ITU Training on Conformance and Interoperability for ARB Region
CERT, 2-6 April 2013,

EMC standards

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Types of EMC measures

- Emission
- Immunity
- 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
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
  ✓ 2 x 470 kΩ resistances
ESD generator
ESD Test setup

Conducting surface

Dielectrical material

Isolating surface
ESD Waveform

**ESD generator equivalent circuit**

Schaffner NSG 435

- **Contact discharge**
  - 330 Ω
  - 150pF
  - stray capacitance

- **Air discharge**
  - 330 Ω
  - 150pF

- **Calibration waveform**
  - $I_{pk} = 15A \pm 10\%$
  - typical ringing waveform
  - 8A ±30%
  - 4A ±30%
  - $t_r = 0.7 - 1\text{ns}$
  - current at indicated voltage of 4kV

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[Image of the circuit with labels and values]
# Table 1 – Test levels

<table>
<thead>
<tr>
<th>Level</th>
<th>Test voltage kV</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>x</td>
<td>Special</td>
<td>x 1)</td>
<td>Special</td>
</tr>
</tbody>
</table>

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.
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</table>
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 insulating surfaces (gun head rounded)

• one discharge each 3 sec

• 10 discharges + and - by point of application

• 4 test levels

• For high levels we must pass by intermediate levels
Choice of discharge points

- Air discharge
- Contact discharge

- Bezels
- Seams
- Keypads
- Protruding LEDs
- Connector shells
- 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 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).
Execution of the test

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;
- the points at which discharges are to be applied;
- at each point, whether contact or air discharges are to be applied;
- the test level to be applied;
- the number of discharges to be applied at each point for compliance testing;
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](https://www.iec.ch/publications)
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 in the load itself.
• The voltage developed across an inductance $L$ by a changing current $i$ is:

$$V = -L \cdot \frac{di}{dt}$$
The EFT phenomenon

switch closed, current flowing

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

$V_L = -L \cdot \frac{di}{dt}$ Limited by $C_s$

Circuit switched off
Electrical fast transients
IEC 61000-4-4

• **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 coupling
  ✓ Capacity of 33 nF for direct injection
  ✓ Ground plane
Electric Fast Transients

EFT – Burst – EN 61000-4-4

- Burst generator
  - With integrated CDN
- Wave form generator
- Coupling/decoupling Network
- EUT
- Ground plane
- Dielectric material
## 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>
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<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>
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</tr>
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**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.

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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

direct strike to primary supply

direct strike to LV supply (esp. in rural areas)

ground strike

fault clearance

Lightning Protection Zone 0

LPZ1

LPZ2
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 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

Dielectric material 0.1 m

EUT
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)

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)
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)

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

Front time: $T_1 = 1.67 \times T = 10 \, \mu s \pm 30 \%$

Time to half-value: $T_2 = 700 \, \mu s \pm 20 \%$

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:

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### Test levels

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<th>Open-circuit test voltage ±10 %</th>
<th>kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>Special</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 earth (two combinations for single phase, three for 3-phase delta, four for 3-phase star).
  - Synchronise the surges to the zero crossings and the positive and negative peaks of the mains supply (four phase values), and apply five pulses in each polarity at each phase.
- Increase the test voltage in steps up to the specified maximum level, so that all lower test levels are satisfied.
Choice of coupling devices

Link to the standard
IEC EN 61000-4-5

Selecting the coupling/decoupling network method

- Mains? [Yes/No]
  - Yes: Coupling?
    - Line to ground
    - Line to line
      - 1 phase: Figure 7
        - 3 phases: Figure 9
      - 1 phase: Figure 8
        - 3 phases: Figure 10
  - No: Shielded?
    - Yes: Symmetrical?
      - Yes: Via arrestors or clamping circuit: Figure 14
        - Via capacitors: Figure 15
        - Or direct (without CDN)
    - No: Grounded at each end: Figure 16
      - Grounded at one end: Figure 17
      - Multiple grounded cables: Figure 18
      - Via capacitors: Figure 11
      - Via arrestors: Figure 12
      - Via clamping devices: Figure 13
Comparision between transient tests
Comparision of transient standards

• The “energy measure” of a given waveform can be described by

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

• ESD : waveform magnitude in ns

• EFT : waveform magnitude in ns

• Surge : waveform magnitude in µs

Surge test is more energetic than ESD and EFT
Immunity tests

2 – LF and RF phenomena
RF coupling phenomenon

RF emitters
Radiated immunity
IEC 61000-4-3
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)
  ✓ Field-meter
Overview

Radiated immunity – IEC 61000-4-3

Field meter

Optic fiber

Field uniformity

Antenna

Power amplifier

Generator

GPIB
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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 with a modulation depth of 80%**.

