

ElectroMagnetic Compatibility

- The ability of an equipment or system to function satisfactorily in its environment without introducing intolerable electromagnetic interference to anything in that environment.

$$\text{EMC} = \text{EME} + \text{EMI}$$

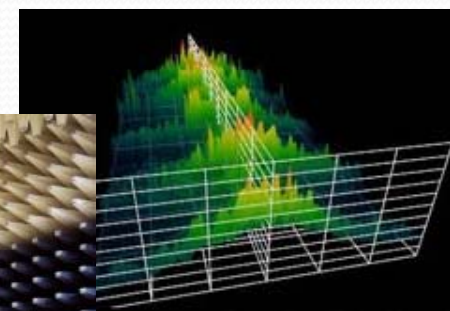
EME=Electromagnetic Emission (Interference)

EMI=Electromagnetic Immunity (Susceptibility)

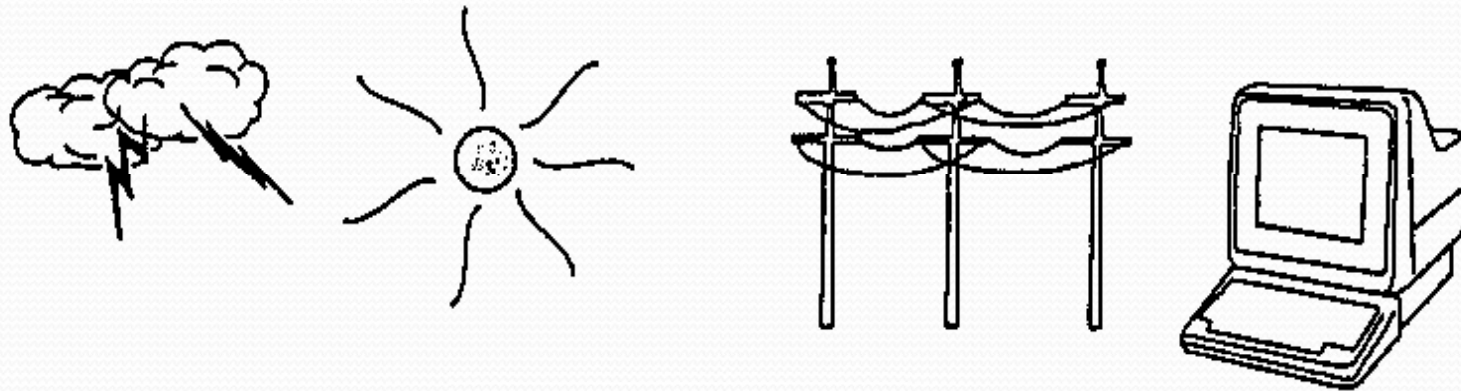
EMC

...A complicated and difficult subject!!!!?

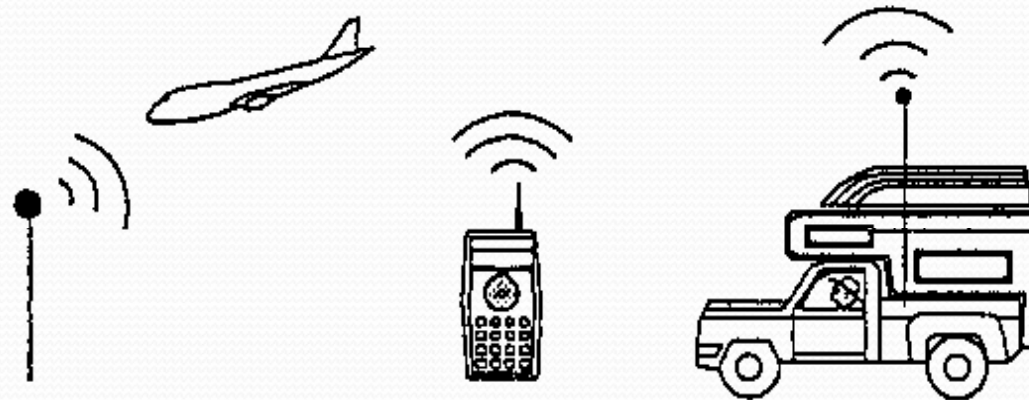
- Talks in Order of Magnitudes
 - Frequency from DC to daylights
 - magnitude μA - kA ; μV - MV
 - works on dB for order of magnitude, and log scale in frequency
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- Different types of EMC requirements, methods, measurements
 - Many different standards



