Overview of EMC Regulations and Testing

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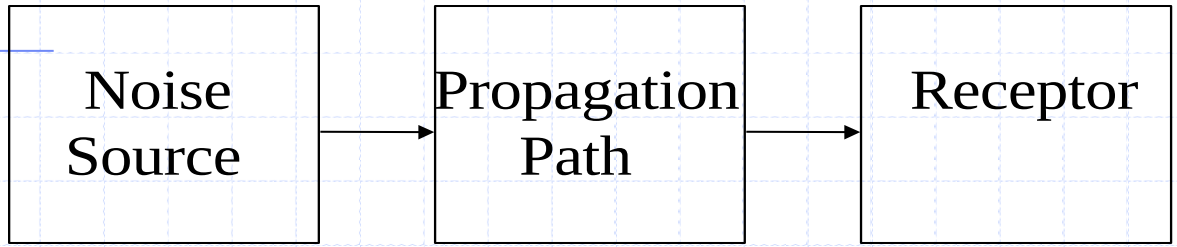
What is EMC

- ***E***lectro-***M***agnetic ***C***ompatibility
  （電磁相容）
- EMC
  - EM**I** (Interference)
    - Conducted Emission
    - Radiated Emission
  - EM**S** (Susceptibility)
    - Conducted Susceptibility
    - Radiated Susceptibility



Natural
Terrestrial
Atmospheric
Sun
.
.

Man-Made
Broadcast
Radar
Fluorescent lights
Computing devices
Microwave Ovens

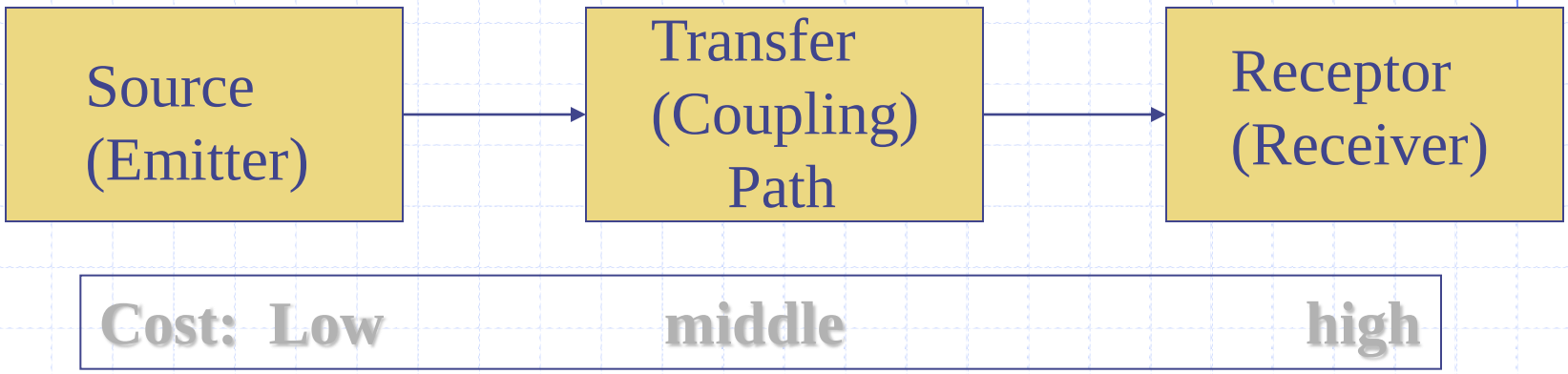
Radiation
Far-Field
Plane Wave
Near-Field
Capacitive cross-talk
Inductive cross-talk

Conduction
Power distribution
Signal distribution
Ground loops

Biological
Man
Animal
Plants

Man-Made
Broadcast receivers
Navigation receivers
Radar receivers
Computing devices
Biomedical sensors

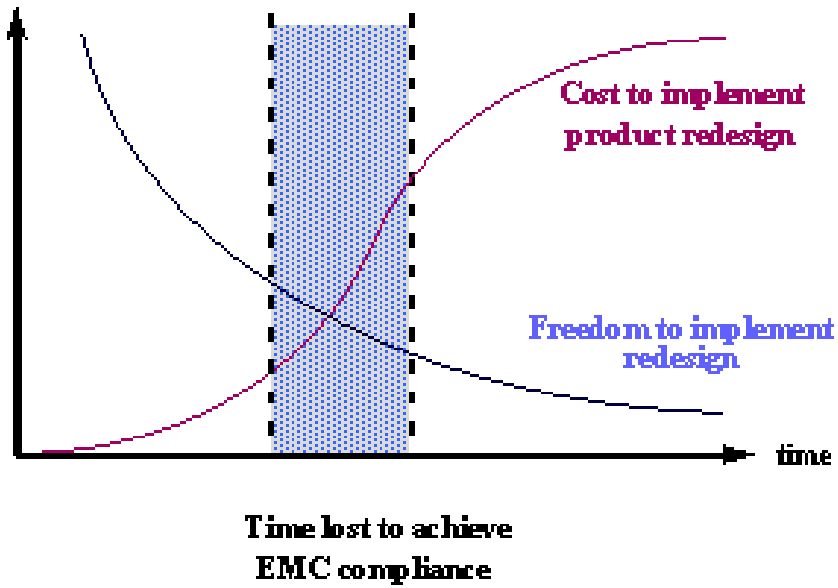
How EMC



- **Suppress the emission at its source**
- **Make the coupling path as inefficient as possible**
- **Make the receptor less susceptible to the emission**

How EMC

Product Slippage



- EMC test failure forces product redesign
- product launch delayed to achieve compliance
- product's time in market reduced
- potential sales and profit reduced

How EMC

- An example: for PC
  - Suppress the emission:
    - Proper layout with EM concept
    - using component with low edge rate as possible
  - Reduce coupling path
    - using shielded enclosure
  - less susceptible receptor
    - differential pairs
    - error-correcting code

EMC Regulations

CISPR 11 : Limits and methods of measurements of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment

CISPR 13 : Limits and methods of measurements of radio disturbance characteristics of broadcast receivers and associated equipment

CISPR 14 : Limits and methods of measurements of radio disturbance characteristics of household electrical appliances, portable tools and similar electrical apparatus

CISPR 19 : Guidance on the use of the substitution method for measurements of radiation from microwave ovens for frequencies above 1GHz

CISPR 22 : Limits and methods of measurements of radio disturbance characteristics of information technology equipment

IEC 61000-3-2 : Limits for harmonic current emissions (equipment input current <16A per phase)

EMC Regulations

IEC 61000-4-2 : Testing and measurement techniques - Electrostatic discharge immunity test
IEC 61000-4-3 : Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test
IEC 61000-4-4 : Testing and measurement techniques - Electrical fast transient/burst immunity test
IEC 61000-4-5 : Testing and measurement techniques - Surge immunity test
IEC 61000-4-6 : Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields
IEC 61000-4-8 : Testing and measurement techniques - Power frequency magnetic field immunity test
IEC 61000-4-11 : Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity

EMC Regulations : CISPR 22

Test Levels
Test Setups and Illustrations

EMC Regulations : Levels

Limits for conducted disturbance at the mains ports of Class A ITE		
Frequency range MHz	Limits dB(μV)	
	Quasi-peak	Average
0.15 to 0.50	79	66
0.5 to 30	73	60
Note – The lower limit shall apply at the transition frequency		

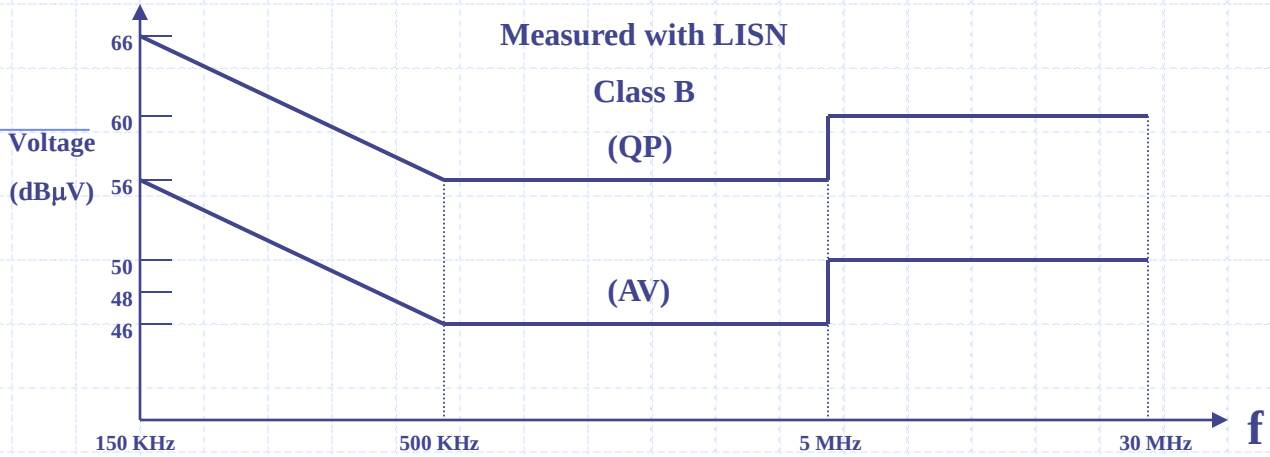
Limits for conducted disturbance at the mains ports of Class B ITE		
Frequency range MHz	Limits dB(μV)	
	Quasi - peak	Average
0.15 to 0.5	66 to 56	56 to 46
0.5 to 5	56	46
5 to 30	60	50

