

Introduction to conducted immunity

Demystifying EMC 2018
22 January 2018

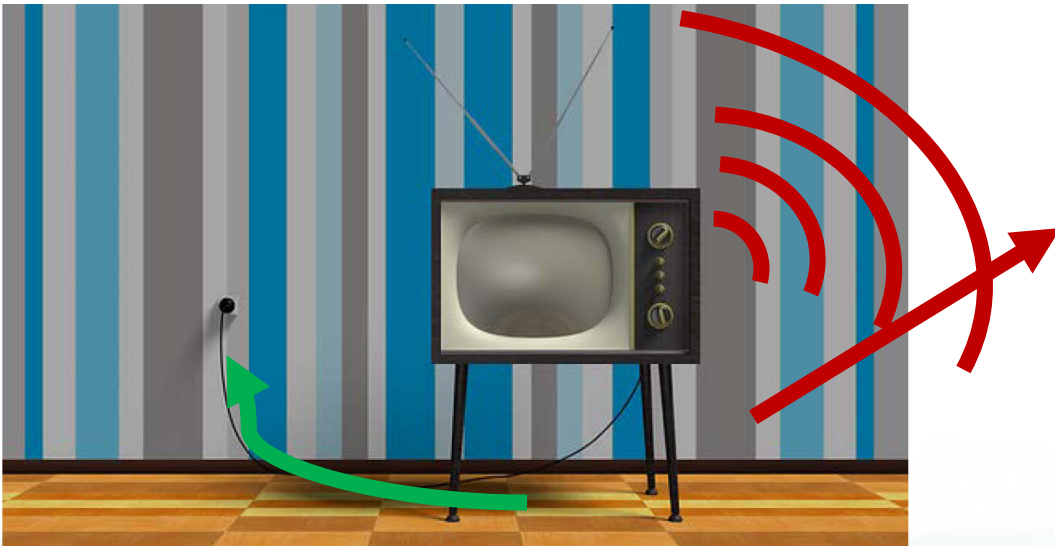


✓What is EMC?

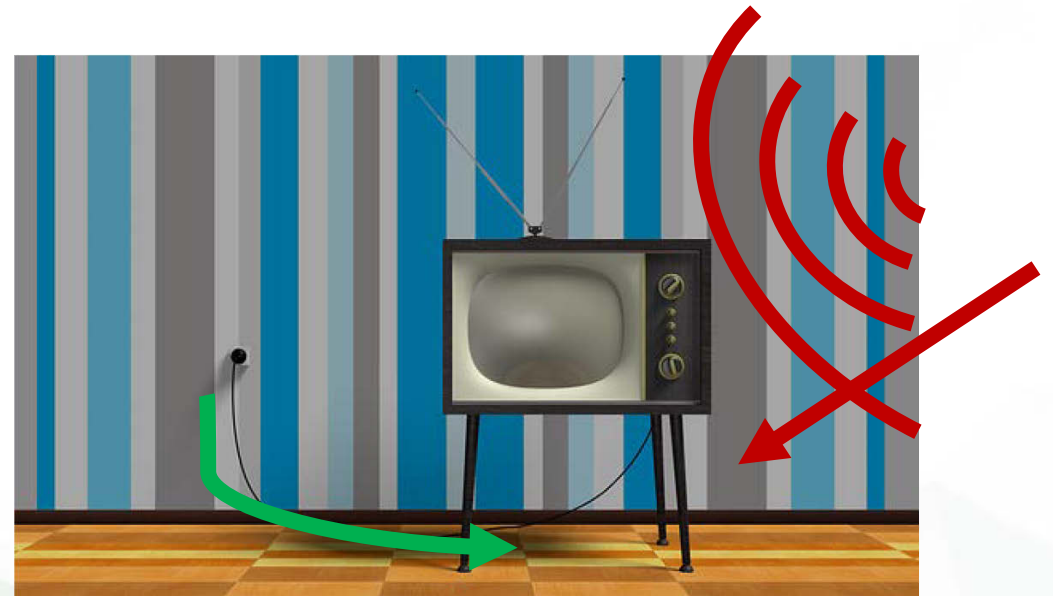
- Conducted interference sources
- Structure of standards
- ElectroStatic Discharges ESD
- Electric Fast Transients EFT (Burst)
- Lightning Stroke (Surge)
- Voltage dips, short interruption and variation
- Damped oscillatory wave
- Basic information about CE mark testing

The two faces of EMC

Emission

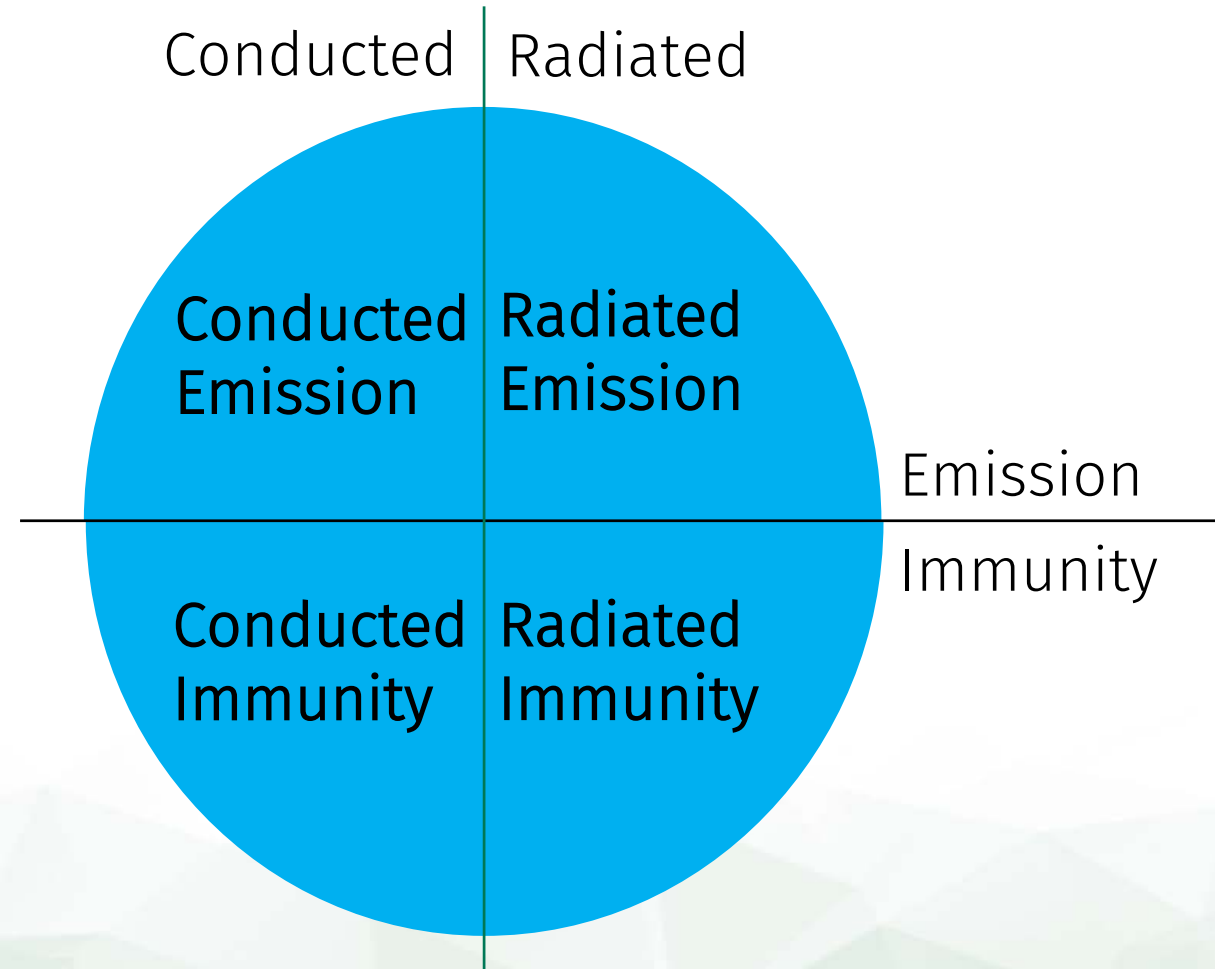


Immunity



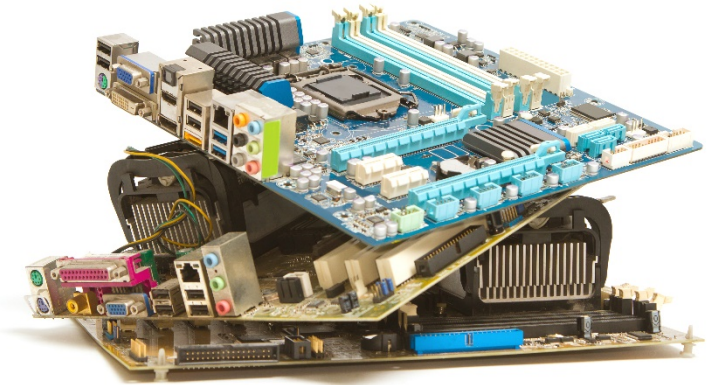
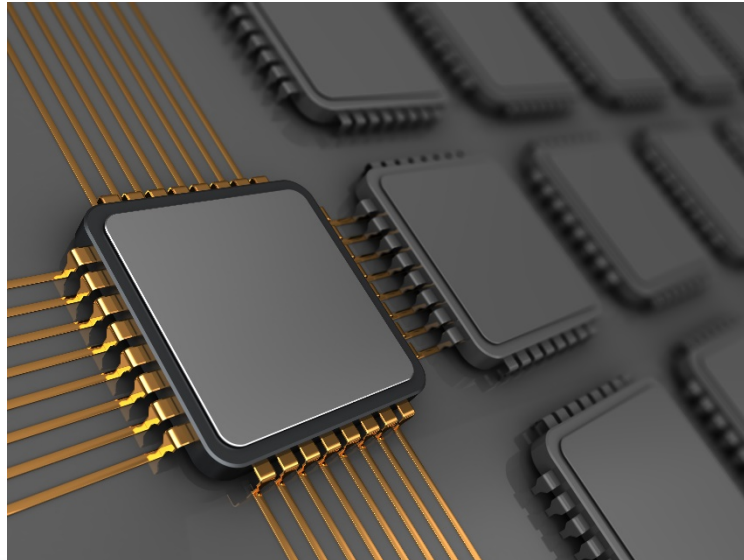
 Conducted
 Radiated

The EMC sectors



Why is EMC so important?

As speed of the controller-chip in digital circuits increases. At integrated circuit level switching power is lower and lower, electronic components are smaller and closer on the circuit board.



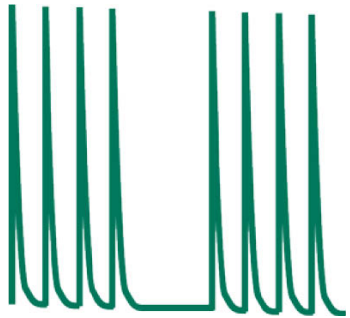
- What is EMC?

✓ **Conducted interference sources**

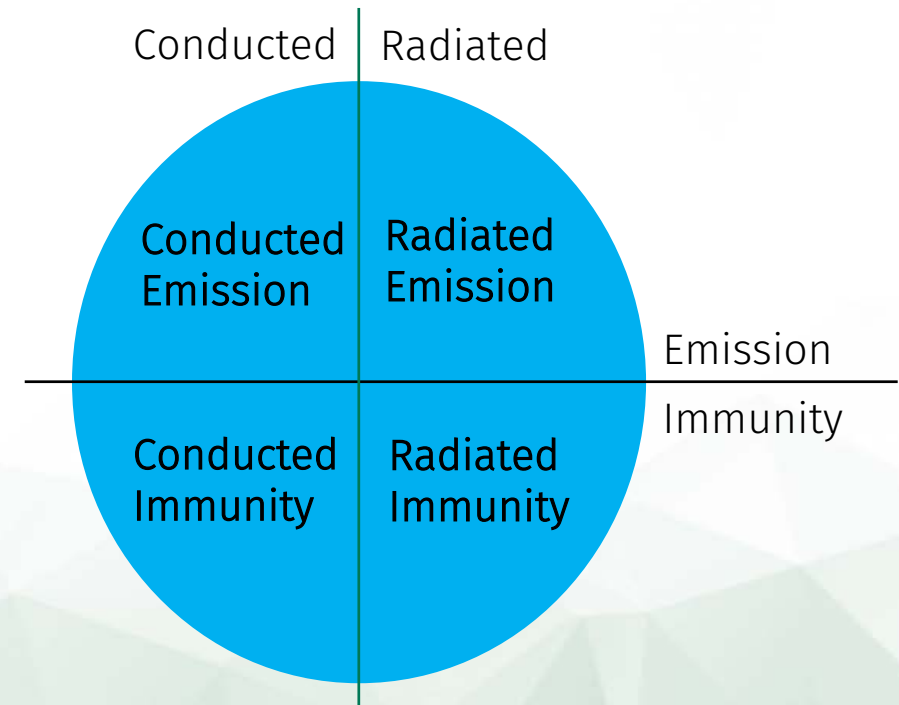
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EMC phenomena that effects the electro-magnetic environment can be divided into two characteristic groups:

- Transient interference



- Continous interference



Transient interference sources

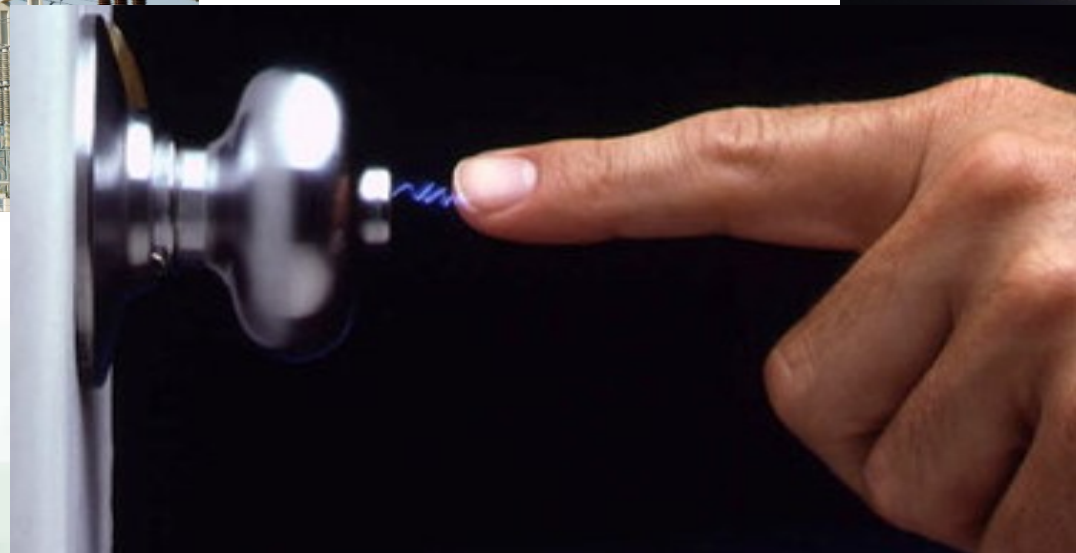
Power line switching



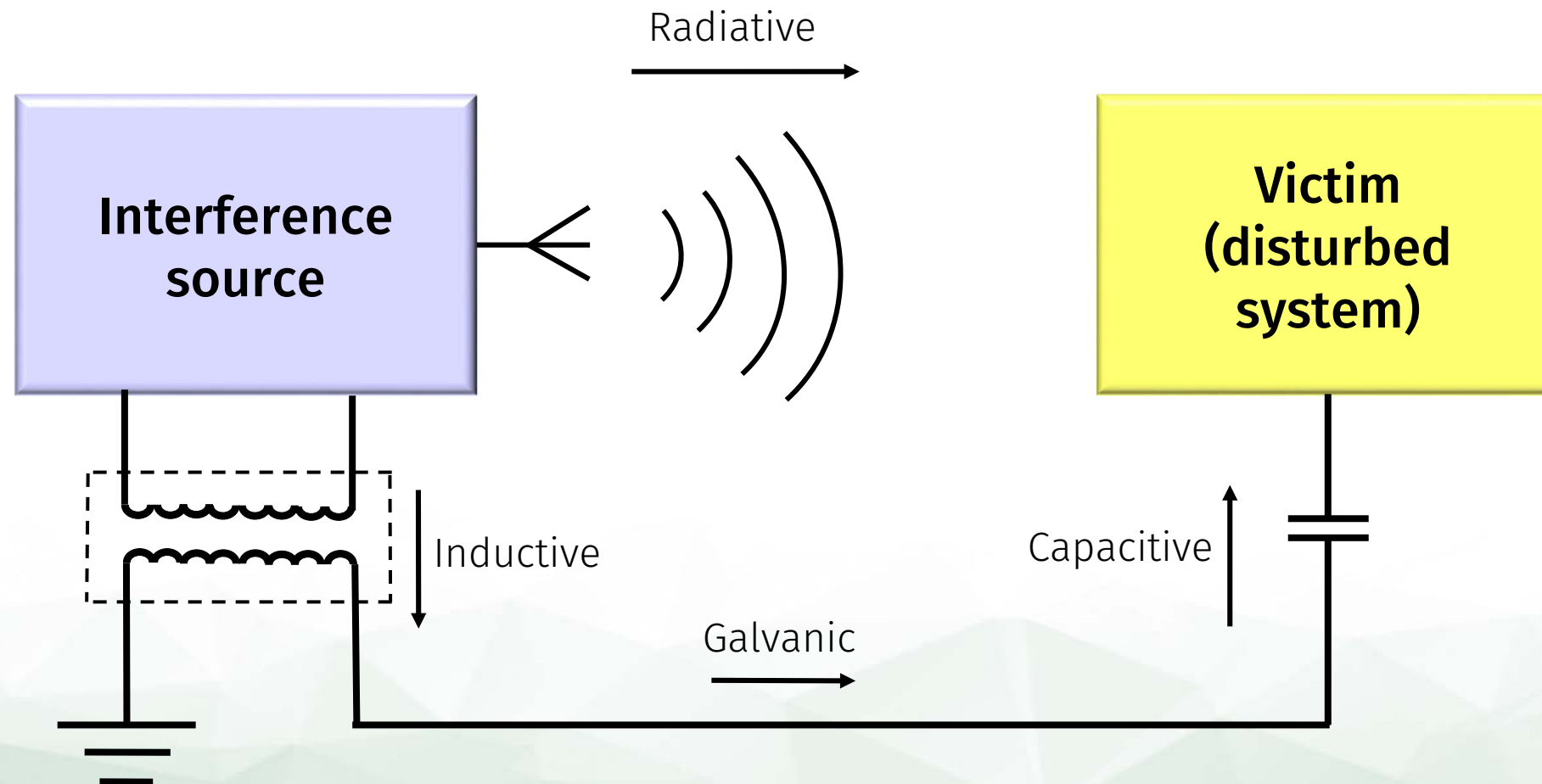
Atmospheric Lightning



Electrostatic Discharge



The EMC model



- What is EMC?
- Conducted interference sources

✓ **Structure of standards**

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Standard Bodies are relevant for CE Marking

- I.E.C. – International Electrotechnical Commission
For information visit <http://www.iec.ch/>
- CENELEC – Comité Européen de Normalisation en Electrotechnique
(European Committee For Electrotechnical Standardization)
For information visit https://www.cenelec.eu/faq/faq_entry.htm.bak

Structure is same for both, CENELEC use IEC standards

Three types of standard

Basic Standards

Used in all
other
standards

Generic Standards

Environment
Specific

Product Standards

Specific to a Product type or group of products

- What is EMC?
- Conducted interference sources
- Structure of standards

✓ **ElectroStatic Discharges ESD**

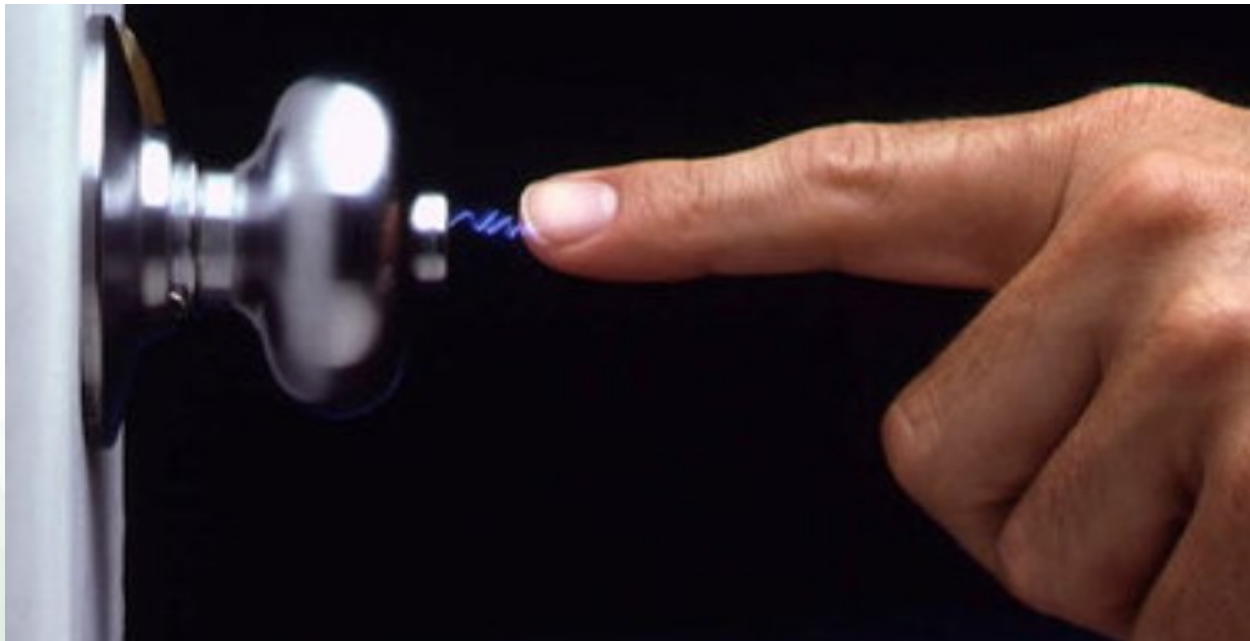
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ESD characteristics

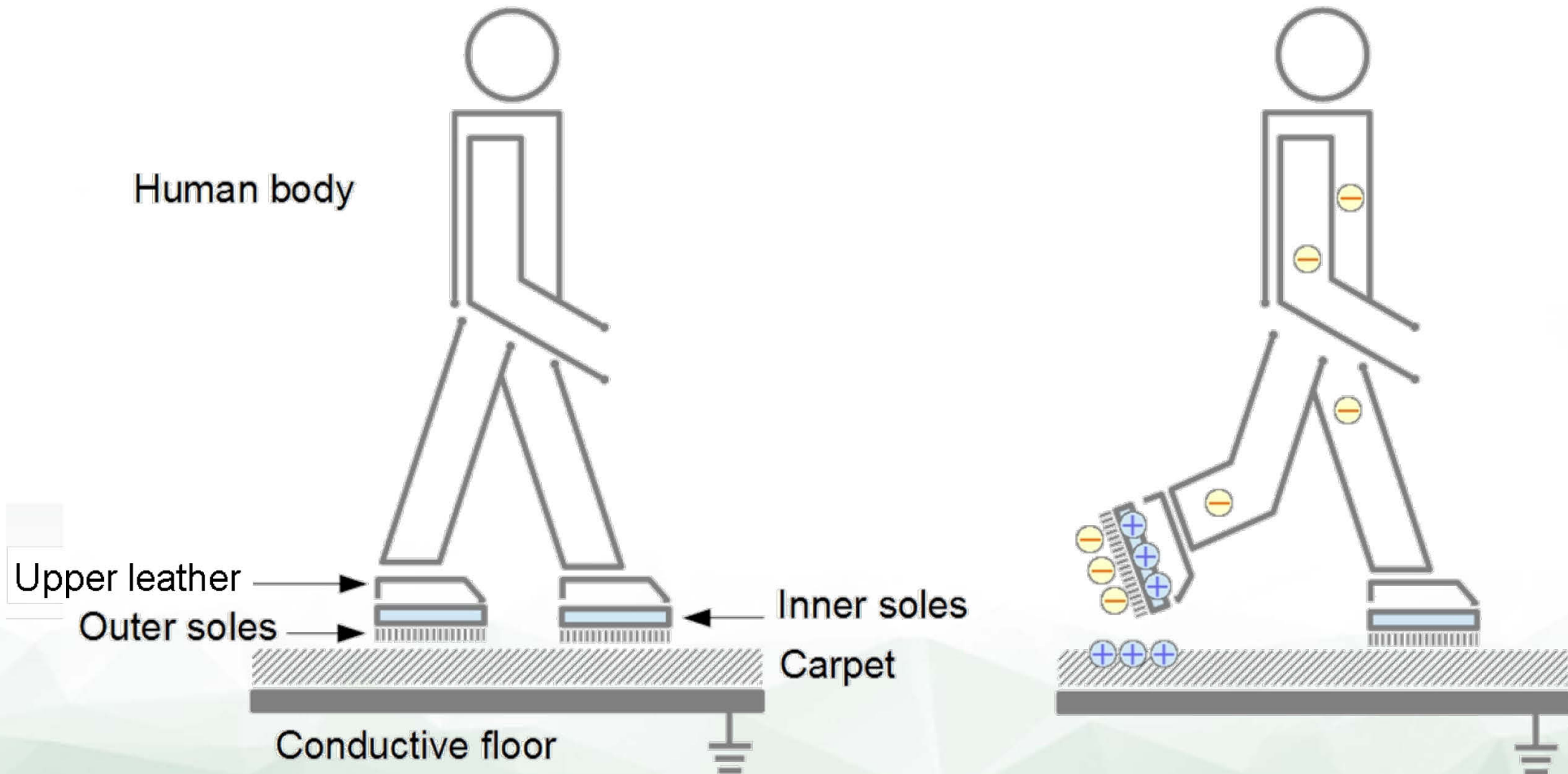
Characteristics	STATIC DISCHARGE	SWITCHING OPERATIONS	LIGHTNING	POWER TRIP	SWITCHING OPERATIONS
Phenomenon	ESD	EFT Burst	Surge	Dips	DOW
Voltage U	Up to 15 kV	Up to 4 kV	Up to 6 kV	Supply voltage	Up to 4 kV
Energies at max. charging voltage	Below 10 mJ	300 mJ	300 J	-	-
Repetition rate	Single impulse	Multiple pulses 5 kHz or 100 kHz	Maximum 6 impulses / min.	Related to the power frequency	Multiple pulses 40 / s - 5000 / s
Application equipment under test	Metal parts, which can be touched by persons	Power, signal, measuring and data lines	Power, signal, measuring and data lines	Power supply AC, DC	HV & MV power transmission stations, electricity metering equipment
Upper frequency limit	Approx. 1 GHz	Approx. 100 MHz	Approx. 350 kHz	Approx. 100 kHz	Approx. 30 MHz
Wave forms	IEC 61000-4-2 	IEC 61000-4-4 	IEC 61000-4-5 	IEC 61000-4-11 	IEC 61000-4-18 