• **Power amplifiers:** to amplify signal (unmodulated and modulated) and provide antenna drive to the necessary field level.
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 levels necessary for the required field strength** and to control the generation of that level for testing.
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 immunity test is obtained.

The field calibration is valid for all EUTs whose individual faces (including any cabling) can be fully covered by the UFA.
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.
• An EMC Lab performing testing at multiple levels 1V/m, 3V/m, 10V/m, 30V/m, and/or others, they need only to perform the calibration at 1.8x the max level they will test to and then they can scale the power down.
AM modulation

unmodulated

80% modulated

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
• Antenna data: based on measured data or gain
  • Calculate out all loses between amplifier and antenna
  • Cables, directional coupler and connectors
  • Intended test distance (1 to 3 meters)
Performance Criteria for Immunity Tests

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<th>Level</th>
<th>Test field strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 V/m</td>
</tr>
<tr>
<td>2</td>
<td>3 V/m</td>
</tr>
<tr>
<td>3</td>
<td>10 V/m</td>
</tr>
<tr>
<td>4</td>
<td>30 V/m</td>
</tr>
<tr>
<td>x</td>
<td>Special</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td><strong>Related IEC</strong></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><strong>Scope</strong></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><strong>Test</strong></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/m 80% AM 80-1000 MHz to EN 61000-4-3, only category IV apparatus, and ride on toys with electronics in category III</td>
<td>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</td>
<td>3 V/m 80% AM ≤80-1000 MHz to EN 61000-4-3, extra spot frequency functional test for TTE</td>
</tr>
<tr>
<td><strong>Conducted RF</strong></td>
<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>
<td>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 &gt; 3 m, with exclusion band, disregarding narrowband responses</td>
<td>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 &gt; 3 m, category IV, extending to 230 MHz for cats. II and III</td>
<td>RF common mode 126 dBmV emf 26-30 MHz, antenna terminal; induced voltages at mains and audio terminals, 0.15-150 MHz 80% AM up to 130 dBmV emf</td>
<td>3 V rms 80% AM 0.15-80 MHz to EN 61000-4-6 on power and all signal cable ports &gt; 3 m, extra spot frequency functional test for TTE</td>
</tr>
<tr>
<td><strong>LF magnetic field</strong></td>
<td>3 A/m to EN 61000-4-8, susceptible devices only</td>
<td>30 A/m to EN 61000-4-8, susceptible devices only</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>1 A/m to EN 61000-4-8, susceptible devices only</td>
</tr>
</tbody>
</table>
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 clamp, …)
  - 6 dB attenuator
Conducted immunity – IEC 61000-4-6
Coupling devices

- CDN
- EM clamp
- Current probe
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 into one box (a coupling/decoupling network, CDN) or can consist of several parts.
- The preferred coupling and decoupling devices are the CDN, for reasons of test reproducibility and protection of the AE.
- However, if they are not suitable or available, other injection methods can be used.
Rules for selecting the injection method

Selecting injection method

Are CDNs suitable?

YES
Use CDN injection subclause 7.2

NO

Is clamp injection applicable?

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

NO
Use direct injection subclause 7.5

Can requirements be met?