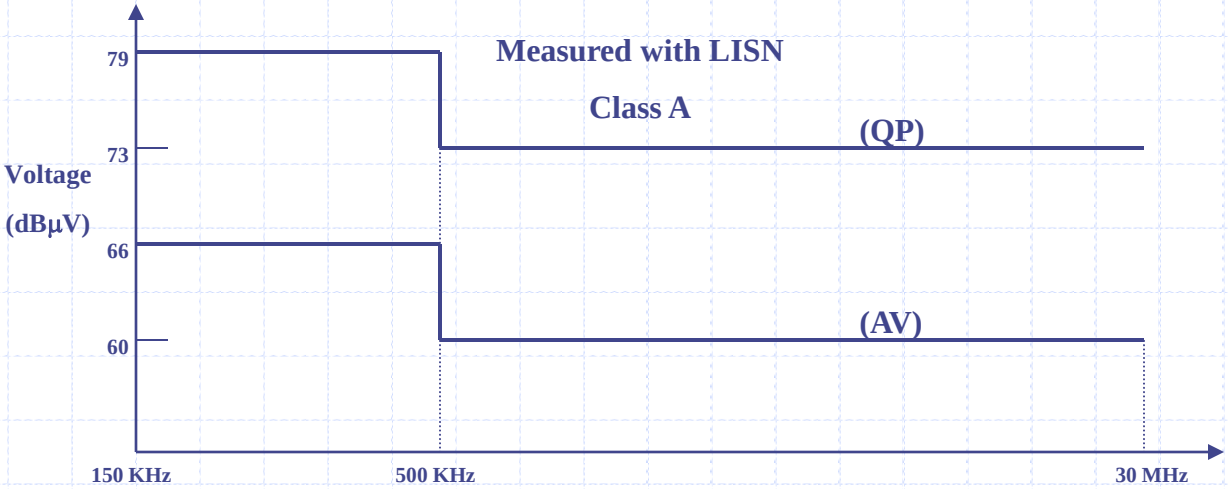
Notes
1. The lower limit shall apply at the transition frequencies
2. The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz

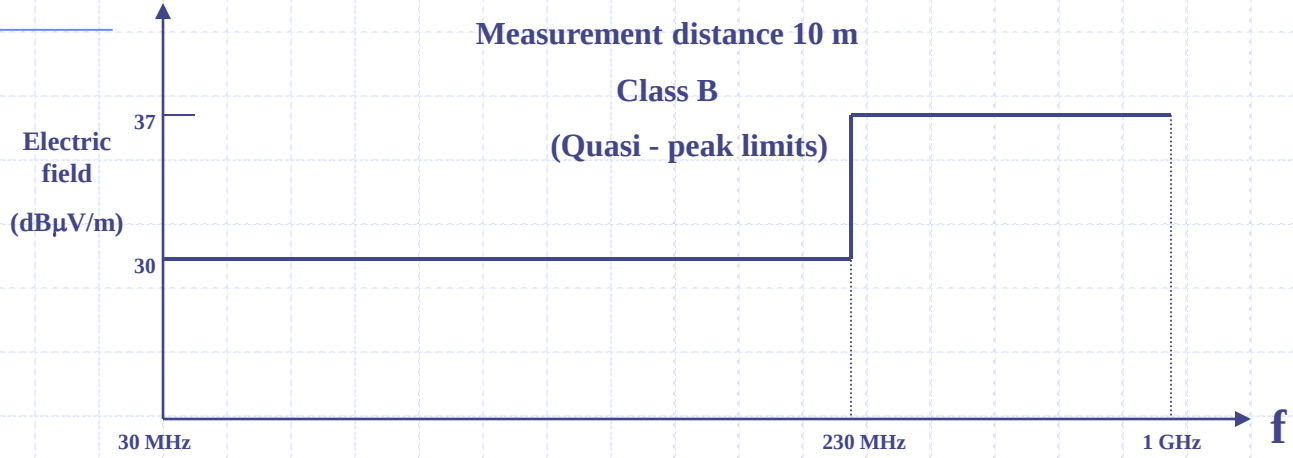
EMC Regulations : Levels

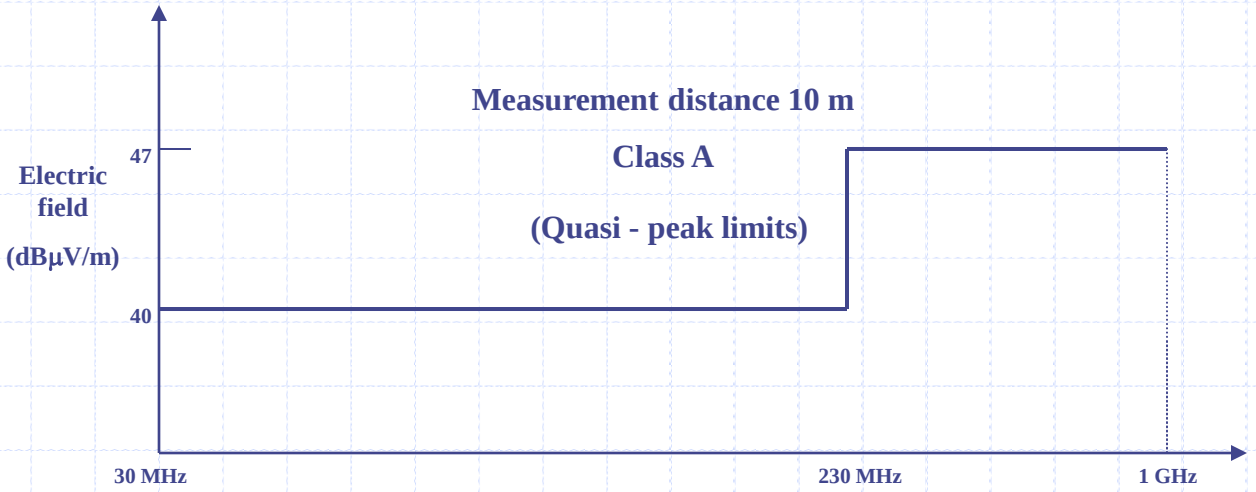
Limits for radiated disturbance of Class A ITE at a measuring of 10 m	
Frequency range MHz	Quasi – peak limits dB(μV/m)
30 to 230	40
230 to 1000	47
Notes 1. The lower limit shall apply at the transition frequency 2. Additional provisions may be required for cases where interference occurs	

Limits for radiated disturbance of Class B ITE at a measuring of 10 m	
Frequency range MHz	Quasi – peak limits dB(μV/m)
30 to 230	30
230 to 1000	37
Notes 1. The lower limit shall apply at the transition frequency 2. Additional provisions may be required for cases where interference occurs	


Measured with LISN
Class B
(QP)
(AV)
Voltage
(dBμV)
66
60
56
50
48
46
150 KHz
500 KHz
5 MHz
30 MHz
f


Measured with LISN
Class A
(QP)
(AV)
Voltage
(dBμV)
79
73
66
60
150 KHz
500 KHz
30 MHz


Measurement distance 10 m
Class B
(Quasi - peak limits)
Electric field (dBμV/m)
37
30
30 MHz
230 MHz
1 GHz
f

