

EFT Transient Immunity

IEC 61000-4-4

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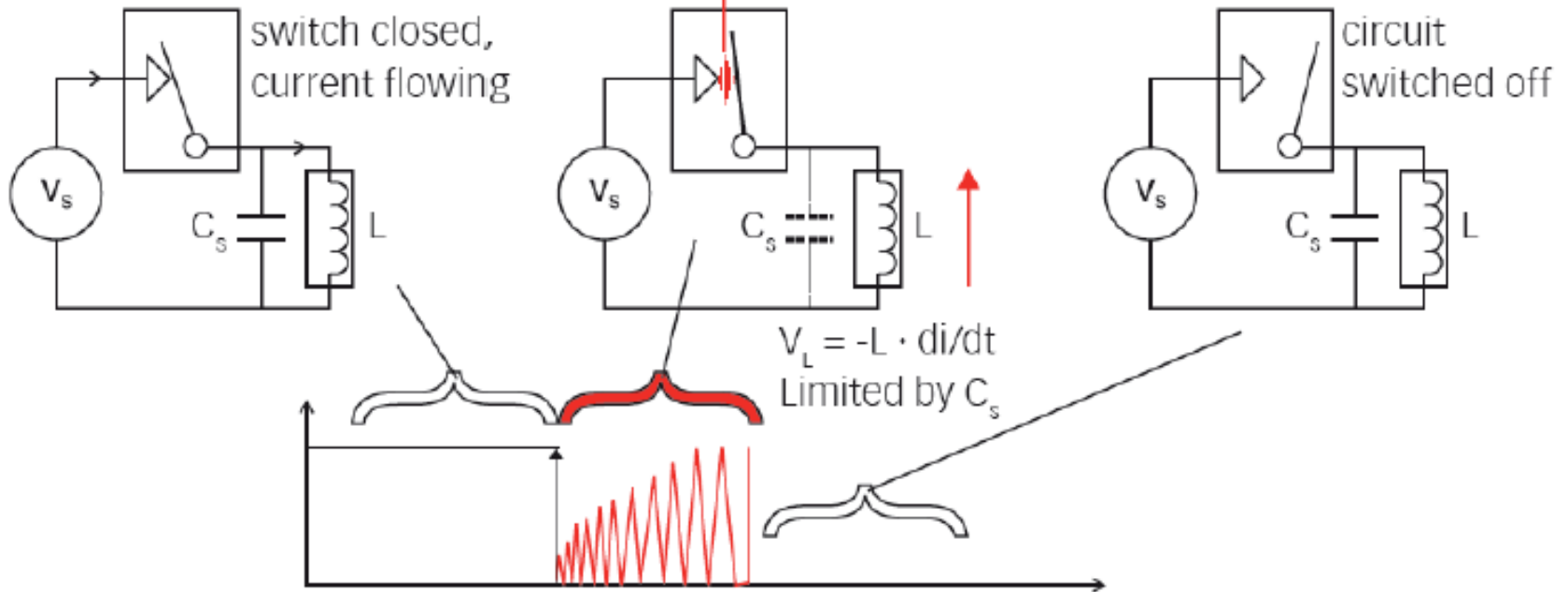
EFT phenomena

- 當電路斷開時，流過開關的電流或多或少地瞬間中斷。
- 在切換時刻有一個無限量的瞬間電流。
- 所有電路都有一些與佈線有關的雜散電感 或某些類型的負載，例如電機馬達或電磁線圈，在負載本身中具有相當多的電感成分。
- 當開關切換時，變化的電流 i 在電感 L 兩端產生的電壓為：