ElectroStatic Discharges (ESD) Phenomena

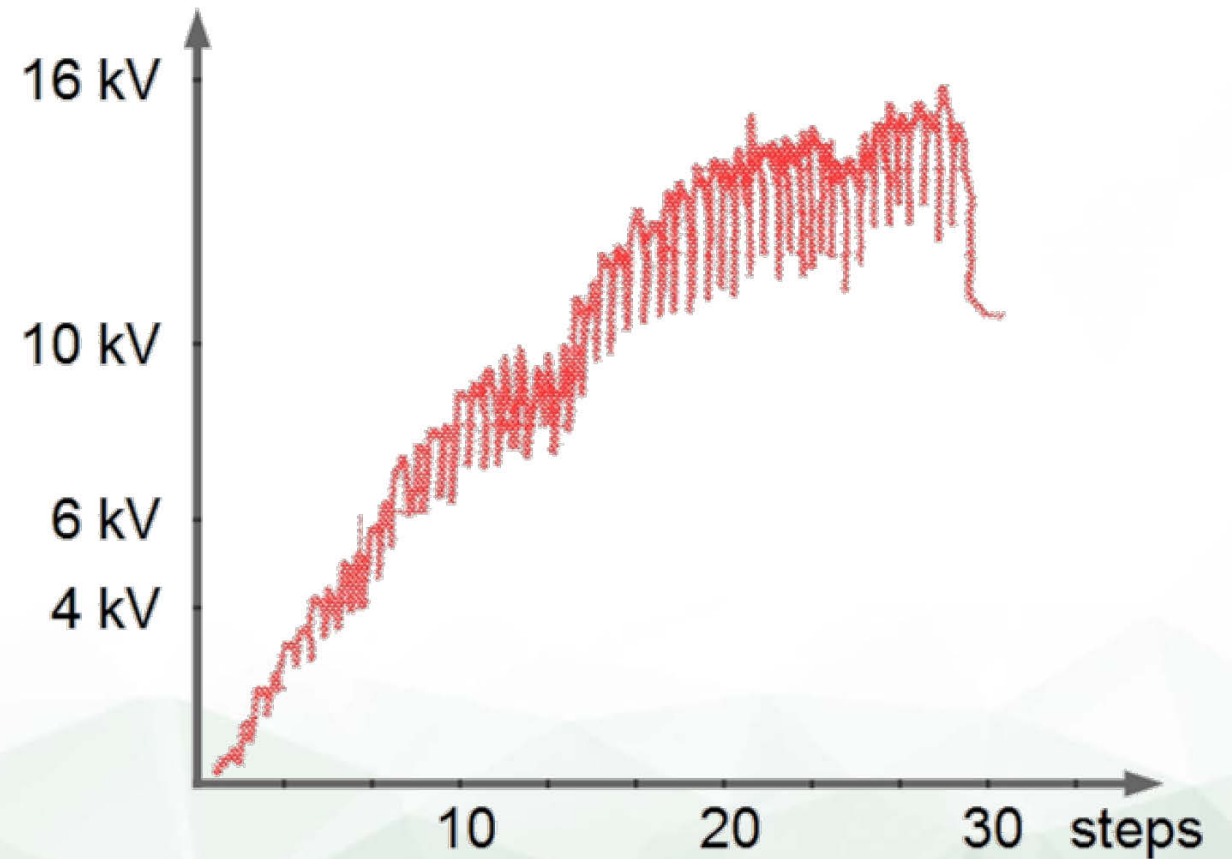
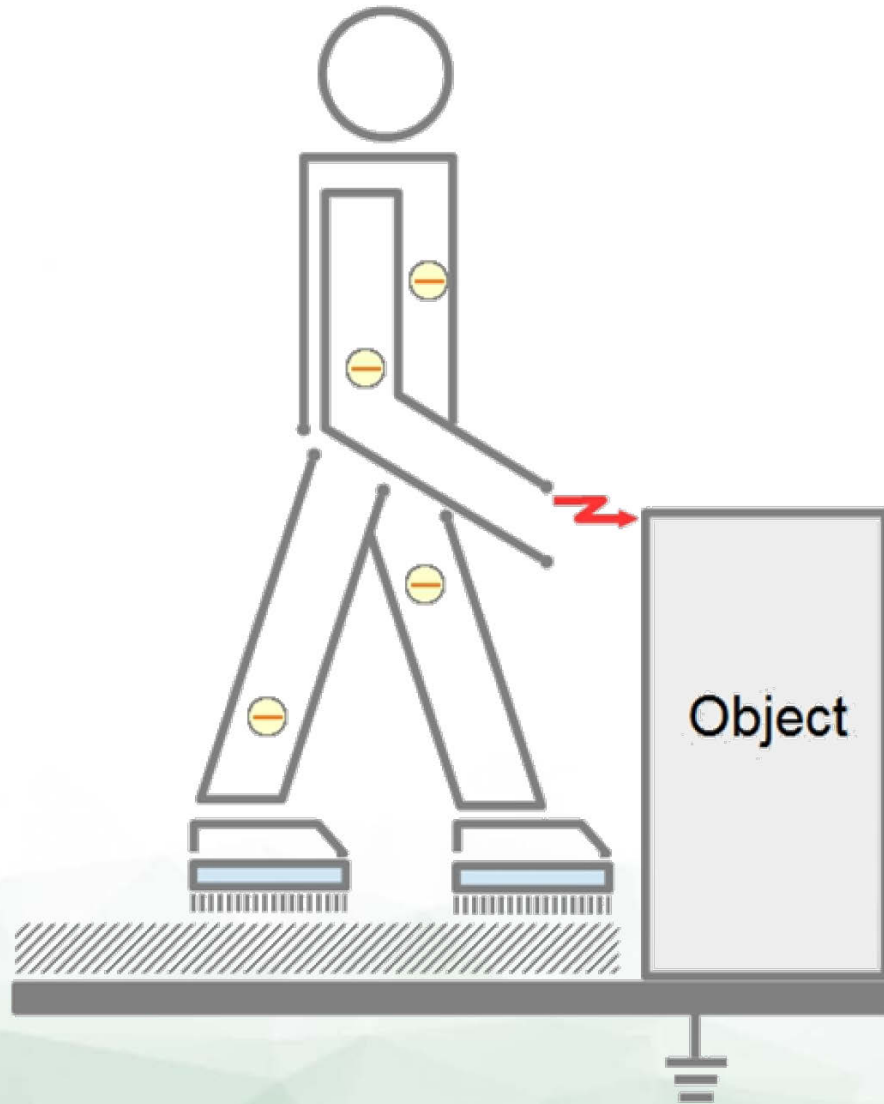
Electrostatic discharge (ESD) is the release of static electricity when two objects come into contact. Familiar examples of ESD include the shock we receive when we walk across a carpet and touch a metal doorknob.



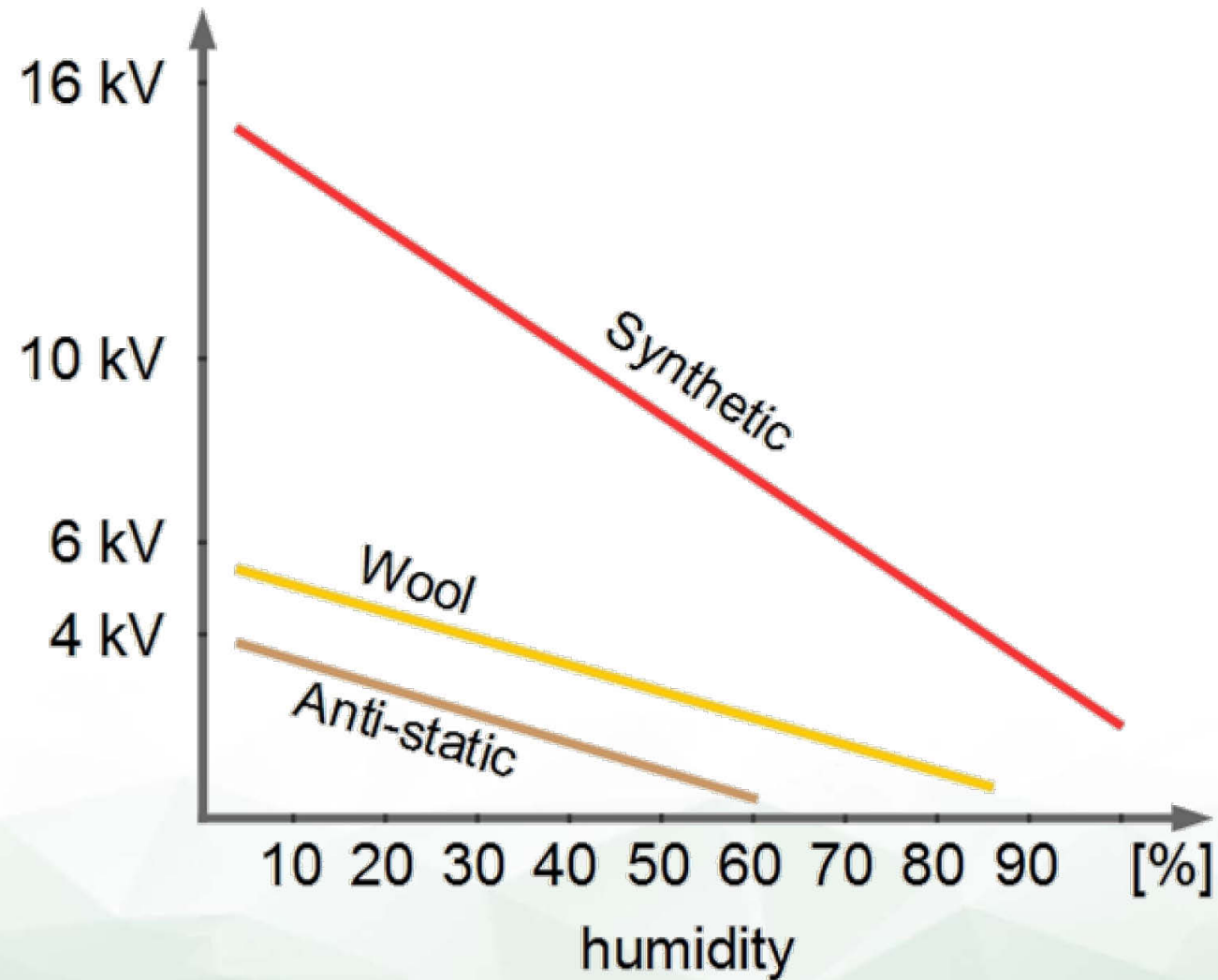
Electrostatic discharge → static electricity discharge