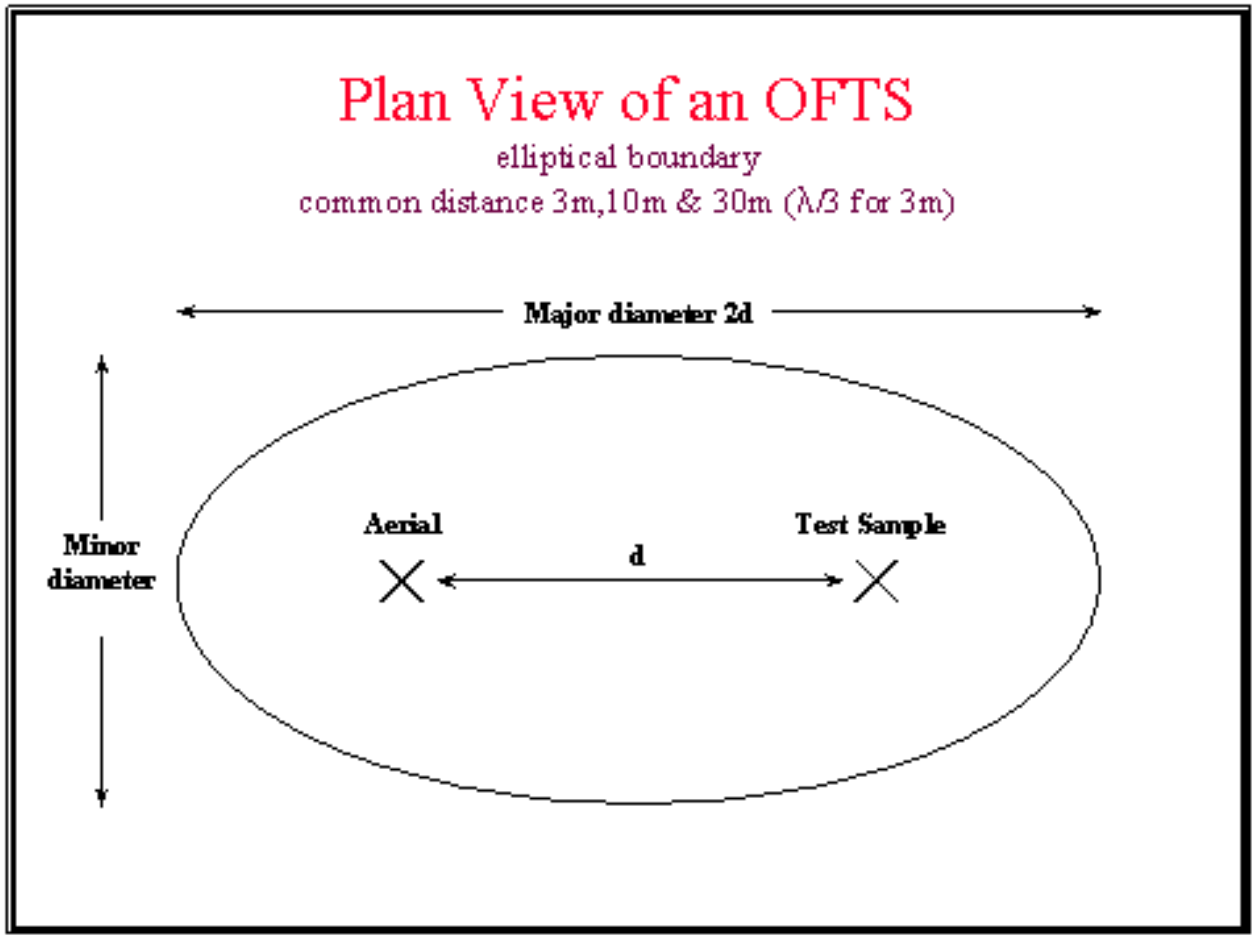

Measurement distance 10 m
Class A
(Quasi - peak limits)
Electric field (dBμV/m)
47
40
30 MHz
230 MHz
1 GHz

Open Area Test Site (OATS)

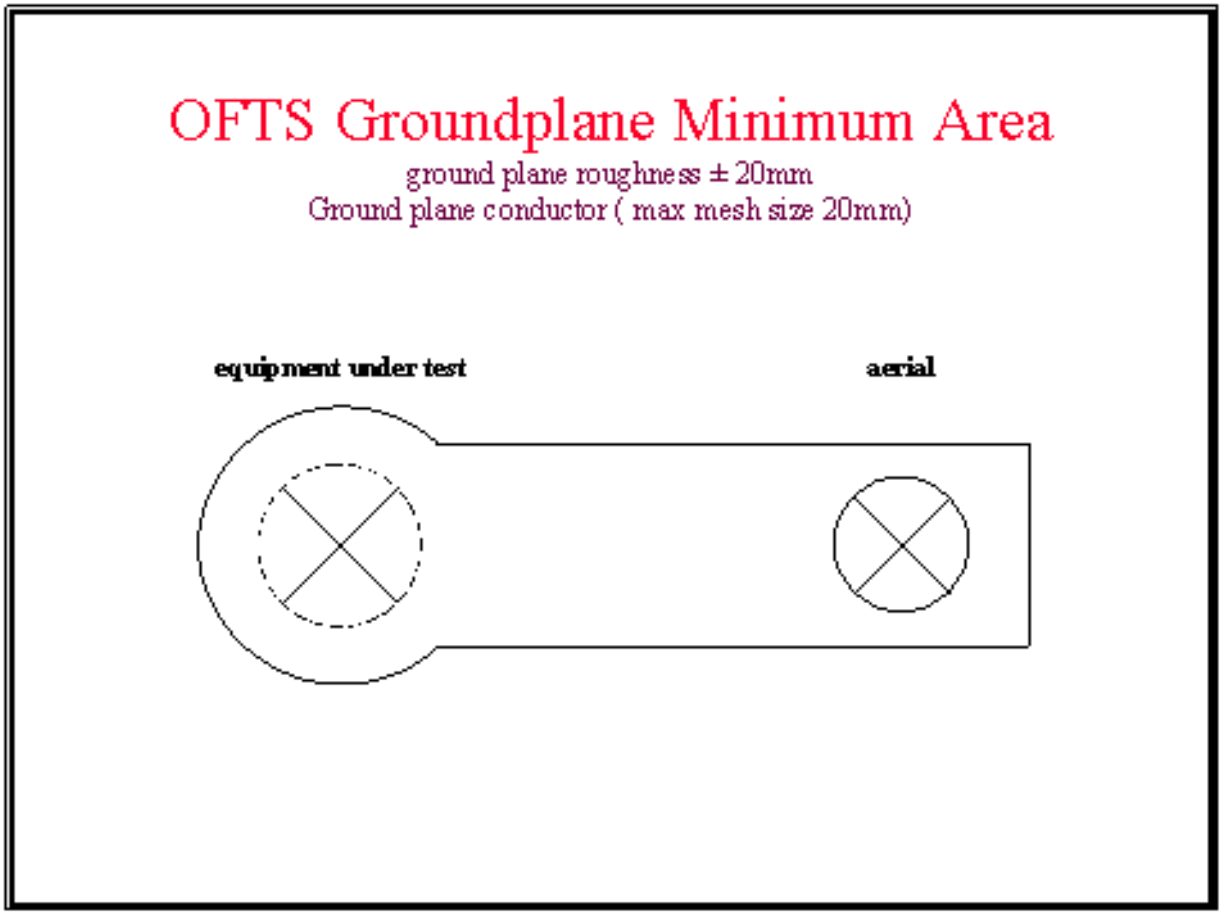
RE measurement (EN55022)

- OFTS
- elliptical boundary
- common distance 3m,10m & 30m ($\lambda/3$ for 3m)
- size of DUT =$2D2/\lambda$ (Rayleigh Range criterion)
- ground plane roughness ± 20mm
- Ground plane conductor (max mesh size 20mm)
- site attenuation ± 3db
- antenna positioned at 1-4m for maximum field strength

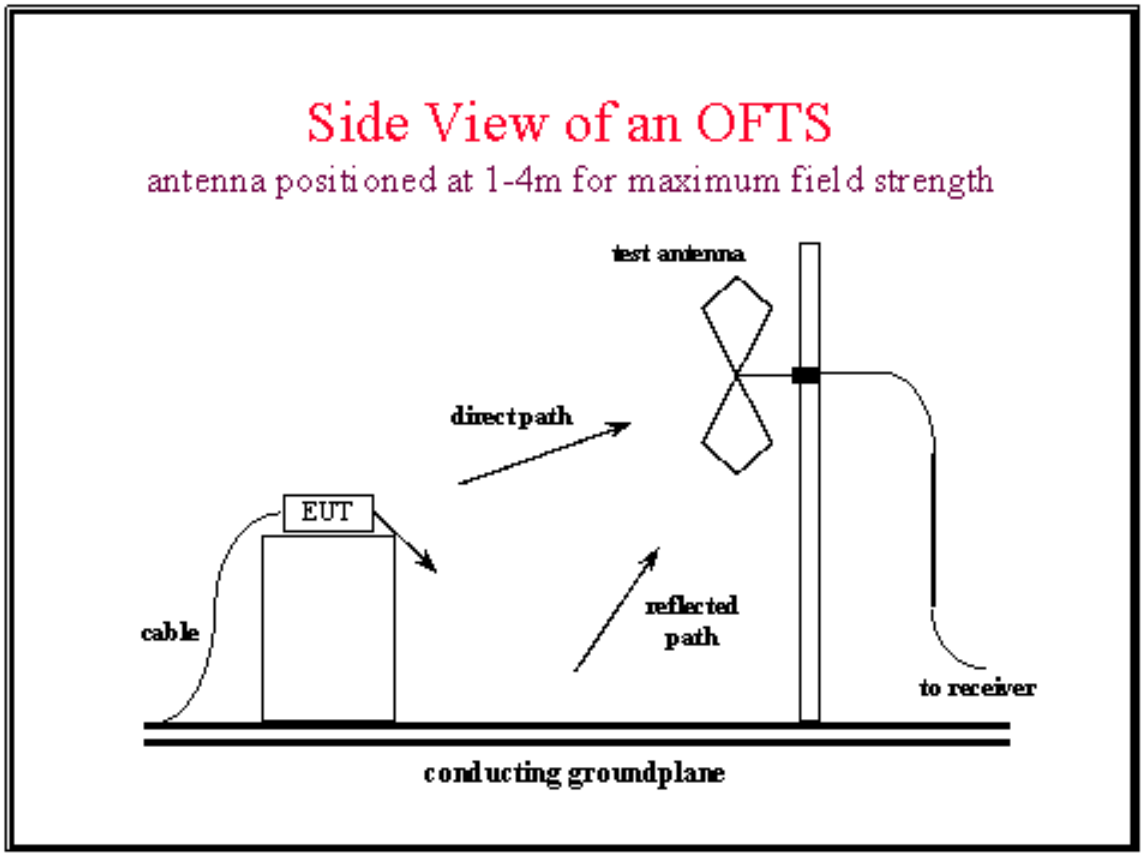
Open Area Test Site (OATS)



