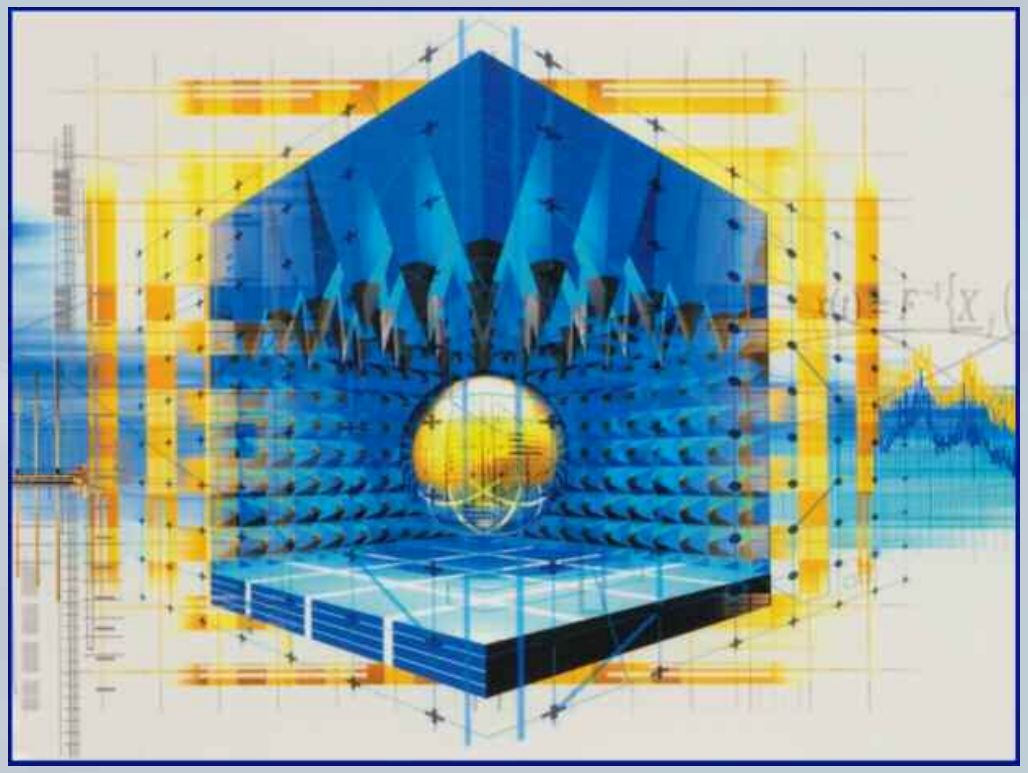
EMC Precompliance Solutions

Kenneth Rasmussen
RSDK



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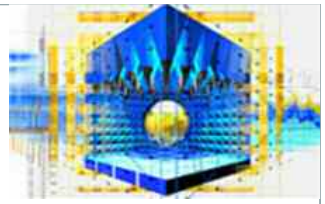
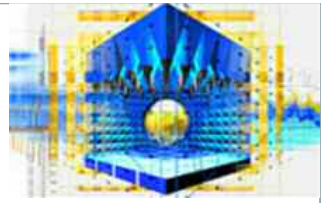
Agenda



- **Welcome & Introduction**
- **EMC overview & history**
- **Transducers for EMI testing**
- **EMI Voltage testing**
- **EMI Power testing**
- **EMI Fieldstrength testing**
- **Test sites & chambers for Fieldstrength testing**
- **Overview of R&S products for EMI testing**
- **EMI software**

Definition of ElectroMagnetic Compatibility (EMC)

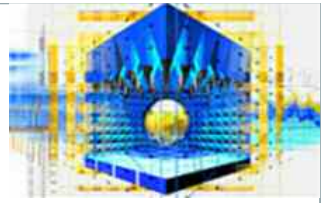


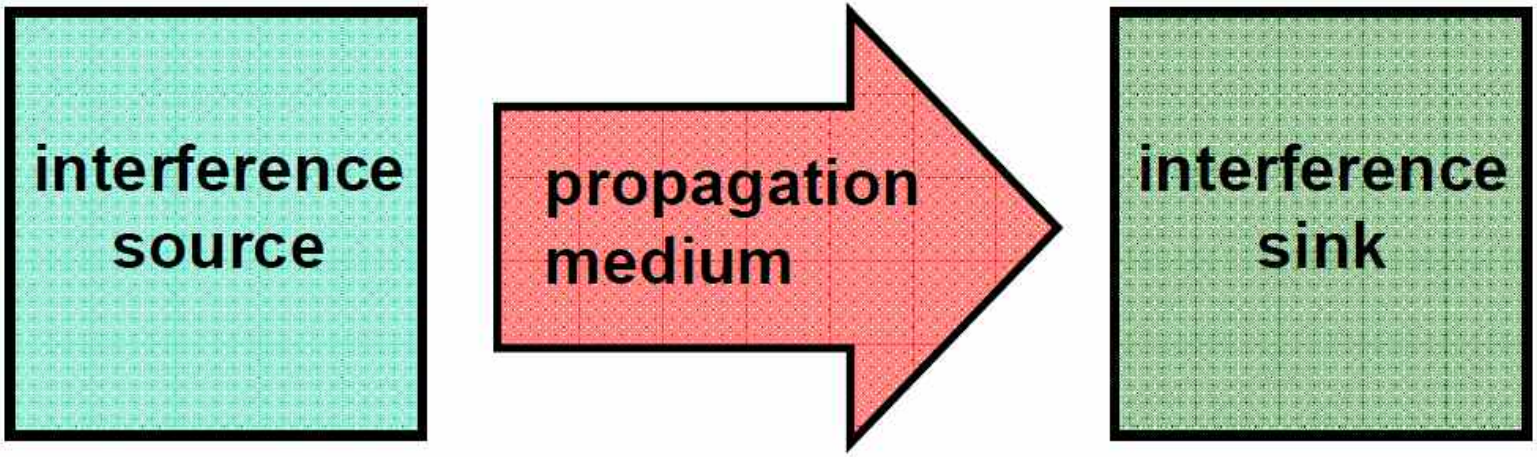
EMC is defined as:

"The ability of devices and systems to operate in their electromagnetic environment without impairing their functions and without faults and vice versa, i. e. to ensure that operation does not influence the electromagnetic environment to the extent that the functions of other devices and systems are adversely affected".

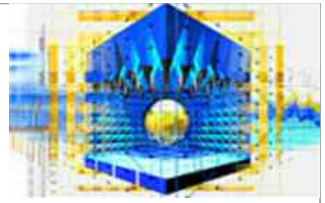
EMS: Susceptibility (immunity) aspect
EMI: Emission aspect ◄ Focus of this presentation

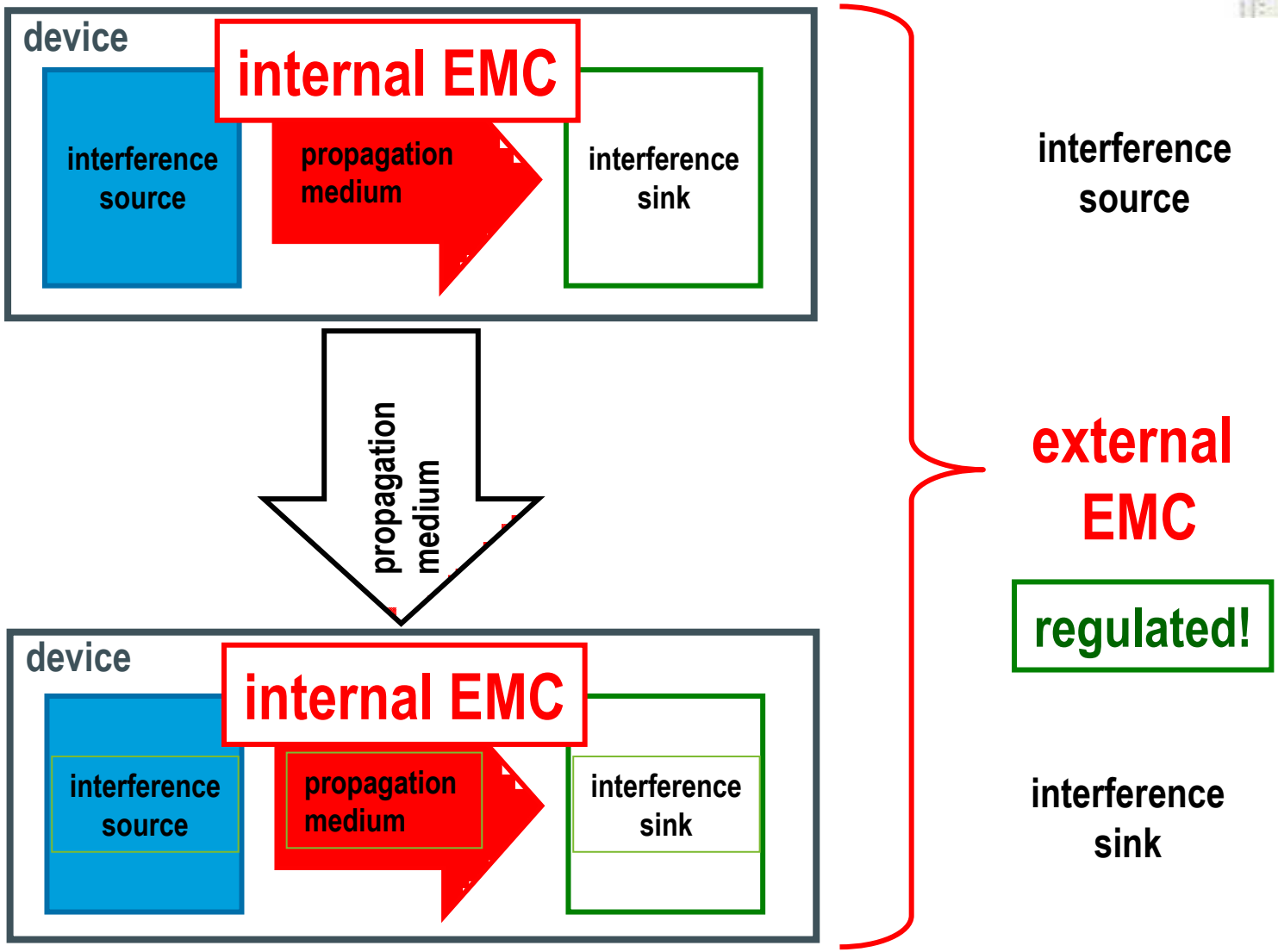
Physics of EMC: Main elements



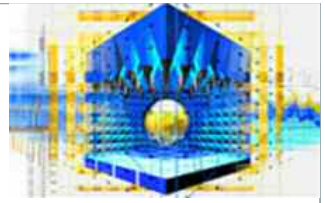


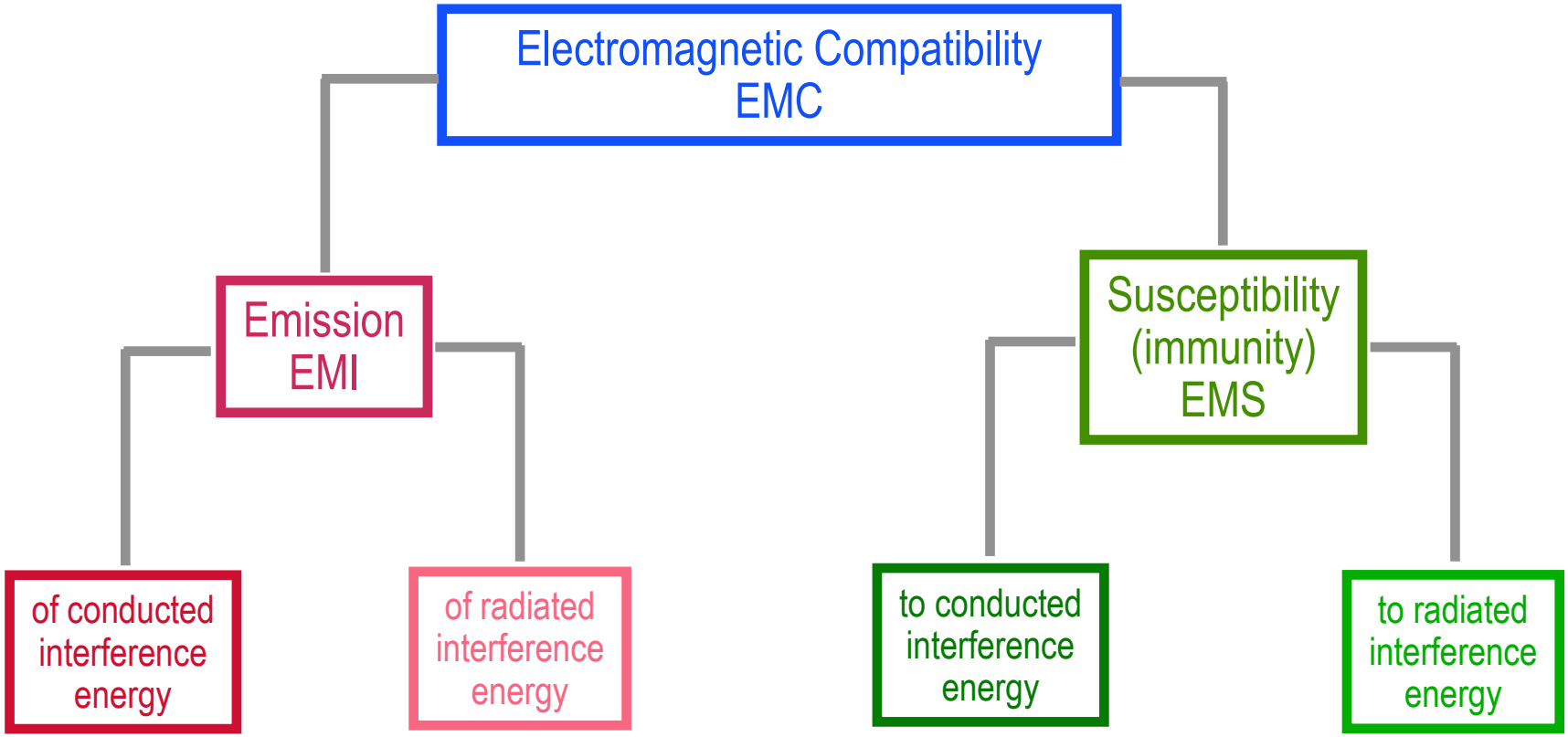
Physics of EMC: Main elements



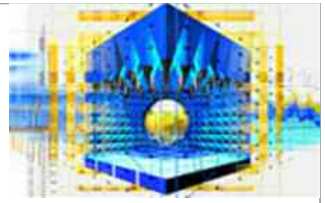


Categories of EMC





Technical sources of RF disturbances



RF disturbance source

natural sources

atmospheric noise
galactic noise
electrostatic discharge

technical sources

intentional generation

narrowband
high RF energy

telecommunications

radio communication
broadcasting
telephone
data transmission

radio monitoring

EMC

non telecommunications

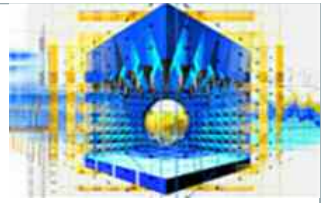
navigation
medical (diathermy, radiology)
household (µwave oven,
inductive heating plate)

unintentional generation

broadband/narrowband
low RF energy

computer
power electronics
energy distrubution
commutating motors
electric arc welding
car ignition systems

CISPR standards (excerpt from more than 30)



CISPR Publication 11
Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment (excluding surgical diathermy equipment)

CISPR Publication 12
Limits and methods of measurement of radio disturbance characteristics of vehicles, motor boats and spark-ignited engine-driven devices

CISPR Publication 13
Limits and methods of measurement of radio disturbance characteristics of sound and television receivers

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

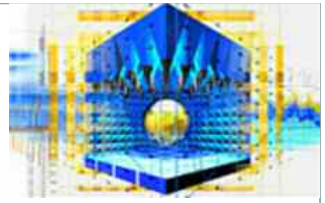
CISPR Publication 15
Limits and methods of measurement of radio disturbance characteristics of fluorescent lamps and luminaries

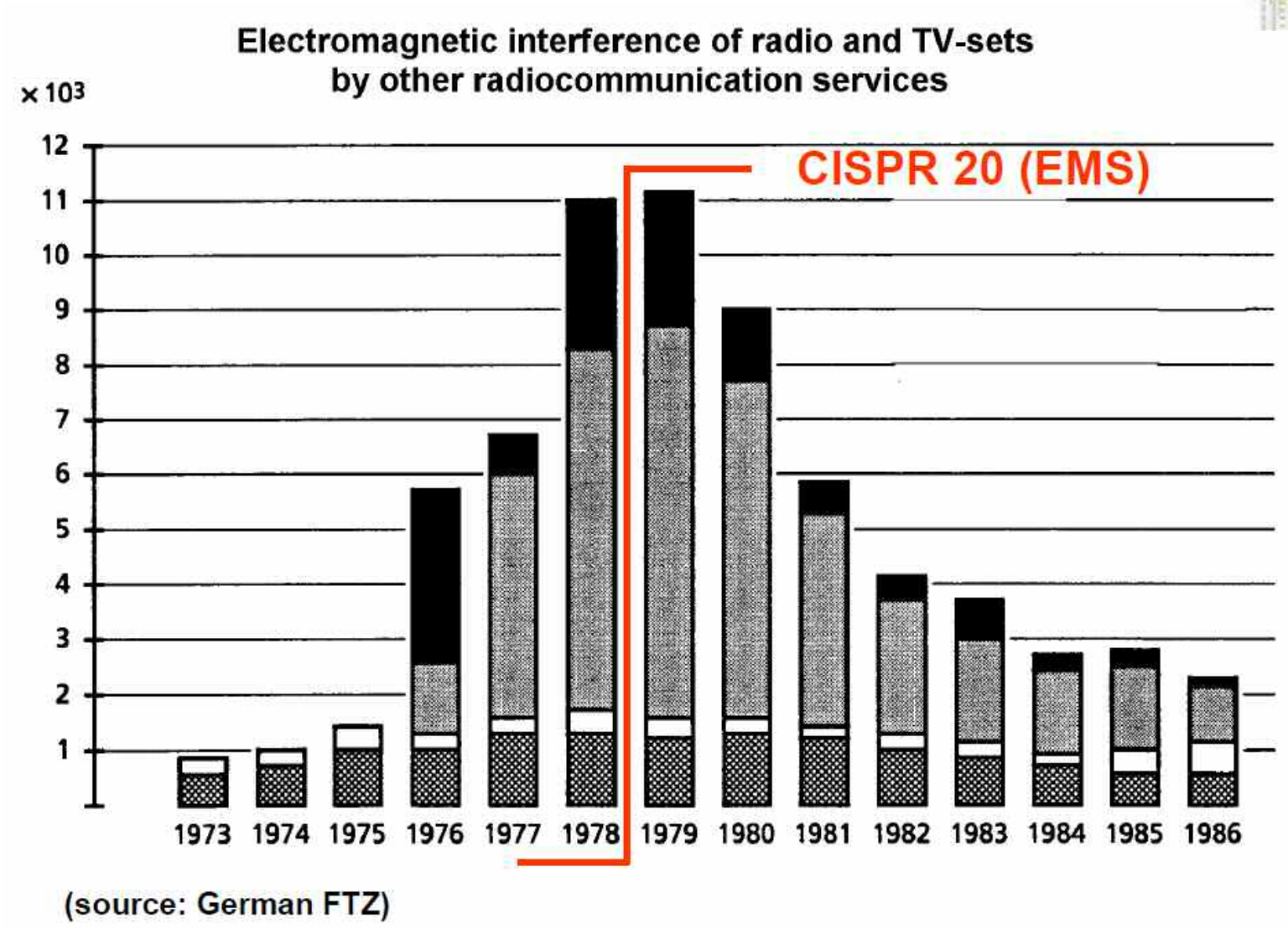
CISPR Publication 16 + Amendment No. 1 + Amendment No. 2
Specification for radio disturbance measuring apparatus and measurement methods