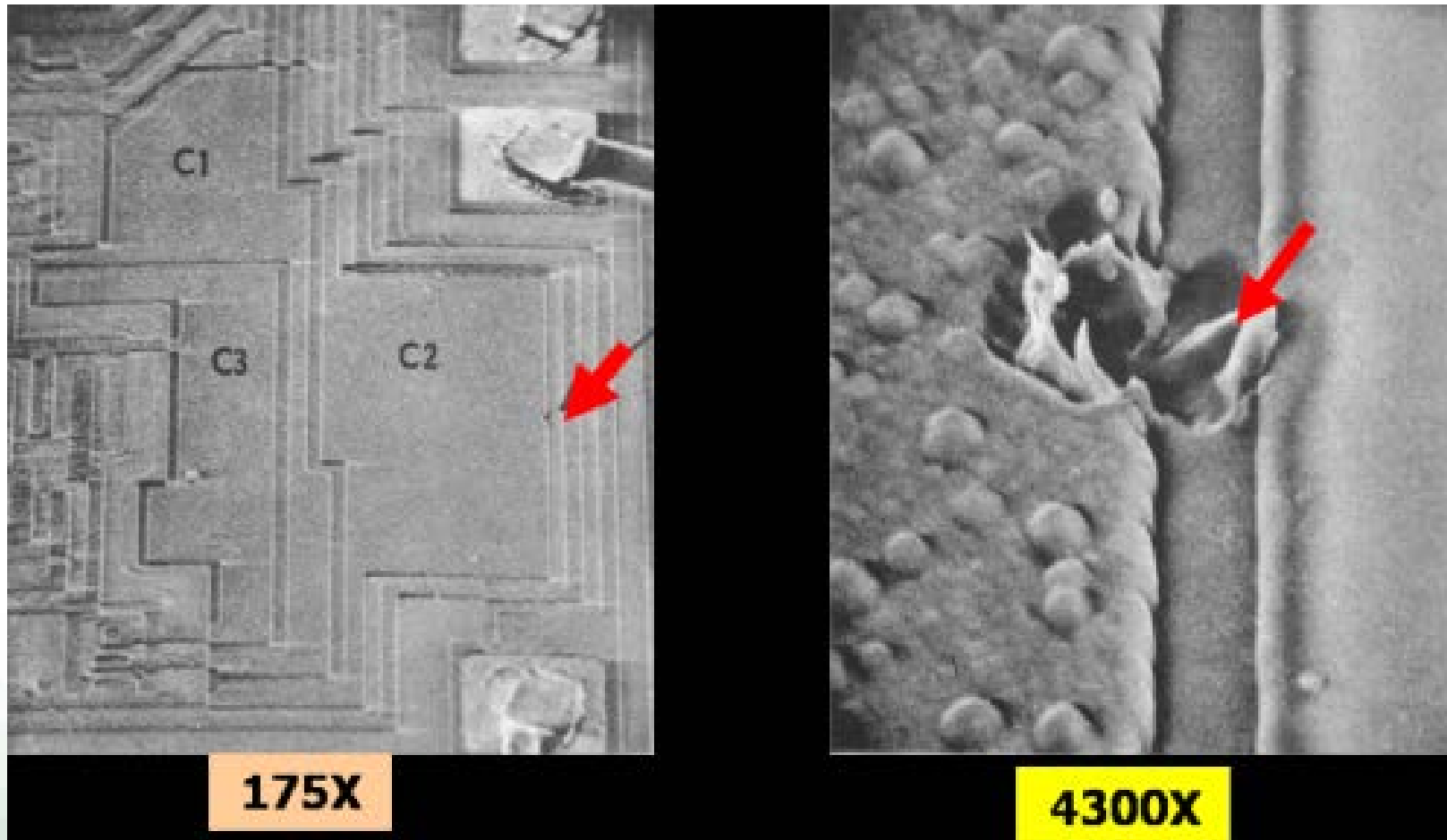
Electrostatic discharge → static electricity discharge



Electrostatic discharge → dependent on relative humidity



Semiconductor components under the microscope showing ESD damage

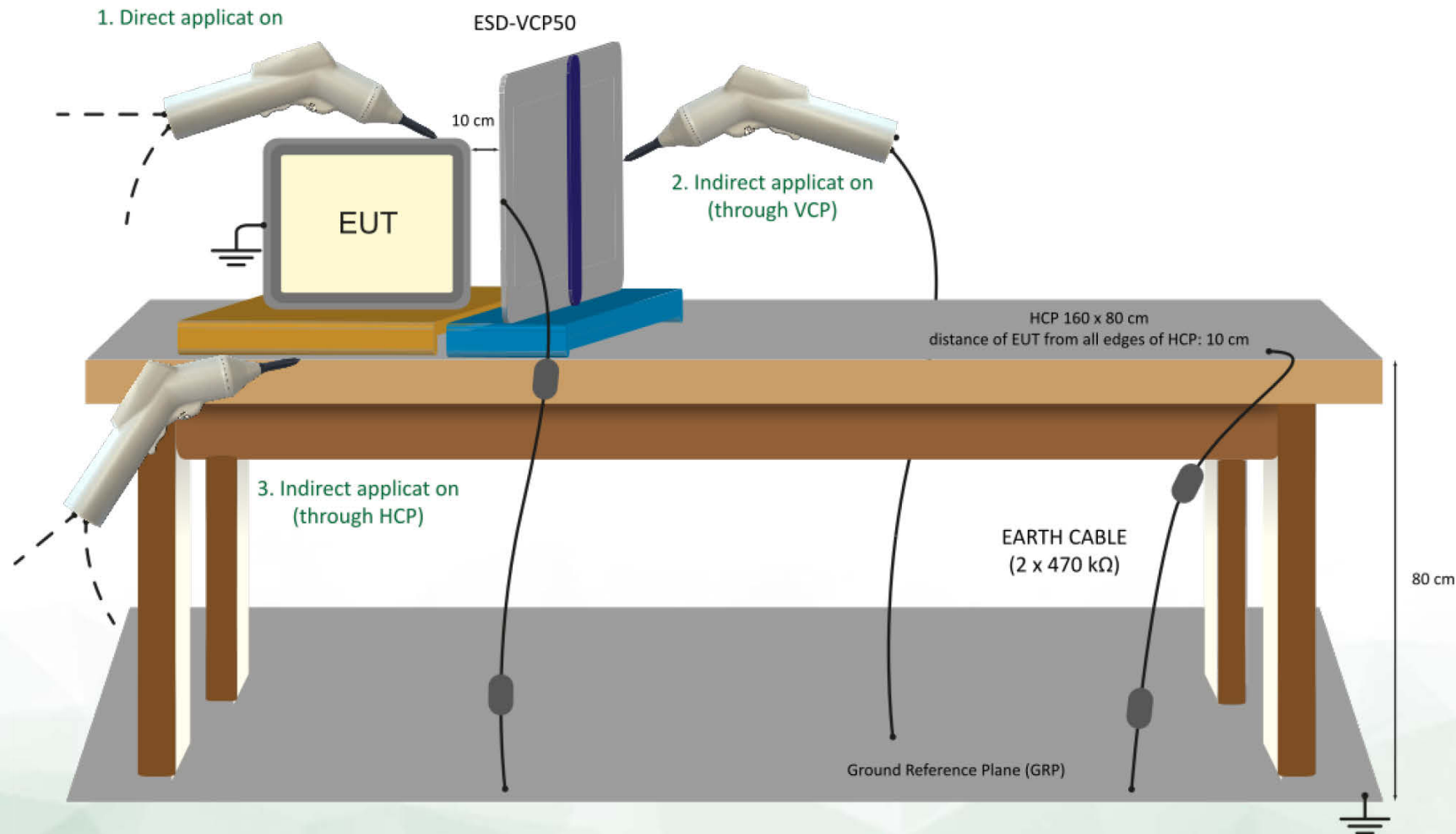


Requirements: Test levels according to IEC 61000-4-2 Ed2



Contact discharge		Air discharge	
Level	Voltage [kV]	Level	Voltage [kV]
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15
x	special	x	special

Example of a ESD test set up according to IEC 61000-4-2 Ed2



- What is EMC?
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- ElectroStatic Discharges ESD

✓ **Electric Fast Transients EFT (Burst)**

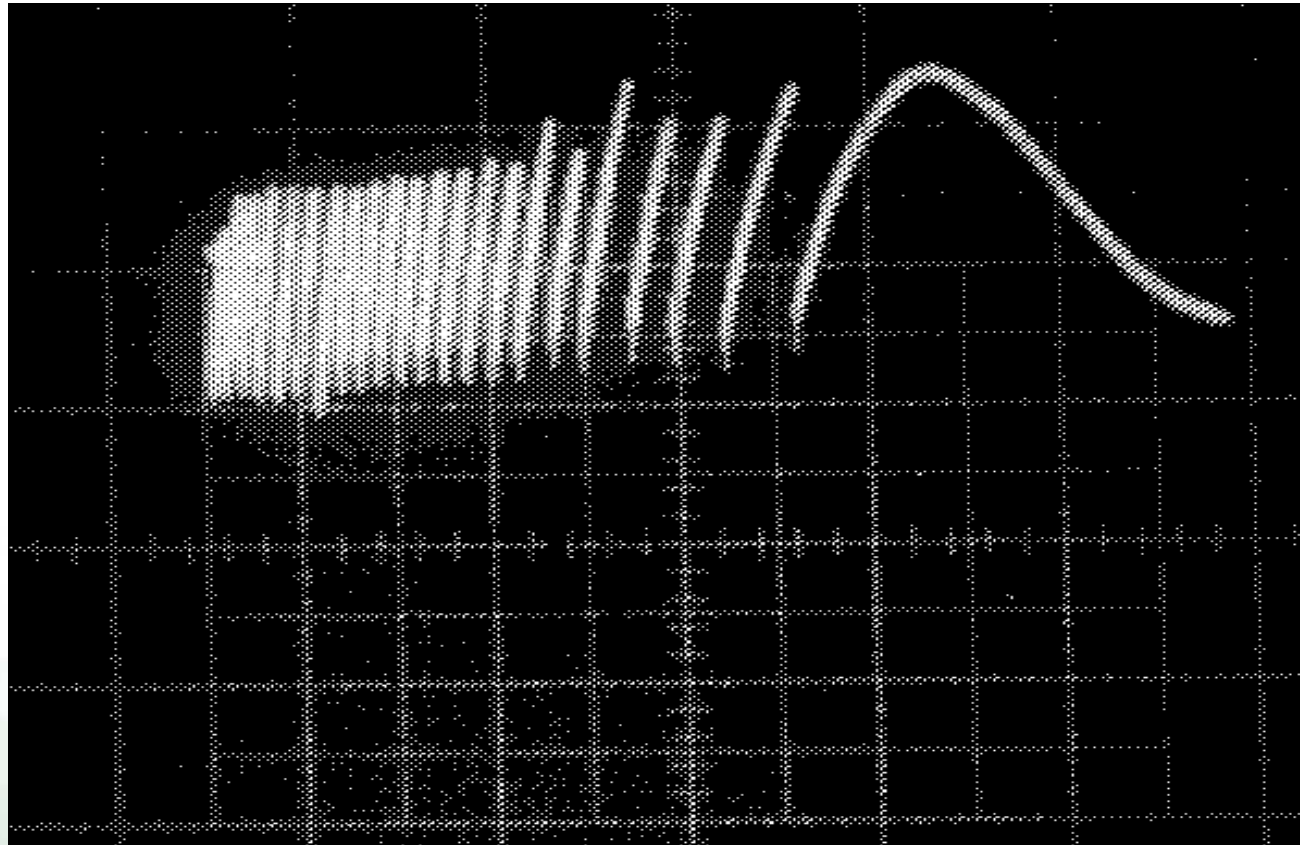
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EFT characteristics

Characteristics	STATIC DISCHARGE	SWITCHING OPERATIONS	LIGHTNING	POWER TRIP	SWITCHING OPERATIONS
Phenomenon	ESD	EFT Burst	Surge	Dips	DOW
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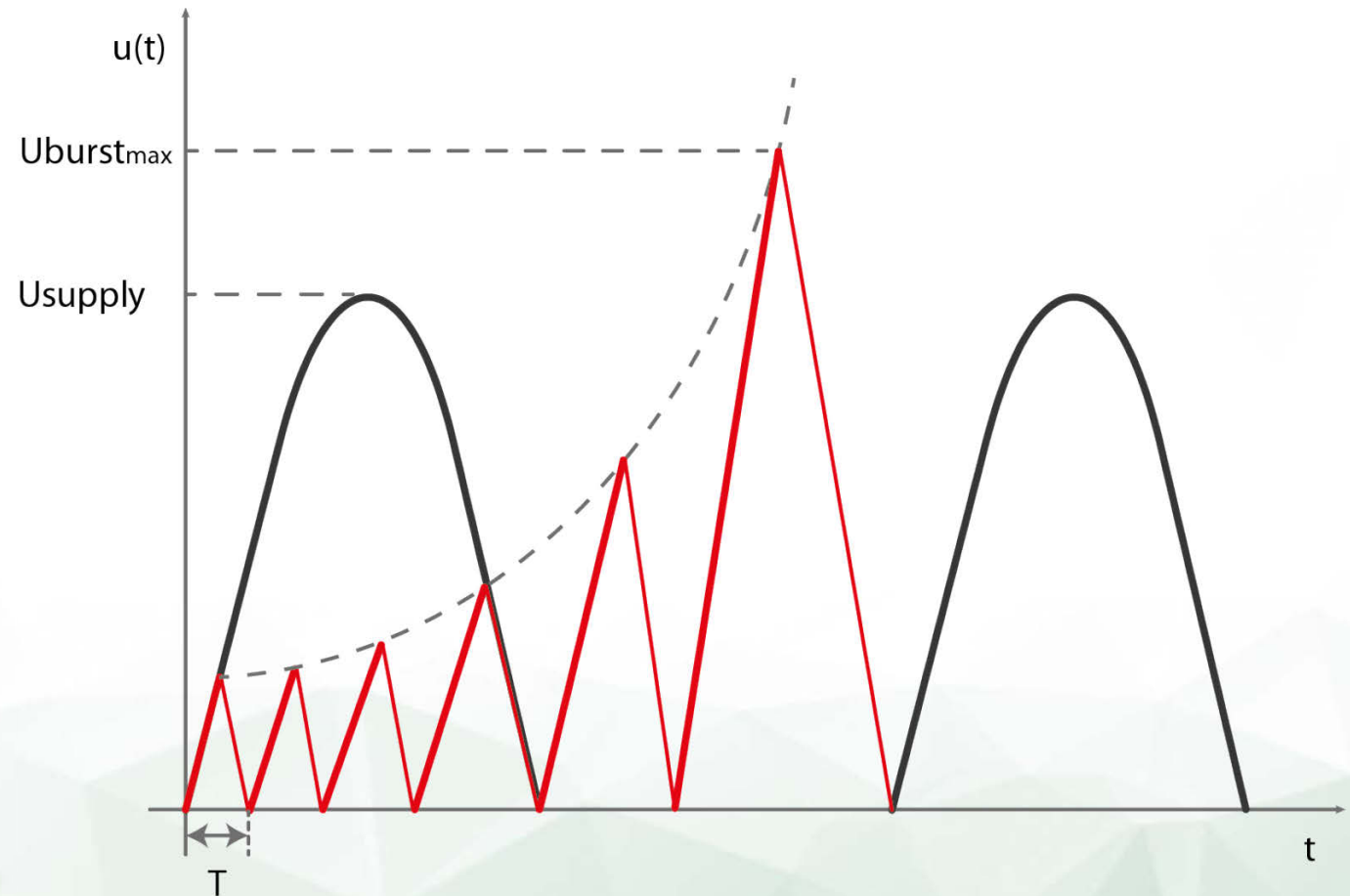
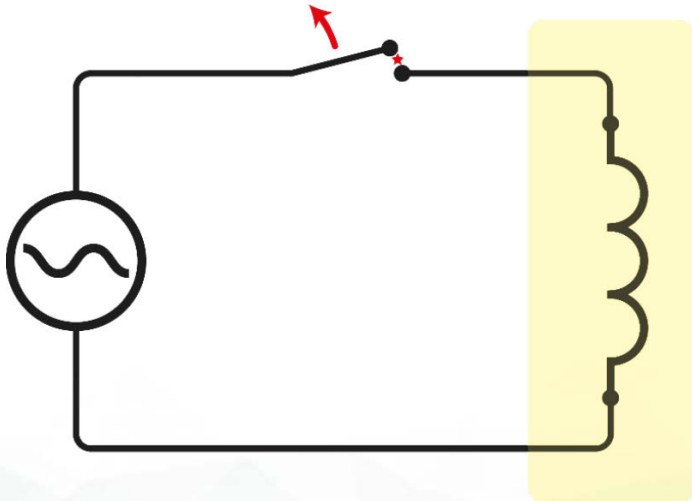
EFT phenomena