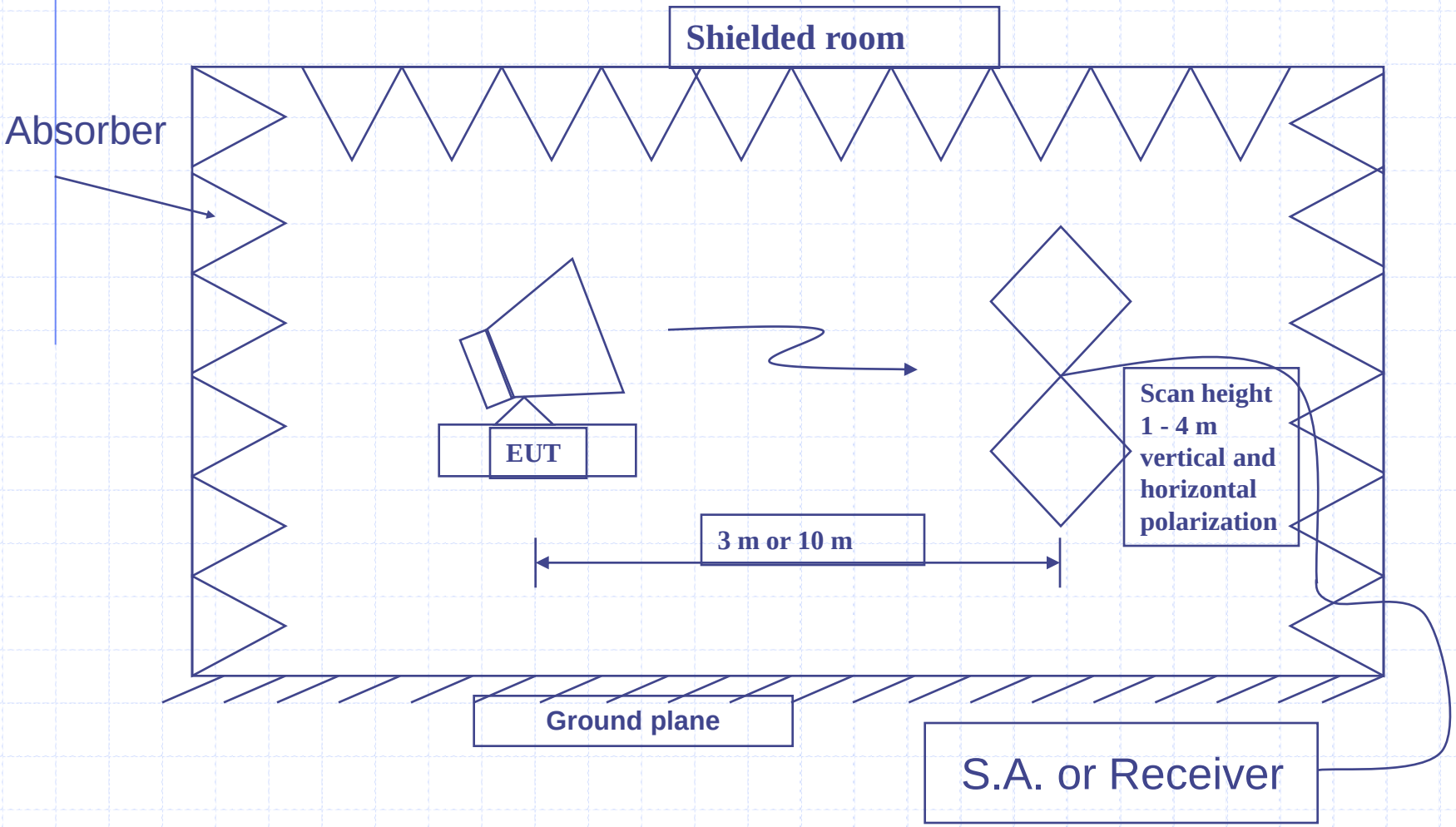
Open Area Test Site (OATS)



Open Area Test Site (OATS)

