recoverable’
Voltage dips and short interruptions - EN 61000-4-11 Overview

**Figure 6M** Example of a 'dip'

A 40% dip with a 20ms duration

60% of V_{NOM}

20ms

This dip started and finished at zero-crossings (as in most tests using IEC 61000-4-11) but real-life dips can happen at any phase angles

**Figure 6N** Example of a 'short interruption'

A 60ms interruption in the mains supply

50ms

This interruption started and finished at zero-crossings (as in most tests using IEC 61000-4-11) but real-life interruptions can happen at any phase angles

**Figure 6S** A typical 'sag' test (example of a 50% sag for 1 second)

Volts rms

230V

115V

Seconds
Emission tests
Emission
CISPR 22 / EN 55022
An ITE is able to perform:
- Receive data from an external source;
- Perform treatments
- Provide a result
• The class B ITE is intended primarily for use in a residential area and may include:
  ✓ the devices having no fixed location of use, such as portable battery powered or batteries incorporated;
  ✓ the telecommunication terminal equipment supplied by a telecommunications network;
  ✓ personal computers and auxiliary devices connected to them.
• Class A consists of all other ATI complying with the limits of disturbance of class A but not those of class B.
• Can be used in commercial or industrial environment.
Conducted emissions
CISPR22/EN 55022
Required equipments

• For power supply lines:
  ✔ LISN (Lines Impedance Stabilisation Network)

• For data lines:
  ✔ ISN (Impedance Stabilisation Network)

• Transient limiter

• EMI receiver or spectrum analyser

• EMI software
Conducted emission – CISPR 22
EN 55022

LISN

Transient

GPIB

Frequency (MHz)

dBµV

0.15 30
0.5 1 5 100
80
10
20
30
40
50
60
70

Conduit CLASSE B Average
Conduit CLASSE B QP
Conducted emission test setup

**L’arrière de l’appareil est placé au ras du bord de la table**

**Table non conductrice**

**AMN = Réseau fictif**
**AE = Appareil auxiliaire**
**EUT = Appareil à l’essai**
**RSI = Réseau de stabilisation d’impédance**
Conducted emissions

Measurement of conducted electromagnetic disturbances must be made:

- by means of a measuring receiver
- with a peak detector
- in the frequency range 9 kHz to 30 MHz.
Conducted limits

• The EUT shall respect the limits of Tables 1 and 2 which include limits on the mean value and limits on quasi-peak value

• A receiver is used to average value detection and a quasi-peak detector
Emission thresholds

Example of reporting measurement uncertainty
(EN 55022 QP Class B shown)

Conducted Emissions dBμV

Limit line plus measurement uncertainty

Pass/fail not proven in shaded area

Limit line minus measurement uncertainty

EN 55022 QP Class B limit line

f MHz
Radiated emissions
CISPR22/EN 55022
Required equipments

- Receiving antennas
- EMI receiver or spectrum analyser
- EMI software
Radiated emission - CISPR22/EN 55022

- Frequency (MHz)
- dBµV/m
- ≥ 0.4 m
- 0.8 m

Graph showing emissions with limits for Class B.
Test setup for radiated emission
Radiated emission

- The measurement of radiated electromagnetic disturbances must be performed by means of a measuring receiver equipped with a quasi-peak detector in the frequency range 30 MHz to 1 GHz or 6 GHz.

- A receiving antenna, associated with a measuring receiver, is placed at a specific location.
• Peak measure to determine the most perturbing condition

• Determining antenna polarisation that most generate disturbances

• For every frequency:

  Determine the antenna height that most generate disturbances.
Radiated field measurement

- EUT
- Measurement antenna
- Reflecting ground
- 1 to 4 m
Open area test site
Frequency (MHz)

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>dBµV/m</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1000</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>600</td>
<td>800</td>
</tr>
</tbody>
</table>

Limite Classe B 55022

Link to the standard EN 55022
Harmonics emission
IEC 61000-3-2
Harmonics emission

Causes

- They are generated by devices that consume non-sinusoidal current, such as fluorescent lighting or power supplies (equipment components nonlinear diodes, thyristors ...)