$$V = - L \cdot di/dt$$

EFT phenomena

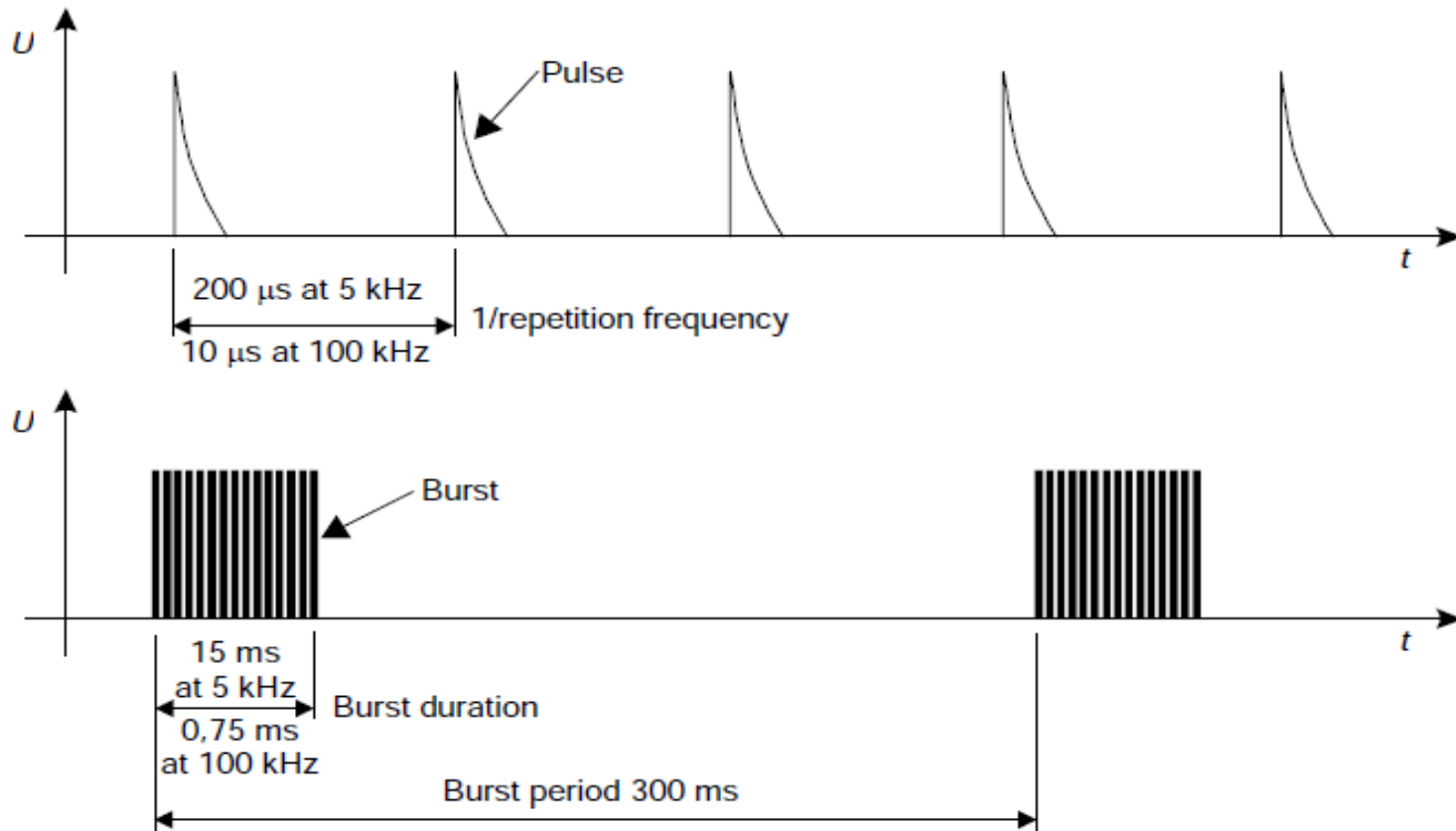
switch opens: arc
generated while gap
cannot maintain V_L



EFT fast transients IEC 61000-4-4

- 測試目的:
抗擾度測試目的在確認電氣設備在開關切換動作的瞬間（對瞬態干擾）的抵抗力。
- 測試設備:
 - EFT generator
 - Coupling & decoupling device (internal or external)
 - Capacitive coupling clamp for telecom line coupling
 - Coupling (injection) Capacitor 33 nF
 - Decoupling inductor > 100 μ H
 - Ground plane

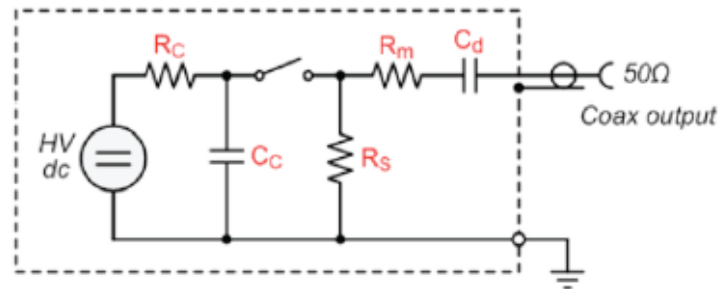
Transient waveform



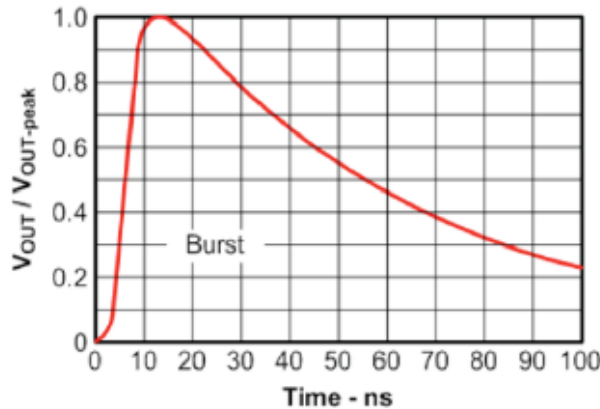
Electrical Fast Transient (EFT) Immunity

IEC61000-4-4

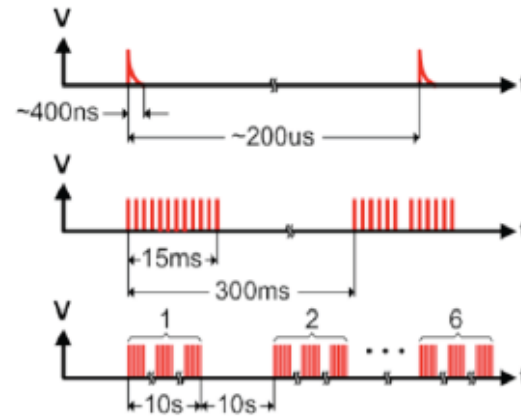
simulates every day's switching transients caused by the interruption of inductive loads, relay contact bounce, etc.