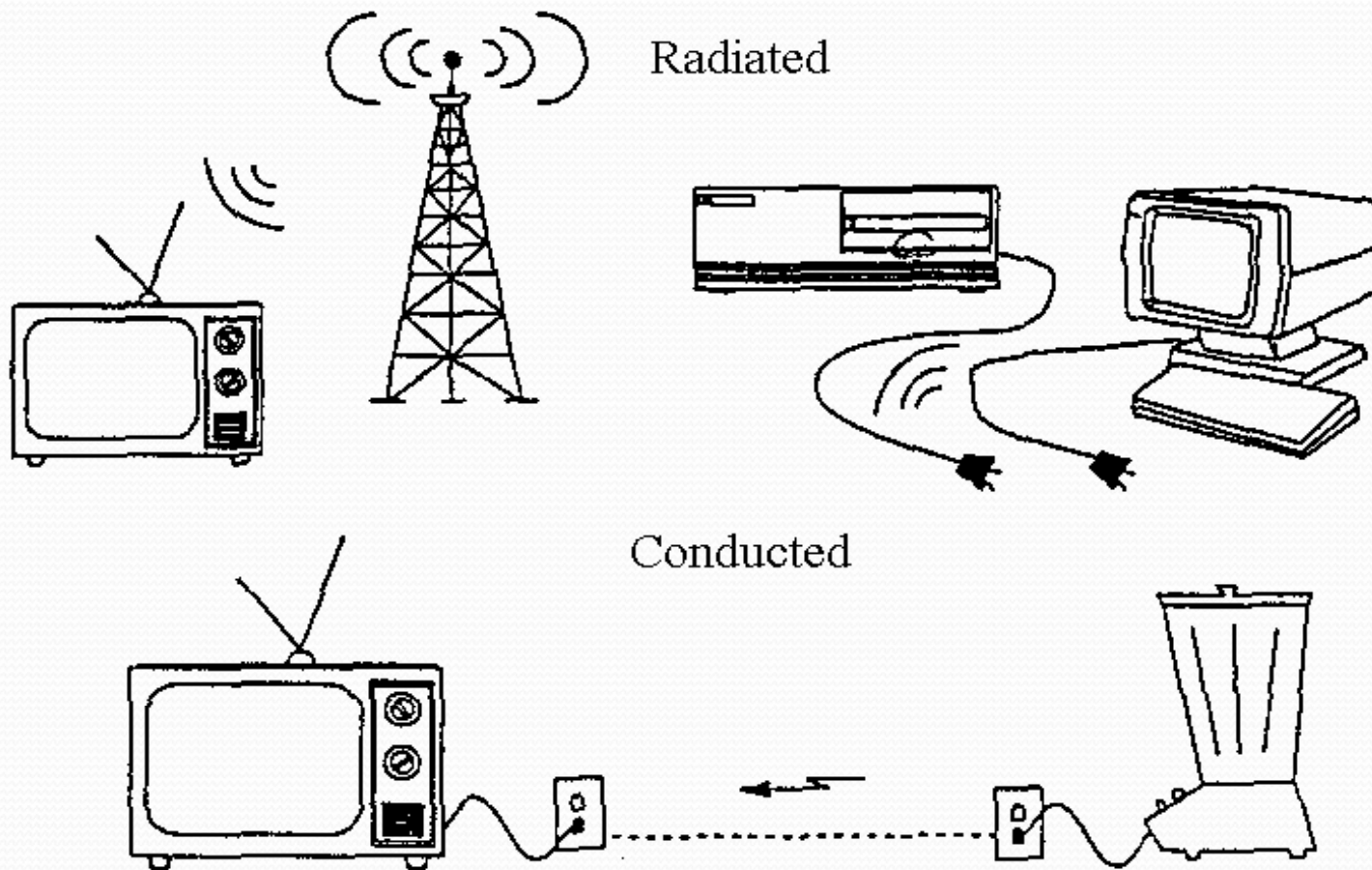
Sources of Emission / Noise



Natural / man-made / intended emission!