The switching of inductivity with electromechanical switch causes in the circuits of neighboring consumers a significant influence. Here is a burst opening contact.



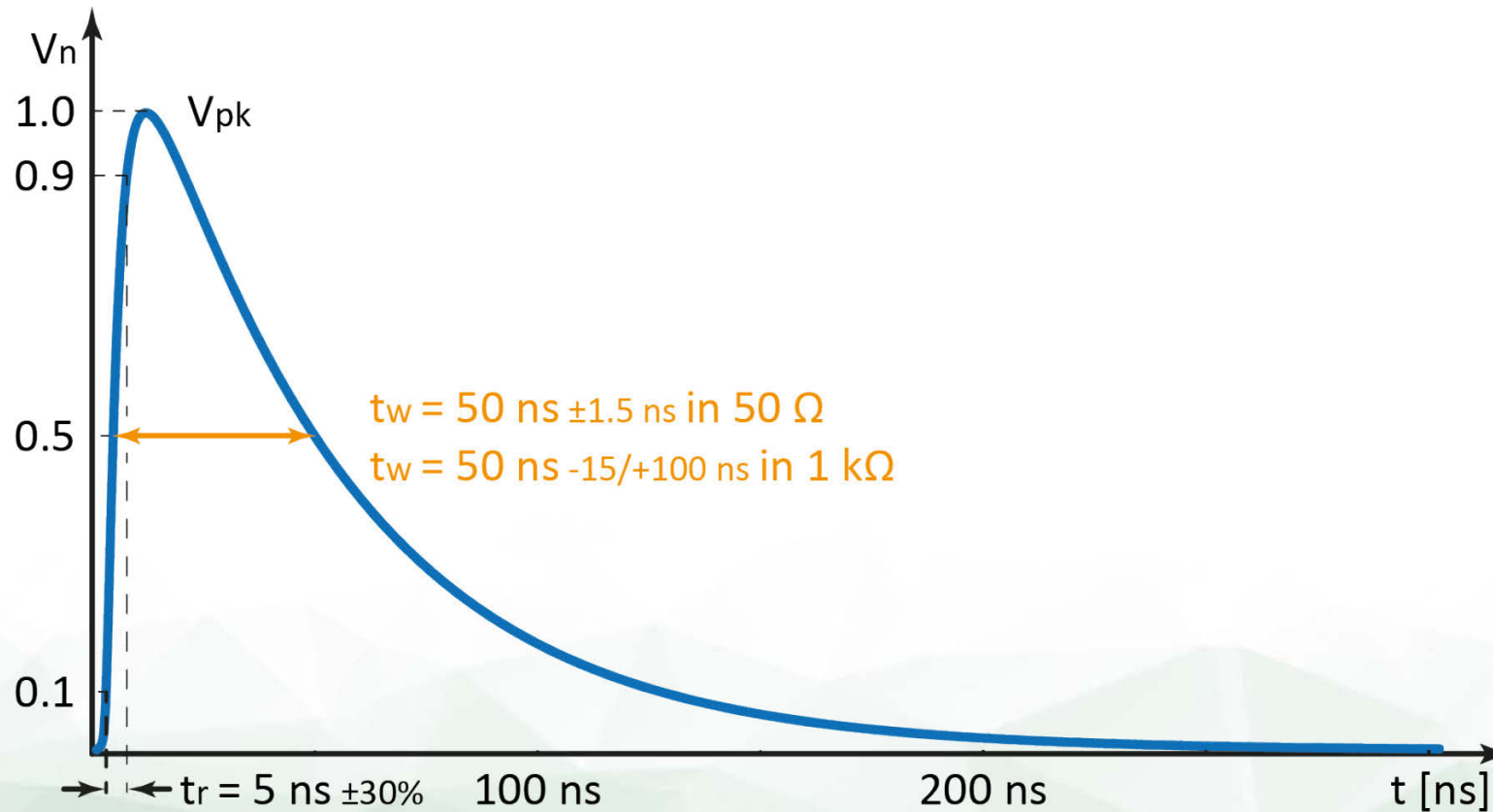
EFT phenomena

Arcing during switching off an inductive load.



Characteristic of a fast transient according to IEC 61000-4-4 Ed3

High amplitude, fast rise time, high repetition rate and low energy pulses



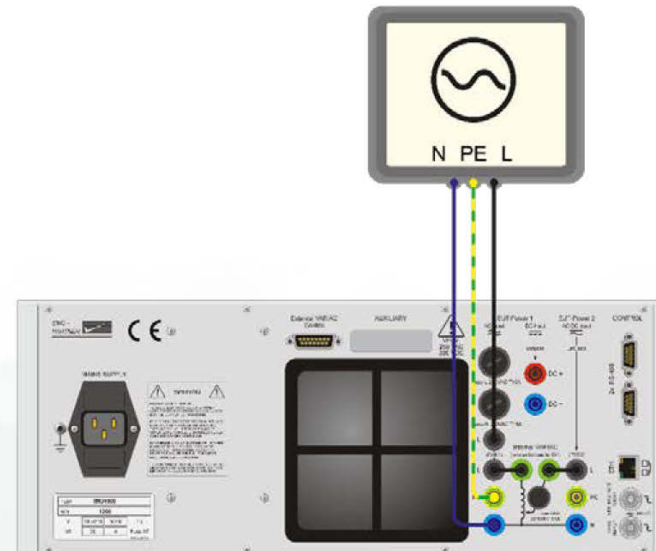
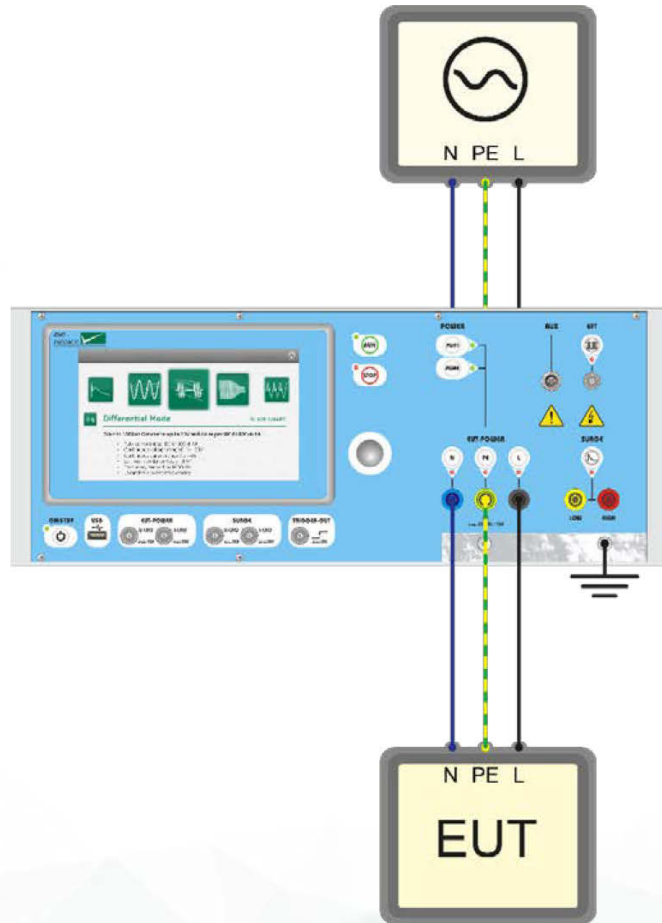
Requirments according to IEC61000-4-4 Ed3: Test levels for power ports, earth port PE

Level	Voltage peak [kV]	Repetition frequency [kHz]
1	0.5	5 or 100
2	1	5 or 100
3	2	5 or 100
4	4	5 or 100
x	special	special

Voltage peak both positive and negative polarity of pulses are required.

x = can be any level above, below or between the others

Example of a test set up for single phase power



The diagram illustrates a power distribution system. On the left, a yellow box labeled 'AE' (Appliance Under Test) is connected to a power source (represented by a ground symbol) and a power distribution unit. The power distribution unit is a long, horizontal black bar with multiple output ports. On the right, a yellow box labeled 'EUT' (Equipment Under Test) is connected to the power distribution unit. The power source is connected to the power distribution unit via a black cable. The power distribution unit has multiple output ports, each connected to the EUT via a blue cable. The power source is also connected to the AE via a black cable. The power distribution unit has a 'POWER' section with 'PWR1' and 'PWR2' buttons, a 'RIZE' button, and a 'CUT-POWER' section with 'N', 'PE', and 'L' buttons. It also has a 'SURGE' section with 'LOW' and 'HIGH' buttons. The power distribution unit is connected to the AE and EUT via blue cables. The power source is connected to the power distribution unit via a black cable. The power source is also connected to the AE via a black cable. The power distribution unit has a 'POWER' section with 'PWR1' and 'PWR2' buttons, a 'RIZE' button, and a 'CUT-POWER' section with 'N', 'PE', and 'L' buttons. It also has a 'SURGE' section with 'LOW' and 'HIGH' buttons. The power distribution unit is connected to the AE and EUT via blue cables. The power source is connected to the power distribution unit via a black cable. The power source is also connected to the AE via a black cable.