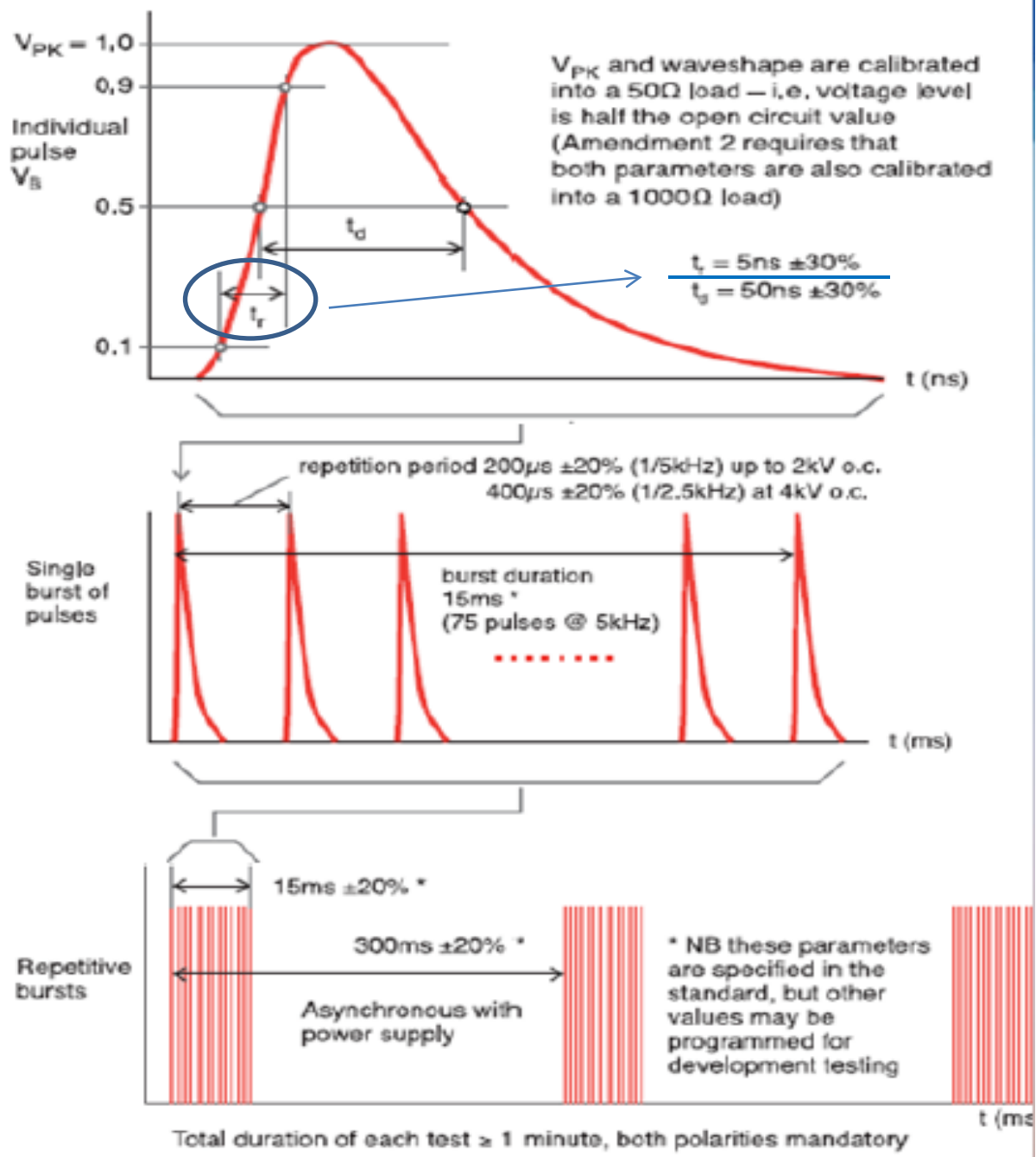
Generator



Waveform



Test pulses



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.

