



Insights and best practice

EMC COMPLIANCE KNOW-HOW



TECHNICAL NOTE 0115

WHAT IS EMC PRE-TESTING AND WHY IS IT IMPORTANT?

Overview

The ability to perform in-house EMC product testing before going to a certified Test Lab for final certification provides product designers and manufacturers with an array of benefits.

This booklet provides an overview of the tests that can be included in a pre-testing schedule, and the standards covered. This includes information about the test set-up required to perform the test, and instruments that are required.

This document is designed to accompany a video recording of a live webinar “What is EMC Pre-testing and Why is it important?” presented by Randy Johnson

Each page of this Technical Note has a time-stamp that corresponds to the relevant section of the video presentation.



You can view the [recording here](#)



Go to video 01:09

Electromagnetic Compatibility (EMC)

EMC is defined as “The ability of an equipment or system (or installation) to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.”

Electromagnetic compatibility therefore has two requirements:

- To ensure that emissions of electromagnetic disturbances are limited to a sufficient degree
- To ensure that equipment has a sufficient level of immunity to maintain adequate performance in the presence of the electromagnetic disturbances to which it is subjected.

Every major region of the world requires some level of certification to ensure products meet globally established Electromagnetic Compatibility (EMC) standards. Some examples of these certification's include:

- CE Marking (EU EMC Directive Testing)
- Japan VCCI
- Korea MIC
- CB EMC Certificate
- Australia C-Tick
- China Compulsory Certification Mark (CCC)
- Taiwan, China BSMI
- US Federal Communication Committee (FCC)
- Russia GOST-R Mark
- Canada ICES
- Eurasian Economic Community EAC Mark

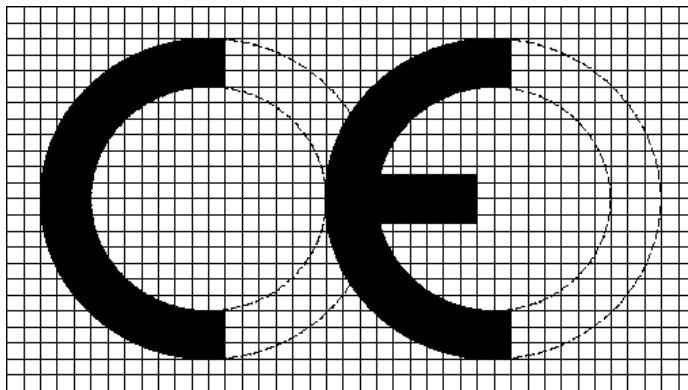


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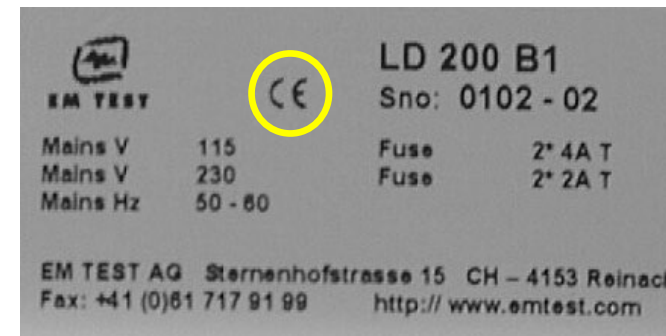
The CE marking is considered the global benchmark for standards compliance and certifies that a product has met the minimum requirements of European Community (EC).

The CE mark is not a quality mark rather, it indicates conformity to the legal requirements of the EU Directives.

Note: Any electronic product sold into Europe must have a CE compliance certification.



Minimum size 5mm !





Go to video 02:53

EMC Pre-testing is the ability to do in-house EMC product testing before going to a certified Test Lab for final certification

Why do Pre-testing -

1. To ensure your equipment has a sufficient immunity to maintain specified performance in the presence of electromagnetic disturbances
2. It allows you to find EMC issues with your products before going to a Test Lab for certification, which can be expensive & allows testing on your schedule
3. It increases the chances your products will pass certification the first time avoiding additional development time and cost
4. Streamlines your product Time to Market by reducing delays
5. Improves communication between testing & engineering groups, gives you real-time feedback from internal resources



Go to video 04:08

Basic Standards

Defines:

- the phenomena
- the test simulator
- the necessary test set-up for the execution of the test
- The basic standard can be an international, European or national one and is without obligation. Commitments are agreed between user and supplier.

Product Standards

- meets special requirements of certain products regarding their operation during measurement and the evaluation of their malfunction.
- precedes the basic standards and the generic standards without being contradictory to them.
- can describe special limit values or amended tests.

Generic Standards

Describes:

- the requirements for emission and immunity under consideration of the environmental conditions.
- A generic standard is mainly composed of definitions of the terms that are important for the evaluation of the electronics to be tested.
- Generic standards are applied if no product standard is applicable for this product.



Go to video 05:32

Basic Standards Testing We Will Discuss in this Presentation

- IEC 61000-4-2 - Electro-Static Discharge (ESD) Testing
- IEC 61000-4-4 - Electrical- Fast Transient (EFT/Burst) Testing
- IEC 61000-4-5 - Combination Wave (Surge) Testing
- IEC 61000-4-11 – Variations, Dips & Interrupt (VDI) Testing

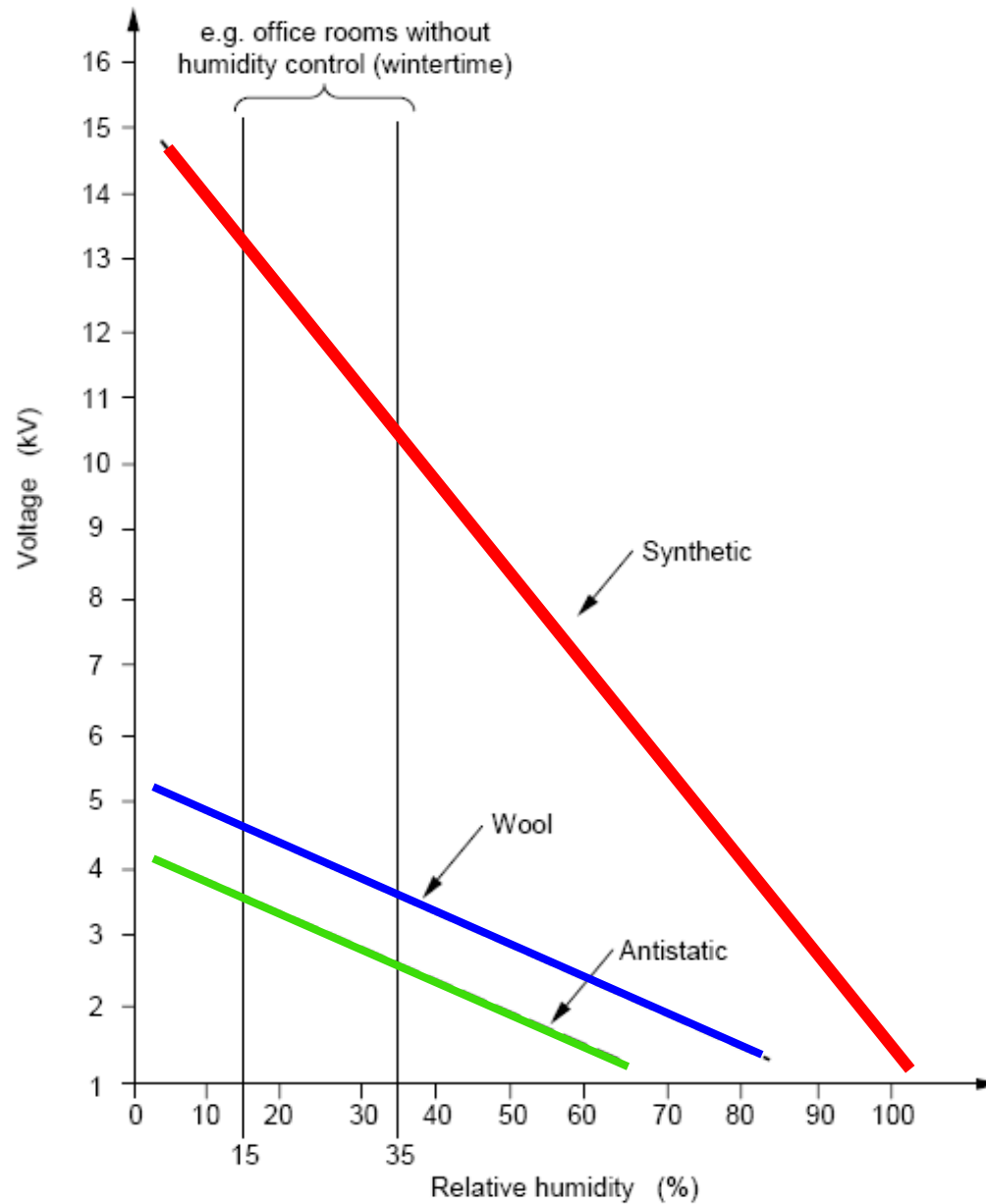
Most companies who do pre-testing start with ESD, Burst, Surge & VDI (we will show examples of these)