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- ✓ **Lightning Stroke (Surge)**
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Surge characteristics

Characteristics	STATIC DISCHARGE	SWITCHING OPERATIONS	LIGHTNING	POWER TRIP	SWITCHING OPERATIONS
Phenomenon	ESD	EFT Burst	Surge	Dips	DOW
Voltage U	Up to 15 kV	Up to 4 kV	Up to 6 kV	Supply voltage	Up to 4 kV
Energies at max. charging voltage	Below 10 mJ	300 mJ	300 J	-	-
Repetition rate	Single impulse	Multiple pulses 5 kHz or 100 kHz	Maximum 6 impulses / min.	Related to the power frequency	Multiple pulses 40 / s – 5000 / s
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Surge phenomena



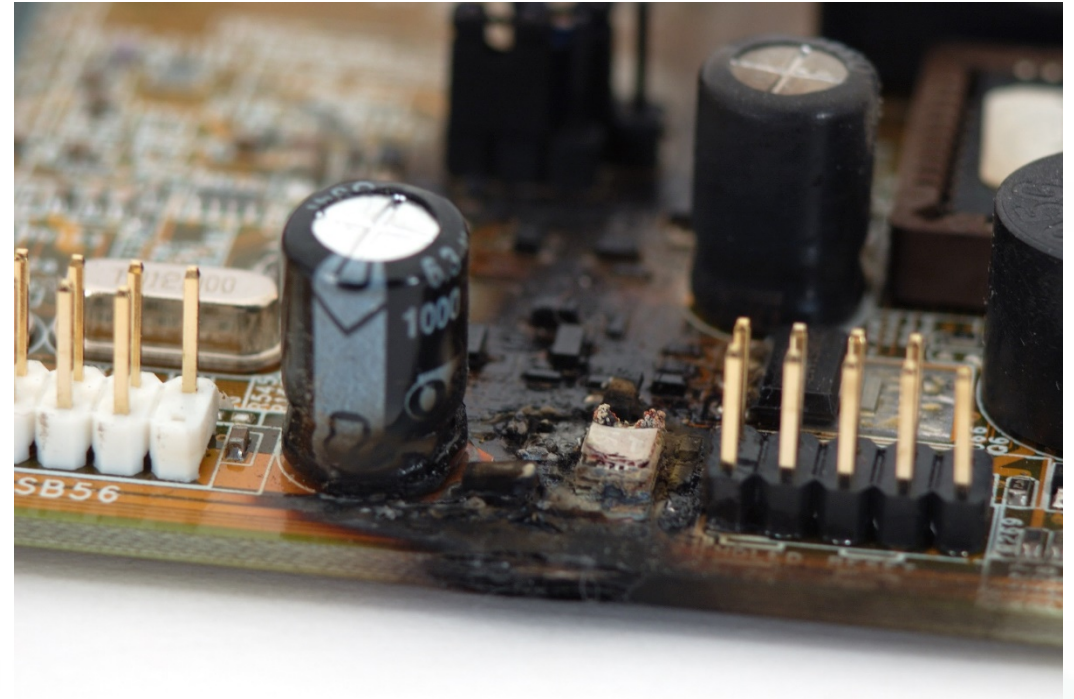
Surge phenomena

Immunity of equipment against surge effects is ensured through tests:

- Lightning
- Electrical short
- Switching of capacitive loads
- Load variation

Characteristic of a surge pulse:

- High amplitude (several kilo volts)
- High impulse energy

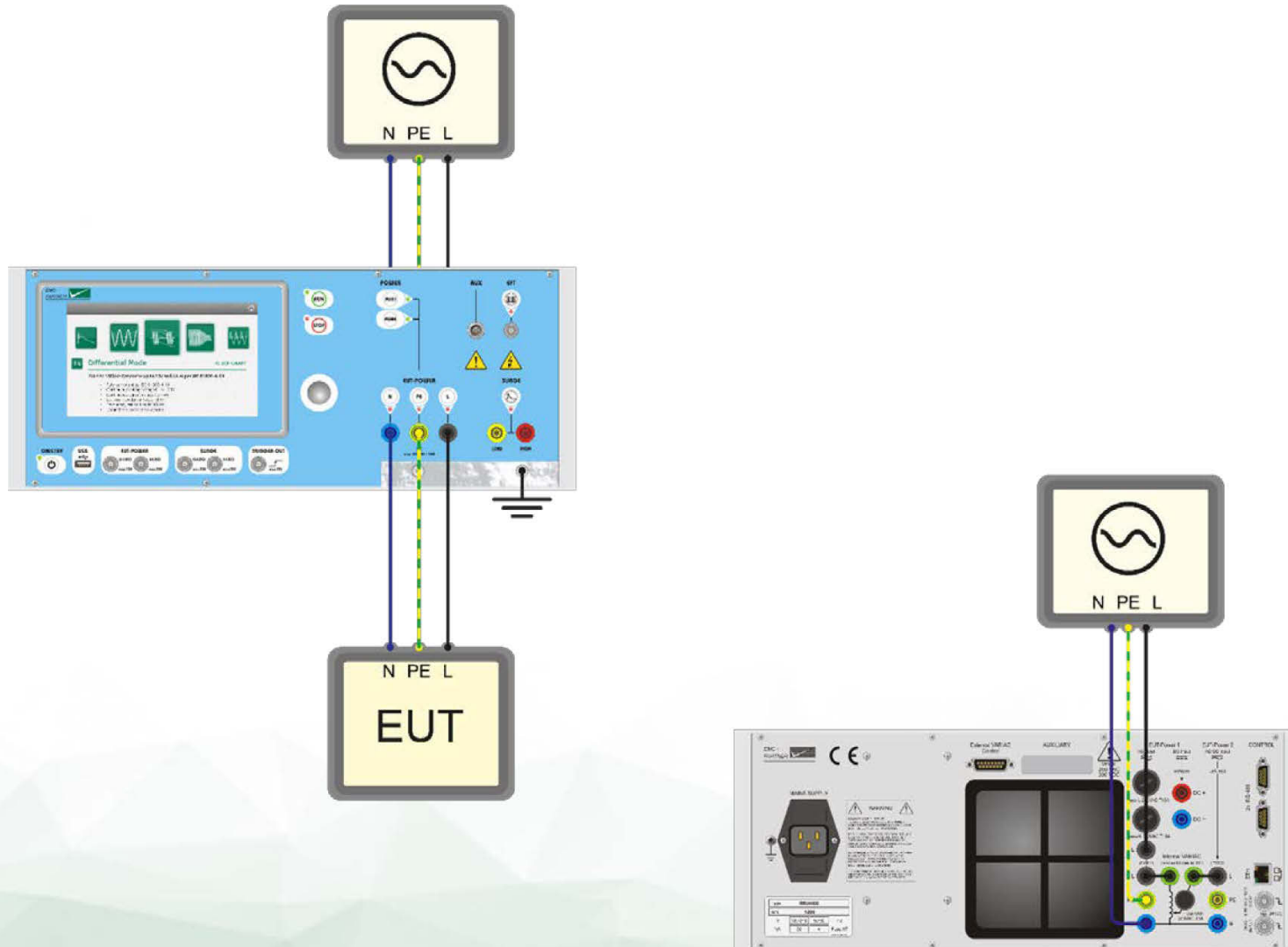


Requirements according to IEC 61000-4-5 Ed.3

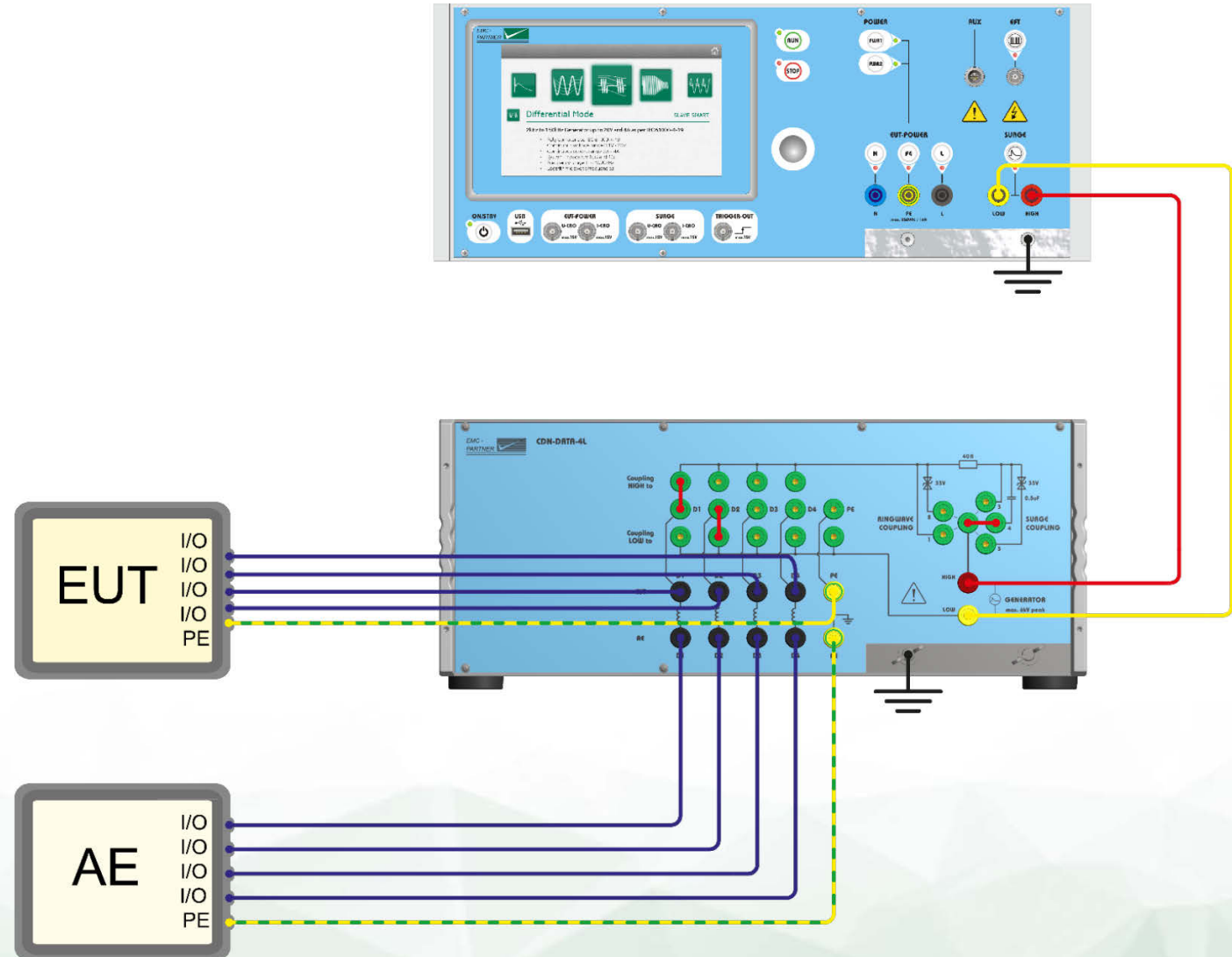
Relationship between peak open-circuit voltage and peak short-circuit current

Open-circuit peak voltage ± 10% at generator output	Short-circuit peak current ± 10% at generator output
0.5 kV	0.25 kA
1 kV	0.5 kA
2 kV	1 kA
4 kV	2 kA

Example of a test set up for single phase power



Example of a test set up for data lines

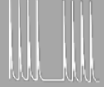
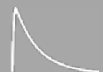


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✓ **Voltage dips, short interruption and variation**

- Damped oscillatory wave
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Dips characteristics

Characteristics	STATIC DISCHARGE	SWITCHING OPERATIONS	LIGHTNING	POWER TRIP	SWITCHING OPERATIONS
Phenomenon	ESD	EFT Burst	Surge	Dips	DOW
Voltage U	Up to 15 kV	Up to 4 kV	Up to 6 kV	Supply voltage	Up to 4 kV
Energies at max. charging voltage	Below 10 mJ	300 mJ	300 J	-	-
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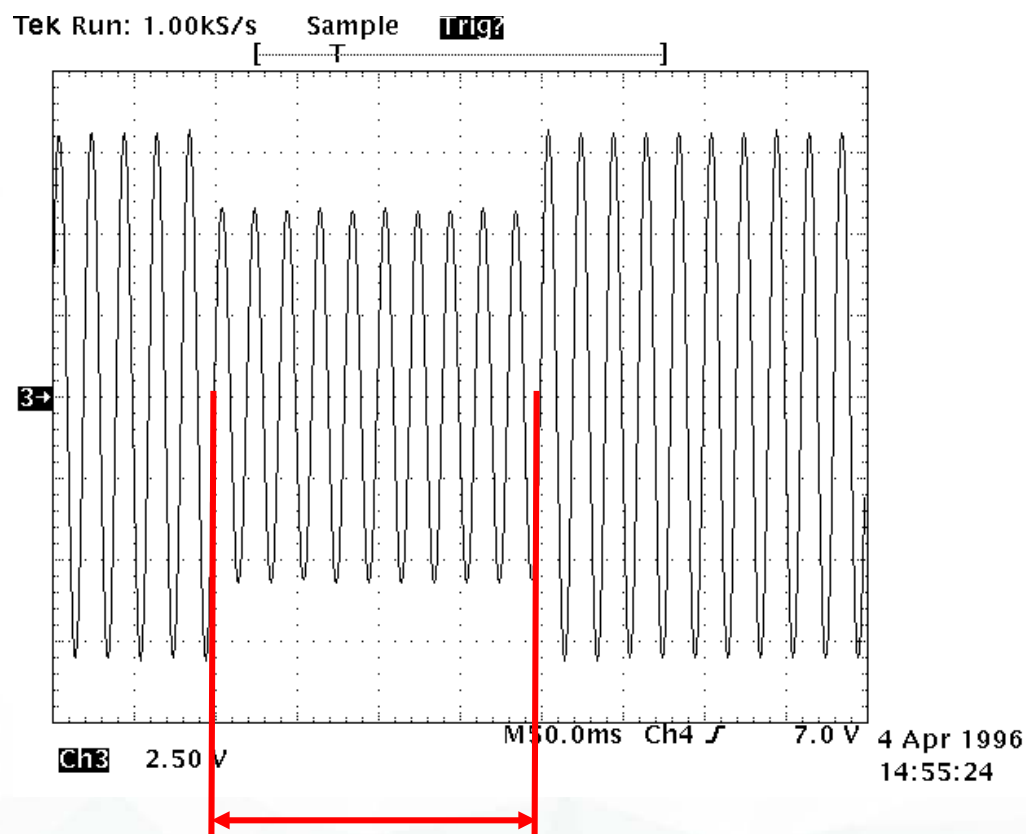
Voltage dips, short interruption and variation phenomena

The causes for disturbances in a low-voltage network (power supply) can occur due to load changes and short circuits.