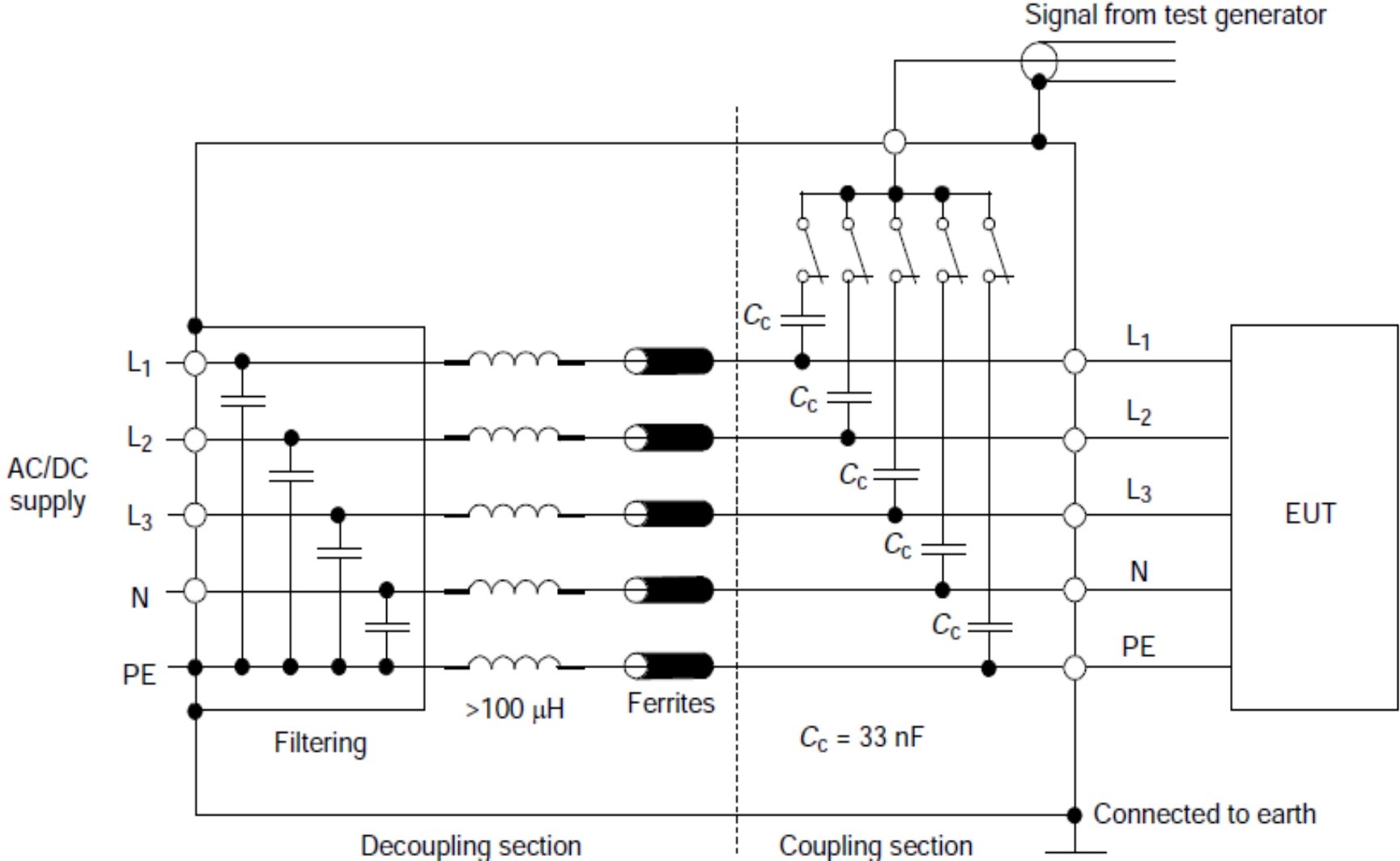
Test setup

- 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.

Test procedure

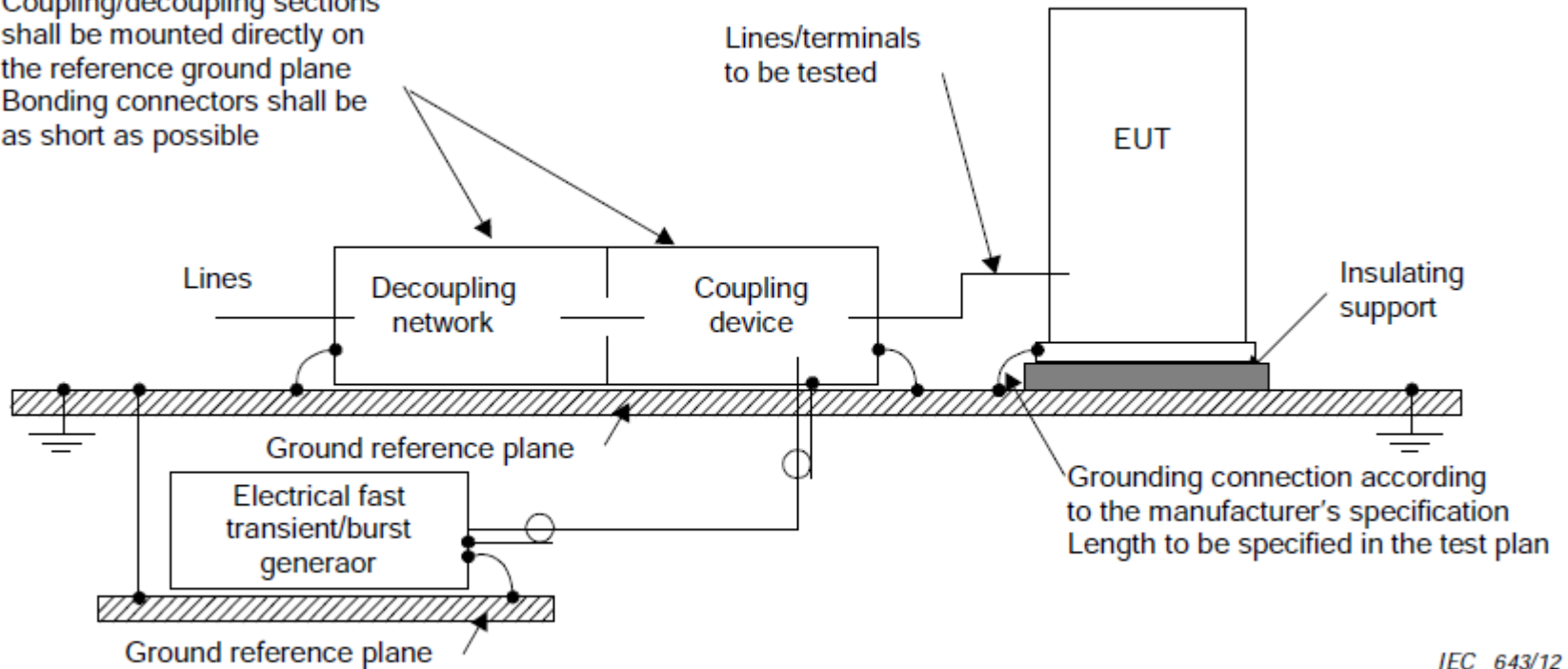
- The test procedure includes:
- the verification of the laboratory reference conditions;
- the preliminary verification of the correct operation of the equipment;
- the execution of the test;
- the evaluation of the test results.