CISPR Publication 22
Limits and methods of measurement of radio disturbance characteristics of information technology equipment (ITE)

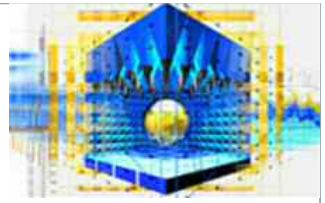
CISPR Publication 25
Limits and methods of measurement of radio disturbance characteristics for the protection of receivers used on board vehicles, boats, and on devices

Introduction of CISPR 20 (immunity of radio/TV)





Military examples

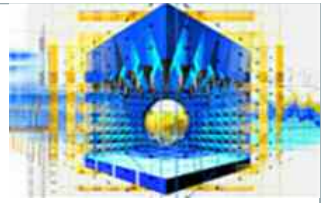


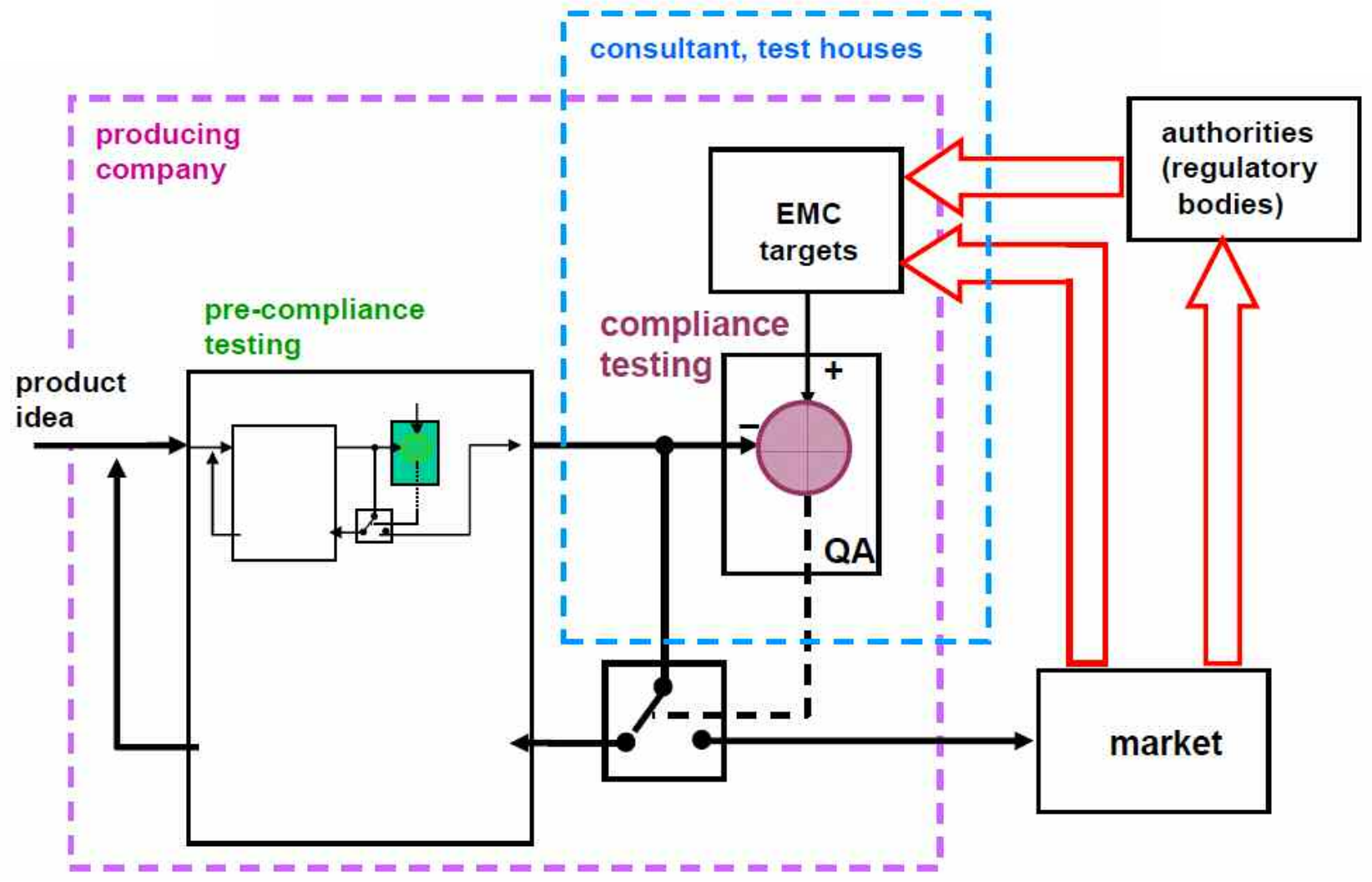
- Crashes of the "Blackhawk" helicopter of the USA Navy (>100 by rumour), caused by susceptibility of onboard electronics to electro magnetic fields.

Crash of a "TORNADO" fighter aircraft of the German Air Force at Rosenheim, caused by the fields emitted by "Radio Free Europe".

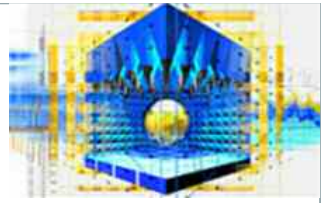
Lab of the EMC Competence Centre of the German Armed Forces (WTD 81): Reaction on the crash of the TORNADO at Holzkirchen. Project costs: Approx. 25 M€

EMC processes



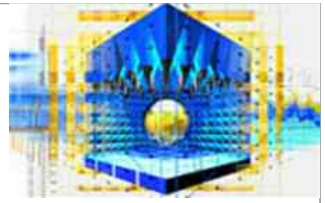


EMC processes: Types of testing



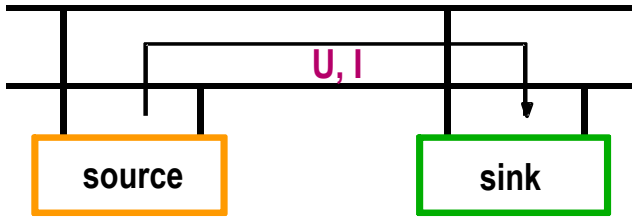
Pre-compliance testing (diagnostic testing) internal and external EMC	for R&D, modification, repair	scopes, spectrum analysers, test receivers, custom - made instruments no conformity required
Pre-certification testing external EMC	for preparation of compliance testing	test receivers / spectrum analysers with limited conformity to EMC regulations
Compliance testing (typically QA) external EMC	for proving compliance to regulations	test receivers (/spectrum analysers) with full conformity to EMC regulations

EMC coupling models



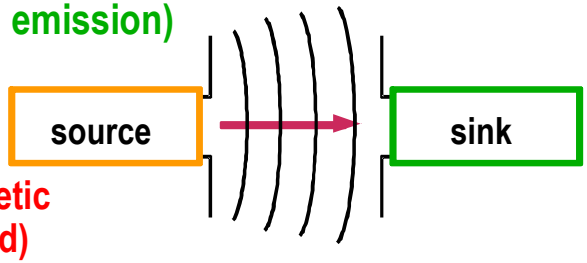
CE (conducted emission)

galvanic coupling

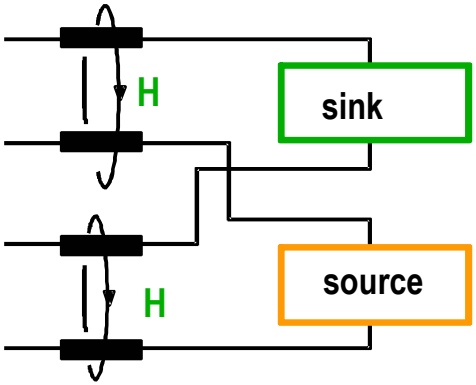


RE (radiated emission)

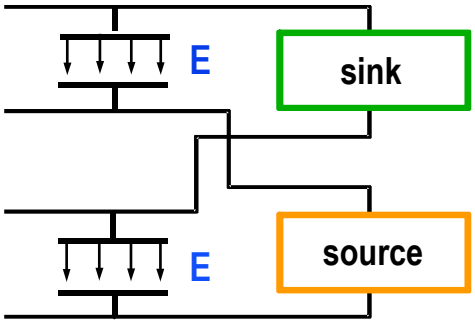
coupling by electromagnetic wave (far field)



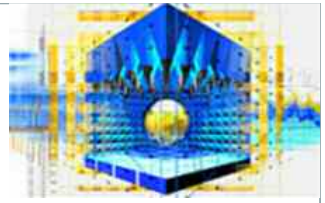
inductive coupling (near field)

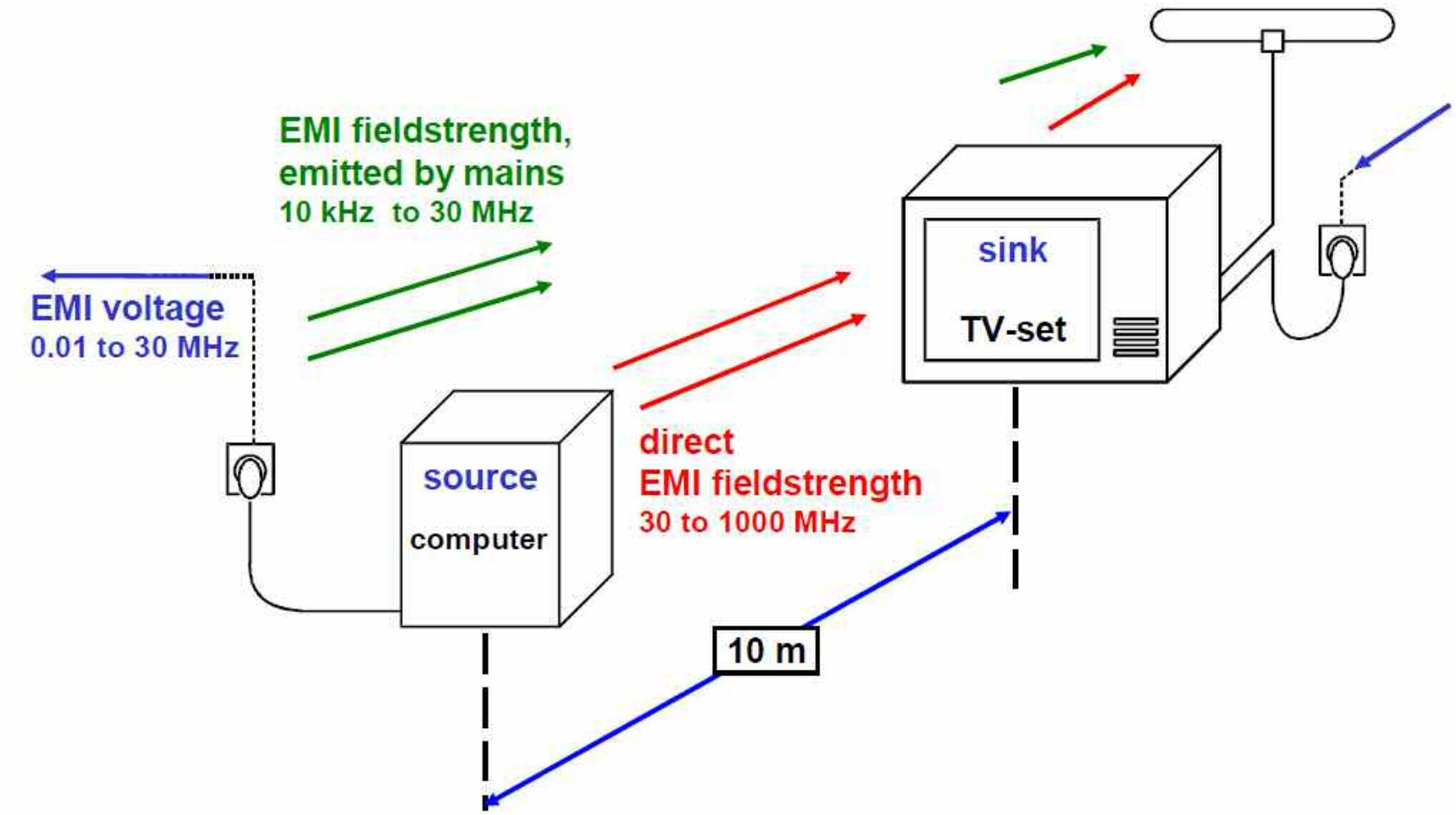


capacitive coupling (near field)

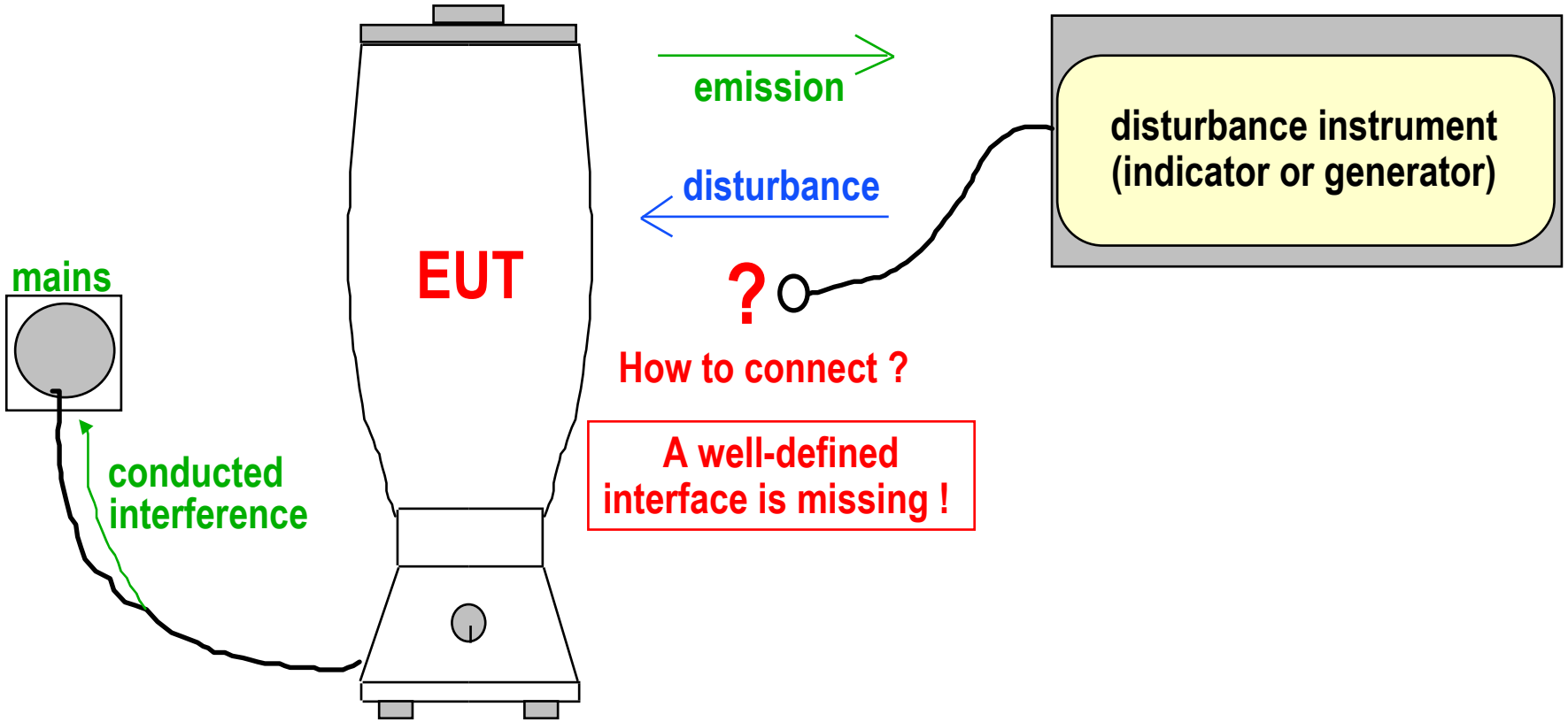


Traditional non-military EMC model for testing

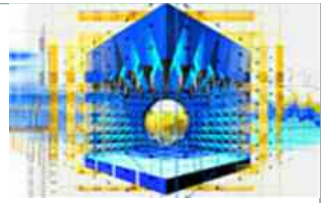


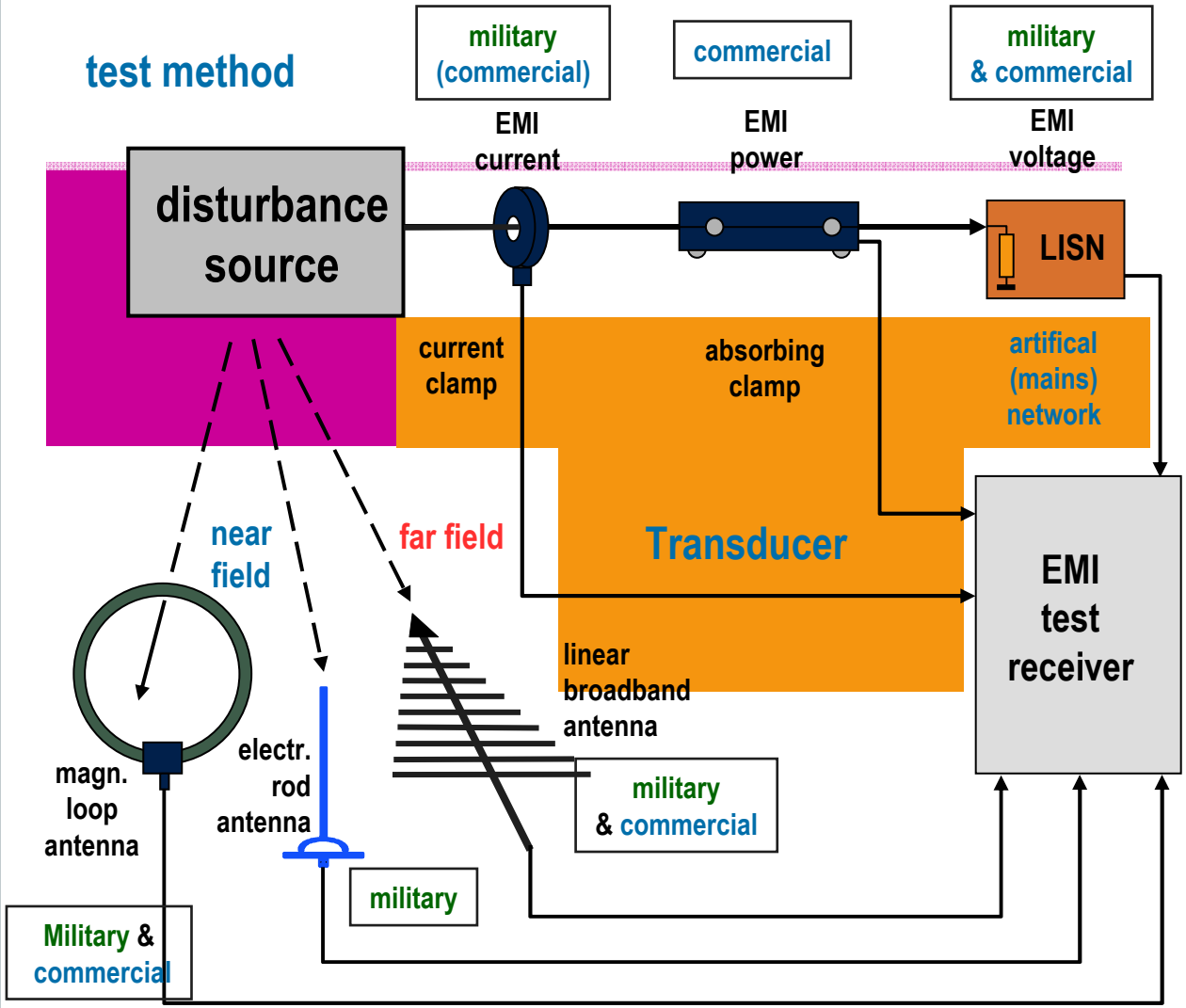


Interface for EMC testing



ElectroMagnetic Interference (EMI) testing (emission)





EMI measurement (commercial stds.)