Coupling



Effects of EME/ EM interference

Equipment to equipment

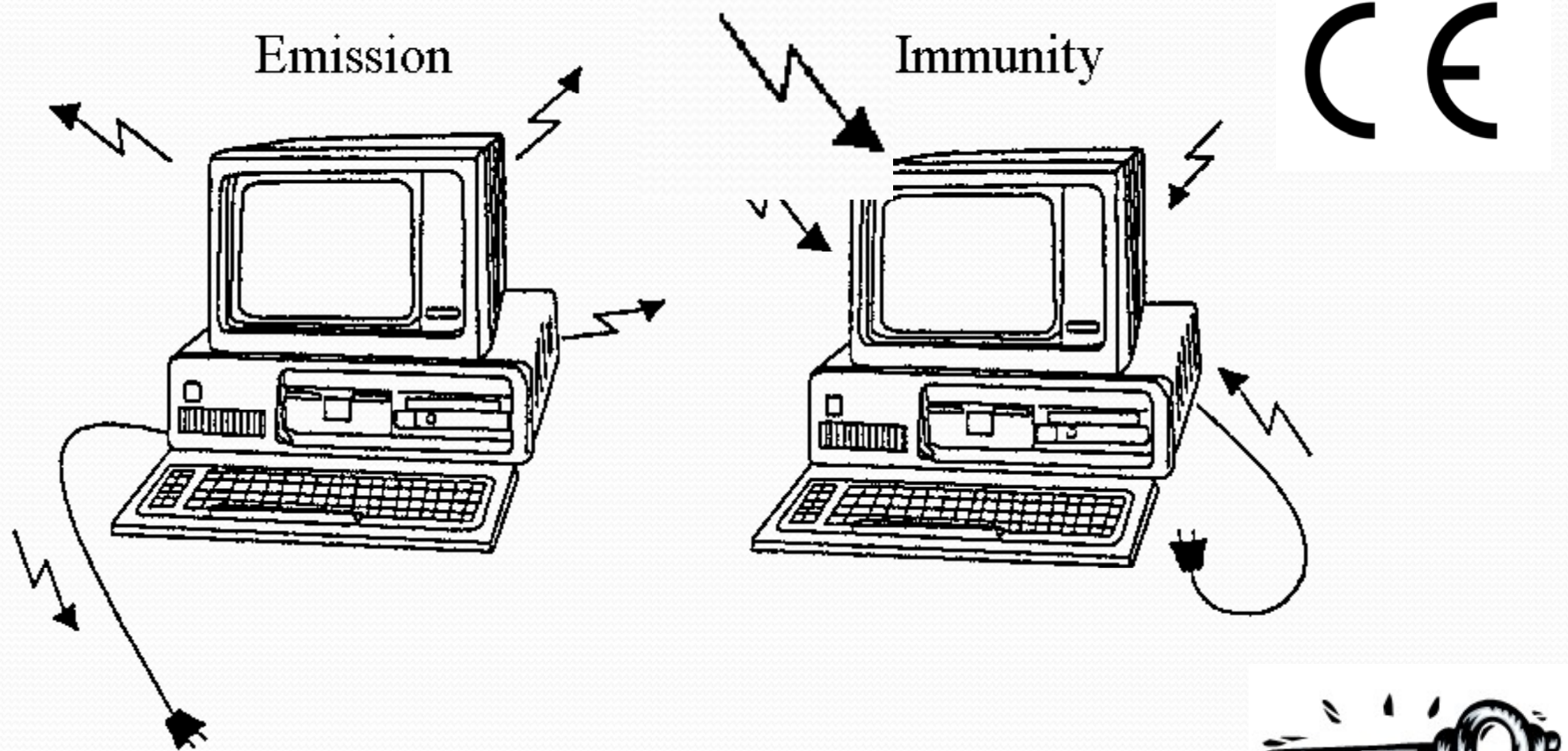
- Loss of data in digital systems or in transmission of data
- Interference to TV and radio reception
- Malfunction of medical electronic equipment
- Malfunction of automotive microprocessor control systems (braking) and navigation equipment
- Malfunction of critical process-control functions (e.g. oil, chemical, airports railways)
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Equipment to Human (Human Safety)

- IEEE C95.1 - Standard For Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3KHz to 300GHz
- ICNIRP - Guidelines limiting exposure to time-varying Electric, Magnetic, and Electromagnetic fields (Up to 300 GHz).