Immunity to the discharge of Electro-Static Electricity (ESD)

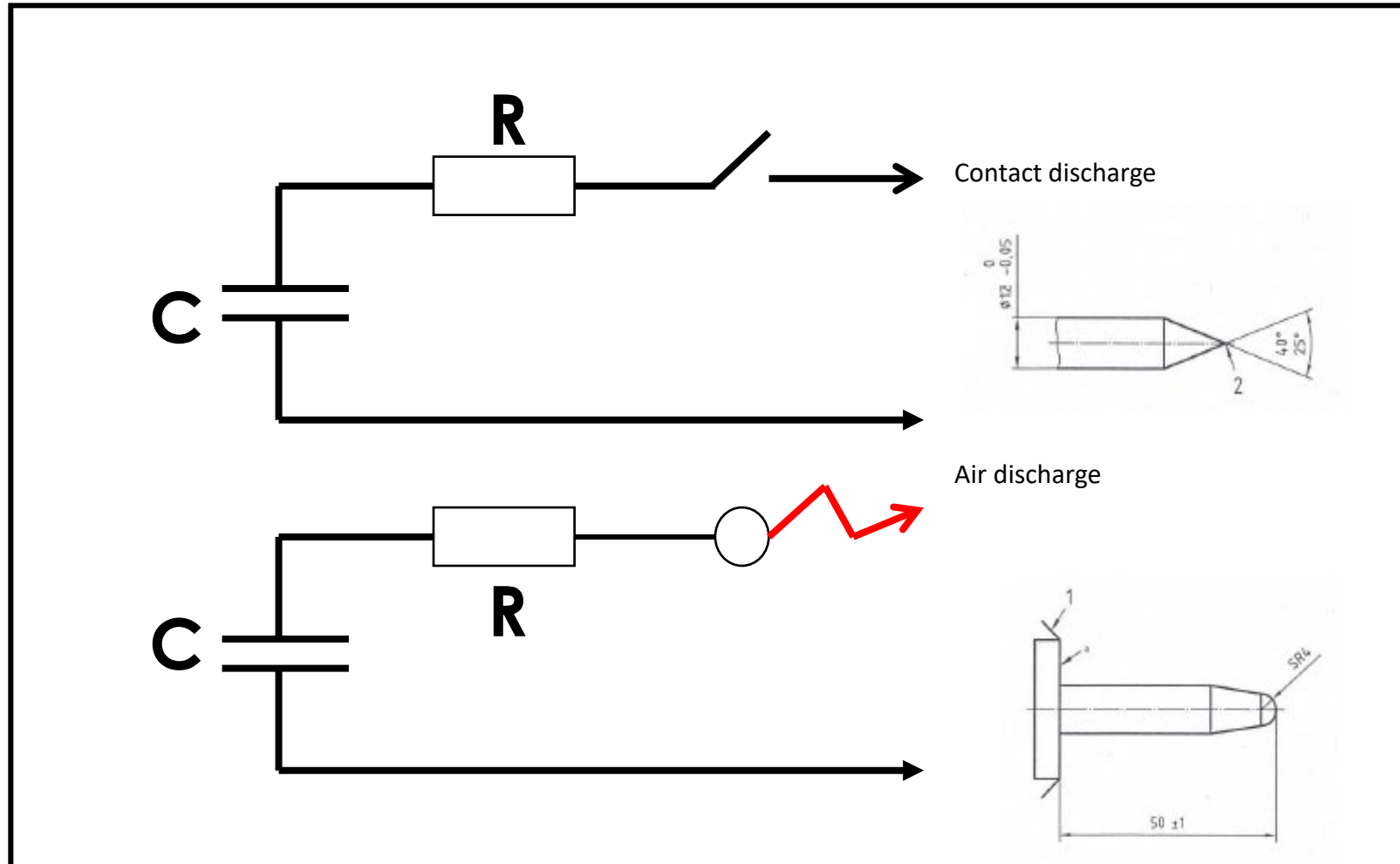


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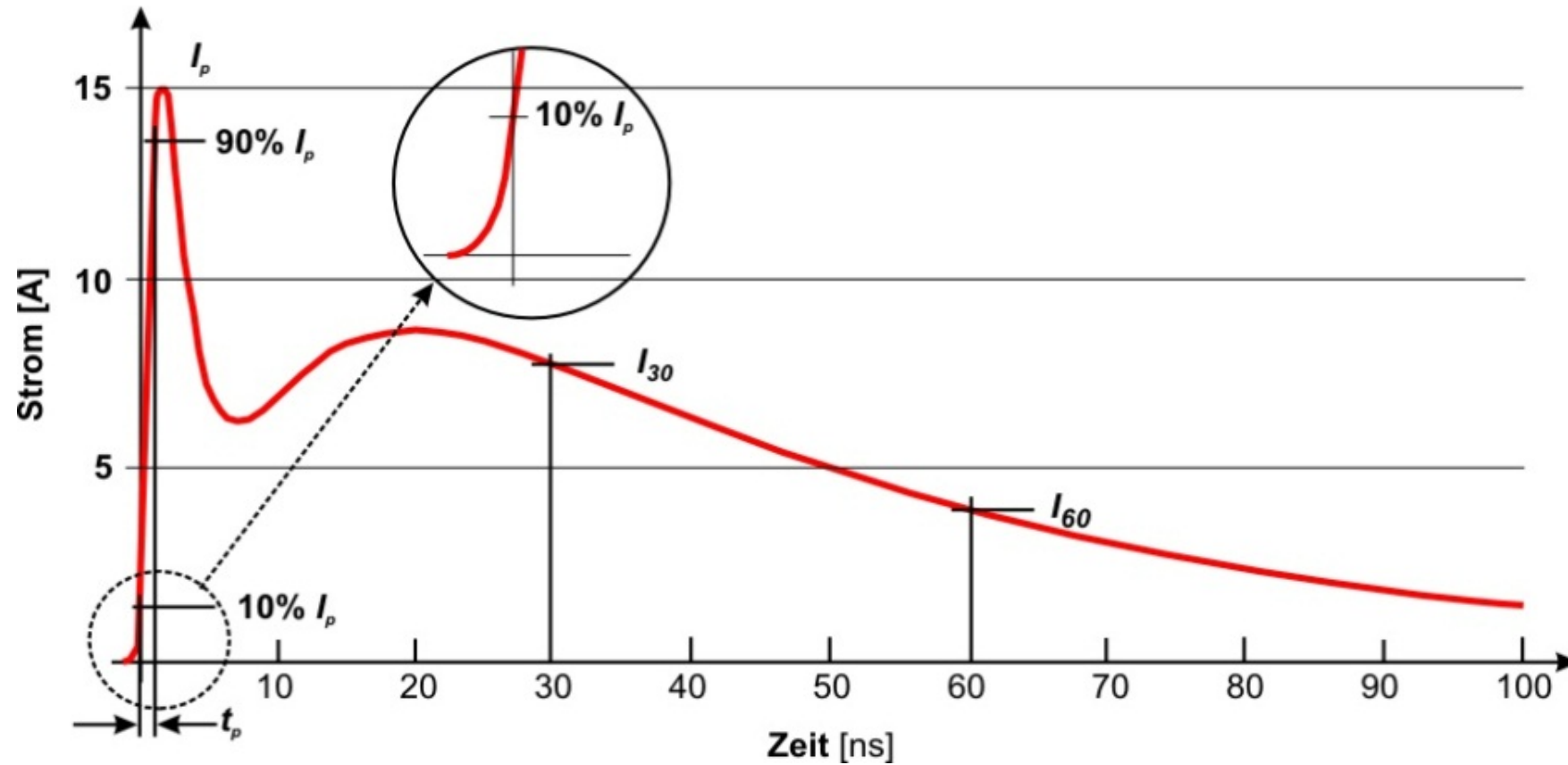
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R – discharge resistor
C – storage capacity