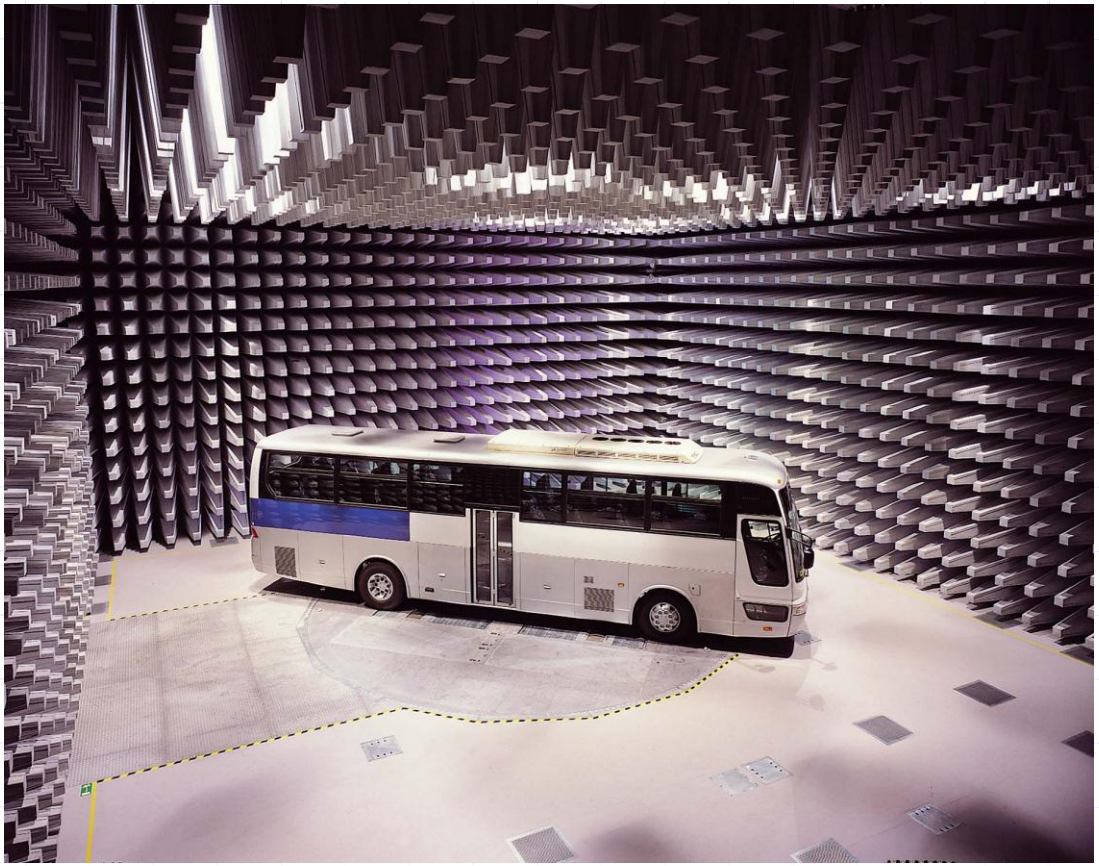


Semi-Anechoic Chamber



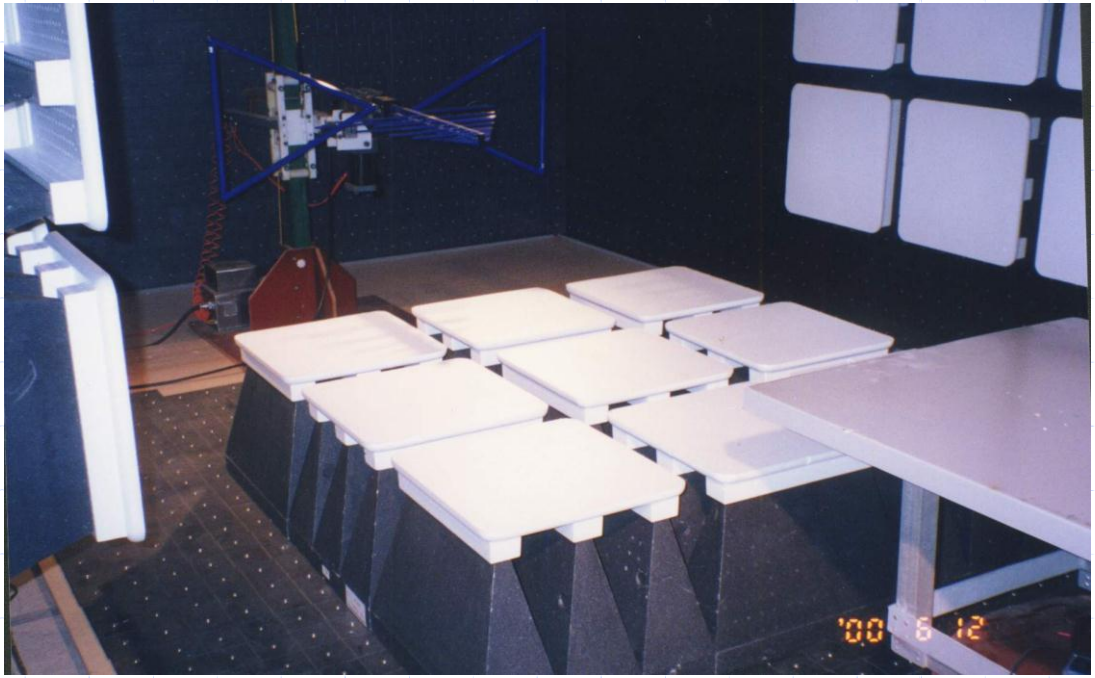
Measurement: EMI

System Level

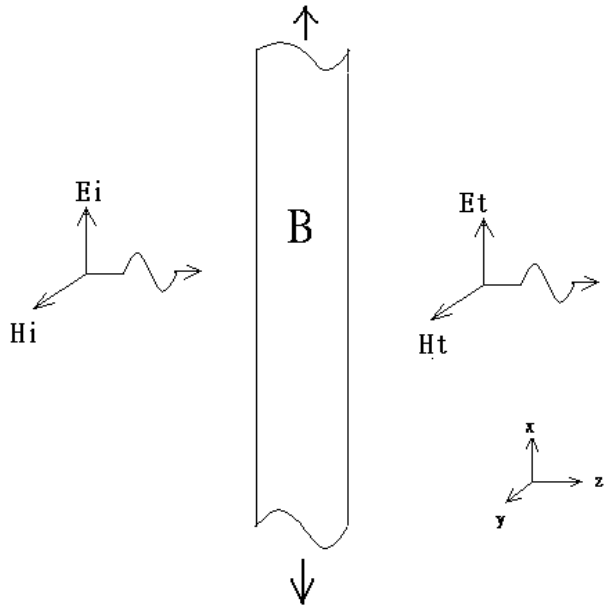


Fully Anechoic Chamber

EMI Measurement Environment

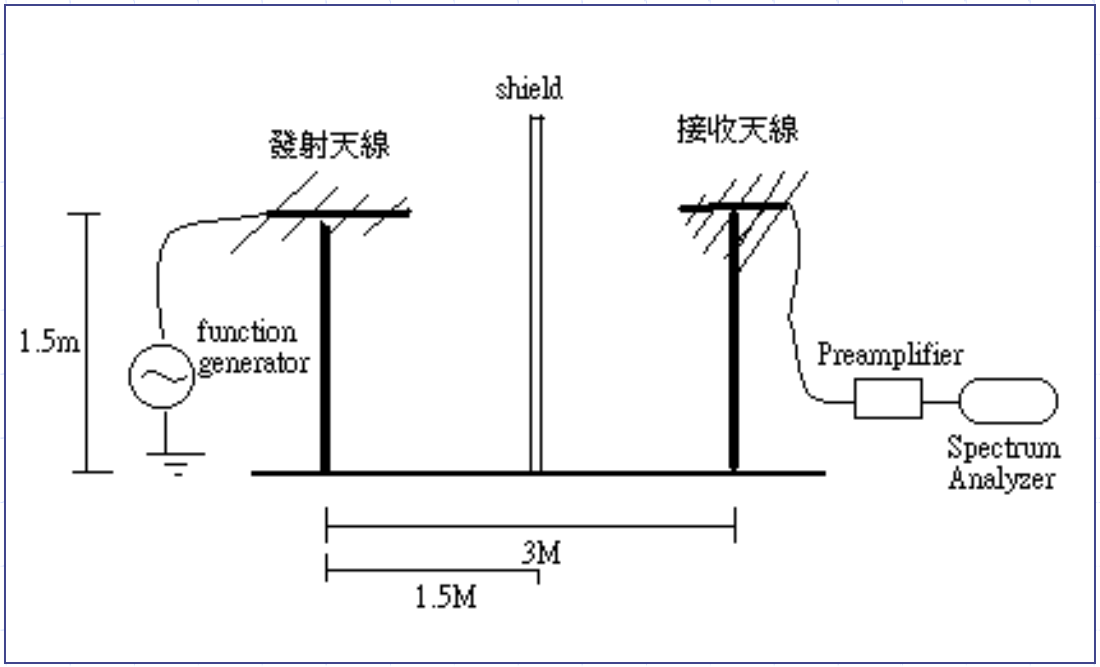


Shielding Effectiveness (EN50147-1)

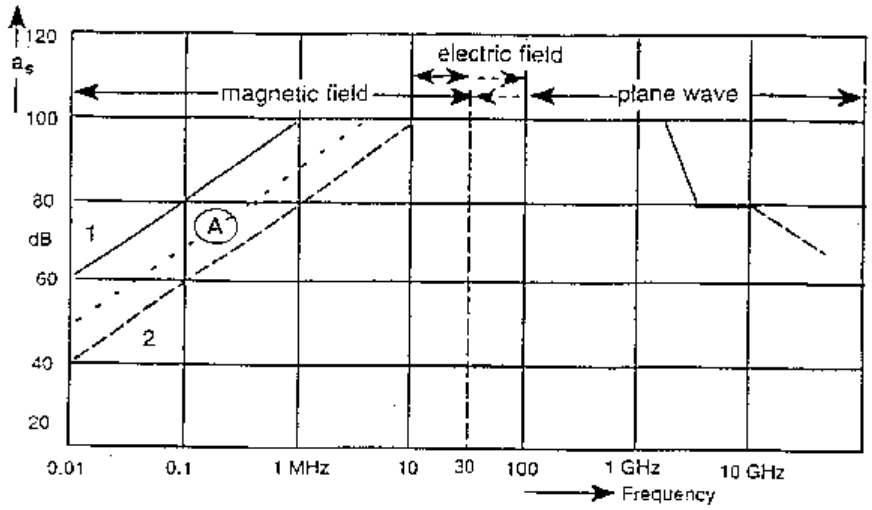


$$SE \equiv 20\log \left| Ei / Et \right|$$

Shielding Effectiveness (EN50147-1)



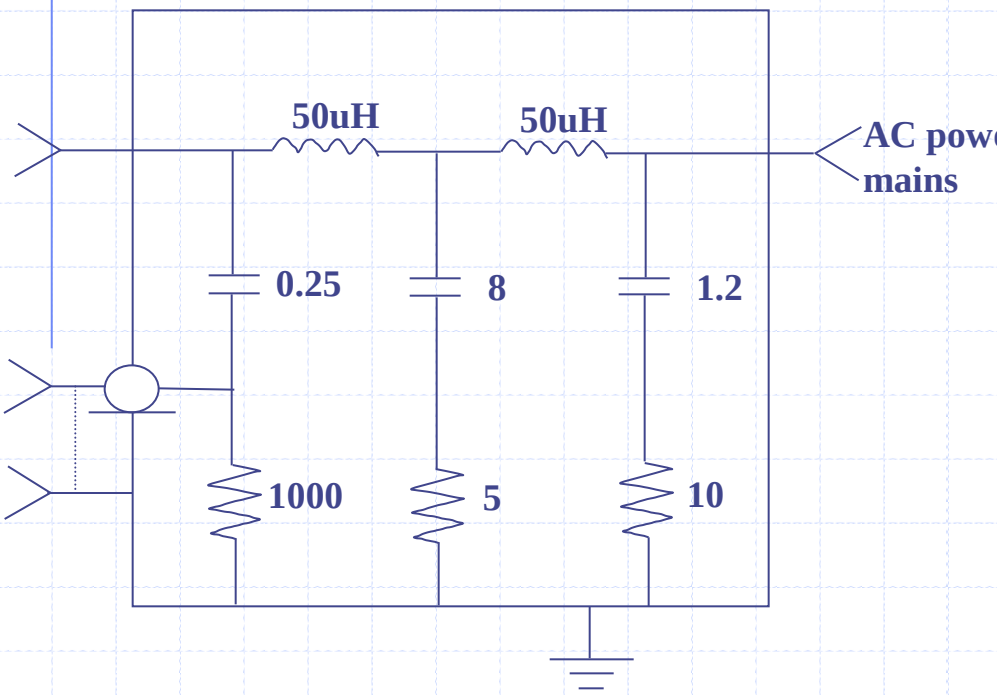
Shielding Effectiveness (EN50147-1)

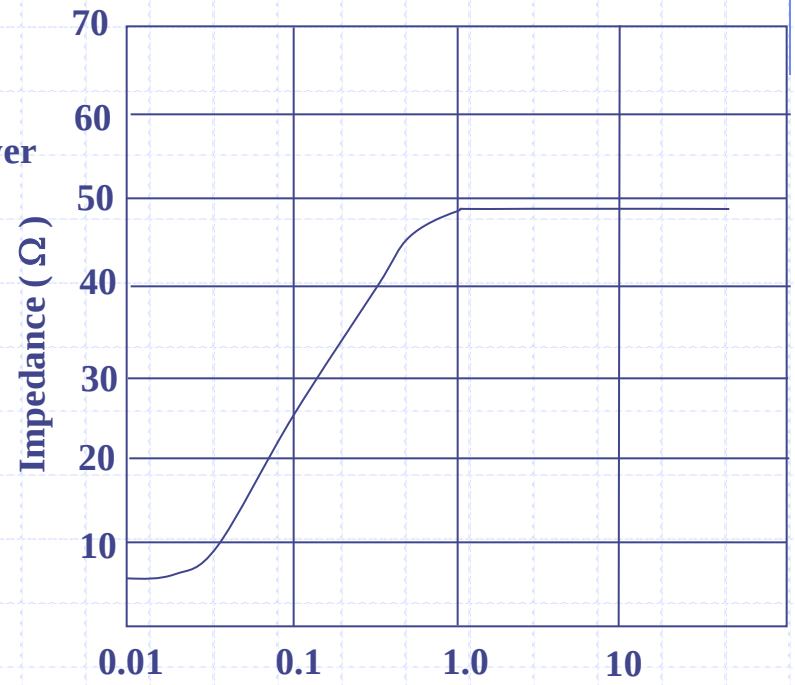


a_s = shield attenuation in dB
curve A = tolerated performance of the door seams for high performance shielded enclosure
curve 1 = high performance of a shielded enclosure
curve 2 = standard performance of a shielded enclosure