CISPR Band A: 9 kHz to 150 kHz
- EMI voltage
- EMI fieldstrength (magn. comp.)

CISPR Band B: 150 kHz to 30 MHz
- EMI voltage
- EMI fieldstrength (magn. comp.)

CISPR Band C: 30 MHz to 300 MHz
- EMI power
- EMI fieldstrength (electr. comp.)

CISPR Band D: 300 MHz to 1000 MHz
- EMI fieldstrength (electr. comp.)

CISPR Band E: 1 GHz to 6 GHz
- EMI fieldstrength (electr. comp.)

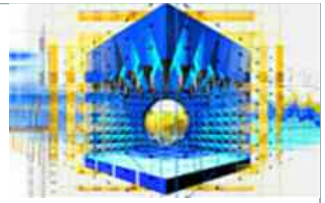
EMI measurements (military stds.)

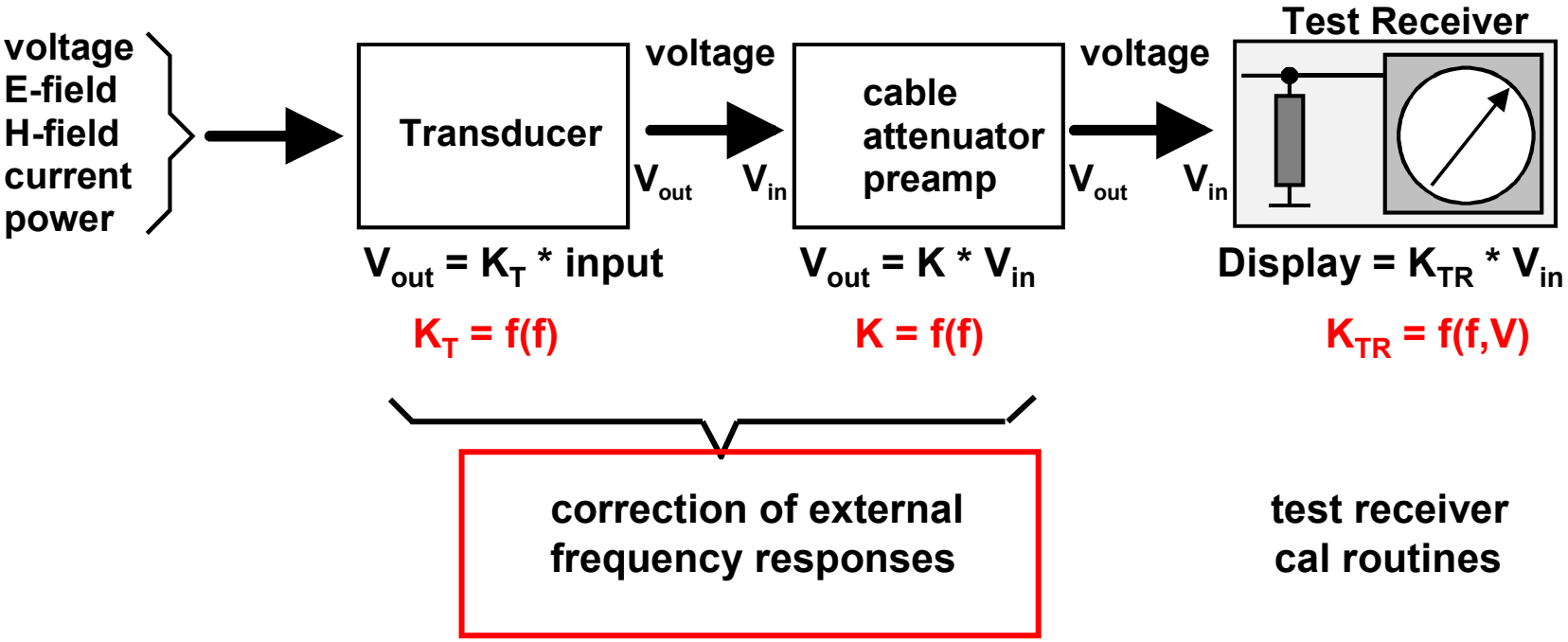
30 Hz to 40 MHz
- conducted emission (voltage)

30 Hz to 50 MHz
- conducted emission (current)

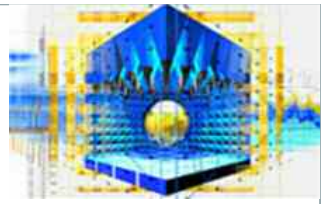
30 Hz to 18 (40) GHz
- radiated emission

Correction factors (1)





Correction factors (2)



Definition of correction factor

linear:
K = output/input

input → **item to be corrected** → output

logarithmic:
k(dB[x/µV]) = output [dBx] - input [dBµV]

„result is level at receiver plus correction“

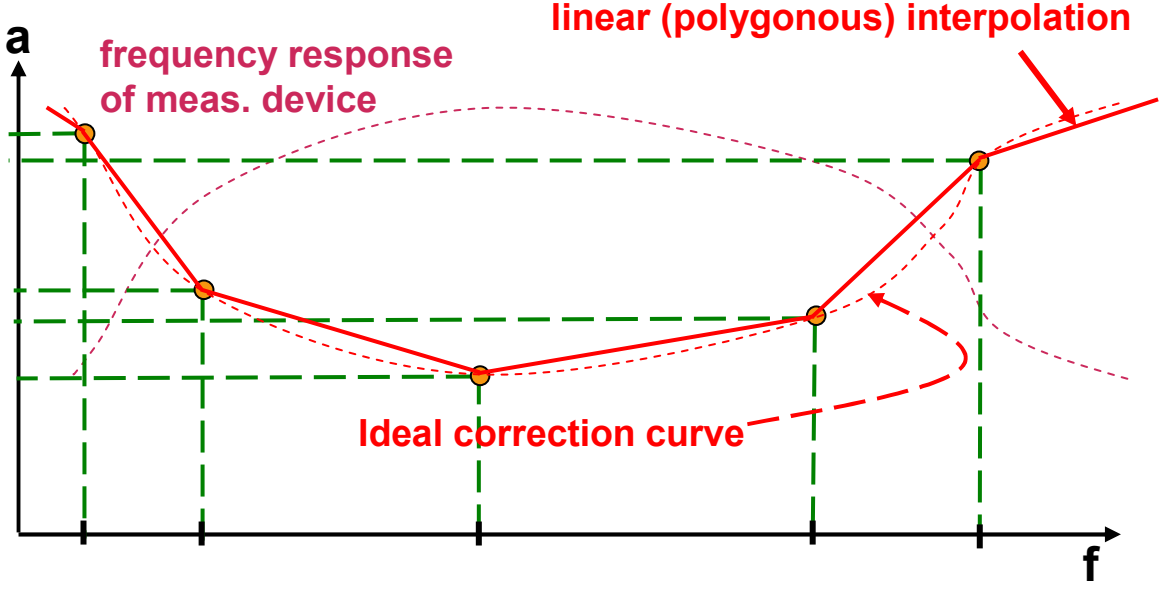
examples for k-factors:

	input	output			k-factor unit
cable	dBµV	dBµV	dB[µV/µV]		= dB
current clamp	dBµA	dBµV	dB[µA/µV]	= dB[A/V]	= dB[1/Ω]
Electric antenna	dBµV/m	dBµV	dB[µV/m/µV]	= dB[V/m/V]	= dB[1/m]
magnetic antenna	dBµA/m	dBµV	dB[µA/m/µV]	= dB[A/m/V]	= dB[1/ Ωm]
absorbing clamp	dBpW	dBµV	dB[pW/µV]	= dB[pVA/µV]	= dB[A]

To be put into correction factor table definitions as “unit“

Correction factors (3)

Error correction during measurements by interpolation



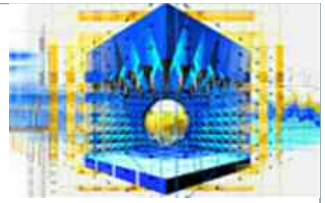
Kalibrierdaten ULTRALOG HL562
Calibration report ULTRALOG HL562

Freq. [MHz]	AF [dB]	Gain [dB]/[dBi]	VSWR
30.00	18.55	-8.71	38.73
30.15	18.50	-8.63	38.65
30.30	18.34	-8.43	38.59
30.45	18.42	-8.45	38.69
30.60	18.42	-8.41	38.62
30.75	18.35	-8.31	38.62
30.90	18.25	-8.16	38.64
31.05	18.28	-8.15	38.61
31.20	18.31	-8.14	38.61
31.35	18.34	-8.13	38.53
31.50	18.28	-8.04	38.43
31.65	18.35	-8.07	38.42
31.80	18.40	-8.10	38.29
31.95	18.42	-8.10	38.05
32.10	18.46	-8.10	38.02
32.25	18.42	-8.04	37.90
32.40	18.39	-7.99	37.75

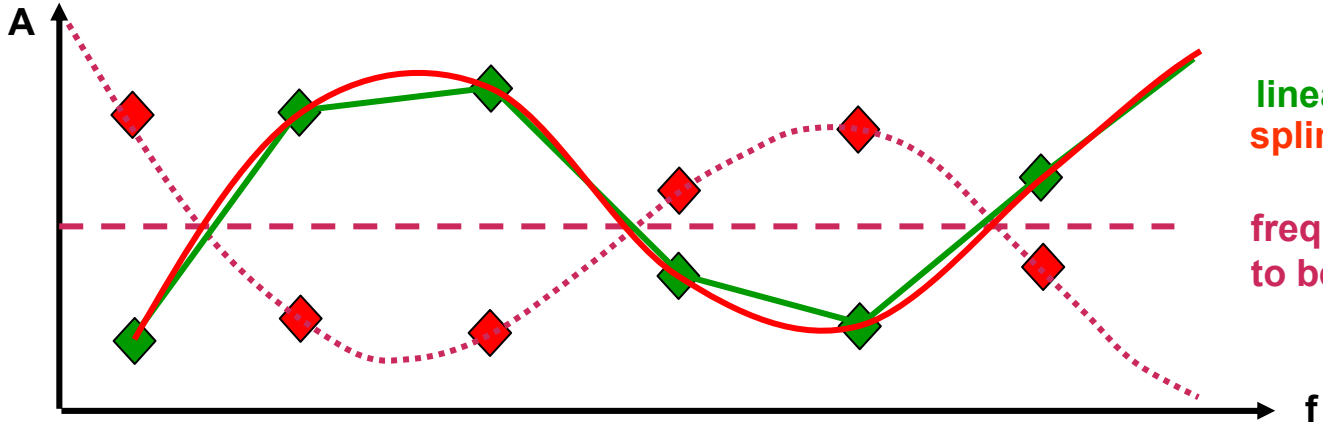
frequency response → inverse correction curve → discrete points → interpolation

- Polygon
- spline
- (polynome)

Correction factors (4)



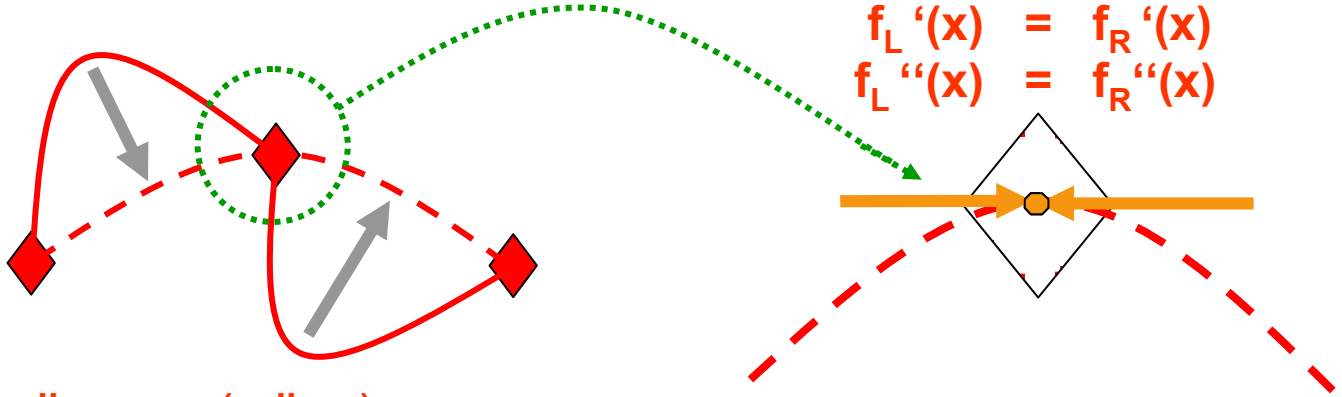
Error correction during measurements by interpolation



linear interpolation
spline interpolation

frequency response
to be corrected

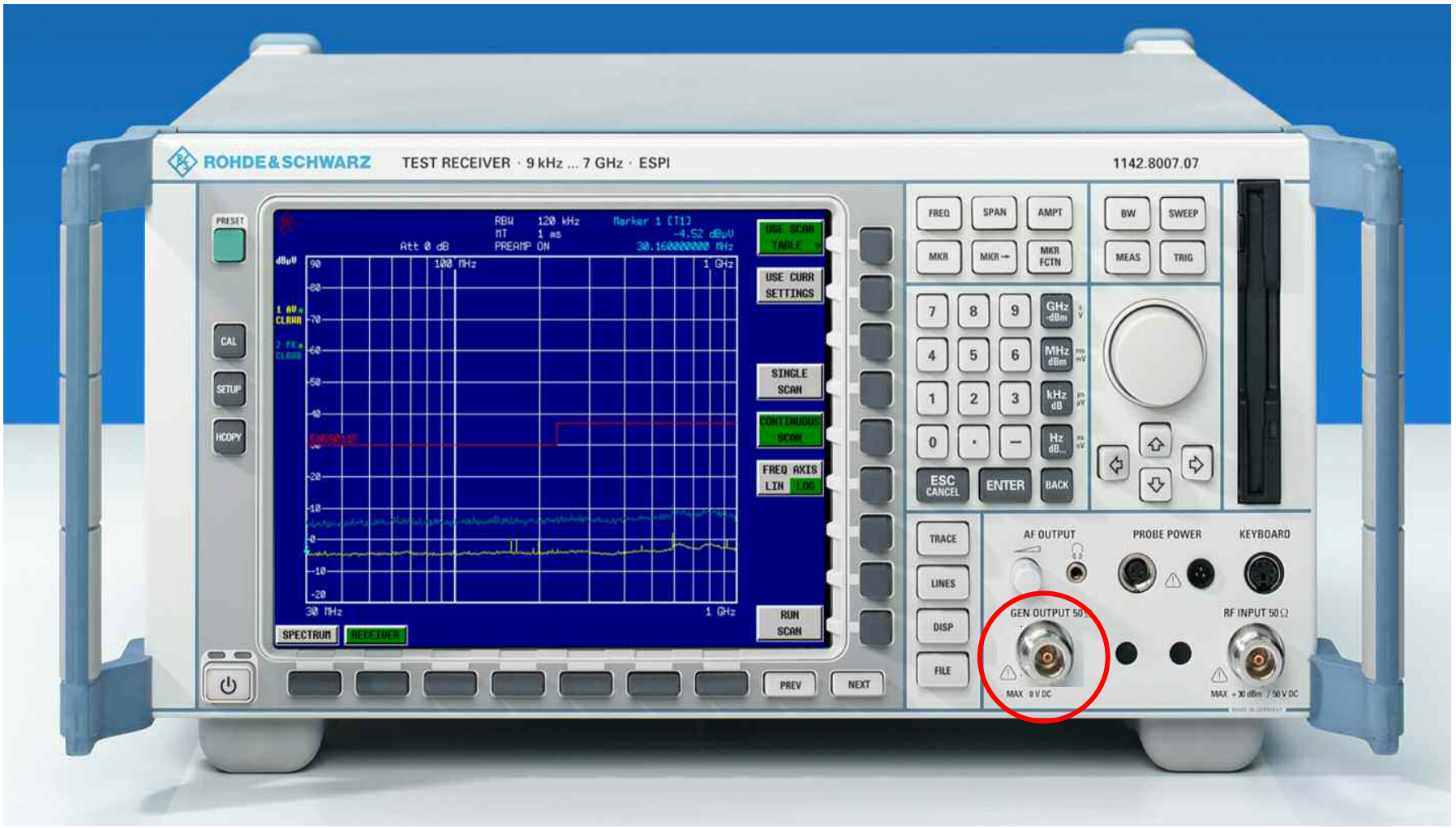
$f_L(x) = f_R(x)$
$f_L'(x) = f_R'(x)$
$f_L''(x) = f_R''(x)$