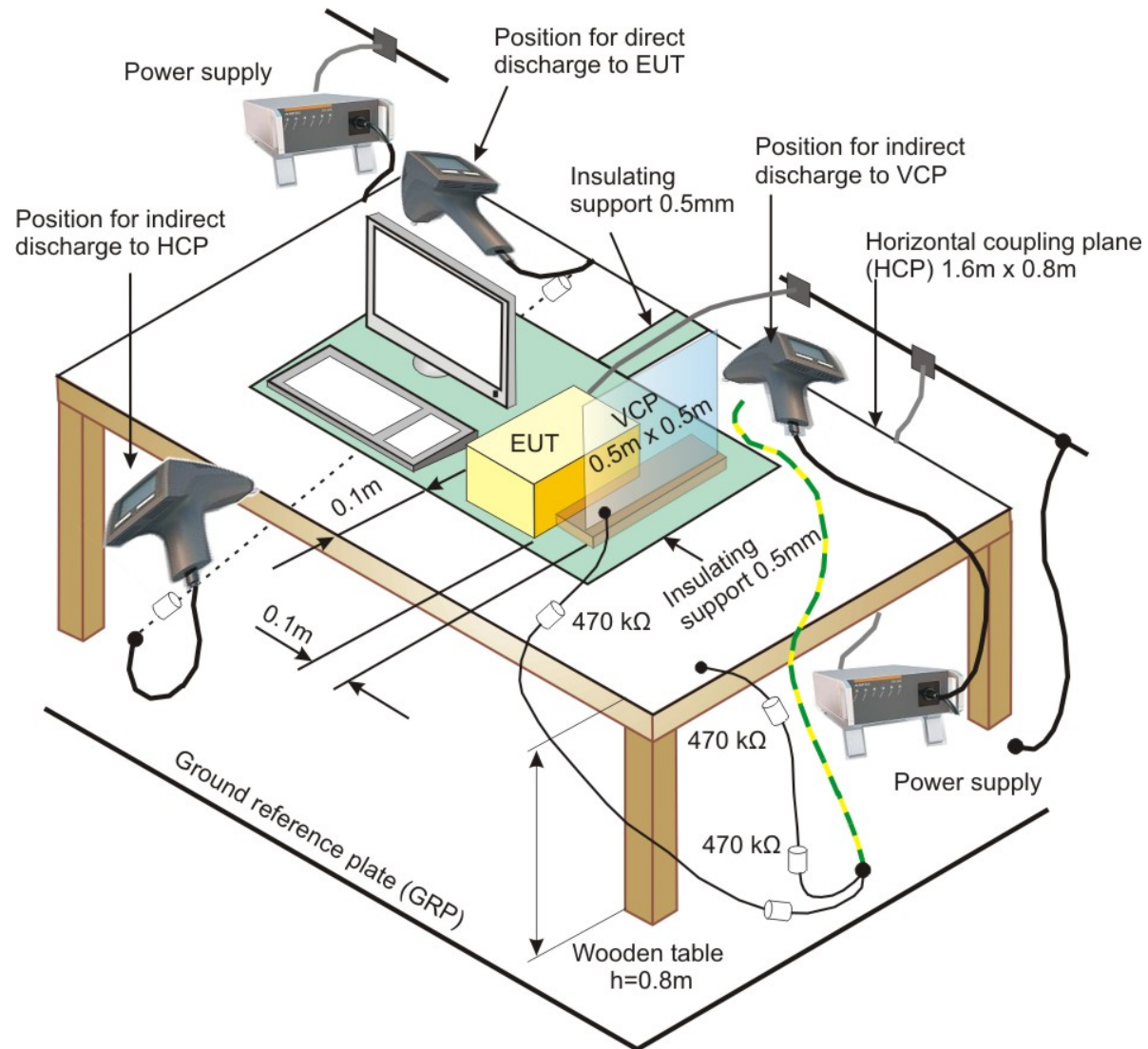
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Test set-up for tabletop devices according IEC 61000-4-2



Go to video 09:26





Go to video 10:24

- For air discharge all test levels up to requirement have to be tested.
- For contact discharge only the specified test levels have to be tested (however, we recommend to continue testing as for air discharge).
- Maximum 1 discharge per second
- minimum 10 discharges each polarity

Level	Air discharge	Contact discharge
1	2 kV	2 kV
2	4 kV	4 kV
3	8 kV	6 kV
4	15 kV	8 kV



Go to video 11:07

- Direct discharge
 - All accessible points (touchable by user)
 - Housing: edges, angles, surfaces, slots, indicator parts
 - Operating parts: switches, buttons, plugs, etc.
 - Interfaces with metallic housing:
only contact discharge on plug housing
 - Interfaces with isolated housing:
only air discharge on plug housing
 - In certain cases product standards can request the discharge on pins
- Indirect discharge
 - Edge of vertical coupling plane, VCP with 10 cm distance to each EUT side.
 - Edge of horizontal coupling plane, EUT with each side with 10 cm distance to the discharge point.