Figure 2: Typical shield attenuation values

Line Impedance Stabilization Network (LISN)

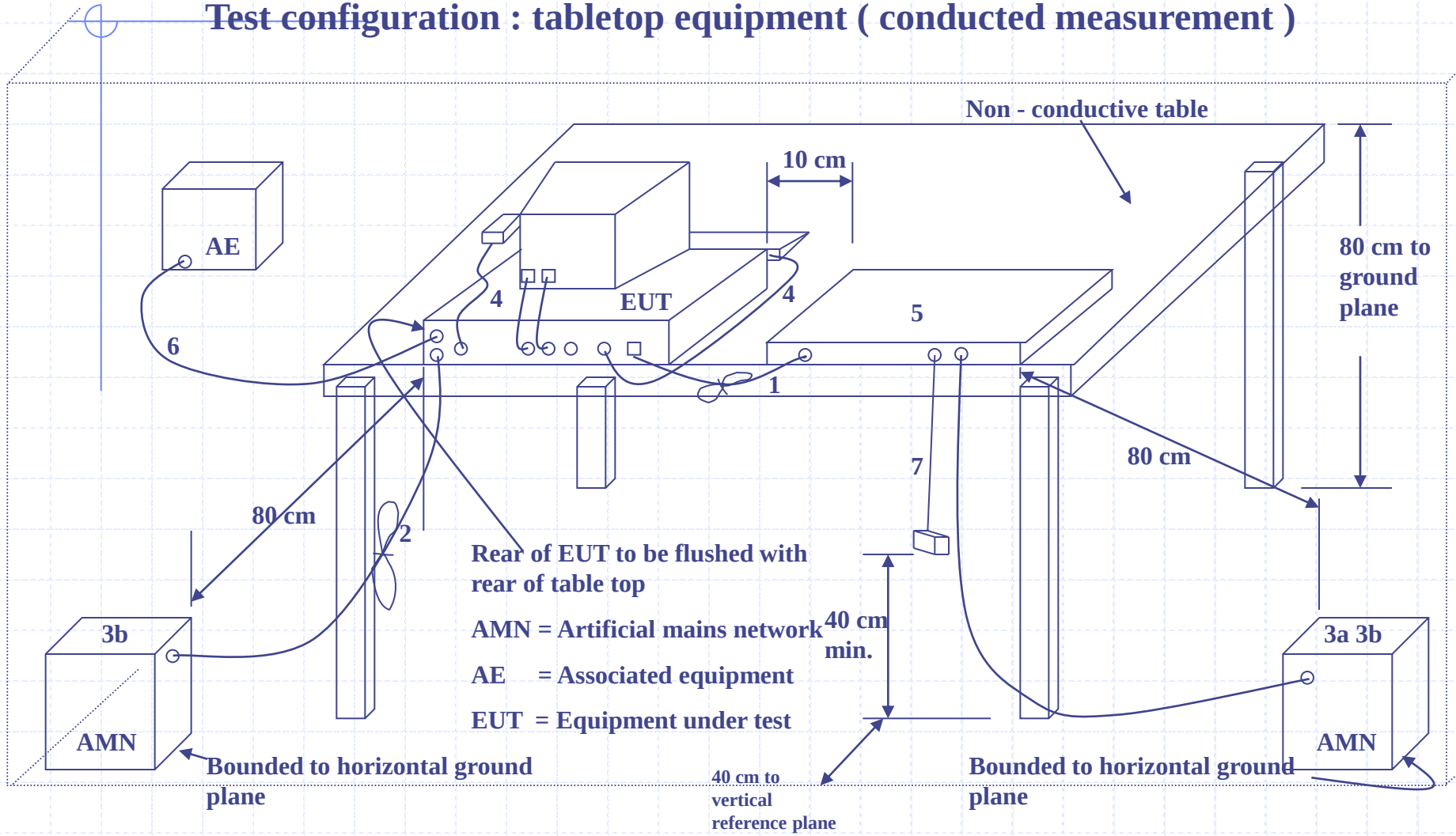




Impedance characteristic of the LISN at EUT port

Test Setups and Illustrations

Test configuration : tabletop equipment (conducted measurement)



If cables, which hang closer than 40 cm to the horizontal metal ground plane, cannot shortened to approximate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
Excess mains cord shall be bundled in the center or shortened to appropriate length.
EUT connected to one AMN. All AMNs may alternatively be connected to the vertical reference plane or metal wall.

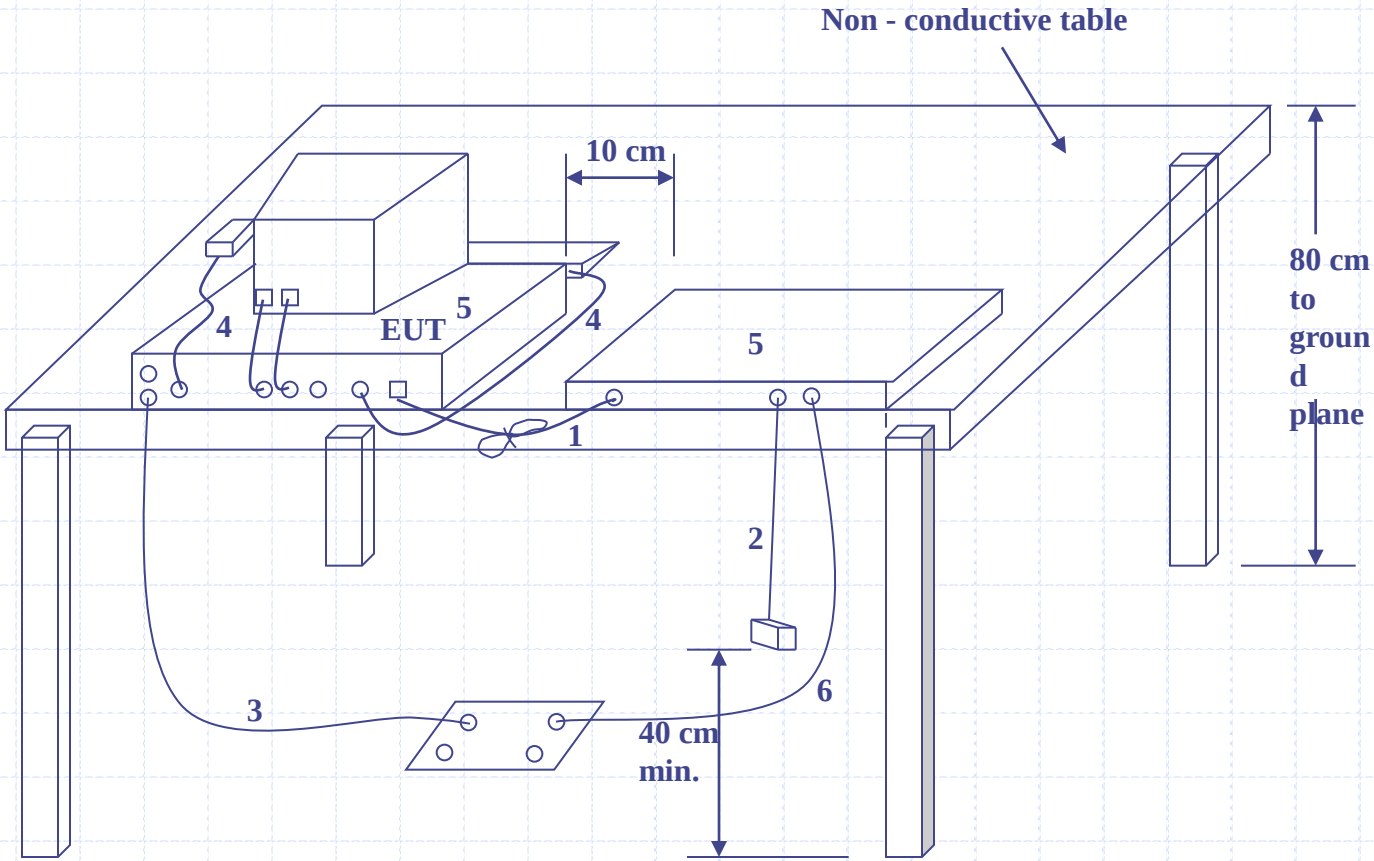
3a) All other units of a system powered from a second AMN. A multiple outlet strip can be used for multiple mains cords.

3b) AMN 80 cm from EUT and at least 80 cm from other units and other metal planes.

3c) Mains cords and signal cables shall be positioned for their entire lengths, as far as possible, at 40 cm from the vertical reference plane.

Cables of hand operated devices, such as keyboards, mouses, etc. shall be placed as for normal usage.
Peripherals shall be placed at a distance of 10 cm from each other and from the controller, except for the monitor which, if for an acceptable installation practice, shall be placed directly on the top of the controller.
I/O signal cable intended for external connection.
The end of the I/O cables which are not connected to an AE may be terminated if required using correct terminating impedance.