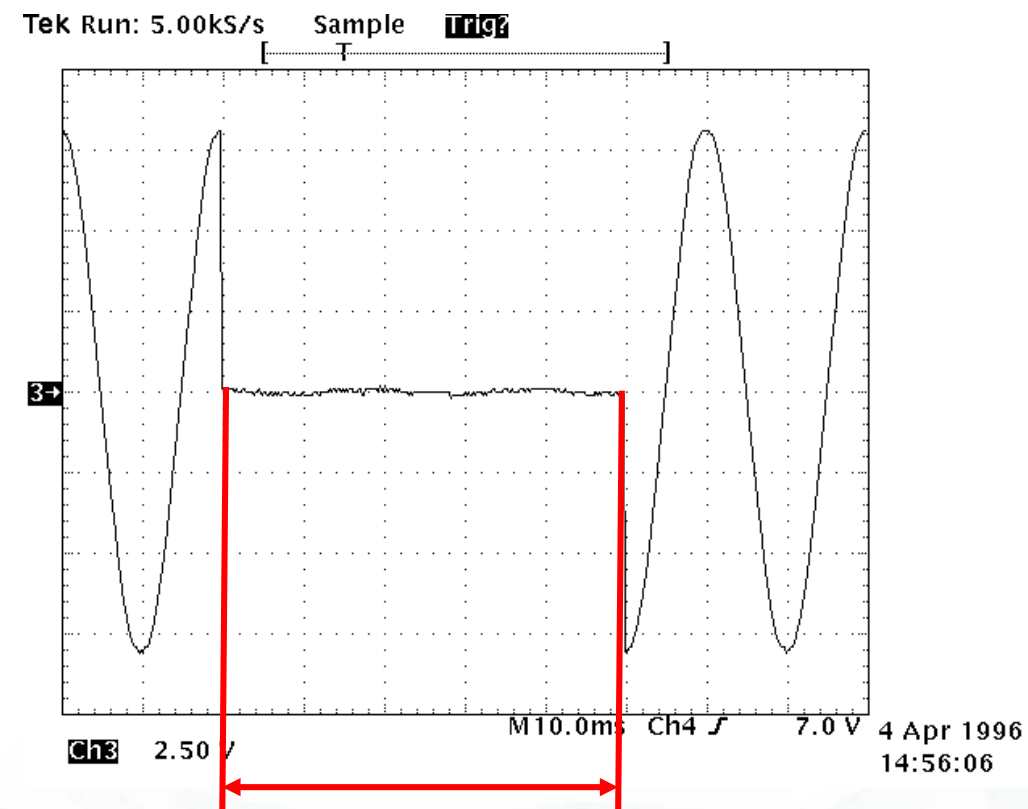
Effects of low-voltage network disturbances:

- Main voltage interruptions
- Main voltage variations
- Main voltage dips

Voltage dips, short interruption and variation phenomena



70% dips with a duration of 200 ms
begin = 0° and end = 0°



0% dips with a duration of 50 ms
begin = 90° and end = 270°

Characteristic of voltage dips according to IEC 61000-4-11+AMD1:2017

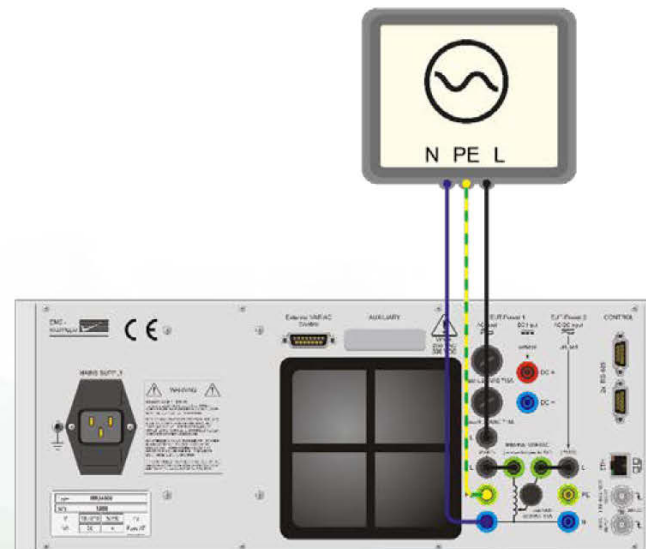
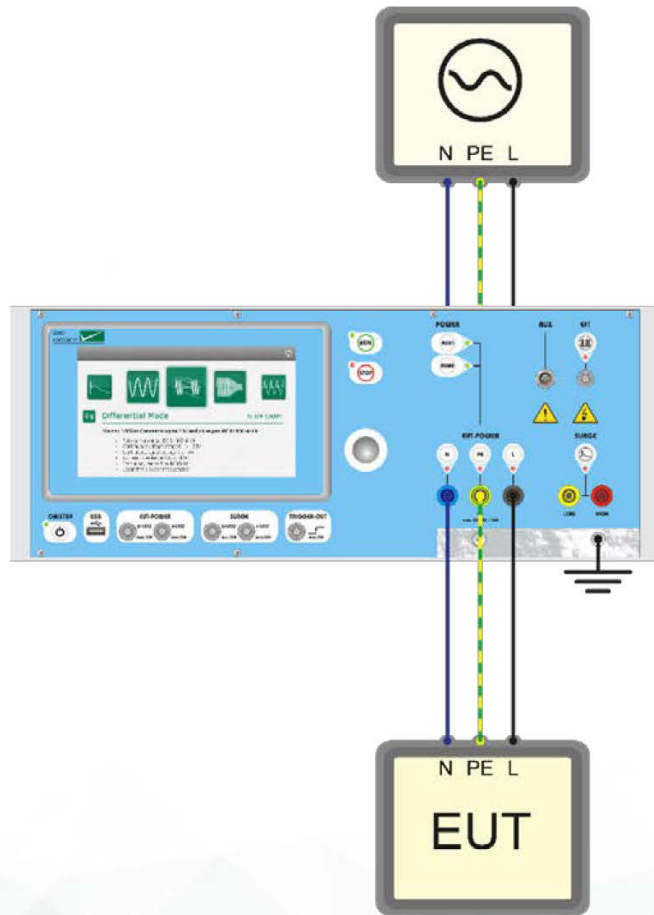
Class	Test levels % U_T for voltage dips
1	Case-by-case according to the EUT requirements
2	0 % of U_T 70 % of U_T
3	0 % of U_T 40 % of U_T 70 % of U_T 80 % of U_T
X	x

U_T = Rated voltage for the equipment as a basis for voltage test level specification

X = To be defined by product committee

For the duration of the voltage dips refer to the standard please.

Example of a test set up for single phase dips and variation

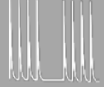
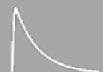


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✓ **Damped oscillatory wave**

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DOW characteristics

Characteristics	STATIC DISCHARGE	SWITCHING OPERATIONS	LIGHTNING	POWER TRIP	SWITCHING OPERATIONS
Phenomenon	ESD	EFT Burst	Surge	Dips	DOW
Voltage U	Up to 15 kV	Up to 4 kV	Up to 6 kV	Supply voltage	Up to 4 kV
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Repetition rate	Single impulse	Multiple pulses 5 kHz or 100 kHz	Maximum 6 impulses / min.	Related to the power frequency	Multiple pulses 40 / s – 5000 / s
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Phenomena

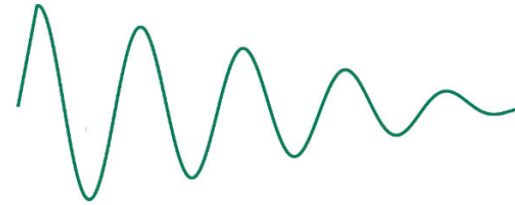


Slow damped oscillatory waves produced by switching in air insulated substations (**AIS**).

Represented frequencies are:

100 kHz

1 MHz.



Fast damped oscillatory produced by gas insulated substations (**GIS**).

Represented frequencies are:

3 MHz

10 MHz

30 MHz.



Standard overview: Test levels according to IEC 61000-4-18:2006+AMD1:2010 CSV

Slow DOW

Test level	CM [kV]	DM [kV]
1	0.5	0.25
2	1	0.5
3	2 [*]	1
4	-	-
X	x	x

Fast DOW

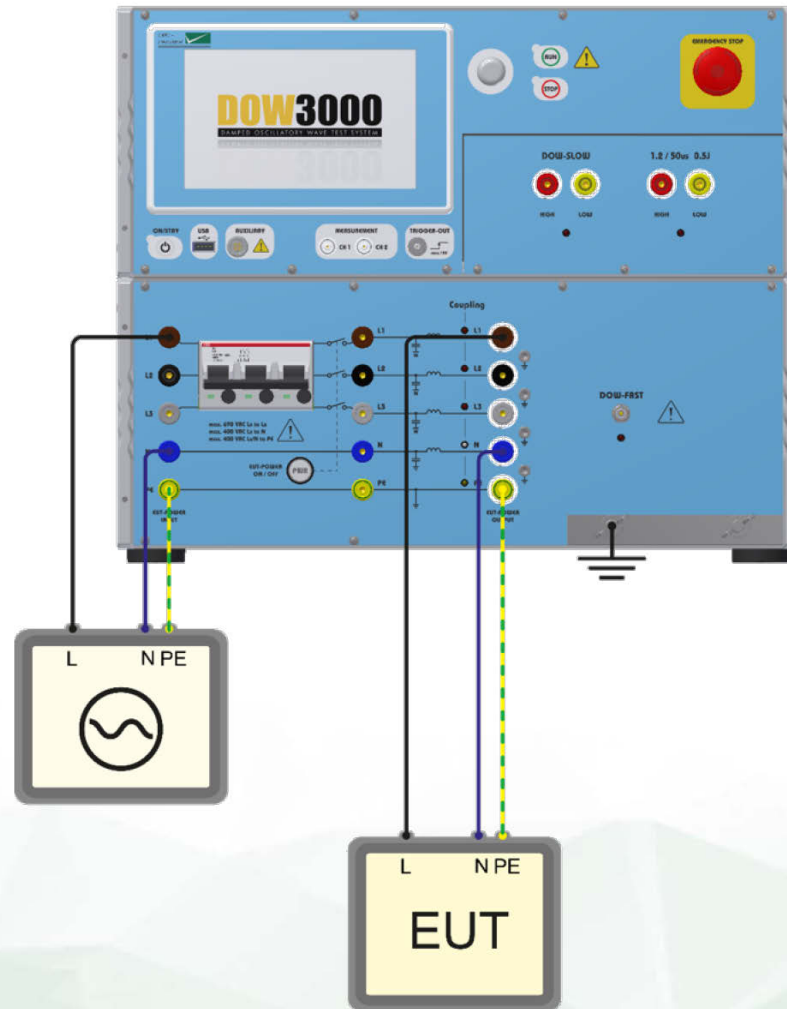
Test level	CM [kV]	DM [kV]
1	0.5	-
2	1	-
3	2	-
4	4	-
X	x	-

* 2.5 kV for substation equipment

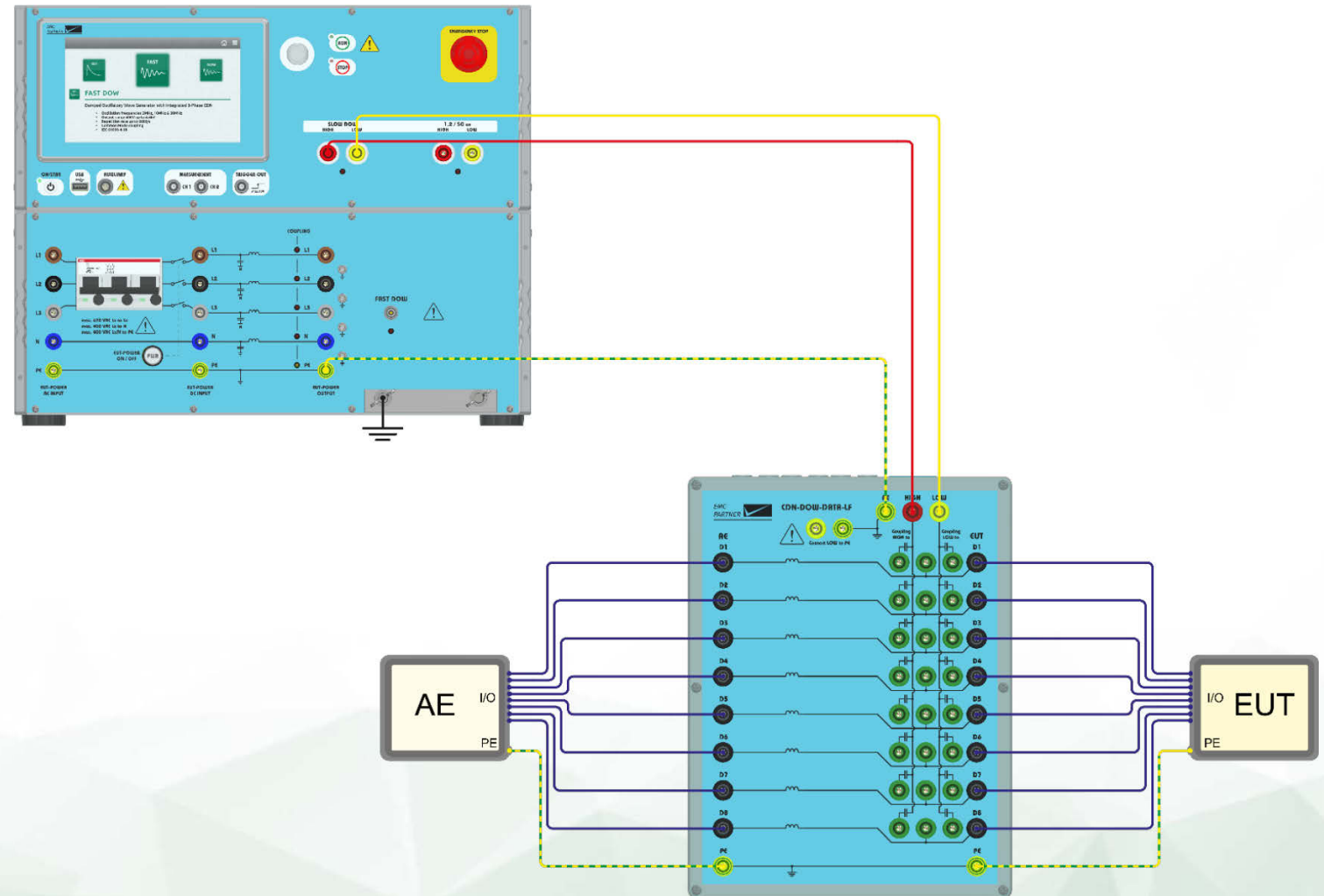
CM = Common mode (line to ground)

DM = Differential mode (line to line)

Example of a test set up for single phase power slow and fast DOW



Example of a test set up for data lines



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✓ **Basic information about CE mark testing**

Why do we need all these tests?