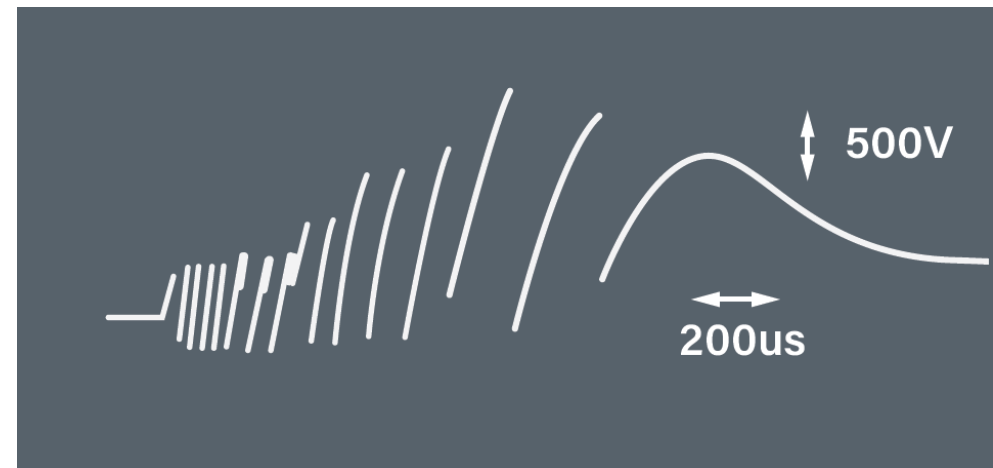
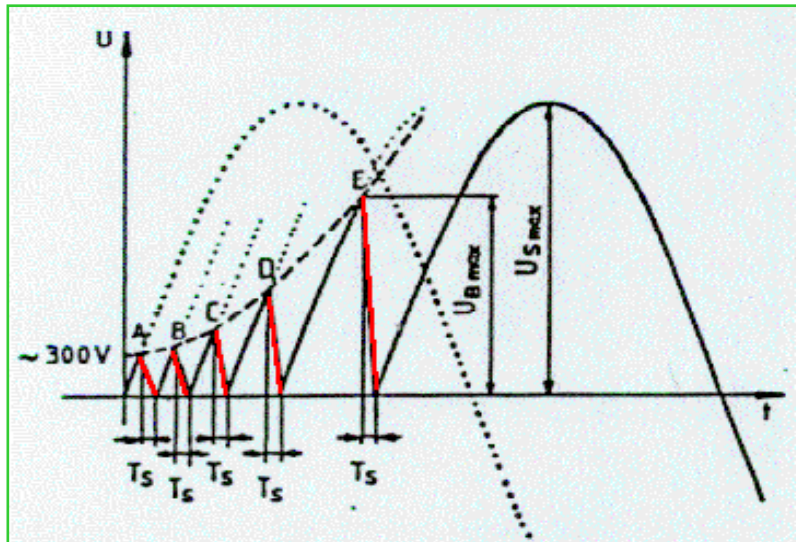
Go to video 12:09

Immunity test procedure for broadband Interferences (EFT/Burst)



Go to video 12:21

Typical voltage waveform across an opening switch (230V Power relays):



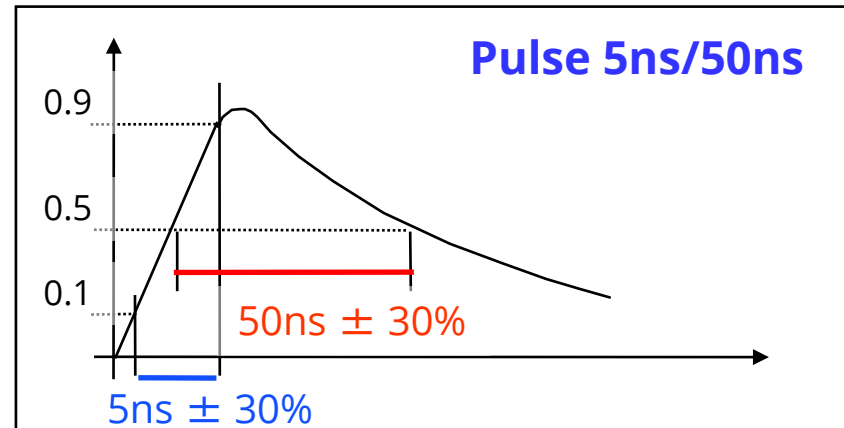


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Single pulse

Rise time $t_r = 5\text{ns}$

Pulse duration $t_d = 50\text{ns}$



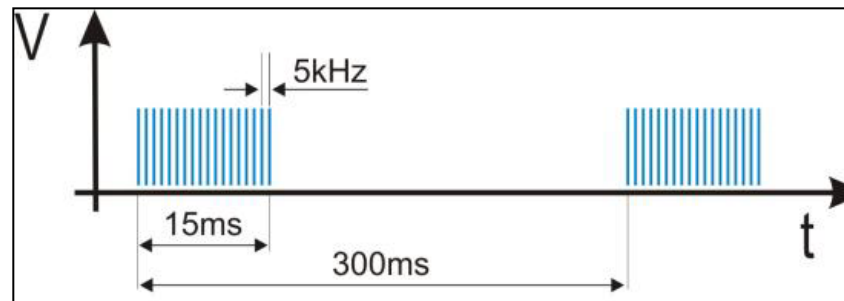
Pulse packet (Burst)

Repetition time $T_r = 300\text{ms}$

As formerly:

Duration burst packet $T_d = 15\text{ms}$

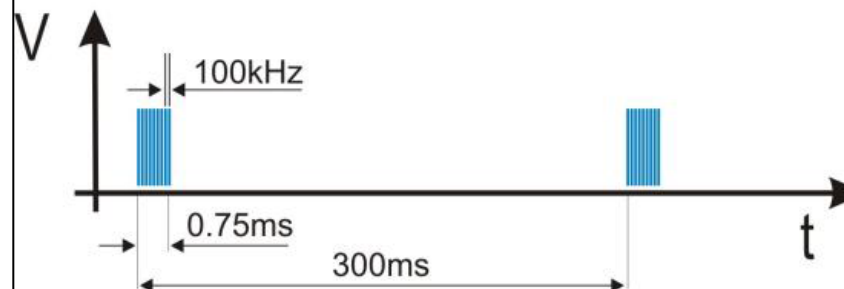
at spike frequency $f = 5\text{kHz}$



Newly added:

Duration burst packet $T_d = 0.75\text{ms}$

At spike frequency $f = 100\text{kHz}$





Go to video 14:19

Table 2 – Output voltage peak values and repetition frequencies

Set voltage	V_p (open circuit) [kV]	V_p (1000 Ω) [kV]	V_p (50 Ω) [kV]	Repetition frequency [kHz]
0.25	0.25	0.24	0.125	5 or 100
0.5	0.5	0.48	0.25	5 or 100
1	1	0.95	0.5	5 or 100
2	2	1.9	1	5 or 100
4	4	3.8	2	5 or 100