Coupling/decoupling network for a.c./d.c. power ports/terminals

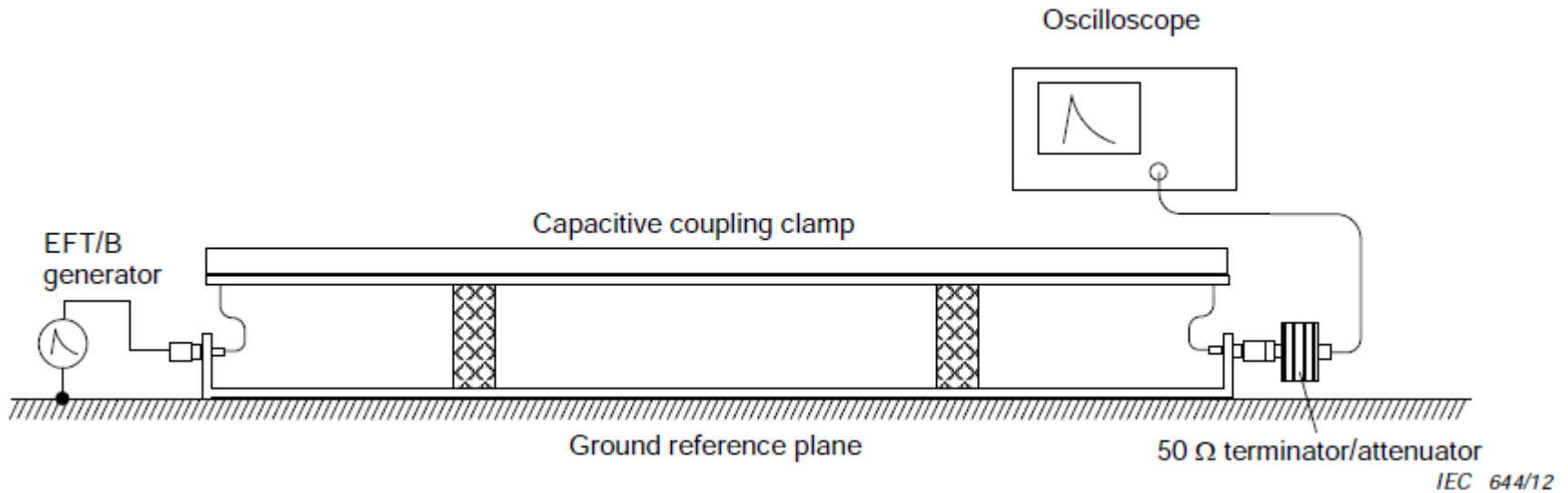


Test setup

Coupling/decoupling sections shall be mounted directly on the reference ground plane
Bonding connectors shall be as short as possible