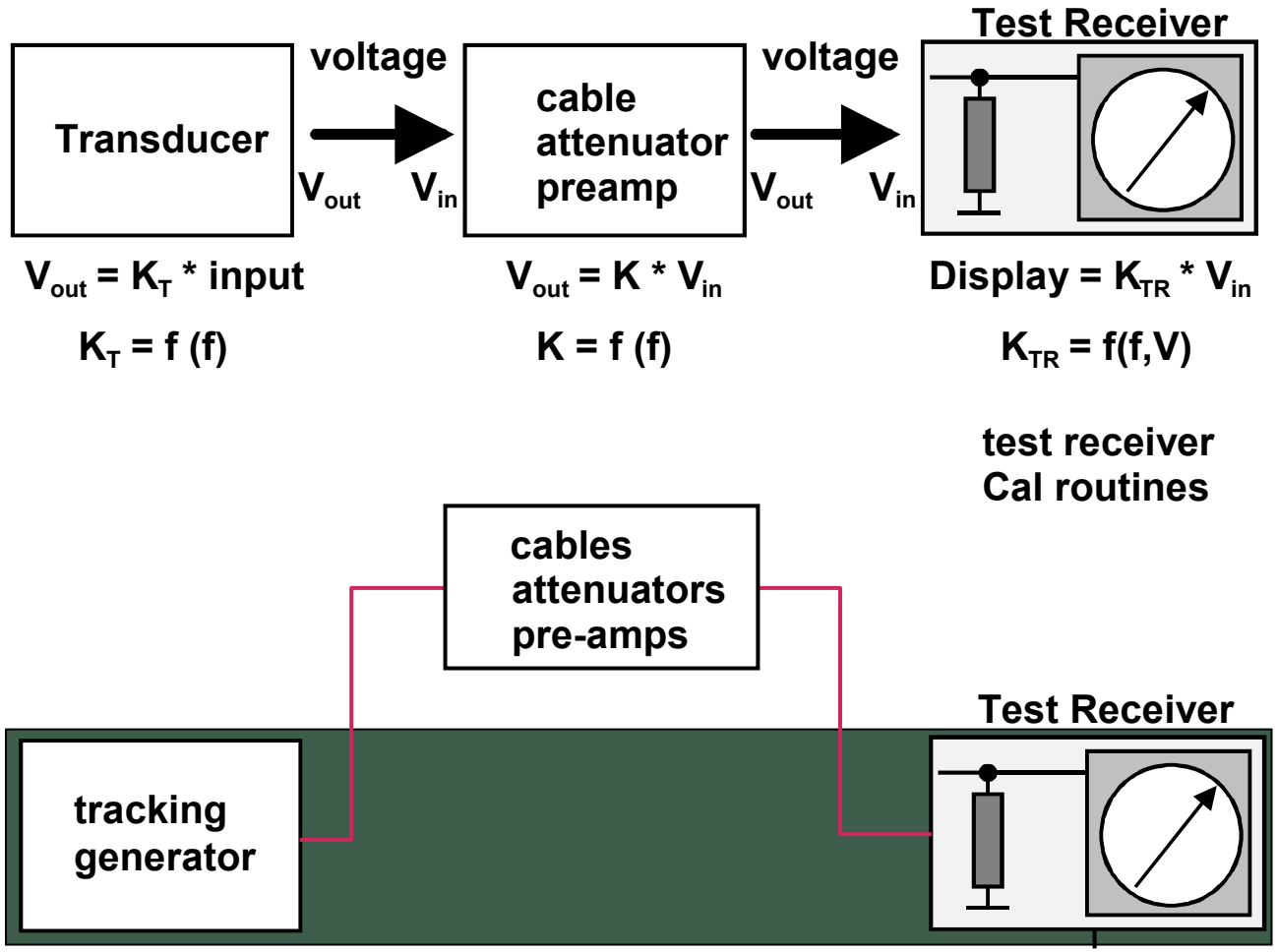
hyperbolic curves (splines)

Calibration of Accessories (1)

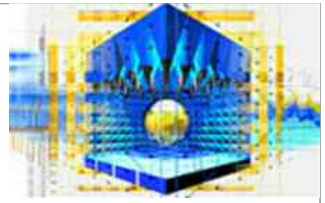
Test Receiver Front Panel



Calibration of Accessories (2)



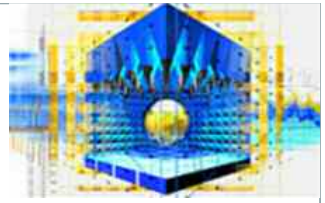
EMI Voltage testing overview



Devices under test: all non-military equipment

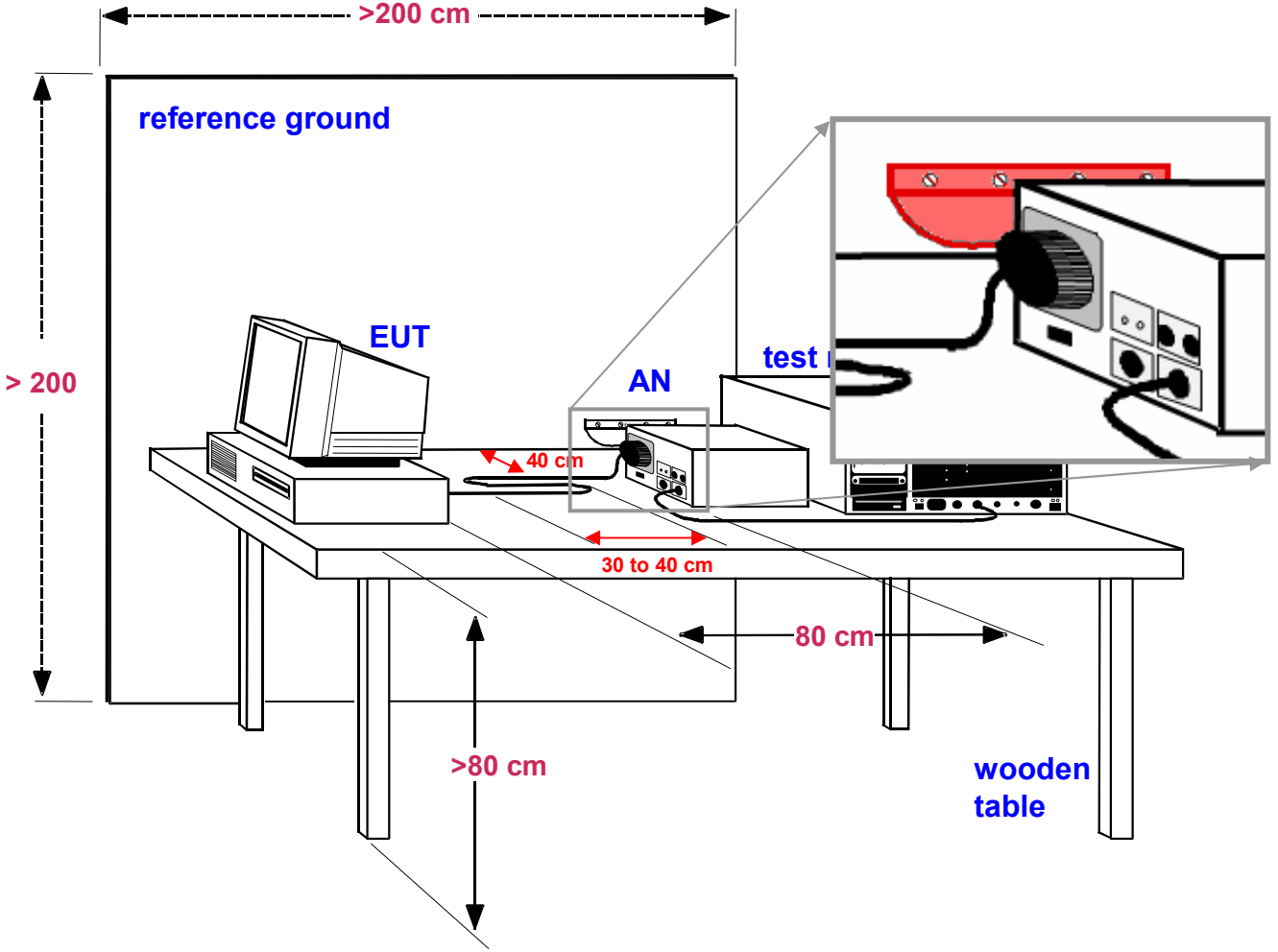
- **measurement of conducted EMI as a voltage using a standardized load impedance**
- **frequency range: (9kHz to)150 kHz to 30 MHz (CISPR band A + B)**
- **main equipment: test receiver, AN, ground plane, (artificial hand)**
- **important for the receiver: pulse protection**
- **important for the operator: electrical safety problem**

EMI Voltage test: Basic test settings

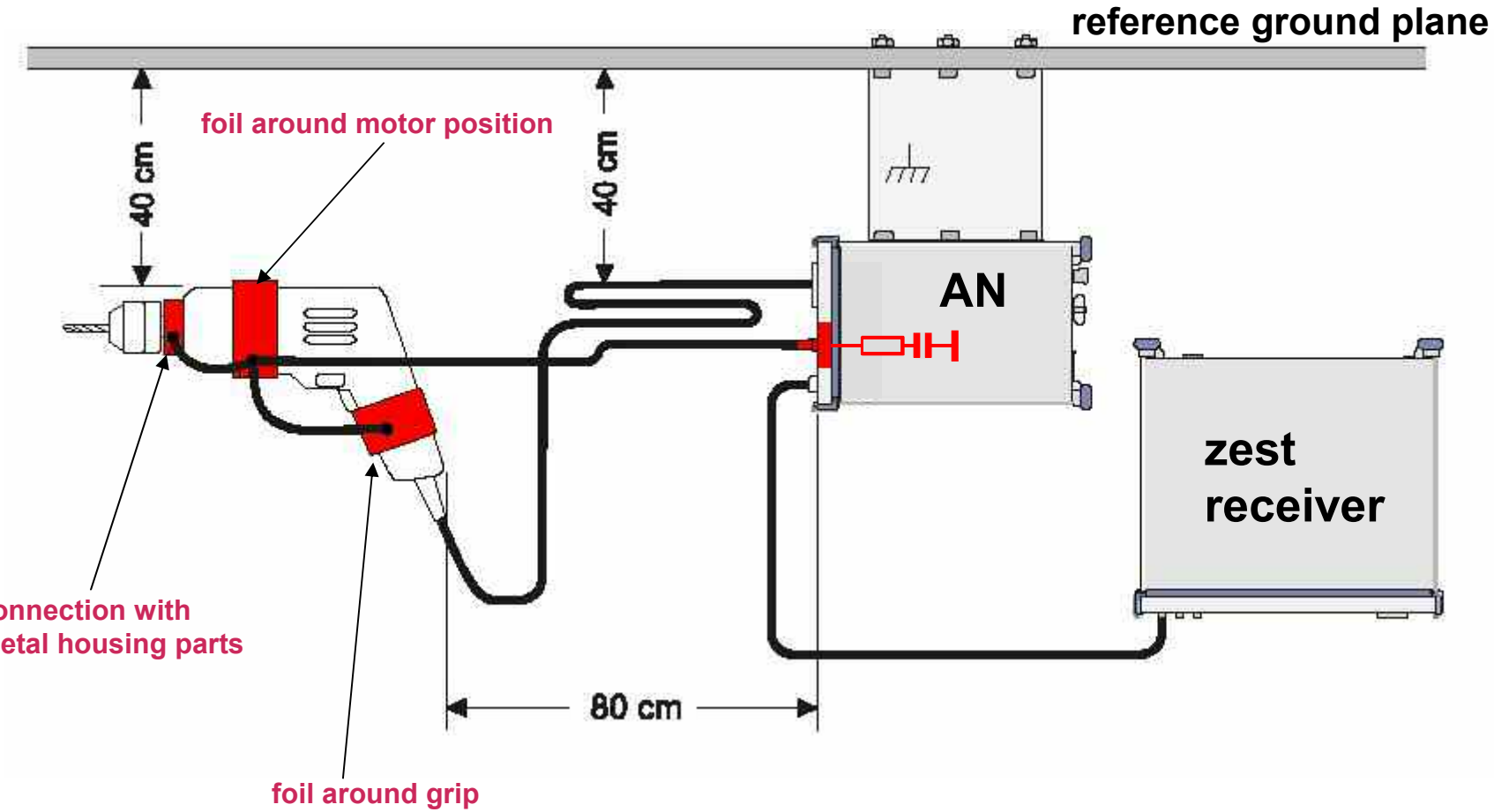


Standard	CISPR 11	CISPR 13	CISPR 14	CISPR 15	CISPR 22
Products	ISM	Radio & TV	Household eq	Lamps	ITE
Port	Mains cable	Mains cable Control cable Load cable	Mains cable Control cable	Mains cable Control cable Load cable	Mains cable Signal cable
Transducer	AMN / probe	AN	AN / probe	AN / probe	AN / ISN
Freq range	(9k)150k...30M	150k...30M	150k...30M	9k...30M	150k...30M
Detector	Qp + Av	Qp + Av	Qp + Av	Qp + Av	Qp + Av
S/N to ambience	>=6 dB	>=10 dB	>=20 dB	-	>=6 dB
Meas time	Up to 15s	Up to 15s	Up to 15s	Up to 15s	Up to 15s
Ground plane size	2m * 2m	Wall of shielded room	2m * 2m	2m * 2m	2m * 2m
Distance ... to table	40cm / 80cm	40 / 80	80cm / 40cm	40 / 80 or spec.	40 / 80 or 80 / 40
... to floor	80 / 40	-	40 / 80	-	80 / isolation
AN to DUT	80cm	80cm	80cm	80cm	80cm
Cable	1m or bundle	0,8m or bundle	1m or bundle	-	1m or bundle

EMI voltage test: Basic test setup

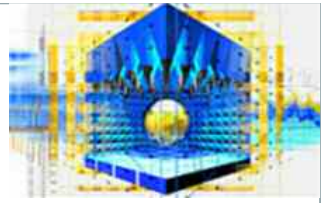


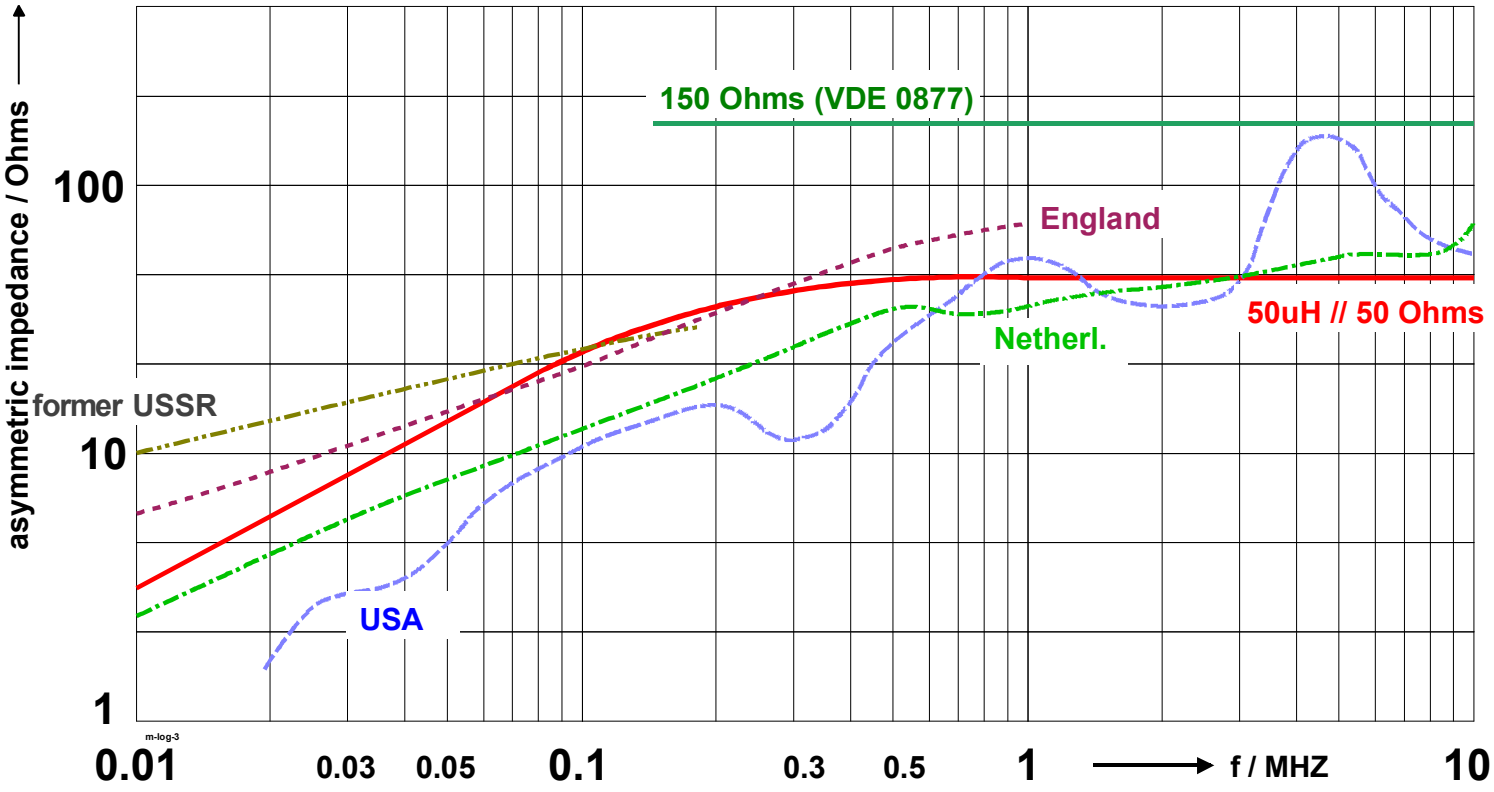
EMI voltage test: Artificial hand (CISPR 14)



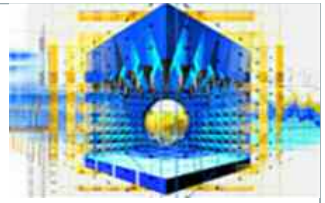
worst case test with and without art. hand !