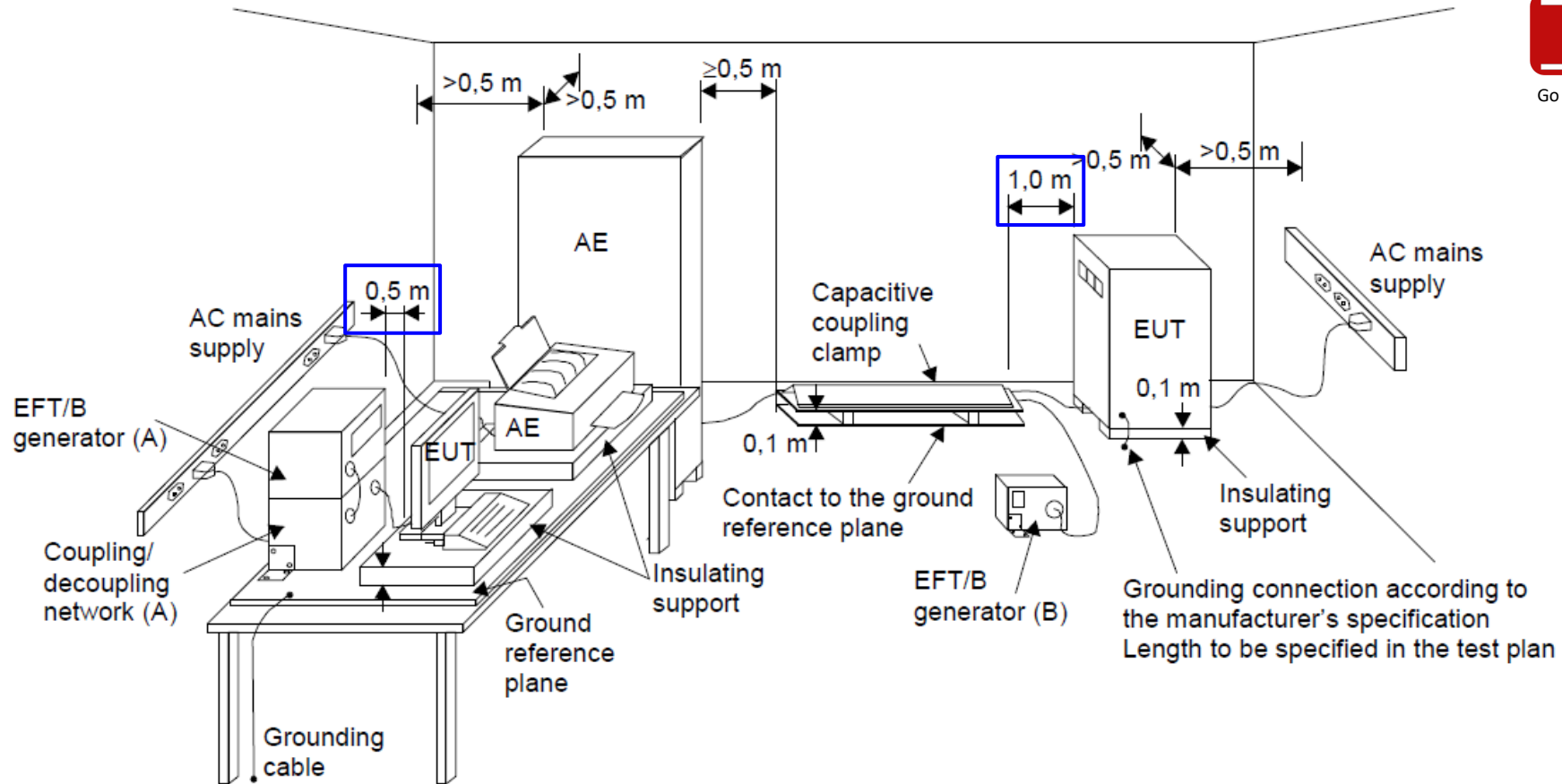
Measures should be taken to ensure that stray capacitance is kept to a minimum.

NOTE 1 Use of a 1 000 Ω load resistor will automatically result in a voltage reading that is 5 % lower than the set voltage, as shown in column V_p (1 000 Ω). The reading V_p at 1 000 Ω = V_p (open circuit) multiplied times 1 000/1 050 (the ratio of the test load to the total circuit impedance of 1 000 Ω plus 50 Ω).

NOTE 2 With the 50 Ω load, the measured output voltage is 0,5 times the value of the unloaded voltage as reflected in the table above.



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- (A) location for supply line coupling
- (B) location for signal lines coupling

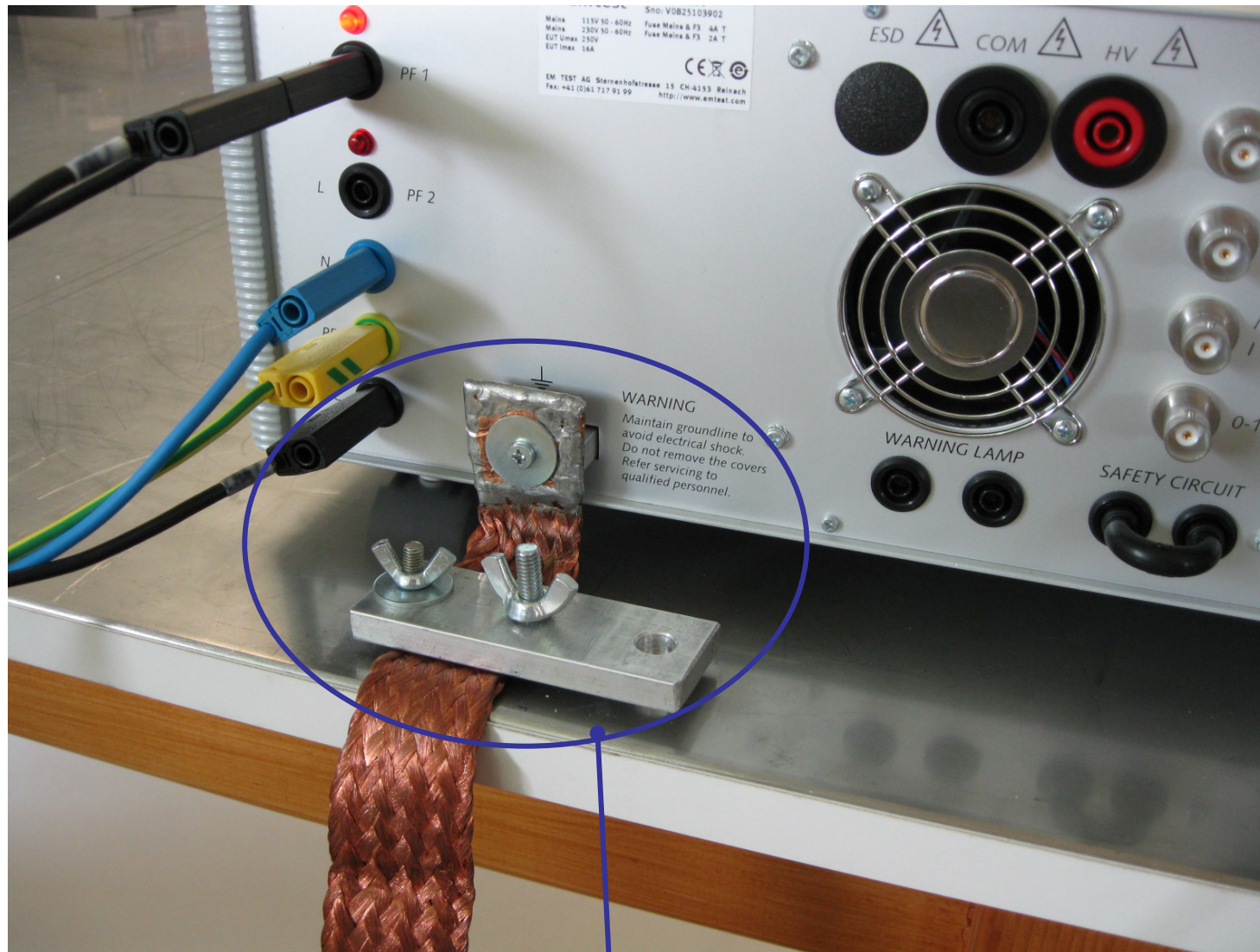
Figure 11 – Example of a test setup for laboratory type tests

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Test setup for EFT/Burst: Connection of coupling network



Go to video 16:01



Important: The coupling network has to be connected with the reference ground in low impedance manner!