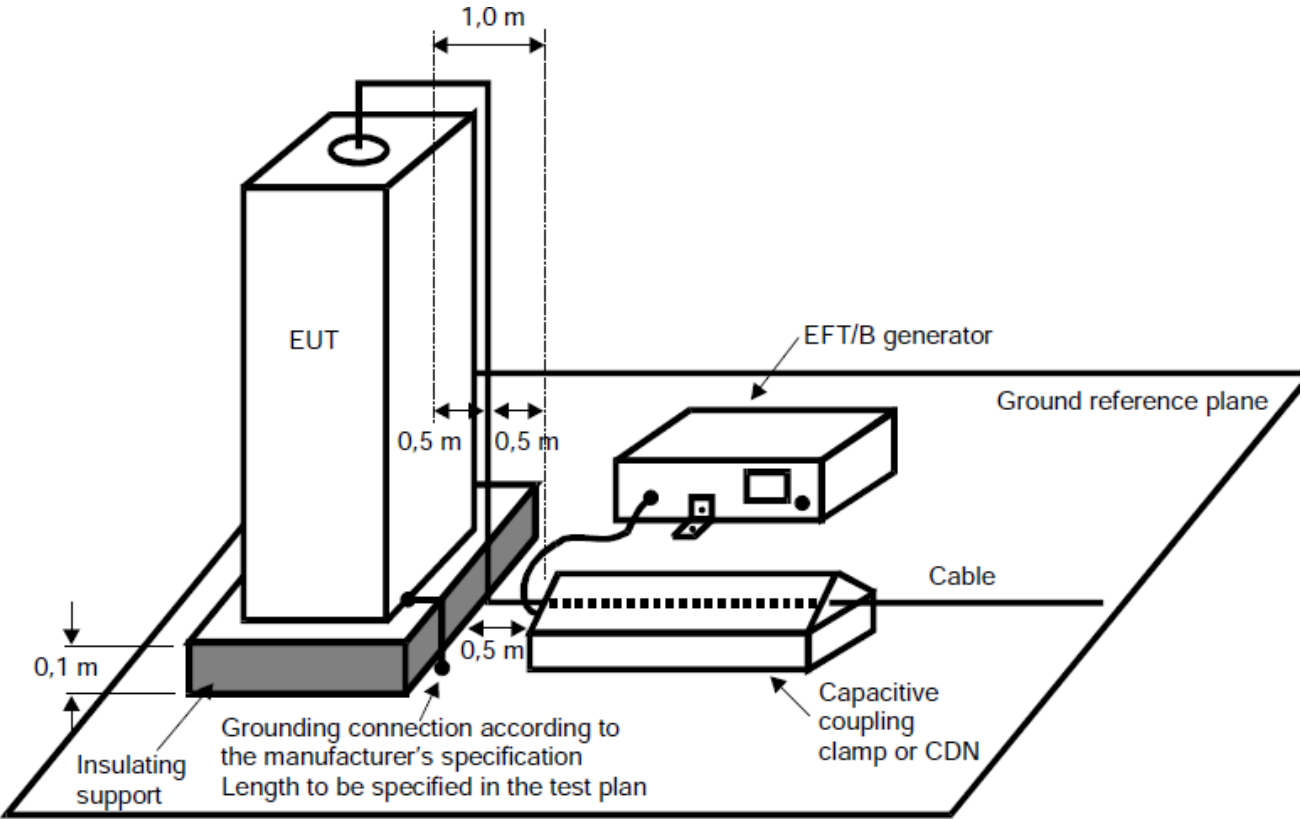


Verification of the capacitive coupling clamp



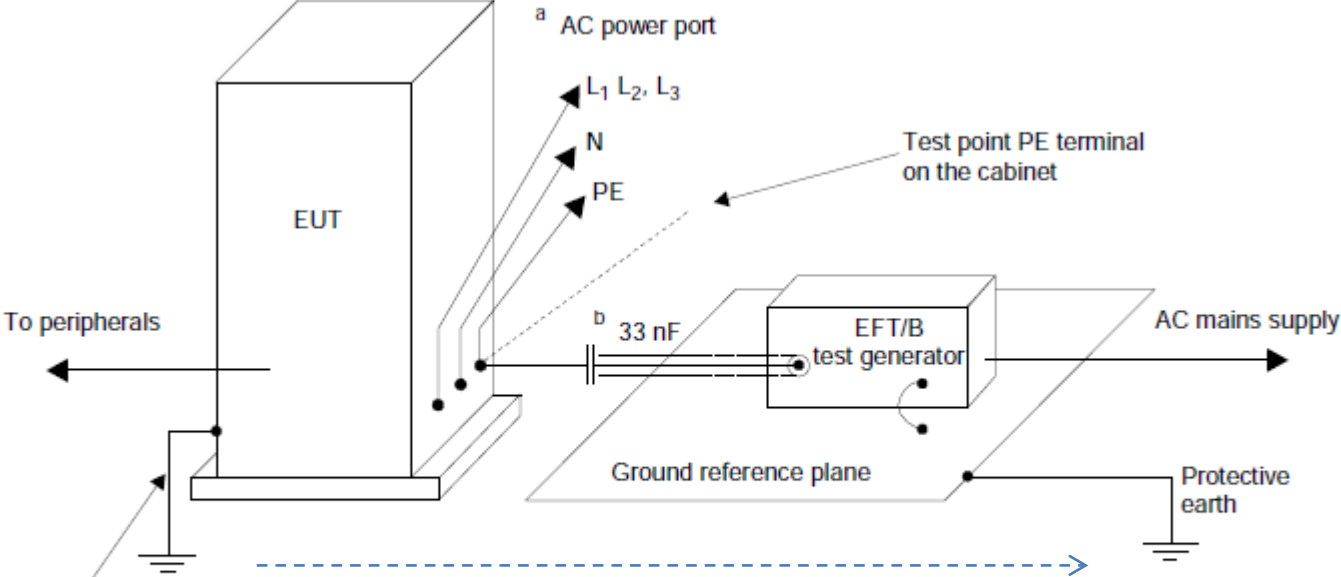
Test Setup

test setup for equipment with elevated cable entries



Test setup for in situ test

Test on Power ports and earth ports



Grounding connection according to the manufacturer's specification
Length to be specified in the test plan

- ^a DC terminals shall be treated in a similar way
- ^b Coupling capacitor(s)