EMI voltage test: Power mains impedances

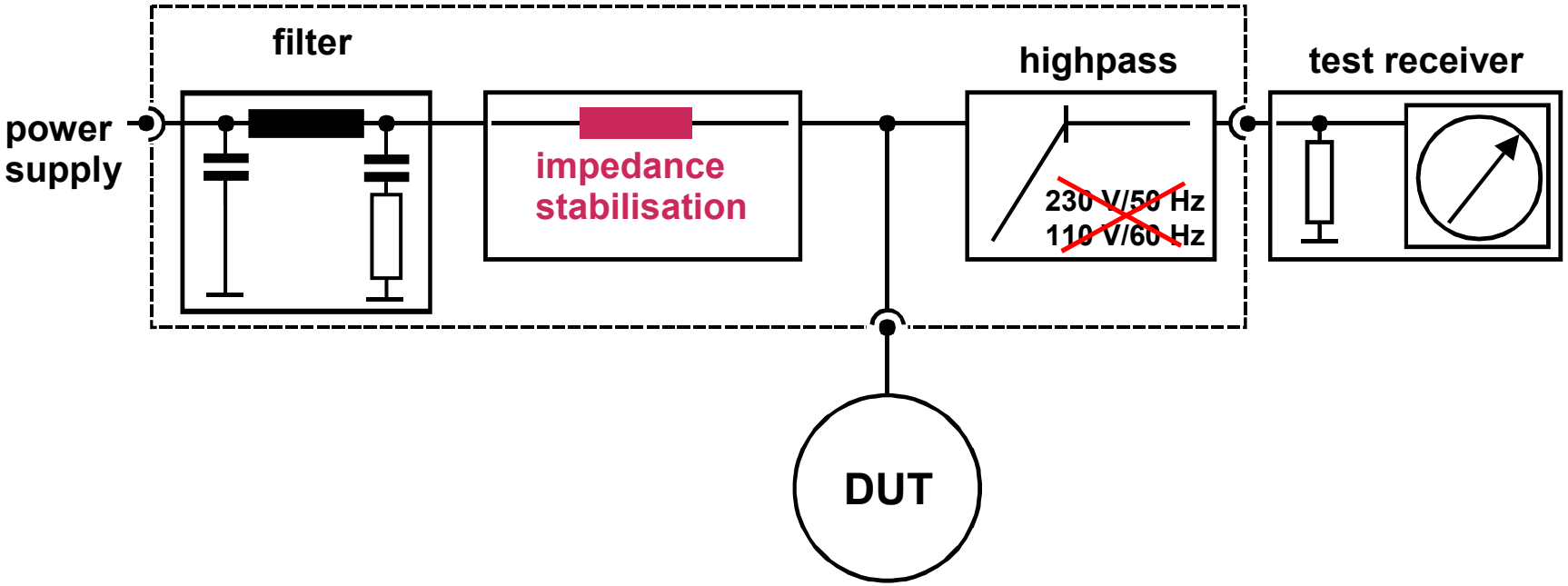




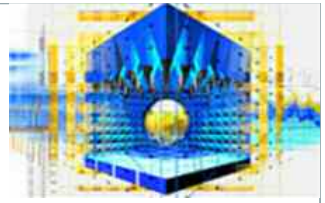
EMI voltage test: AN functional principle



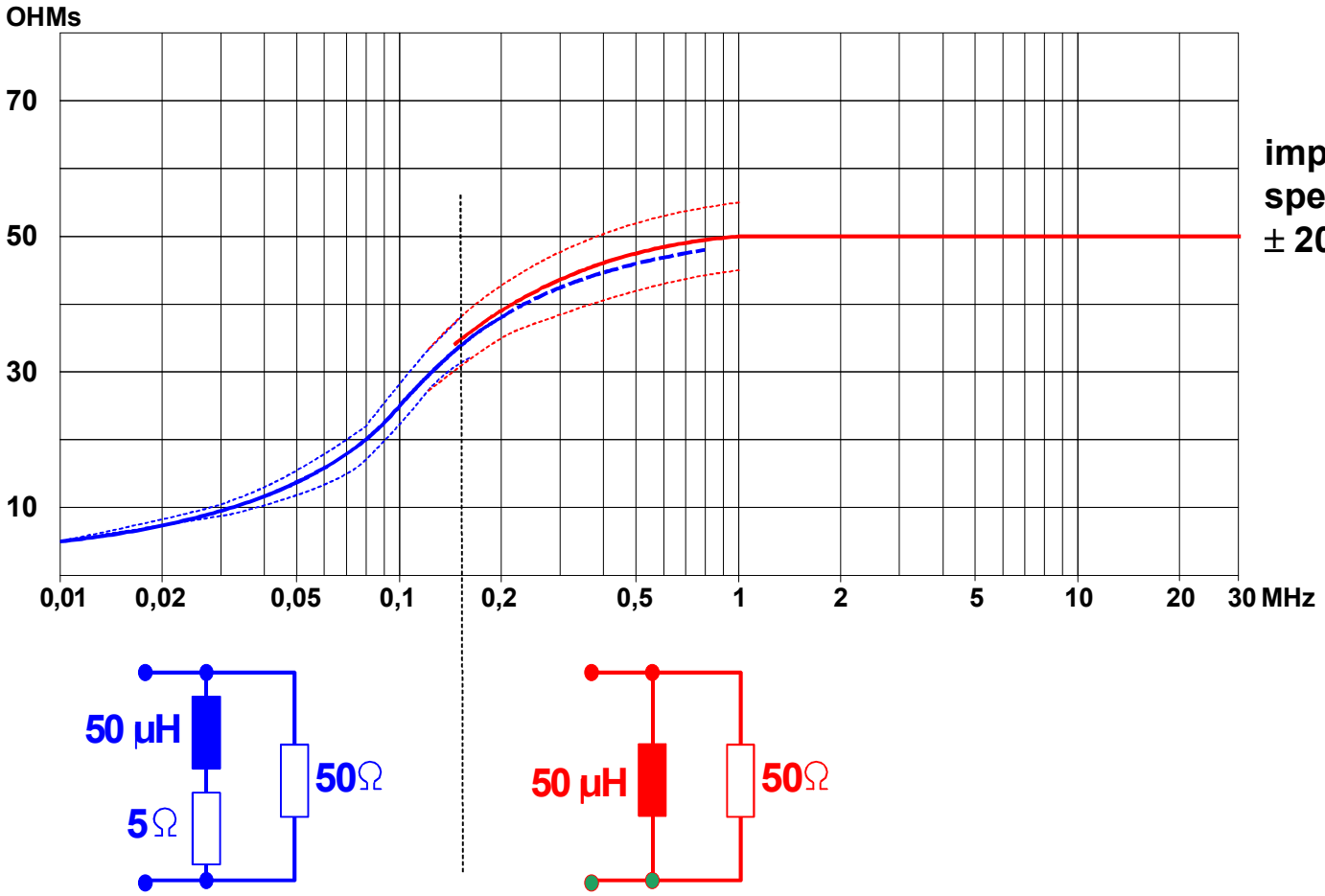
Names:
Artificial Mains Network AMN
Artificial Network AN
Line Impedance Stabilisation Network LISN



EMI voltage test: V-type LISNs

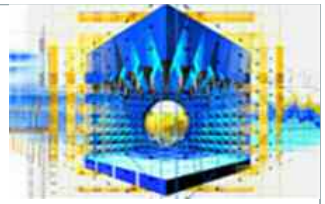


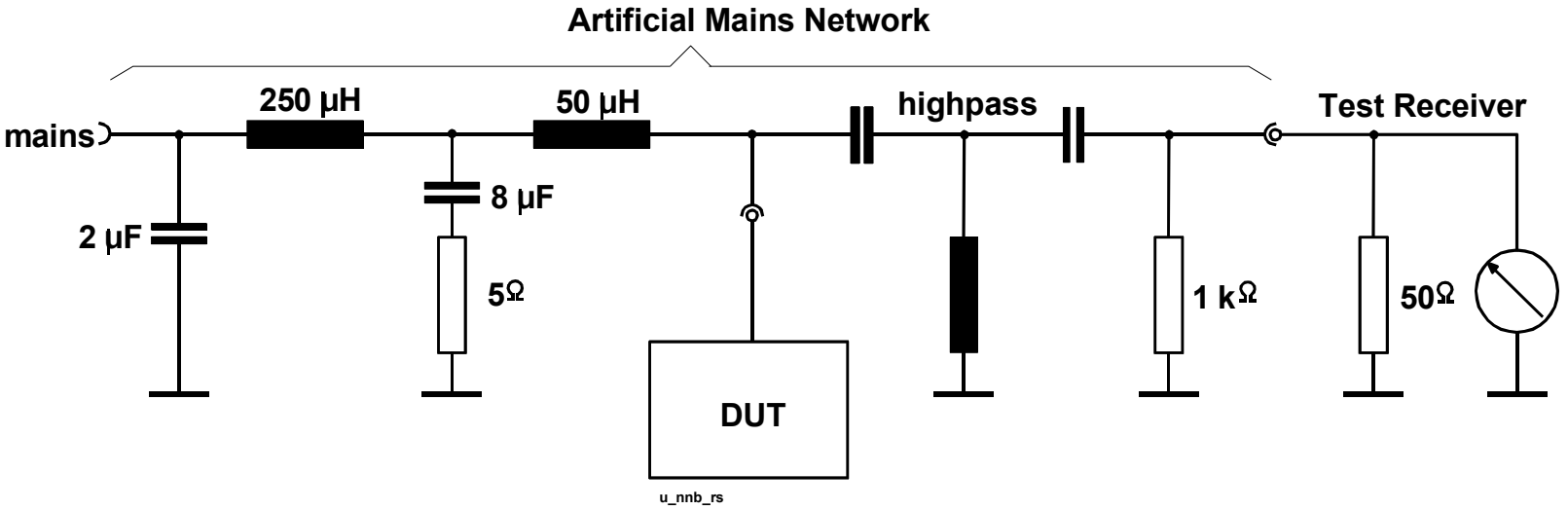
50Ω / 50µH + 5Ω V-Type LISN from 9 kHz to 150 kHz
50Ω / 50µH V-Type LISN from 150 kHz to 30 MHz



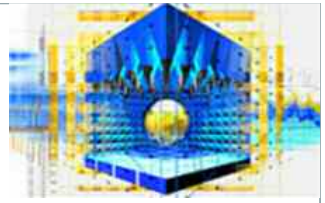
impedance specification ± 20 %

EMI voltage test: Typical circuit of LISN





EMI voltage test: R&S LISNs



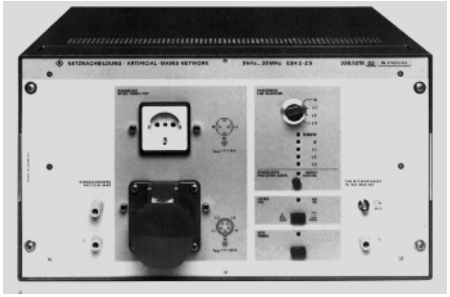
ESH3-Z5
2-line artificial mains
V-network

for AC standard applications
frequency range 9 kHz to 30 MHz
continuous max. current 2*10(16) A

ENV 216
2-line artificial mains
V-network

for AC standard applications
frequency range 9 kHz to 30 MHz
continuous max. current 2*16 A
improved functions

ESH2-Z5
4-line artificial mains
V-network

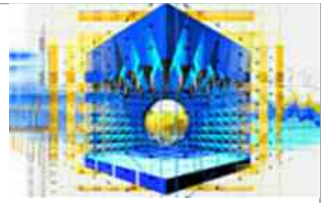


for 3- phase systems
frequency range 9 kHz to 30 MHz
continuous max. current 4*25 A

ENV 4200
4-line artificial mains
V-network

for 3- phase systems
frequency range 150 kHz to 30 MHz
continuous max. current 4*200 A

Input capability of test receivers



(RF-Att ≥ 10 dB)

AC voltage	132 dBuV (= 7V ≈ 1 W)
Pulse density	97 dBuV/MHz

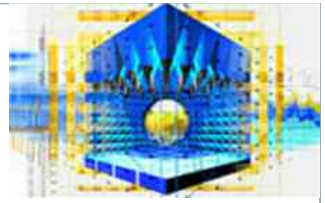
Boundary to damage:

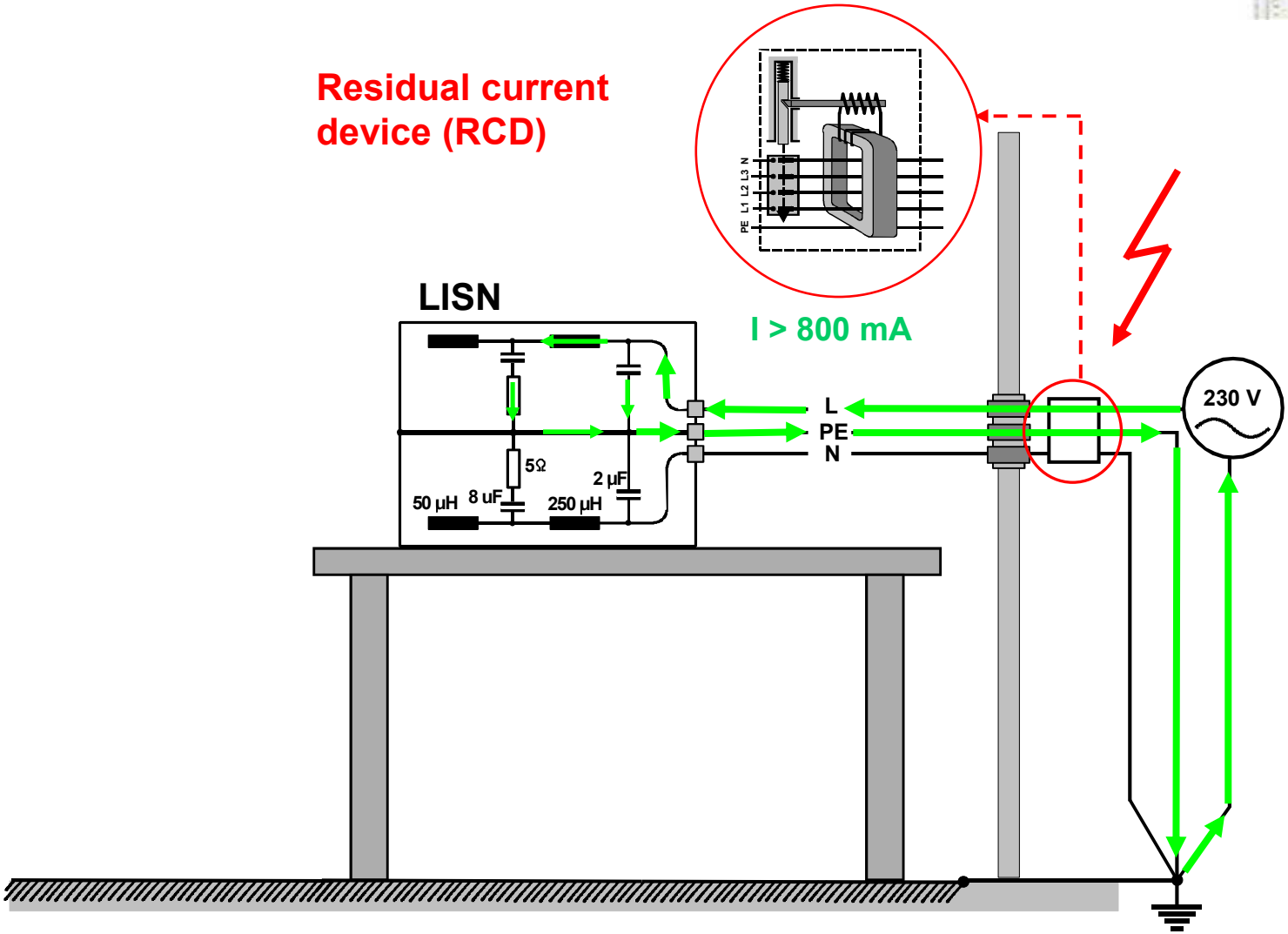
DC voltage: DC coupling AC coupling	0 V ± 50 V (DC-Blocking Capacitor)
Pulse voltage	150 V
Pulse energy	1 mWs (for 10 us = 100W)

use of a pulse-limiter recommended !