YES
Use clamp or current clamp injection subclause 7.3

NO
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>
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 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($\mu$V)</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>Special</td>
<td></td>
</tr>
</tbody>
</table>

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$^a$ X is an open level.</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Related IEC</td>
</tr>
<tr>
<td>Scope</td>
</tr>
</tbody>
</table>

**Test Requirements**

| 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 emf 26-30 MHz, antenna terminal; induced voltages at mains and audio terminals, 0.15-150 MHz 80% AM up to 130 dBmV emf | 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 | 1 A/m to EN 61000-4-8, susceptible devices only |
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: \( \frac{v_{stress}}{6} \) or \( V_{stress} - 15.6 \text{ dB} \) (resistive divider)

- For the 50 ohms systems, the required power: \( \frac{V_{stress}}{2} \) or \( V_{stress} - 6 \text{ dB} \) (open circuit)
Immunity to magnetic fields
IEC 61000-4-8
Magnetic field immunity – IEC 61000-4-8

50 Hz

EUT

MC 2630

UCS 500M

MV2616
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### Radiated RF
- **3 V/m 80% AM 80-1000 MHz to EN 61000-4-3**
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- **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
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### 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
- **1 A/m to EN 61000-4-8, susceptible devices only**
Immunity to voltage dips and short interruptions
IEC 61000-4-11
Voltage dips and short interruptions –
IEC 61000-4-11

Power fail generator

Variac

EUT
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’
Voltage dips and short interruptions – EN 61000-4-11

Overview
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.
Equipements Classes (2)

- Class A consists of all other AT systems 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 – CISPR22/EN 55022

LISN

Transient limiter

GPIB

EMI receiver or spectrum analyser
Conducted emission test setup

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 dBuV

- Limit line plus measurement uncertainty
- "Pass/fail not proven" in shaded area
- EN 55022 QP Class B limit line
- Limit line minus measurement uncertainty

"Fail"

"Pass"

f MHz
Radiated emissions
CISPR22/EN 55022
Required equipments

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

EMI receiver or spectrum analyser

GPIB

≥ 0.4 m

10 m or 3 m

0.8 m
Test setup for radiated emission
Radiated emission

• The measurement of radiated electromagnetic disturbance 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 distance from the EUT (test equipment)
Radiated EM field measure

• Peak measure to determine the most perturbing condition

• Determining antenna polarisation that most generate disturbances

• For every frequency:
  ✓ Determine the antenna height that captures the maximum measured level
  ✓ Determine the angle that generated the maximum of disturbances
Radiated field measurement

Measurement antenna

Reflecting ground

1 to 4 m
Open area test site

Site de mesure en espace libre
Measure

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
• Heating cables (neutral wire three-phase)
• Premature aging of electronic components
Harmonics emission – IEC 61000-3-2

Stable source

Harmonics analyser

EUT
DPA connection
Spectral effects

Temporal

Spectral
Time vs frequency representation

![Graph showing time vs frequency data with various parameters and readings.](image-url)
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 of the following classes.

- Class B: Portable tools, arc welding equipment which is not professional equipment

- Class C: Lighting equipment.

- Class D: PC, PC monitors, radio, or TV receivers. Input power $P \leq 600$ W.
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
5. Print the report
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. An internal timer in the DPA stops automatically the measurement.

• The data are ready for upload on the internal hard disk.

• The DPA will overwrite the measurement by starting the next measurement.
Test parameters

[Image of a software interface showing options for Standard, Select class, Percentage of limits, Japan Parameters, and Maximum smoothed data.]
Test result

Limit values are indicated and harmonics exceeding the specified limit are marked in red colour.
Flickers emission
IEC 61000-3-3
Flicker

- 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 EN IEC 61000-3-3 sets the limits for voltage fluctuation caused by electrical apparatus.
Flickers emission – IEC 61000-3-3

Stable source  Flickers analyser  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, save valuable test time.
Flickers parameters

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% or 6.7%). The dmax value is a % value relative to the nominal AC voltage of 230V AC.
- **dt**: Time with voltage variation >3.3%. During max. 500ms the voltage is allowed to be above the 3.3% limit.
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, $d_c$, shall not exceed 3,3 %;
Limits

- the maximum relative voltage change $d_{max}$, 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>

- **dc**: 3.3%  
- **dmax**: 3.3%  
- **Steady state value**:  
- **Trigger point**:  
- **Tolerance band**:  

**Graph:**
- **U (t)**
- **dc**: Vertical line at 3.3%
- **dmax**: Horizontal line at 3.3%
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

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Kais.siala@cert.mincom.tn