Go to video 16:28

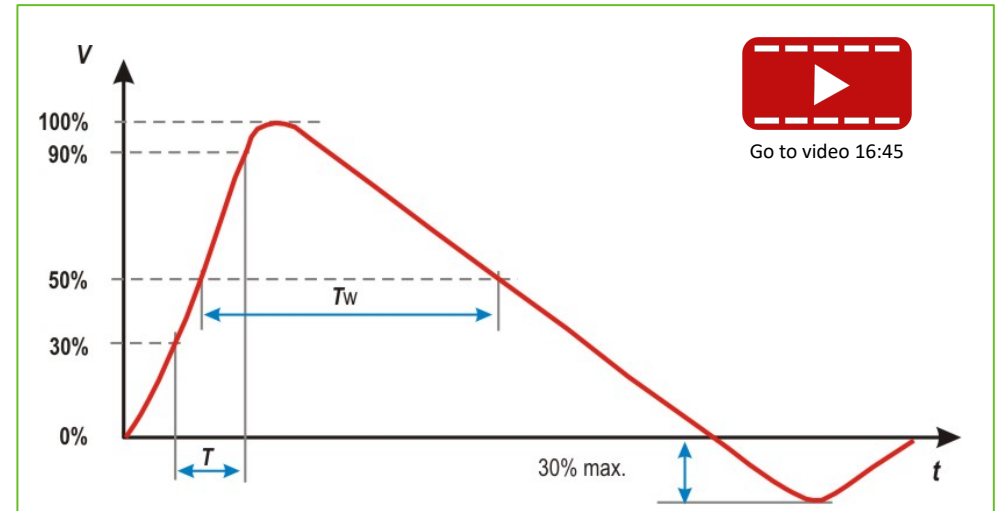
Immunity to high-energy surge voltages (Surge)



- **Open circuit voltage :** 1.2/50µs

Front Time: $T_f = 1.67 \times T = 1.2\mu\text{s} \pm 30\%$
Duration: $T_d = T_w = 50\mu\text{s} \pm 20\%$

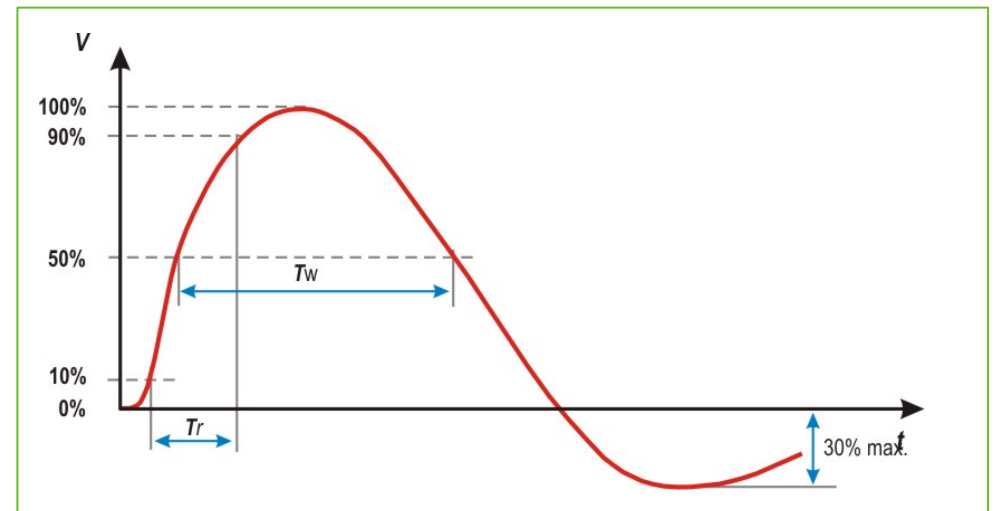
NOTE: The open circuit voltage waveform at the output of the coupling/decoupling network may have a considerable undershoot, in principle as the curve shown in Figure



- **Short circuit current:** 8/20µs

Front Time : $T_f = 1.25 \times T_r = 8\mu\text{s} \pm 20\%$
Duration: $T_d = 1.18 \times T_w = 20\mu\text{s} \pm 20\%$

NOTE :The 30 % undershoot specification applies only at the generator output. At the output of the coupling/decoupling network there is no limitation on undershoot or overshoot.





Go to video 17:26

Table 1 – Test levels

Level	Open-circuit test voltage	
	kV	
	Line-to-line	Line-to-ground ^b
1	---	0,5
2	0,5	1
3	1	2
4	2	4
X ^a	Special	Special

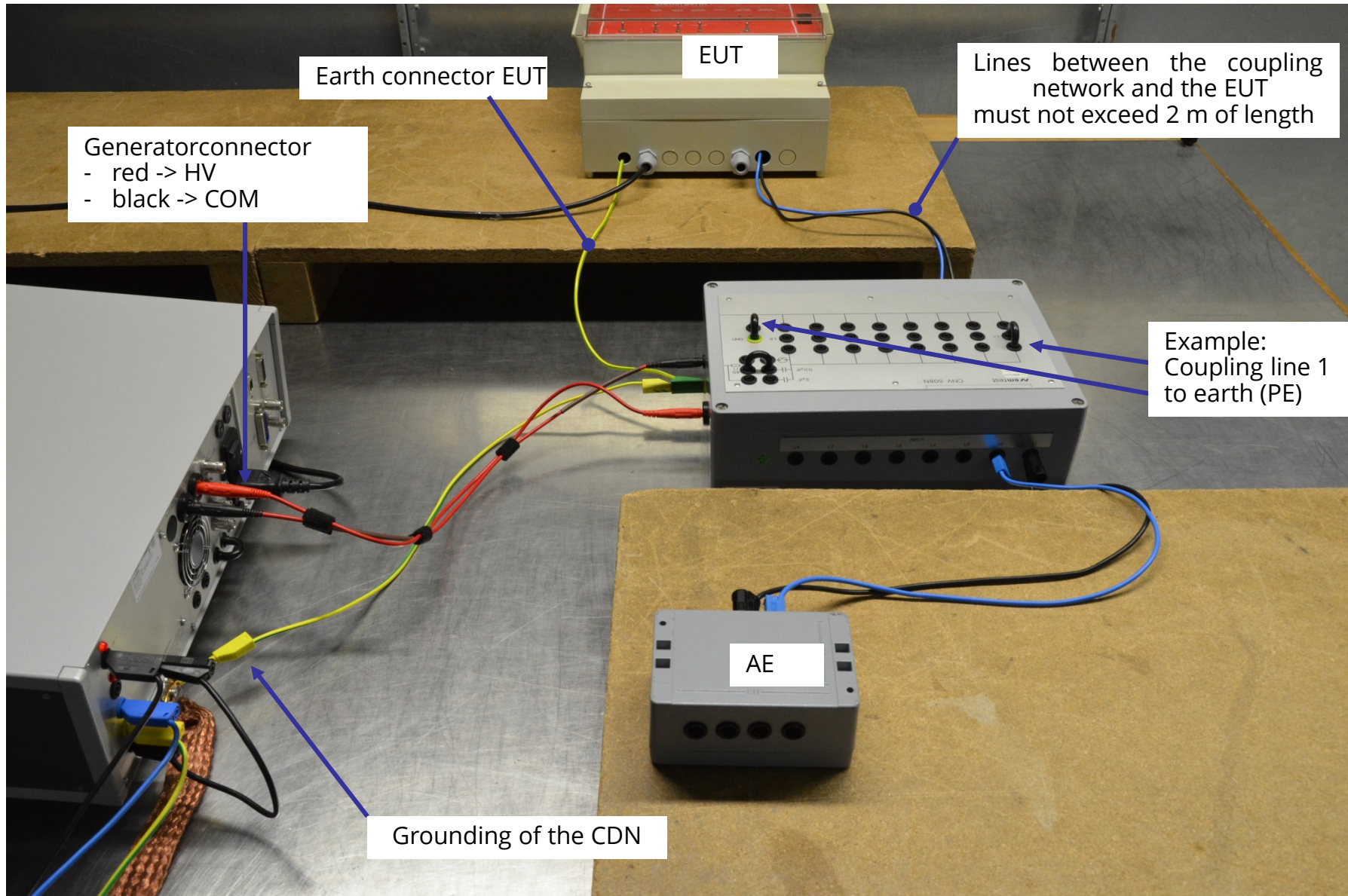
^a "X" can be any level, above, below or in between the others. The level shall be specified in the dedicated equipment specification.