Test setup for in situ test

Test on signal and control ports

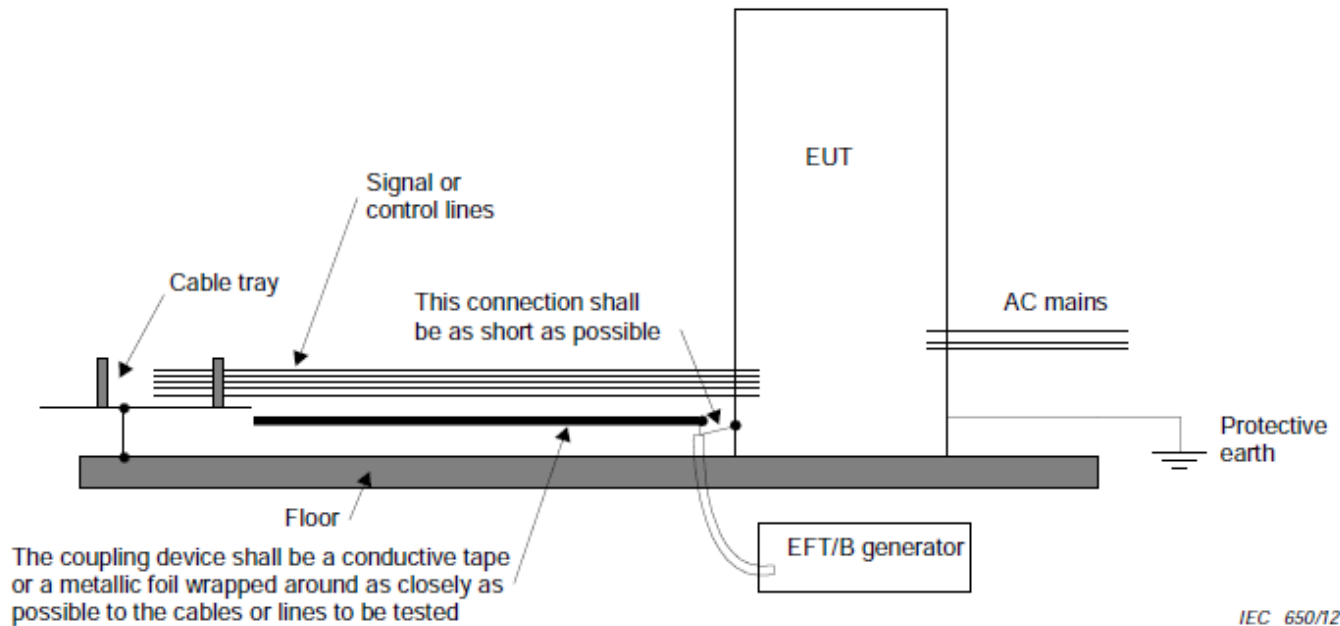


Figure 16 – Example of in situ test on signal and control ports without the capacitive coupling clamp

Select test level by environment

Open circuit output test voltage and repetition frequency of the impulses				
Level	Power ports, earth port (PE)		Signal and control ports	
	Voltage peak kV	Repetition frequency kHz	Voltage peak kV	Repetition frequency kHz
1	0,5	5 or 100	0,25	5 or 100
2	1	5 or 100	0,5	5 or 100
3	2	5 or 100	1	5 or 100
4	4	5 or 100	2	5 or 100
X ^a	Special	Special	Special	Special

Level 1: Well-protected environment, computer room may represent this environment.

Level 2: Protected environment, the control room or terminal room of industrial and electrical plants may represent this environment.

Level 3: Typical industrial environment, the area of industrial process equipment may represent this environment.

Level 4: Severe industrial environment, outdoor area without specific installation.

Level X: Special situations to be analysed, it may require the use of a higher or lower environmental level than those described above.

Measurement uncertainty (MU)

- MU it is necessary to be evaluated
 - Rise time of the EFT/B **Voltage rise time**

Table C.1 – Example of uncertainty budget for voltage rise time (t_r)

Symbol	Estimate	Unit	Error bound	Unit	PDF ^a	Divisor	$u(x_i)$	c_i	Unit	$u_i(y)$	Unit
$T_{10\%}$	0,85	ns	0,10	ns	triangular	2,45	0,041	-1,02	1	0,041	ns
$T_{90\%}$	6,1	ns	0,10	ns	triangular	2,45	0,041	1,02	1	0,041	ns
δR	0	ns	0,15	ns	normal ($k = 1$)	1,00	0,150	1,02	1	0,152	ns
A	360	ns·MHz	40	ns·MHz	rectangular	1,73	23,09	$-44 \cdot 10^{-5}$	1/MHz	0,010	ns
B	400	MHz	30	MHz	rectangular	1,73	17,32	$39 \cdot 10^{-5}$	ns/MHz	$6,78 \cdot 10^{-3}$	ns
^a Probability Density Function							$u_c(y) = \sqrt{\sum u_i(y)^2}$			0,16	ns
							$U(y) = 2 u_c(y)$			0,33	ns
							Y			5,33	ns
							Expressed in % of 5,33 ns			6,2	%

Measurement uncertainty (MU)