EME and EMI Testsc

RE, CE, RI, CI, ESD, Fast transient and Burst, Surge, H-field, Voltage dip.....



Different characteristics of emissions

Radiated Emission-

- Far field radiation
- near field radiation
 - E field source
 - H field source



Conducted Emission

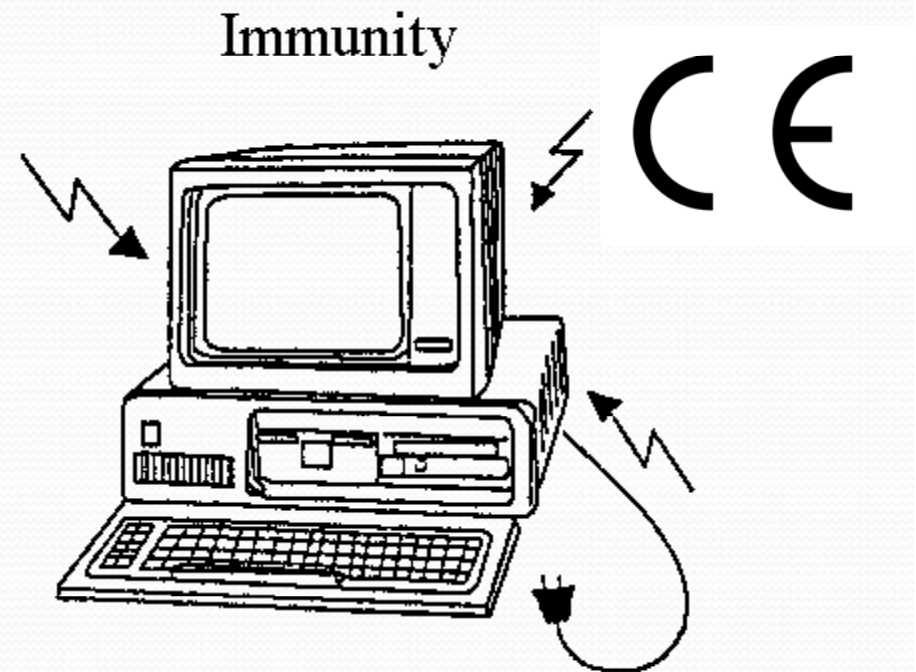
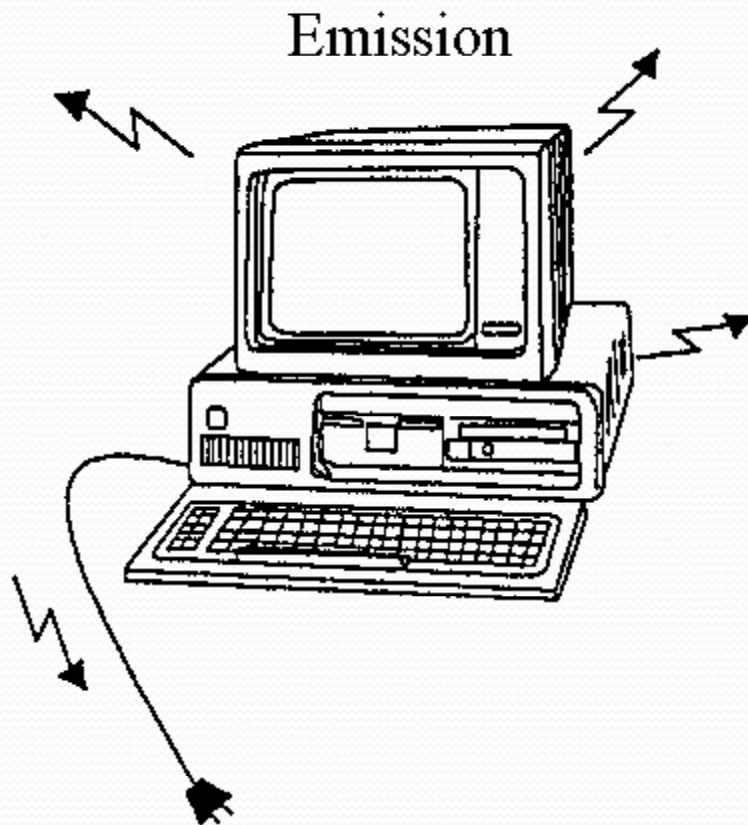
- Different paths
....dc port, power port, communication port