Test configuration : tabletop equipment (radiated measurement)



If cables, which hang closer than 40 cm to the horizontal metal ground plane, cannot shortened to approximate length, the excess shall be folded back and forth forming a bundle 30 cm to 40 cm long.
The end of the I/O cables which are not connected to a peripheral may be terminated if required for proper operation using correct terminating impedance.
Mains junction box(s) shall be flush with and bonded directly to the metal ground plane.

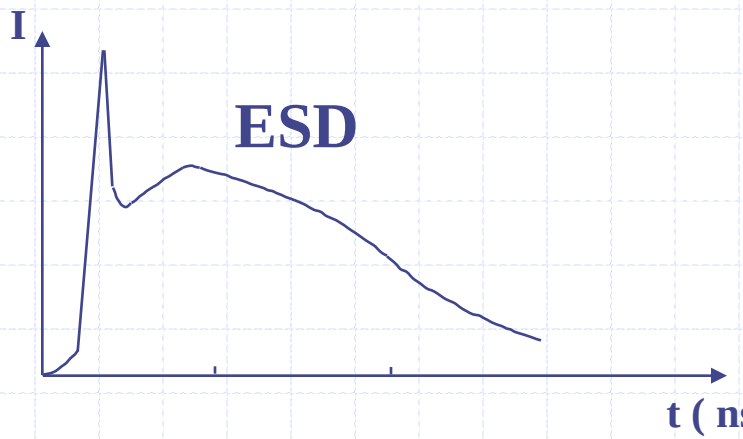
NOTE - If used, the AMN shall be installed under the horizontal metal ground plane.

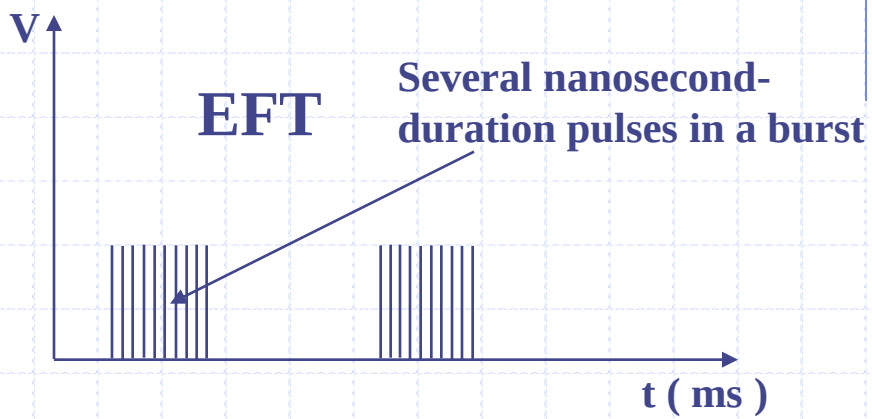
Cables of hand operated devices, such as keyboards, mouses, etc. shall be placed as for normal usage.
Peripherals shall be placed at a distance of 10 cm from each other and from the controller, except for the monitor which, if for an acceptable installation practice, shall be placed directly on the top of the controller.
Mains cables shall drape to the floor and then routed to receptacle. No extension cords shall be used to mains receptacle.

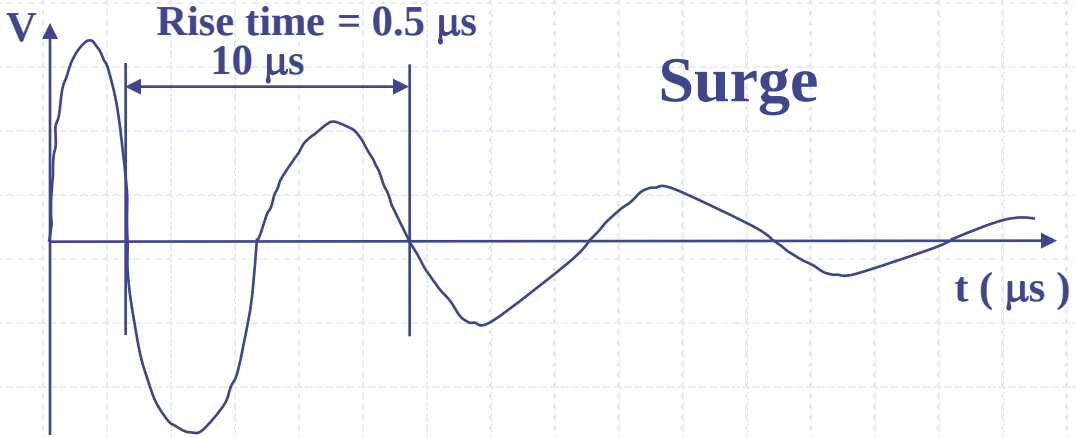
Typical Characteristics of Pulsed EMI

	ESD	EFT	Surge
Waveform	See the next page		
Feature	Superfast rise time	Fast rise time, repetitive pulses, and box-car integration	Relatively slower rise time, large energy concentrator
Rise time	less than 1 ns	~ 5 ns	μs
Energe	low (mJ)	medium (mJ)	high (J)
Duration	ns	ns, and repeating	ms
Peak voltage (into high impedance)	up to about 15 kV	kV	several kV
Peak current (into low impedance)	medium (A)	low (A)	high (kA)
Sources	accumulation of static electricity	activation of gaseous discharge, make / break of electrical circuits	lightning, power switching

Waveforms of pulsed EMI







Test Levels and Test Result Classifications

1a – Contact discharge		1b – Air discharge	
Level	Test voltage kV	Level	Test voltage kV
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15
x	Special	x	Special

"x" is an open level. The level has to be specified in the dedicated equipment specification. If higher voltages than those shone are specified, special test equipment may be needed.

Waveform parameters					
Level	Indicated voltage kV	First peak current of discharge ± 10% A	Rise time ξ with discharge switch ns	Current (± 30%) at 30 ns A	Current (± 30%) at 60 ns A
1	2	7.5	0.7 to 1	4	2
2	4	15	0.7 to 1	8	4
3	6	22.5	0.7 to 1	12	6
4	8	30	0.7 to 1	16	8

Test levels for radiated immunity (80 MHz to 1000 MHz)	
Level	Test field strength V/m
1	1
2	3
3	10
x	Special
NOTE – x is an open test level. This level may be given in the product specification. The signal is 80 % amplitude modulated with 1 kHz sinewave to simulate actual treats.	

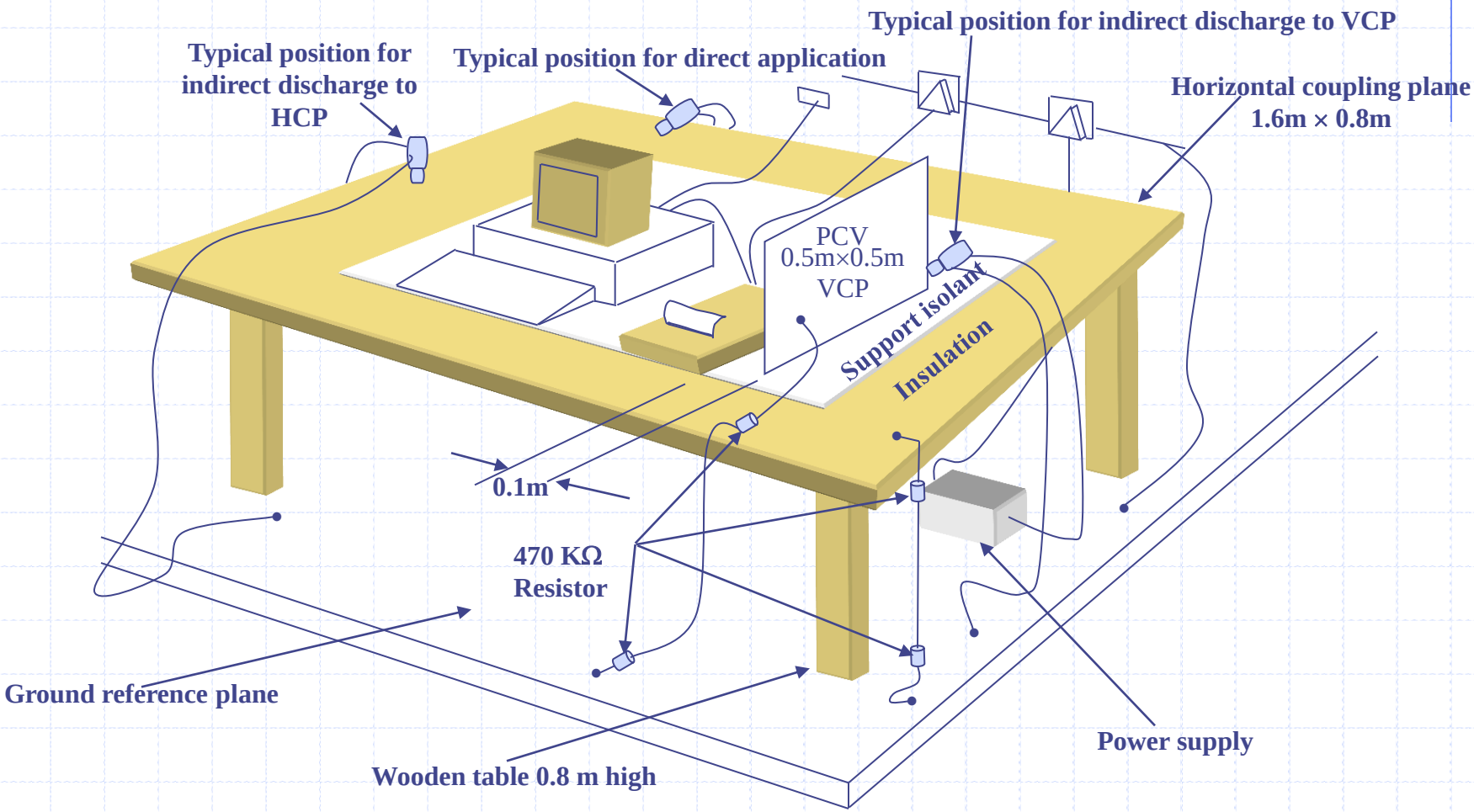
Test levels for EFT test				
Open – circuit output test voltage (± 10 %) and repetition rate of the impulses (± 20 %)				
Level	On power supply port , PE		On I/O (input /output) signal data and control ports	
	Voltage peak kV	Repetition rate kHz	Voltage peak kV	Repetition rate KHz
1	0.5	5	0.25	5
2	1	5	0.5	5
3	2	5	1	5
4	4	2.5	2	5
x	Special	Special	Special	Special
X is an open level. The level has to be specified in the dedicated equipment specification.				