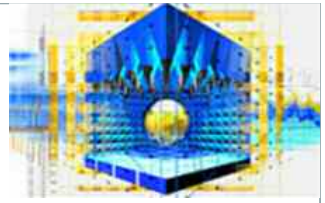
100 mWs **ESH3-Z2**

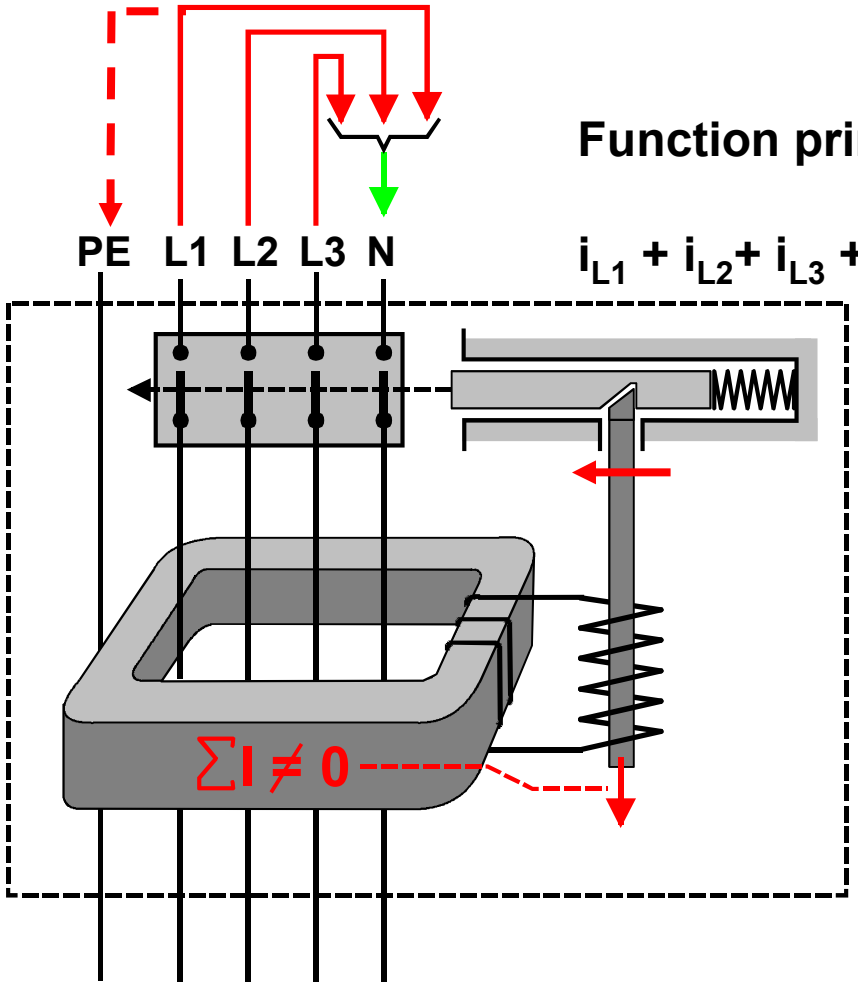
EMI voltage test: Electric safety





EMI voltage test: Residual current device

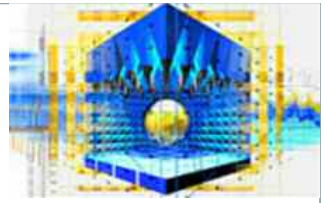


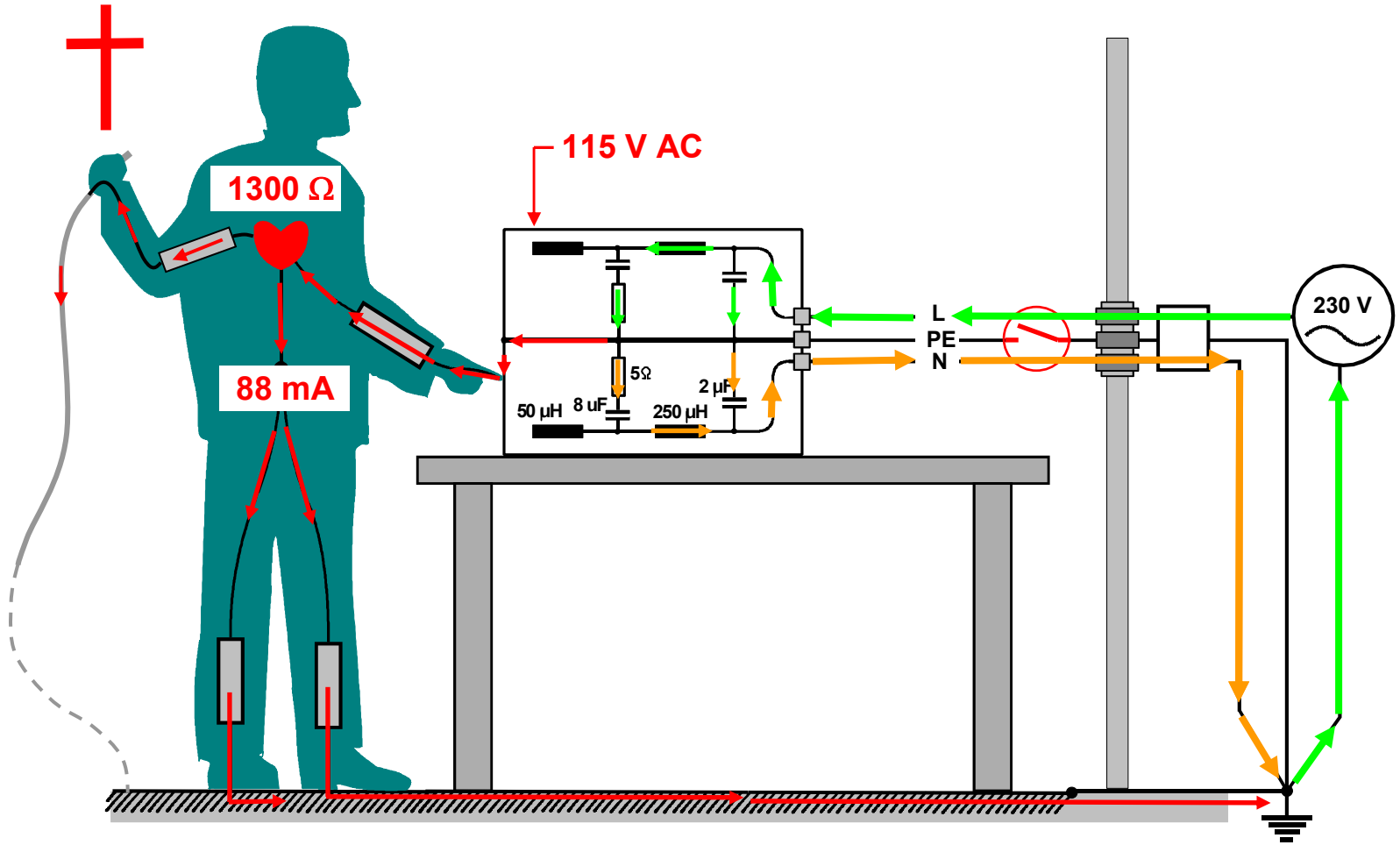


Function principle

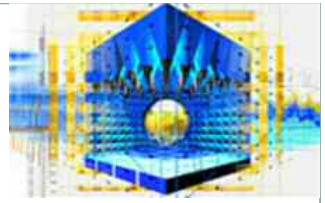
$i_{L1} + i_{L2} + i_{L3} + i_N \neq 0$ ➡ **circuit break**

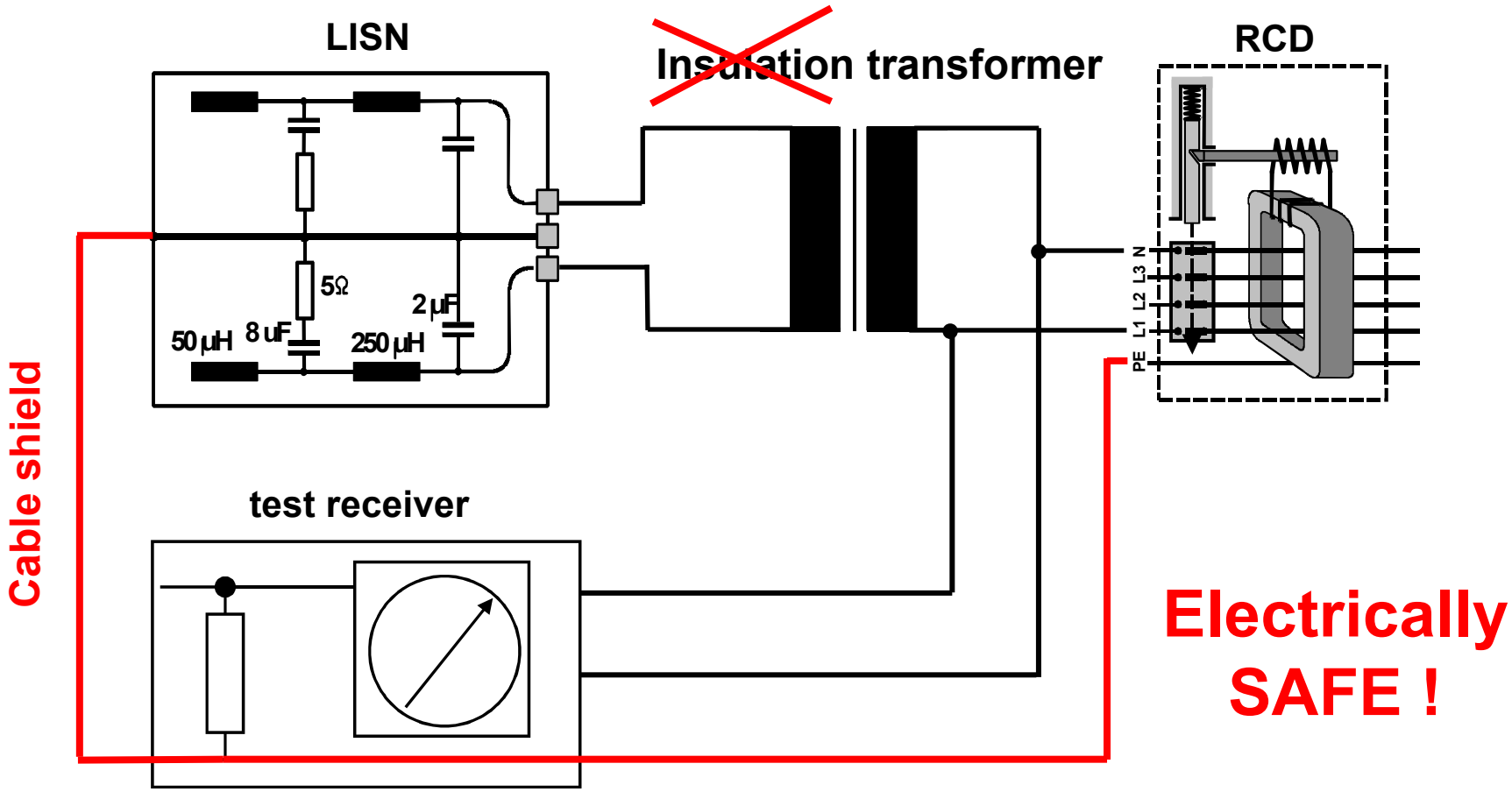
EMI voltage test: Electric safety



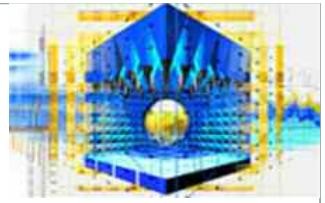


EMI voltage test: Electric safety





EMI voltage test: ENV 216



Caution!

Before using for the first time, the network must be connected to an additional conductor that is compliant with VDE0100.

Users must be aware that it is possible for socket connections and grounding conductors to become disconnected. A further grounding conductor with adequate diameter must be connected between a grounding conductor connection for the measurement area and the grounding bolt (1) on the ENV216.

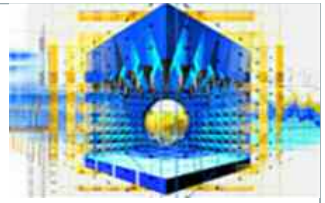
Only then may the network be connected to the mains power supply.

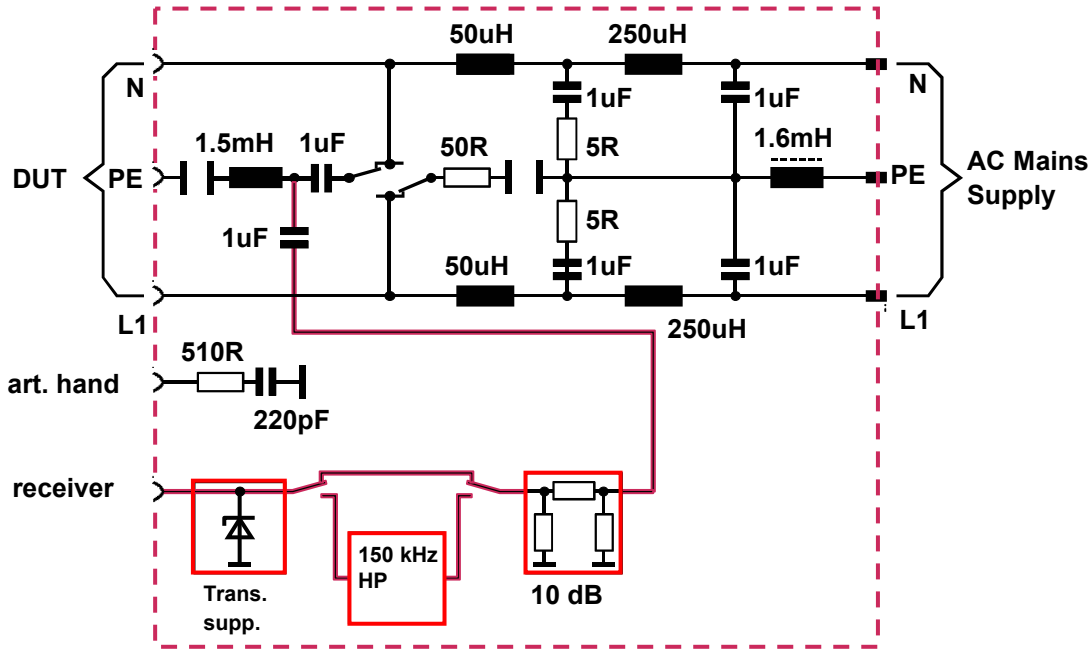
At shutdown, the same procedure must be followed in the reverse order:

First the ENV216 must be disconnected from the mains power supply, and only then should the additional grounding conductor connection be removed.

Excerpt of manual

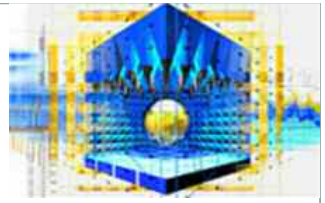
EMI voltage test: ENV 216





ENV 216

EMI voltage: Precompliance Solutions from R&S



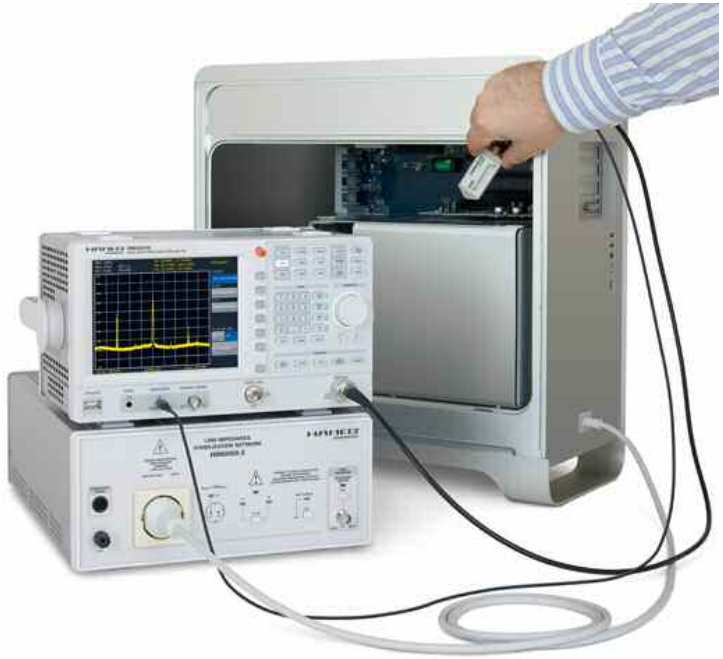
ESPI

FSV

ENV 216

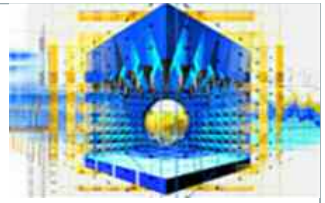
ESL / FSL

and Hameg...



HMS3000 + HM6050-2

EMI power testing overview



Devices under test: household equipment
partly Radio/TV equipment

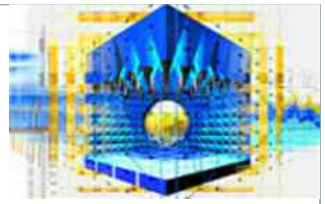
- **measurement of radiated EMI as a conducted signal using a current clamp + standardized load impedance**

- **frequency range: 30 MHz to 300 MHz (CISPR band C)**

- **main equipment: test receiver, MDS with special cable**

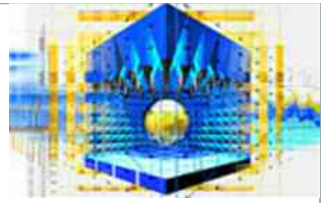
- **special correction factor handling**

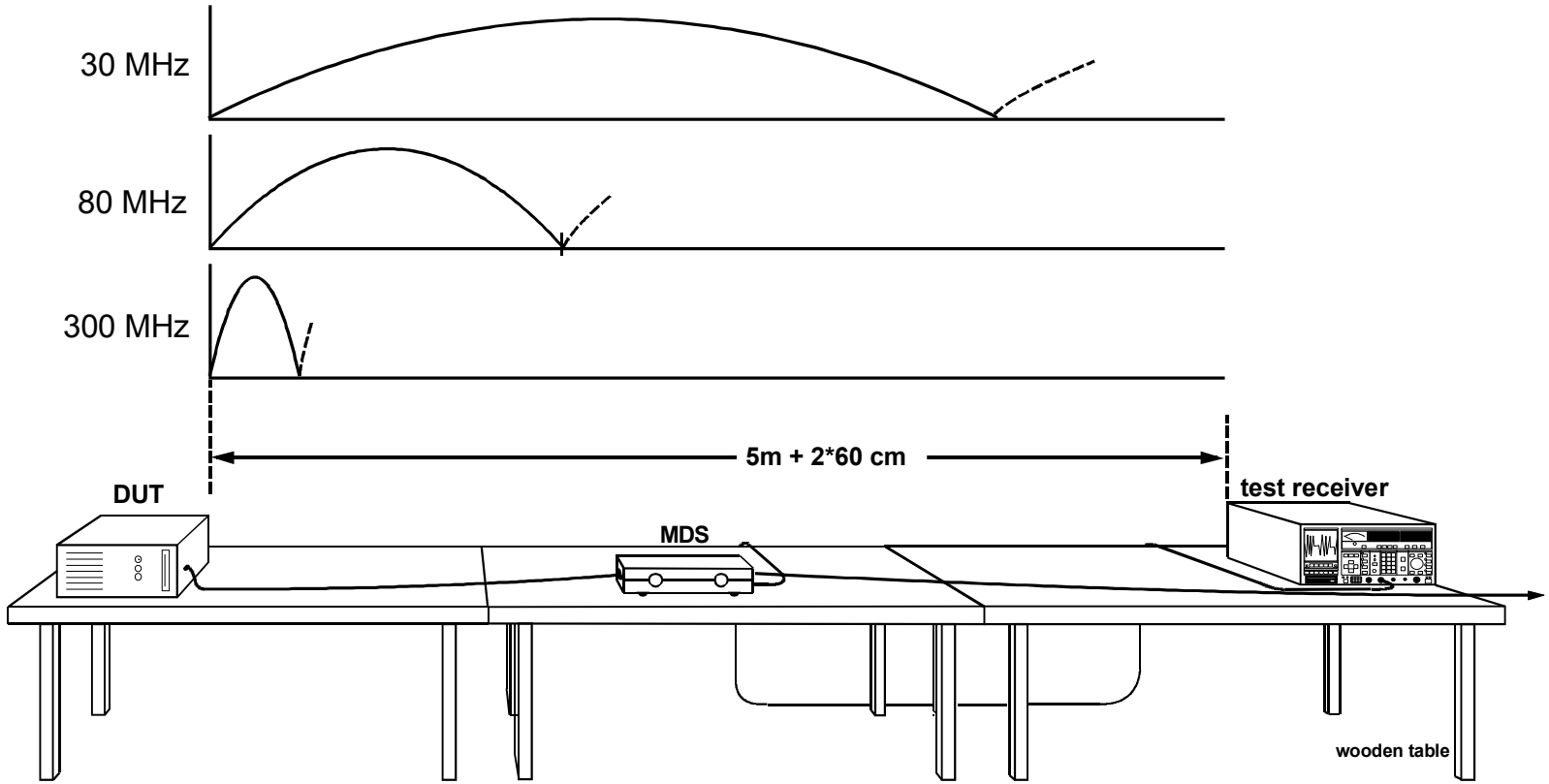
EMI power test: Testing parameters



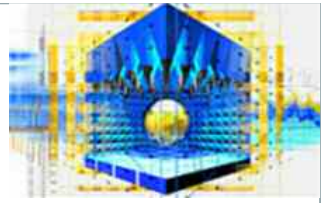
standards	**CISPR 13 (Radio & TV)**	**CISPR 14 (Household Equ.)**
DUTs	only associated equipment	
ports	all cables ≥ 25 cm	mains cables control cables ≥ 25 cm
transducer	MDS	MDS
frequency range	30 MHz ... 300 MHz (..1 GHz)	30 MHz ... 300 MHz
detector		Qp / Av
distance to metal parts	≥ 80 cm	≥ 40 cm
cable length	1 halfwave at 30 MHz + 2*0.6 m	1 halfwave at 30 MHz + 2*0.6 m
S/N to ambience	≥ 10 dB	≥ 20 dB
not measured cables	disconnected or with ferrites 90° angle to meas.cable	disconnected or with ferrites (90° angle to meas.cable)