Electromagnetic Coupling



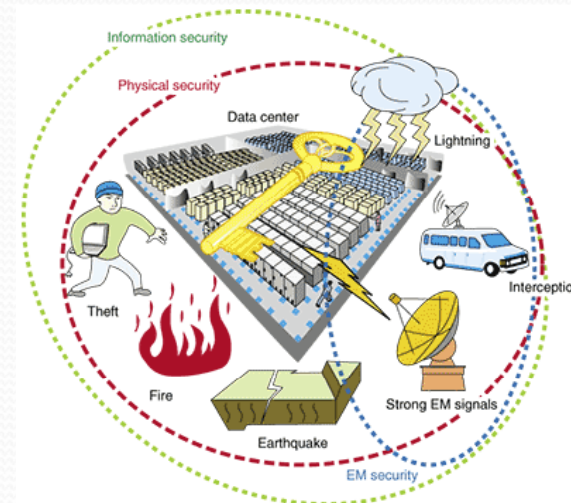
RE, CE, RI, CI

RE, CE, RI, CI, ESD, Fast transient and Burst, Surge, H-field, Voltage dip.



RE, CE, RI, CI

- EMC tests emulate general emissions in environment.
- Conducted, 9kHz ~230MHz
- Radiated, 30 MHz ~1 GHz
- Limits : e.g. RE in terms of V/m, generally expressed as dB μ V/m, taken as far field radiation, in E field values.



**Table 5 – Limits for radiated disturbance of class A ITE
at a measuring distance of 10 m**

Frequency range MHz	Quasi-peak limits dB(μ V/m)
30 to 230	40
230 to 1 000	47
NOTE 1 The lower limit shall apply at the transition frequency. NOTE 2 Additional provisions may be required for cases where interference occurs.	

RE : 40 dB μ V/m ~ 0.01V/m

the mains ports

Frequency range MHz	Limits dB(μ V)	
	Quasi-peak	Average
0,15 to 0,50	66 to 56	56 to 46
0,50 to 5	56	46
5 to 30	60	50
NOTE 1 The lower limit shall apply at the transition frequencies. NOTE 2 The limit decreases linearly with the logarithm of the frequency in the range 0,15 MHz to 0,50 MHz.		

CE : 60 dB μ V/m ~ 0.001V/m

Examples of some limits in Radiated Emission

...from CISPR22

EMC- A reasonable good margin between RE and RI, for general consideration!!

Radio-frequency electromagnetic field. Amplitude modulated	80 to 1 000 3 80	MHz V/m % AM (1 kHz)	IEC 61000-4-3 c
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RI requirement3V/m

RE : 40 dB μ V/m ~ 0.01V/m

2.1	Radio-frequency common mode	0,15 to 80 3 80	MHz V % AM (1 kHz)	IEC 61000-4-6
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CI requirement3V

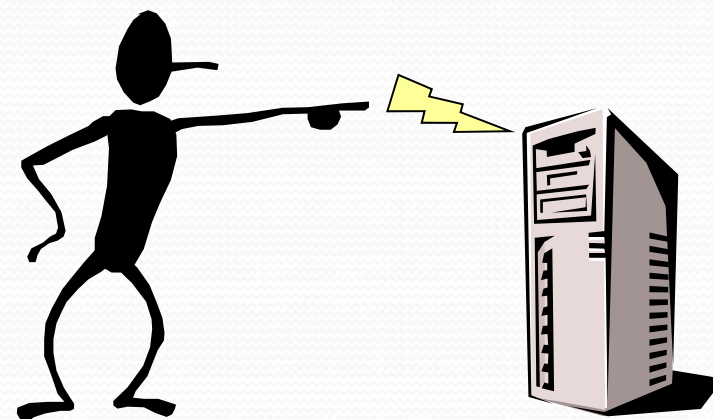
CE : 60 dB μ V/m ~ 0.001V/m

Examples of some limits in Radiated Immunity

from IEC 61000-6-1 for RCLI

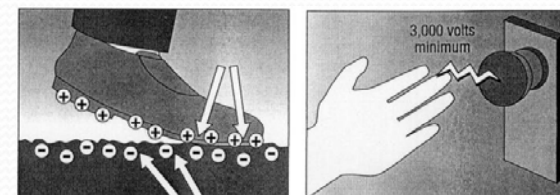
ELECTROSTATIC DISCHARGE (ESD)

A transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact.