Test Result Classifications

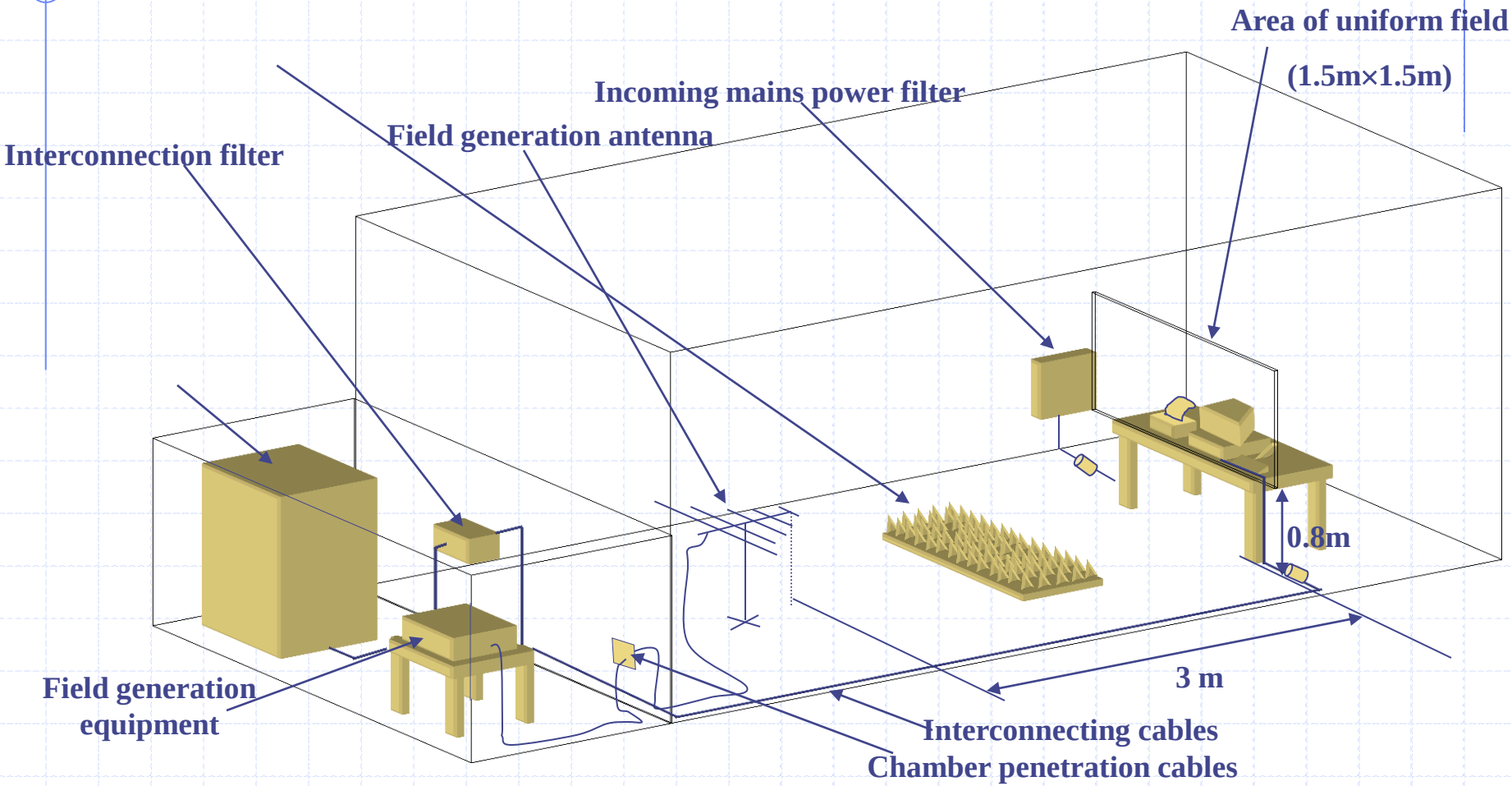
Normal performance within the specification limits
Temporary degradation or less of function or performance which is self - recoverable
Temporary degradation or loss of function or performance which requires operator intervention or system reset
Degradation or loss of function which is not recoverable due to damage of equipment (components) or software, or loss of data

Test Setups and Illustrations

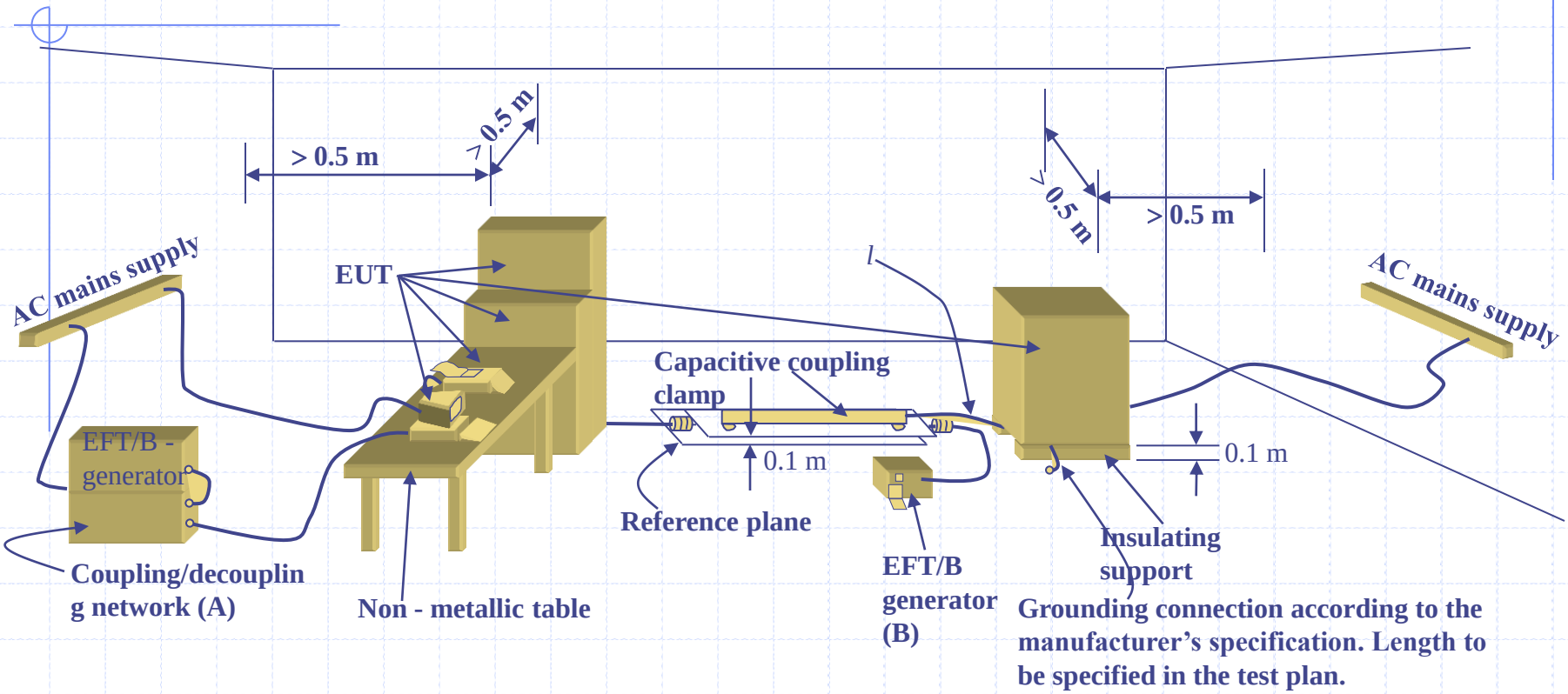
Example of test set-up for table-top equipment, laboratory for ESD tests



Example of suitable test facility for radiated immunity



General EFT test set-up for laboratory type tests



l = length between clamp and EUT to be tested, should not be more than 1 m

(A) = location for supply line coupling

(B) = location for signal coupling