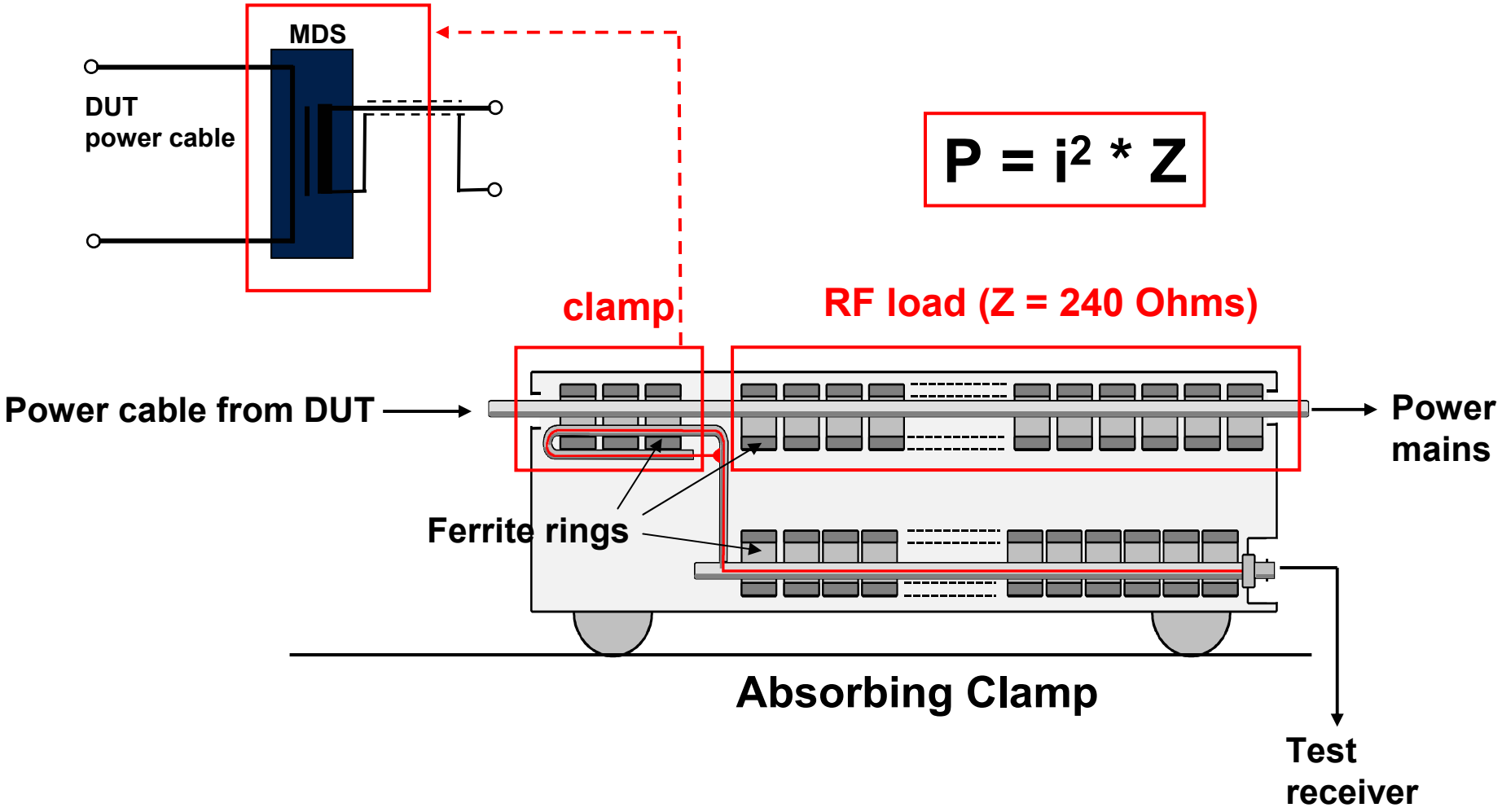
EMI power test: Test setup



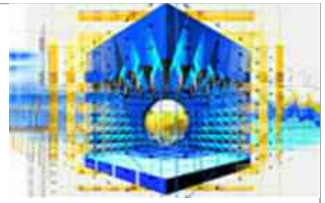


EMI power test: Absorbing Clamp MDS

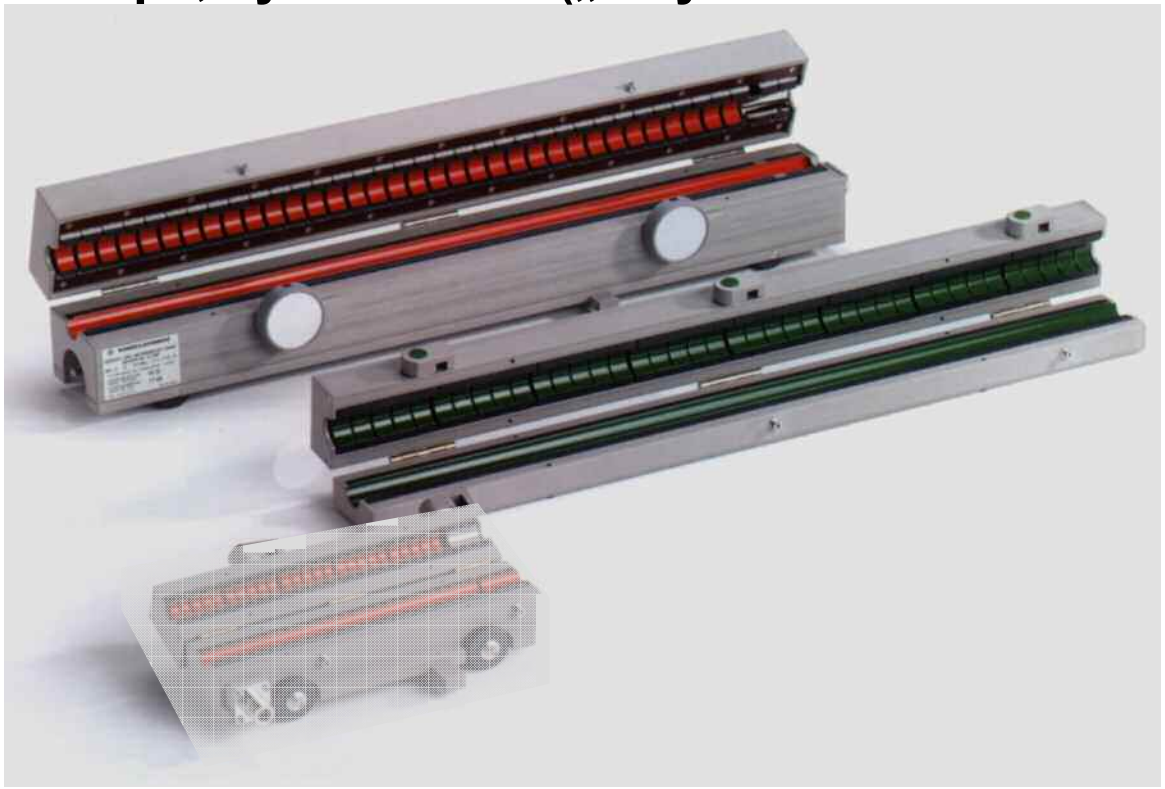




EMI power test: R&S accessories



clamps, system MDS („Meyer de Stadelhofen“)



MDS 21

EZ-24

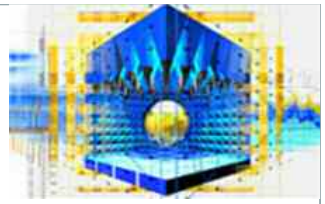
MDS 22

MDS 21 EMI power absorption clamp (30 to 1000 MHz)

EZ-24 additional absorber

MDS 22 EMI power absorption clamp (300 to 2500 MHz)

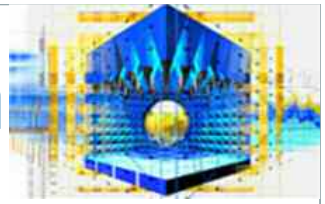
EMI fieldstrength (magnetic) overview

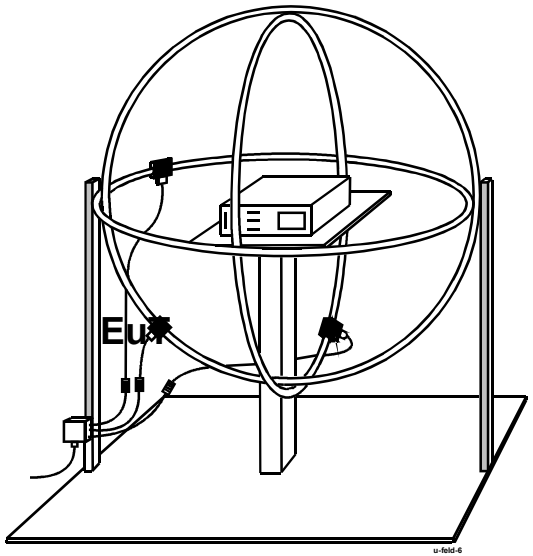


Devices under test: **Induction heating plates (ISM, CISPR 11)**
electric lighting (CISPR 15)

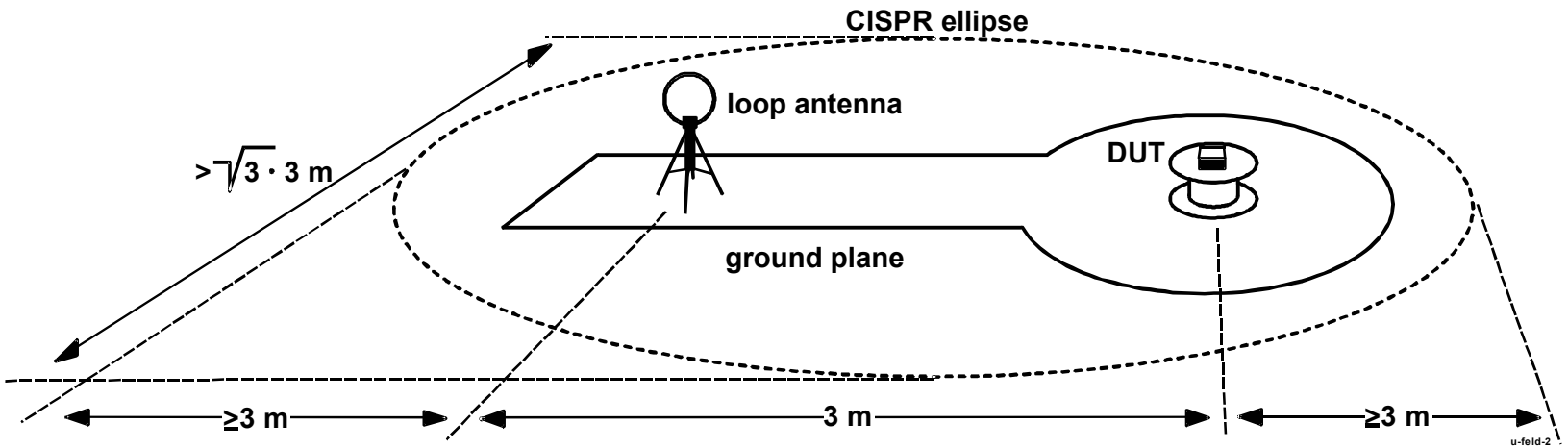
- **measurement of magnetic radiation using a loop antenna**
- **frequency range: 9kHz to 30 MHz (CISPR band A+B)**
- **main equipment: test receiver, loop antenna, triple-loop**
- **EuT and loop rotation for max. result**

EMI fieldstrength test: Magnetic fieldstrength

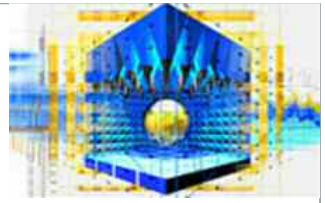




CISPR Tripple-loop antenna
H-field, 10 kHz to 30 MHz

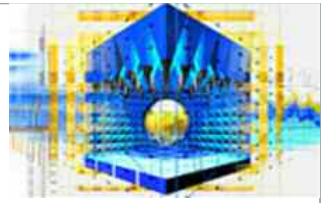


EMI fieldstrength test: Testing parameters

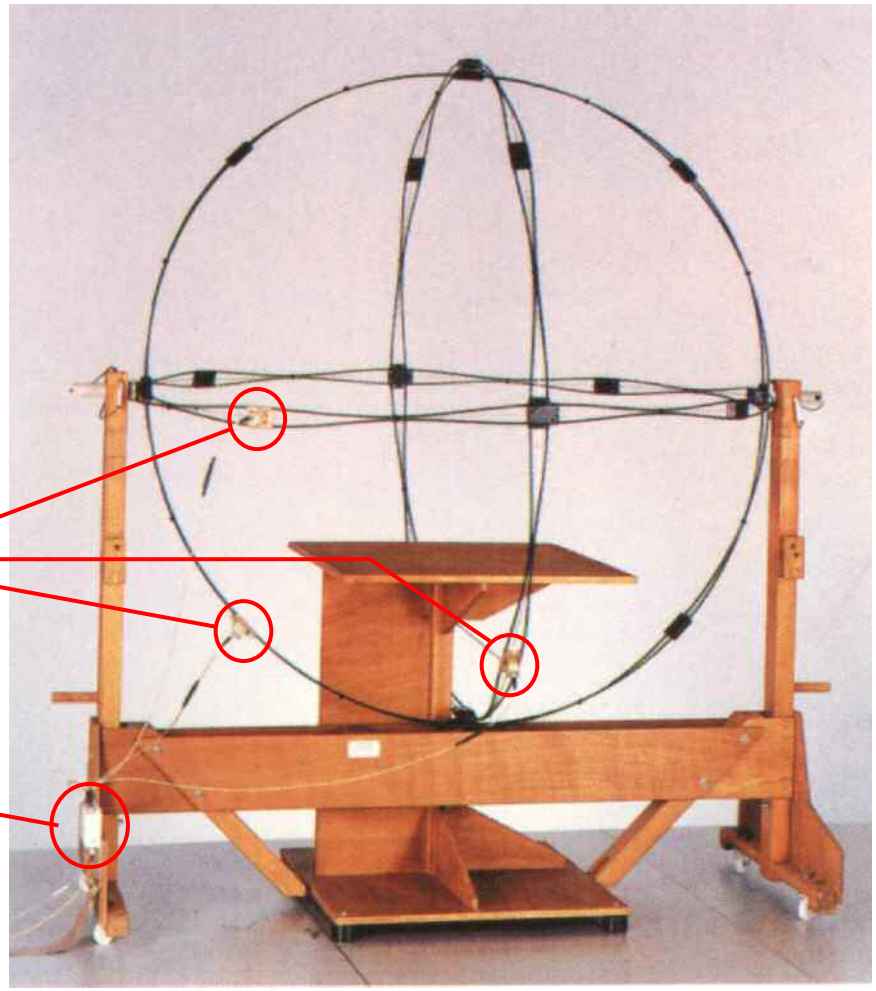


standard	**CISPR 11** (ISM)	**CISPR 15** (lamps)
magnetic field		
DUTs	induction heating plates Class 2 equipment	devices working above 100 Hz
transducer	triple loop / loop	triple loop
frequency range	9k ...(150k)... 30 M	9k ... 30 M
detector	Qp	Qp
S/N to ambience	6 dB	
test distance	3m / 10m / 30m	-
result unit	dBuV/m dBuA/m dBuA	dBuV/m dBuA/m dBuA

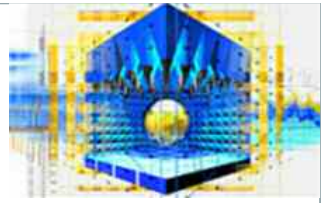
EMI fieldstrength test: HM 020 Triple-Loop ant.

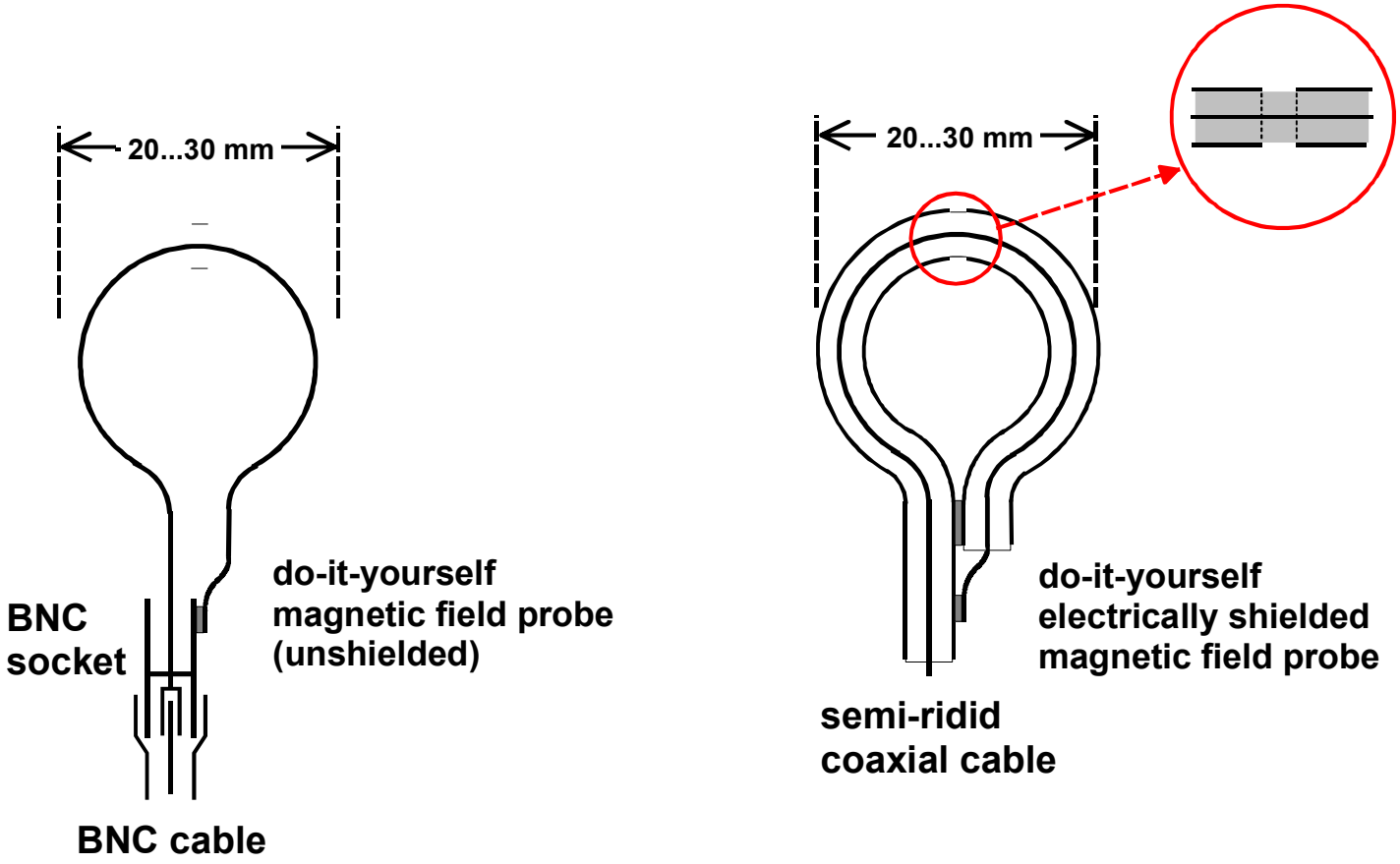


- results measured with tripple loop given in dBµA
- antenna current probes conversion factor = 1 V/A
  $\Rightarrow$ k-factor = 0 dB[1/ Ω].