Effects
Harmonics emission – IEC 61000-3-2

Stable source

Harmonics analyser

EUT
DPA connection

Diagram showing the connection between a PC Computer, NetWave, DPA 500N1 Power Analyser, and various power inputs and outputs.
Spectral effects

Temporal

Spectral
Time vs frequency representation
There are 4 different classes in the EN 61000-3-2 that have different limit values:

- Class A: Balanced 3-phase equipment, household appliances excluding equipment identified as class D, tools, excluding portable tools, dimmers, for incandescent lamps, audio equipment, and all other equipment, except that stated in one
Test procedure

1. Select the correct test observation period (Table 6.1) of the EUT (min. 10s)

2. Enter the following data (only Class C and D), if available
   Class D : Max. Power or Class C : Maximum Fund. current and Max Power Factor

1. Start the measuring

2. Upload the data to the computer

3. Select the Class A...D

4. Start the evaluation
Data flow

• The DPA measures simultaneously on all 2 or 6 input channels, carries out the Fourier transformation in real time.
• Stores all data on the internal hard disk.
• When measuring fluctuations the system generates approx. 1 Mbyte data per minute on the hard disk. The upload of a 2.5 minute measurement needs less than 20 seconds.
Test parameters

Evaluation acc. EN/IEC or JIS C 61000-3-2

Standard
- EN/IEC 61000-3-2 Ed.3
- JIS C 61000-3-2 (Japan)

Select class
- Class A ≤ 150% of the limit
- Class B
- Class C > 25W
- Class D
- Class X

Percentage of limits
- Enable [ ]
- Percent 100%

Japan Parameters
- Vnam: 100.00 V
- 1 Ph. [ ] 3 Ph. Delta [ ]
- Household luminaire [ ]

Maximum smoothed data
- Power: 23.70 W
- Fund. Current: 0.106 A
- Power Factor: 0.557

Evaluation
End
Limit values are indicated and harmonics exceeding the specified limit are marked in red colour.
Flickers emission
IEC 61000-3-3
Flicker standards are imposed to limit voltage variations caused by loads connected to the supply network that would cause lights connected at the same circuit to flicker.

For device single phase up to 16A the standard
Flickers emission – IEC 61000-3-3

Stable source

Flickers analyser

USB

EUT
The flicker analysis is based on a standards library including the basic standards but also, and even more important, product-specific Requirements such as hair dryers and vacuum cleaners.

The actual flicker values are continuously displayed. A test can be stopped once a limit is exceeded. This could, in case, safe valuable test time.
After the flicker measurement the values of dc, dmax, dt are displayed on the screen.

- dc: Relative continuous voltage variation (must be smaller than 3.3%) The dc value is a % value relative to the nominal AC voltage of 230V AC.

- dmax: Max. relative voltage variation (must be smaller than 4.7%) The dmax value is a % value relative to the nominal AC voltage of 230V AC.
Limits

• The limits shall be applicable to voltage fluctuations and flicker at the supply terminals of the equipment under test:

• The following limits apply:
  – the value of $P_{st}$ shall not be greater than 1,0;
  – the value of $P_{lt}$ shall not be greater than 0,65;
  – the value of $d(t)$ during a voltage change shall not exceed 3,3 % for more than 500 ms;
  – the relative steady-state voltage change, $dc$, shall
Limits

the maximum relative voltage change $d_{\text{max}}$, shall not exceed

a) 4 % without additional conditions;

b) 6 % for equipment which is:
   • switched manually, or
   • switched automatically more frequently than twice per day

c) 7 % for equipment which is
   • attended whilst in use
   • switched on automatically, or is intended to be switched on manually, no more than twice per day, and also has either a delayed restart
# Test results

**Result flicker measurement (maximum value)**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>Limit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pst</td>
<td>0.758</td>
<td>0.758</td>
<td>0.758</td>
<td>1.00</td>
<td>PASS</td>
</tr>
<tr>
<td>Plt</td>
<td>0.498</td>
<td>0.498</td>
<td>0.498</td>
<td>0.65</td>
<td>PASS</td>
</tr>
<tr>
<td>dc [%]</td>
<td>2.986</td>
<td>2.986</td>
<td>2.985</td>
<td>3.00</td>
<td>PASS</td>
</tr>
<tr>
<td>dmax [%]</td>
<td>5.121</td>
<td>5.126</td>
<td>5.126</td>
<td>4.00</td>
<td>FAIL</td>
</tr>
<tr>
<td>dt [s]</td>
<td>0.030</td>
<td>0.030</td>
<td>0.030</td>
<td>0.20</td>
<td>PASS</td>
</tr>
</tbody>
</table>

- Measurement time: 10 min
- Number of measurement: 12

![Graph showing U(t) with annotations for dc, dmax, and tolerance band](image)

- Steady state value
- Trigger point
- Tolerance band

U(t) over time (t)
Example of a product standard

EN 55024
Example of a generic standard

EN 61000-6-1
Example of a test report

Link
EMC standards

Presented by: Karim Loukil & Kaïs Siala