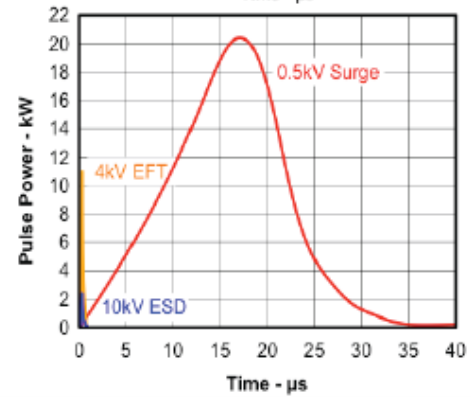
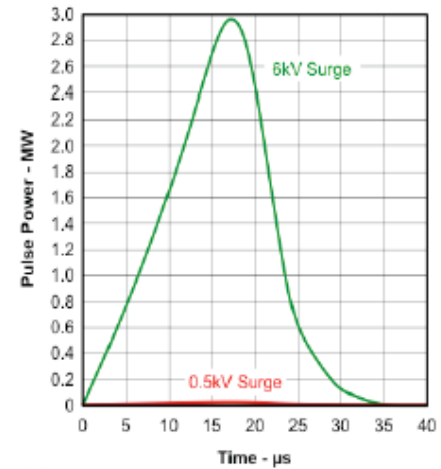
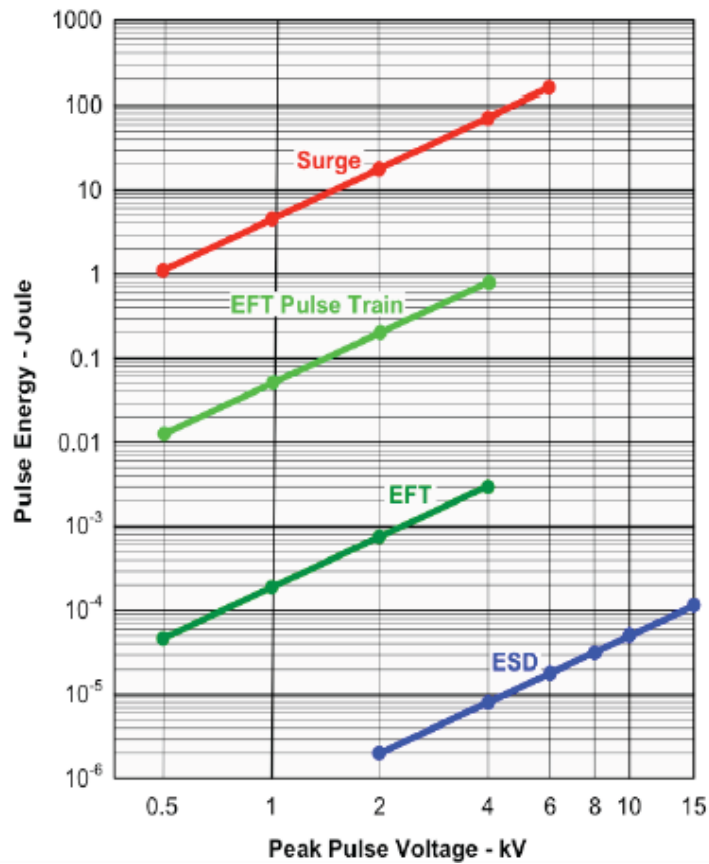
- Evaluated the peak voltage of the EFT/B

Table C.2 – Example of uncertainty budget for EFT/B peak voltage value (V_p)

Symbol	Estimate	Unit	Error bound	Unit	PDF ^a	Divisor	$u(x_i)$	c_i	Unit	$u_i(y)$	Unit
V_{PR}	3,75	V	0,007 3	V	triangular	2,45	0,003 0	1 000	1	2,99	V
A	1 000	1	50	1	rectangular	1,73	28,9	3,75	V	108	V
δR	0	1	0,03	1	normal ($k = 1$)	1,00	0,030	3 751	V	112,5	V
δV	0	1	0,02	1	rectangular	1,73	0,012	3 751	V	43,3	V
β	7,0	MHz	0,8	MHz	rectangular	1,73	0,462	0,328	V/MHz	0,152	V
B	400	MHz	30	MHz	rectangular	1,73	17,32	-0,005 8	V/MHz	0,099 5	V
^a Probability Density Function							$u_c(y) = \sqrt{\sum u_i(y)^2}$		0,162		kV
							$U(y) = 2 u_c(y)$		0,32		kV
							y		3,75		kV
							Expressed in % of 3,75 kV		8,6		%

- **Comparison between transient tests**

Transient Powers in Comparison



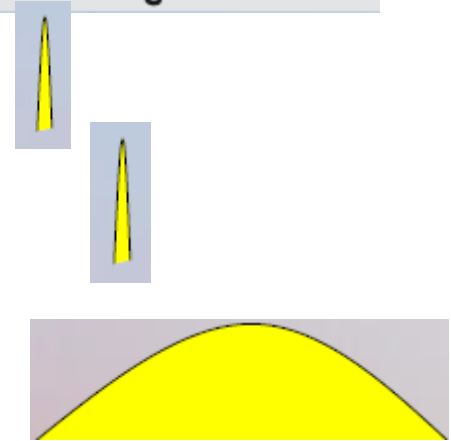
Transient Energy Comparison

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

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

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

- ESD : waveform magnitude in ns
- EFT : waveform magnitude in ns
- Surge : waveform magnitude in μs



Surge test is more energetic than ESD and EFT

Standards Call

Standard	Scope	ESD	EFT-burst	Surge
IEC/EN 61000-6-1: 2001	Residential, commercial & light industrial generic	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power > 10 m, signal and functional earth > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC power input; 0.5 kV L-L & L-E DC power > 10 m, to IEC/EN 61000-4-5
IEC/EN 61000-6-2: 2005	Industrial generic	4 kV contact, 8 kV air to IEC/EN 61000-4-2	2 kV AC power, DC power > 3 m, 1 kV signal and functional earth > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC power; 0.5 kV L-L & L-E DC power connected to a distribution network; 1 kV L-E signal > 30 m, to IEC/EN 61000-4-5
EN 55014-2: 1997 + A1: 2001	Household appliances etc.	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power, signal and control > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC mains, to IEC/EN 61000-4-5
EN 55020: 2002	Broadcast receivers etc.	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power to IEC/EN 61000-4-4	Not required
EN 55024: 1998 EN 55035:2017	Information technology equipment	4 kV contact, 8 kV air to IEC/EN 61000-4-2	1 kV AC power, 0.5 kV DC power, signal and telecom > 3 m to IEC/EN 61000-4-4	1 kV L-L, 2 kV L-E on AC mains, 0.5 kV L-E on DC power with outdoor cables, to IEC/EN 61000-4-5; 1.5 kV 10/700 μ s on signal/telecom ports with outdoor cables, to ITU-T K recs.

Question ?

Thank you for attendance!