Source of CE mark: https://ec.europa.eu/growth/single-market/ce-marking_en

Manufacturer who produce their goods within the European Union or who import their goods into the European Union must comply to

- safety,
- health,
- environmental

protection requirements. The CE mark is a process that indicates that the manufacturer or importer meets all CE requirements for the product. CE marking shows that the responsible person has verified product conformity to all relevant European Union directives.

Is CE marking mandatory?

Yes, if the product is to be sold within the European Union.

What is a directive?

A directive is an act of the European Union. EU member states should harmonize national standards to European Union rules.

For information visit:

https://ec.europa.eu/growth/single-market/ce-marking_en

Steps to get CE marking

- Step 1** Find directive(s) that apply to product.
- Step 2** Check technical requirement of product.
- Step 3** Determine need of third-party assessment or in-house tests.
- Step 4** Assessment of product conformity (testing & documentation)
- Step 5** Creating & maintaining technical documentation
- Step 6** Declaration of conformity & affixing CE mark.

Harmonised standard EN 50470-1:2006 contains following tests and measurement:

Tests	Standard	Example of test equipment
Impulse voltage test 1.2/50 μ s with energy 0.5 Joule	IEC 60060-1	DOW3000
Damped oscillatory waves	EN 61000-4-18	
Electrostatic discharges	EN 61000-4-2	ESD3000 + ESD3000DM1
Power frequency magnetic fields	EN 61000-4-8	IMU4000 + MF1000-1
Voltage dips and short interruptions	EN 61000-4-11	IMU4000
Electrical fast transients/bursts	EN 61000-4-4	
Surges	IEC 61000-4-5	
Radiated RF electromagnetic fields	EN 61000-4-3	We don't offer equipment for radio frequency (RF).
Conducted disturbances, induced RF fields	IEC 61000-4-6	
Radio interference	EN 55022	

Example of test equipment which covers the test requirements

Generator ESD3000 with
discharge module DM1 for testing:

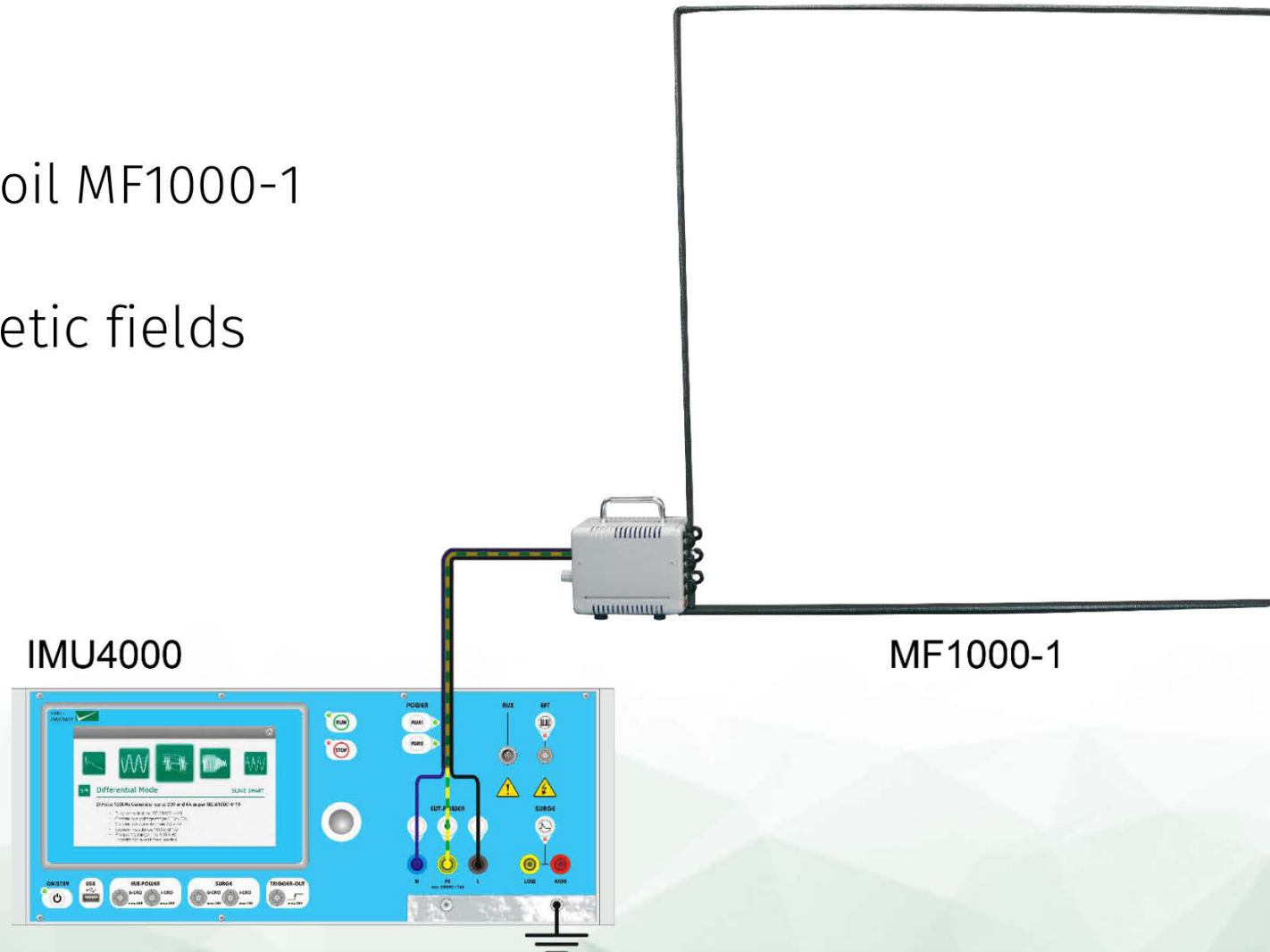
- Electrostatic discharges
IEC 61000-4-2



Example of test equipment which covers the test requirements

Generator IMU4000 with coil MF1000-1 for testing:

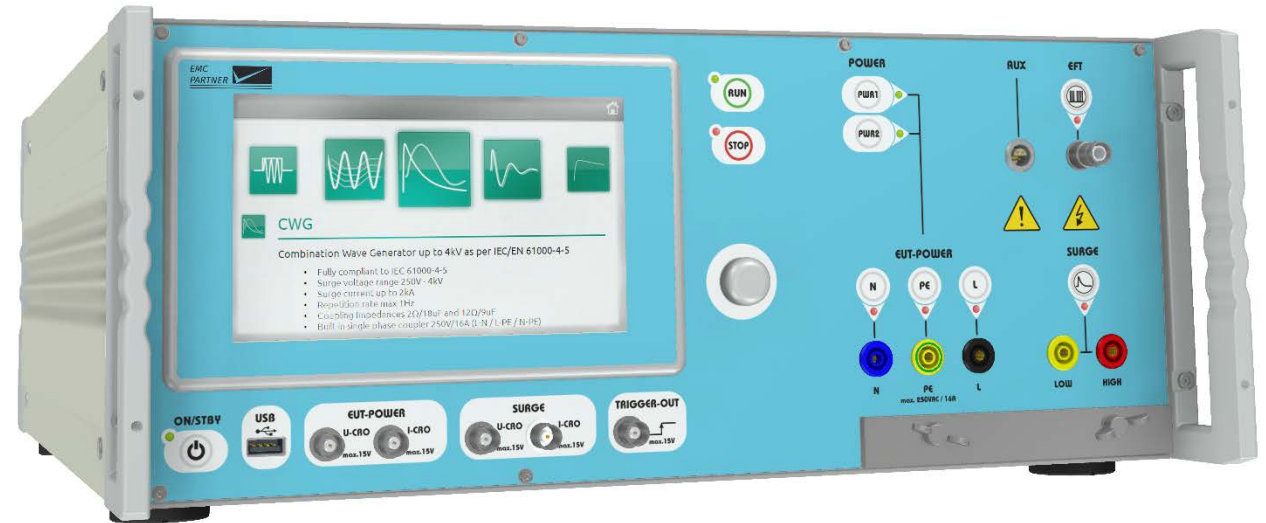
- Power frequency magnetic fields
IEC 61000-4-8



Example of test equipment which covers the test requirements

Generator IMU4000 for testing:

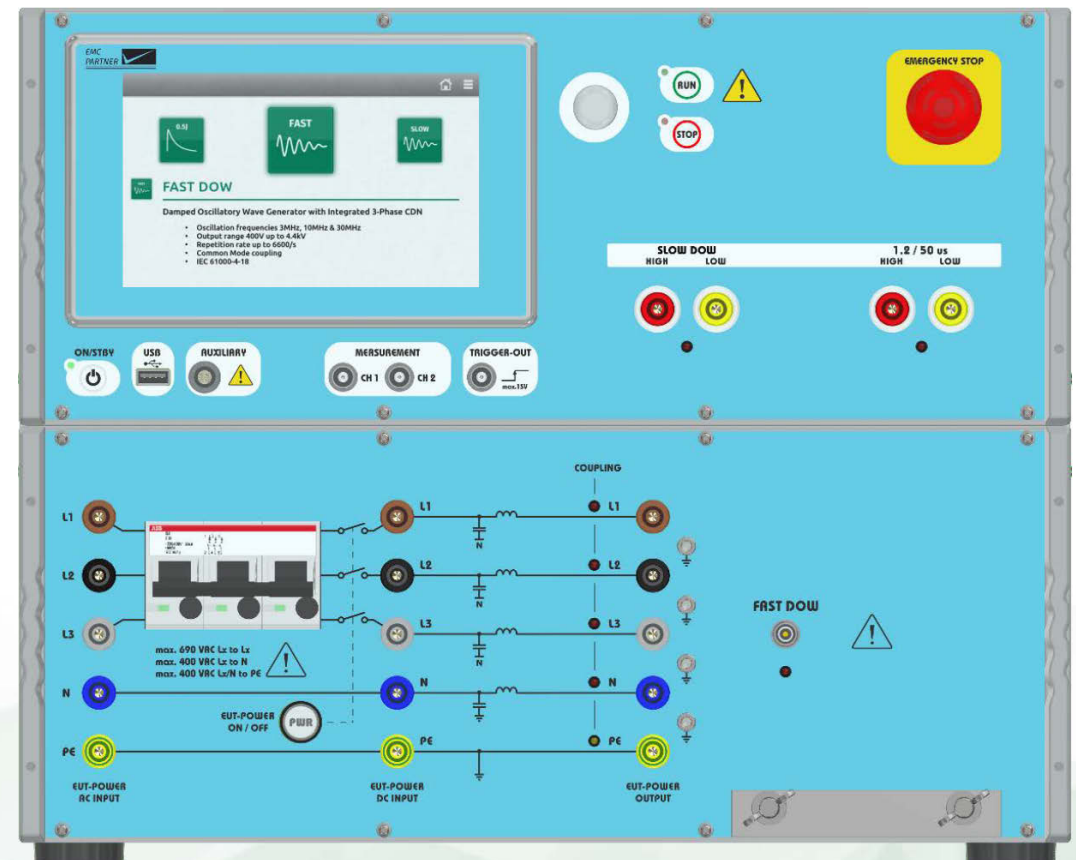
- Voltage dips and short interruptions
IEC 61000-4-11
- Electrical fast transients/bursts
IEC 61000-4-4
- Surges
IEC 61000-4-5
- Etc.



Example of test equipment which covers the test requirements

Generator DOW3000 for testing:

- Damped oscillatory waves
IEC 61000-4-18
- Impulse voltage test
1.2/50 μ s with 0.5 Joule
- Additionally feature of the generator
Damped oscillatory magnetic field
IEC 61000-4-10



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