^b For symmetrical interconnection lines the test can be applied to multiple lines simultaneously with respect to ground, i.e. "lines to ground".

The test levels shall be selected according to the installation conditions; classes of installation are given in Annex C.

The test shall be applied at all test levels in Table 1 up to and including the specified test level (see 8.3).

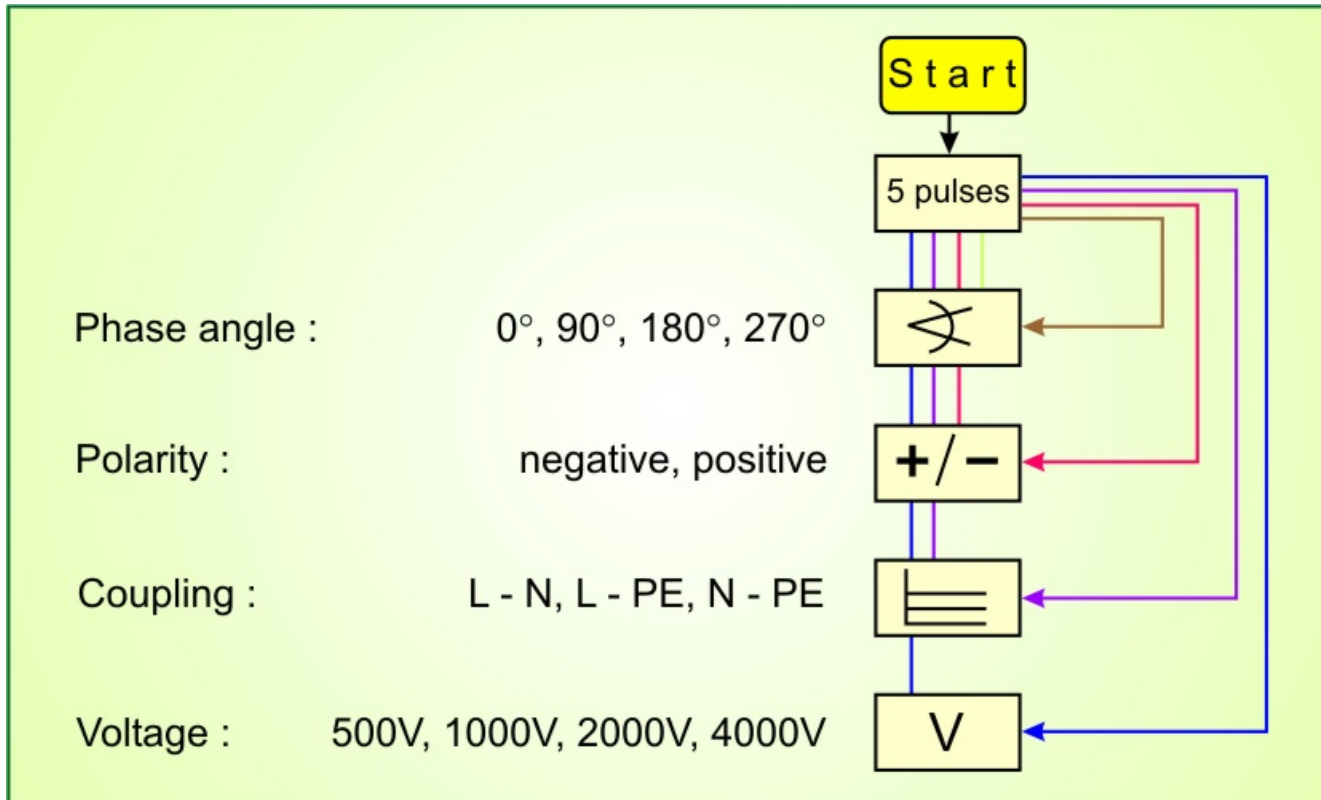
For selection of the test levels for the different interfaces, refer to Annex B.



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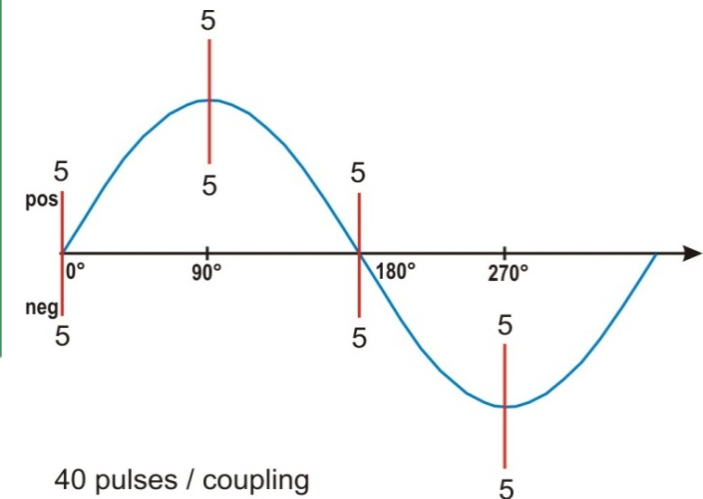


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Example: Requirement :
Differential mode (DM): 1kV
Common mode (CM): 2kV

Coupling	Level in kV		
	0,5kV	1kV	2kV
L-N	apply	apply	no test
L-PE	apply	apply	apply
N-PE	apply	apply	apply



- 5 test-pulses for every setting (Level, Coupling, Angle, Polarity).
- time between successive pulses: 1 min or less.



Go to video 19:52

Immunity to voltage dips, short interruptions and voltage variations (VDI)

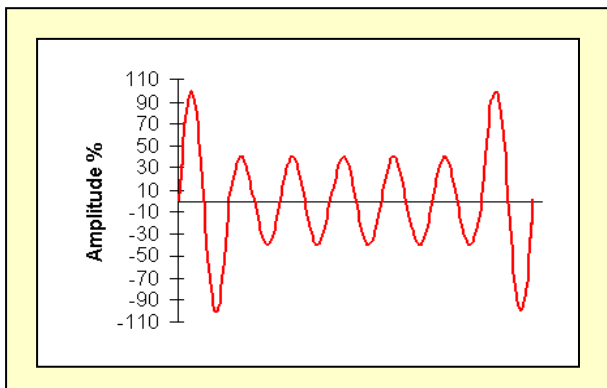


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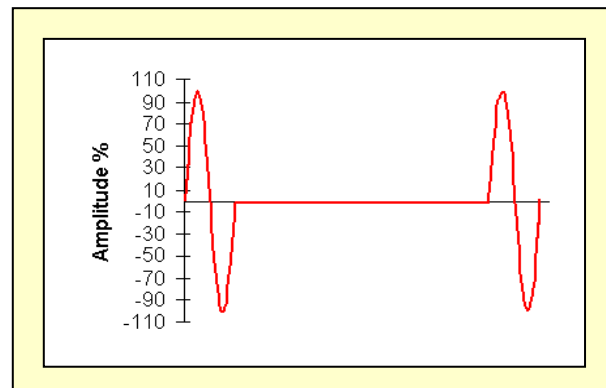
- Load change in the same electric circuit
- Start and breaking characteristic of engines
- Short circuits and electrical fault conditions
- Switch on of systems with high peak current during start

Generally, it is considered in this EMC standard, that the voltage of the described sources can not be higher than 100%.
The standard simulate the following phenomena's:

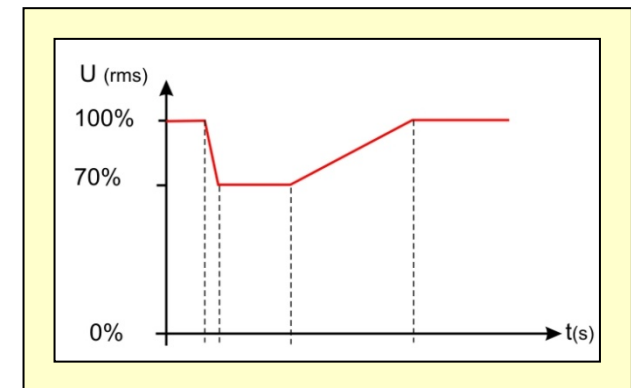
Voltage dips



Voltage interruptions



Voltage variations





Go to video 20:53

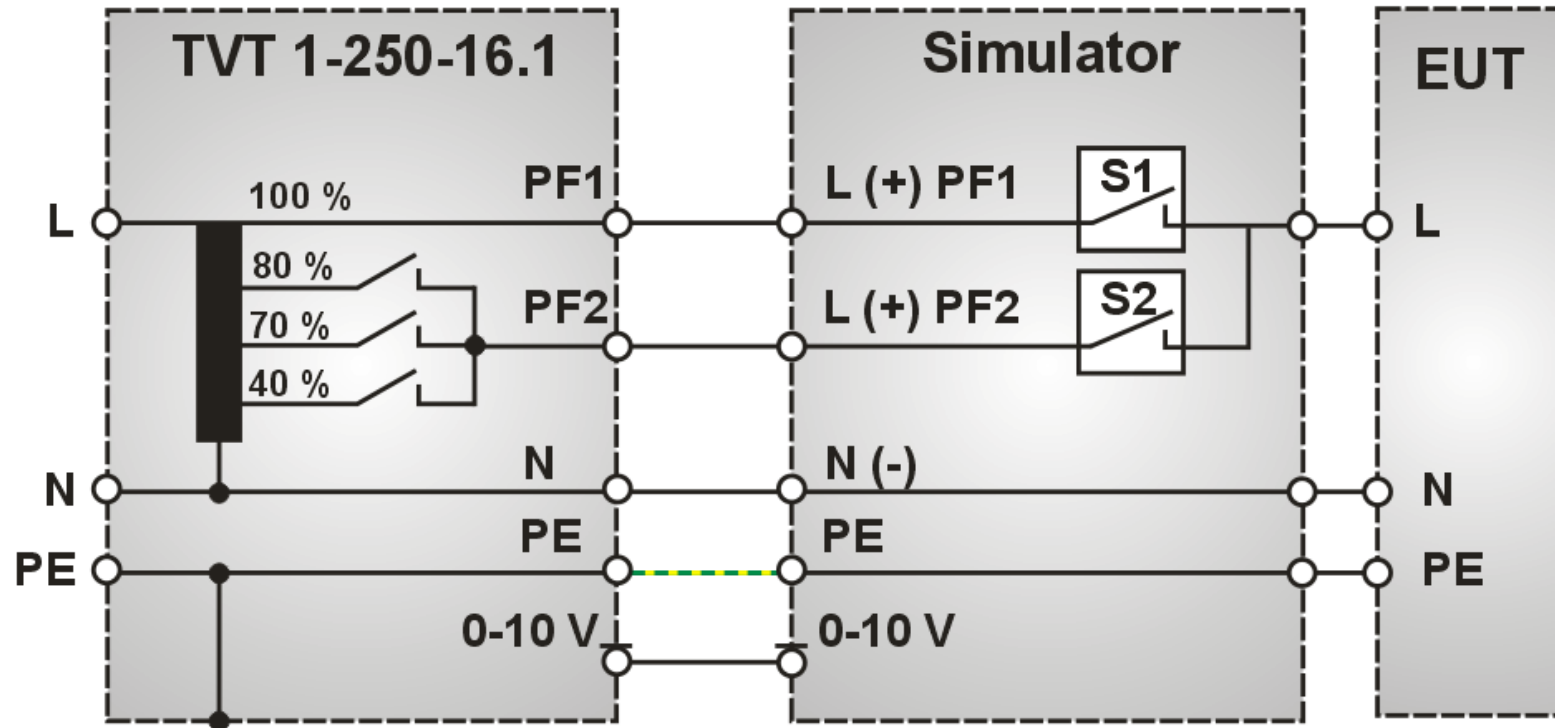
<p>Voltage variations on the output of the simulator</p> <p>100%-output, 0 to 16 A</p> <p>80%-output, 0 to 20 A</p> <p>70%-output, 0 to 23 A</p> <p>40%-output, 0 to 40 A</p>	<p>less than 5% of U_T</p> <p>less than 5% of U_T</p> <p>less than 5% of U_T</p> <p>less than 5% of U_T</p>
<p>Peak inrush current capacity</p>	<p>1000 A for 250 V to 600 V</p> <p>500 A for 200 V to 250 V</p> <p>250 A for 100 V to 120 V</p>
<p>peak overshoot/undershoot of the actual voltage, generator loaded with 100 Ω</p>	<p>less than 5% of U_T</p>
<p>Time of voltage variations for rise and fall with 100 Ω load</p>	<p>between 1 μs and 5 μs</p>



Test setup with tapped transformer



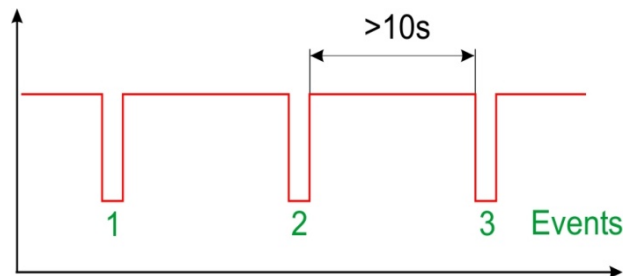
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Go to video 22:28

- The EUT shall be tested for each selected combination of test level and duration with a sequence of **three** dips / interruptions with **intervals of 10 s minimum** (between each test event).



- Each representative mode of operation shall be tested.
- For voltage dips, changes in supply voltage shall occur at **zero crossings** of the voltage, and at additional angles considered critical by product committees or individual product specifications preferably selected from 45° , 90° , 135° , 180° , 225° , 270° and 315° on each phase.
- The switching is happening on the phase line and not on neutral line.



Go to video 23:14

We showed examples of Basic Standards Testing (IEC 61000-4 series) Examples of Product and Generic Standards are beyond the scope of this discussion, but include the following:

Product Standards:

- IEC 60601-1-2 (Medical Electrical Equipment)
- IEC 62599-2 (Alarm and Electronic Security Systems)
- IEC 61851-21 (Electric Road Vehicles Charging Systems)
- IEC 61326-1 (Electrical Equipment for Measurement, Control and Laboratory use)

Generic Standards:

- IEC 61000-6-1 (Immunity for Residential, Commercial and Light-Industrial Environments)
- IEC 61000-6-2 (Immunity for Industrial Environments)



Go to video 24:52

Reasons for Pre-Testing:

- To ensure your equipment has a sufficient immunity to maintain specified performance in the presence of electromagnetic disturbances
- It allows you to find EMC issues with your products before going to a Test Lab for certification, which can be expensive & allows testing on your schedule
- It increases the chances your products will pass certification the first time avoiding additional development time and cost
- Streamlines your product Time to Market
- Improves communication between testing and engineering groups, gives you real-time feedback from internal resources
- Pre-Testing for IEC 61000-4-2, -4,-5 & -11 solves many immunity issues and can easily be done at your location for a reasonable cost versus relying only on outside testing that could drive up cost, development time, and put your schedules at risk – it's like doing your homework in school so your ready when it's time to take a test



Insights and best practice

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