Effect:

Cause damage to electronic equipment.



ELECTROSTATIC DISCHARGE (ESD)

Hard failures (irreversibly)

- Junction burnout
- IC metal burnout
- Dielectric breakdown

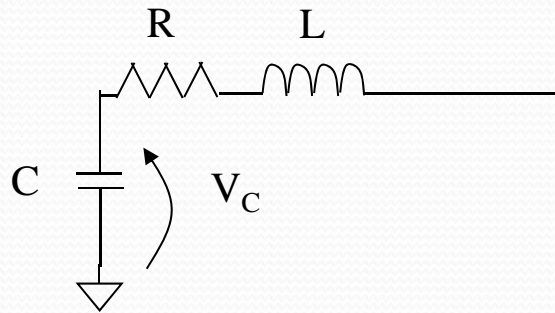
Soft failures (mainly digital circuits)

Transient interference (eg. Radio)

Logic errors, System resets, Lost data, Lost program flow



HUMAN BODY MODEL

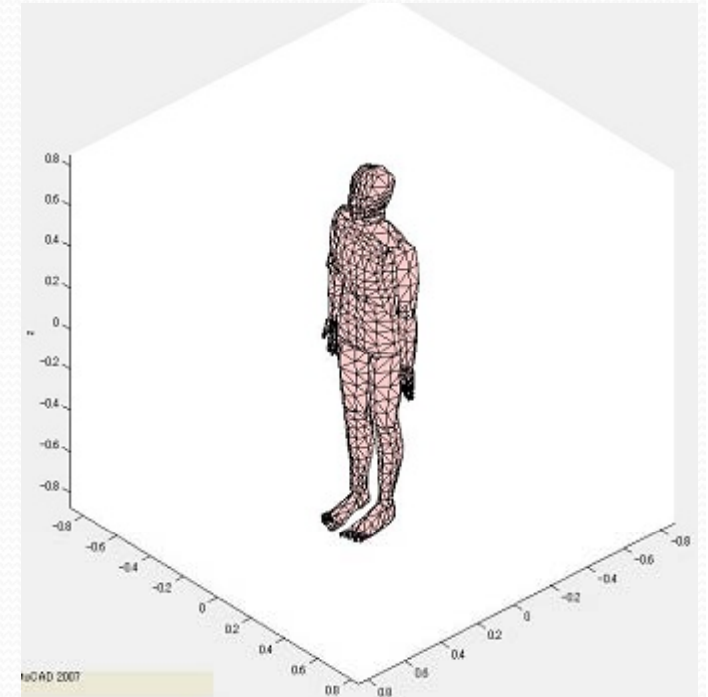


$C = 50 \text{ to } 250 \text{ pF}$

$R = 500\Omega \text{ to } 10\text{k}\Omega$

$|V_C| = 0 \text{ to } 30\text{kV}$ (above 30V will have corona effect)

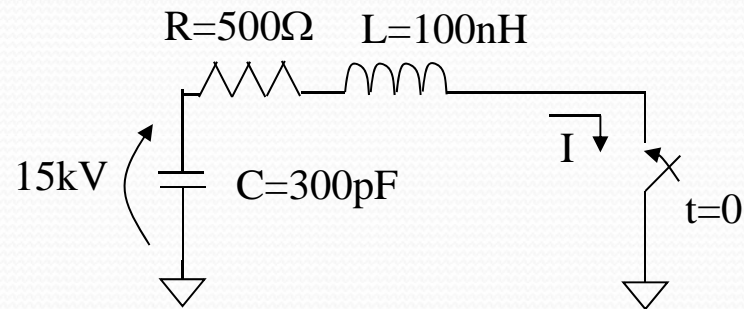
$L = 50 - 200\text{nH}$



First order model, TRIBOELECTRIC EFFECT

**EN 61000-4-2 Testing and measurement techniques –
Electrostatic discharge immunity test**

DISCHARGE INTO AN IDEAL GROUND



$$I_{pk} = \frac{15kV}{500\Omega} = 30A$$