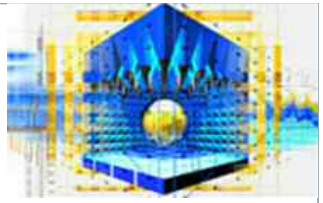


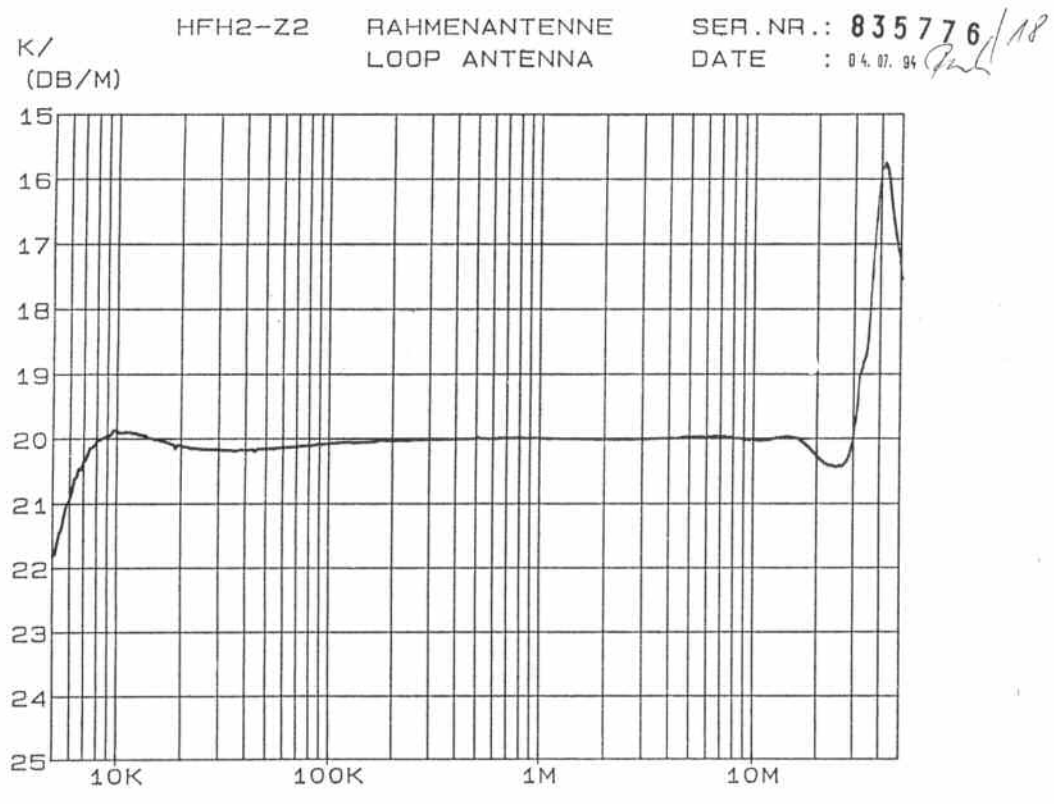
EMI fieldstrength test: Loop Antenna principle



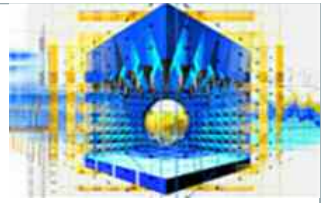


EMI fieldstrength test: HFH2-Z2 loop antenna





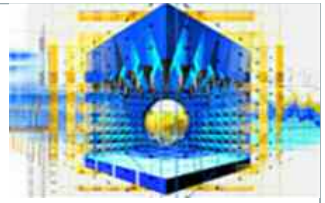
EMI fieldstrength (electric) overview

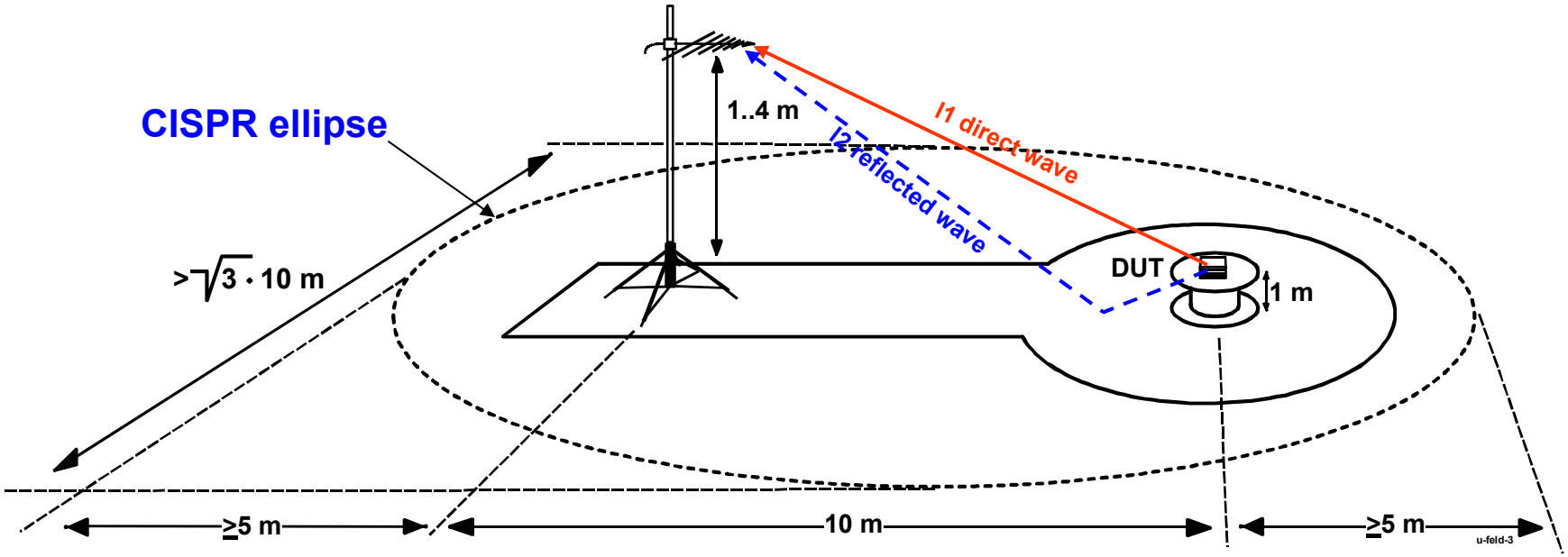


Devices under test: **ISM, ITE, partly radio/TV**
not household equ. (EMI power)

- **measurement of electric fieldstrength using linear antennas**
- **frequency range: 30 MHz to 1000 MHz (CISPR band C+D+E) and above**
- **main equipment: test receiver, linear broadband antennas**
- **special test site (OATS)**

Open Area Test Site for fieldstrength measurements (OATS)



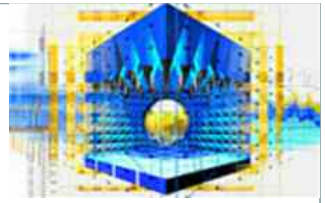


for φ (l2 – l1) = n • 180° with n = 1,3,5… ⇨ counter-phase superposition ⇒ extinction of fieldstrength

for φ (l2 – l1) = n • 180° with n = 2,4,6… ⇨ in-phase superposition ⇒ increase (≤ 6 dB)

Anechoic Chambers for fieldstrength measurements

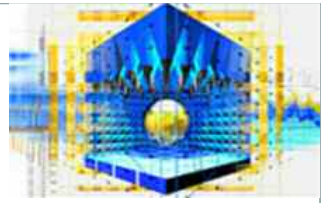
”Open Area Test Site” controlled environment



Edwards Air Force Base, Benefield Anechoic Facility facts:

- 76 x 80 x 21 meter Steel Plate Box
- 816,000 pyramidal foam cones
- Turntable diameter = 48 meter (handles weight >450 ton)
- RFI shielding >> 100 dB

Anechoic Chamber types (1)



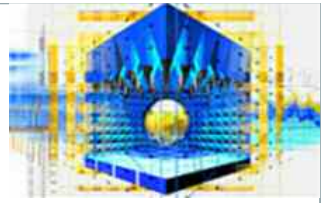
Semi Anechoic Chamber:

- Absorbers on walls and ceiling
- Metal plate floor

- Requires antenna tower mast to adjust antenna height

- For CISPR compliant measurements below 1 GHz

Anechoic Chamber types (2)



Full Anechoic Chamber:

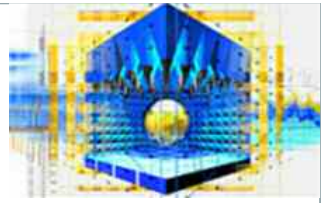
- Absorbers on ALL surfaces
- Required by EN 55022 / CISPR 22, starting October 2011 for frequencies > 1 GHz

Advantages over semi-anechoic chamber:

- ✓ The field uniformity (immunity) performance is more stable (better)
- ✓ There is only one chamber set up (no need to take ferrite tiles and pyramid in and out of the chamber for emissions/immunity changeover.
- ✓ The chamber is smaller
- ✓ Auto height scan mast & controller not required
- ✓ No dwell time for auto mast so much quicker test cycle time.

Electromagnetic Reverberation Chamber

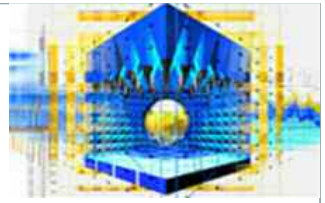
or Mode Stirred Chamber (MSC)



Reverberation Chamber:

- No absorbers on surfaces
- Mainly for Immunity testing
- The concept can be compared to a microwave oven,

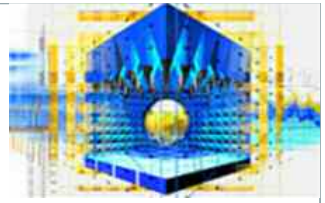
EMI fieldstrength test: Testing parameters



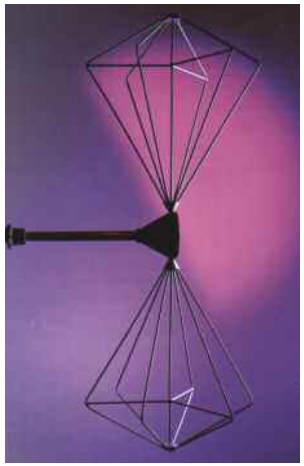
standard	CISPR 11	CISPR 13	CISPR 15	CISPR 22
Electric field < 1GHz				
DUTs			lamps with generators	
transducer	broadband aerials linear dipoles	broadband aerials linear dipoles	broadband aerials linear dipoles	bb aerials linear dipoles
frequency range	30M ... 1000M	80M ... 1000M	ISM frequencies	30M ... 1000M
detector	Qp	Qp	Qp	Qp
S/N to ambience	≥ 6 dB	≥ 10 dB		≥ 6 dB
test distance	10 m 3m (limit corr.) 30 m	3 m	10m	10m 3m (limit corr.)
result unit	dBuV/m	dBuV/m	dBuV/m	dBuV/m
testing parameters	azimuth height 1 - 4 m polarisation	azimuth height1-4m, 2-4m polarisation	azimuth height1-4m polarisation	azimuth height1-4m polarisation
special	test distance	algorithm	not well defined	test distance

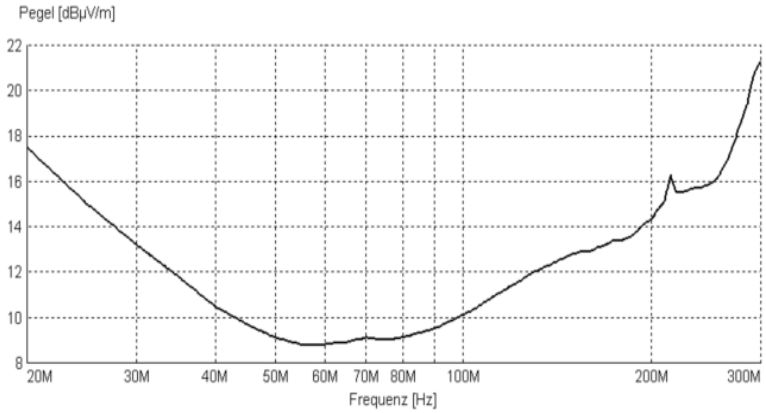
3 m test distance only with suitable antennas and relatively small EUTs!

EMI fieldstrength test: Electric Antennas



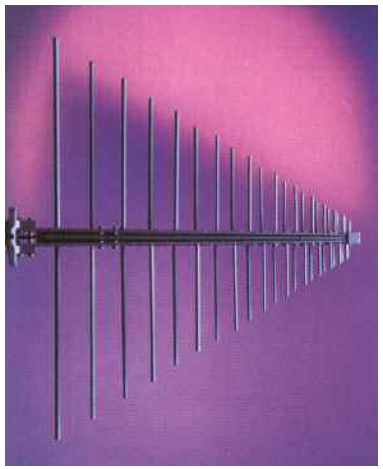
Biconicle Antenna HK 116

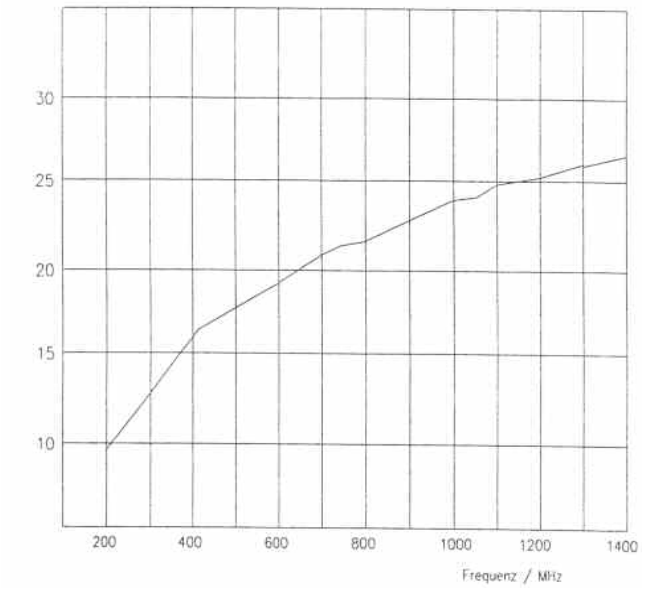




Frequency range
20 MHz to 300 MHz

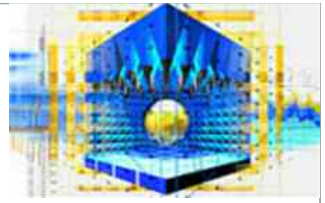
Log.-per. Antenna HL223





Frequency range
200 MHz to 1.4 GHz

EMI fieldstrength test: Electric Antennas

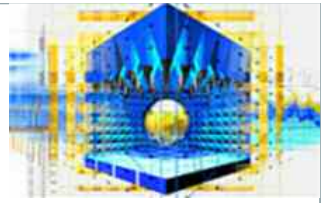


Ultralog Antenna HL 562

- frequency range 30 MHz to 3 GHz

- limited sensitivity close to 30 MHz

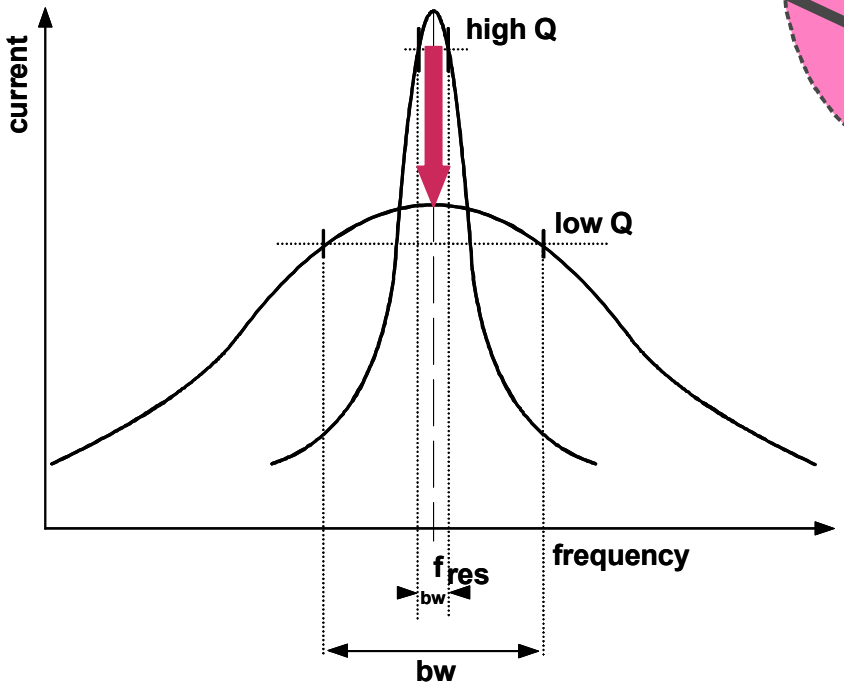
EMI fieldstrength test: Broadband Antennas



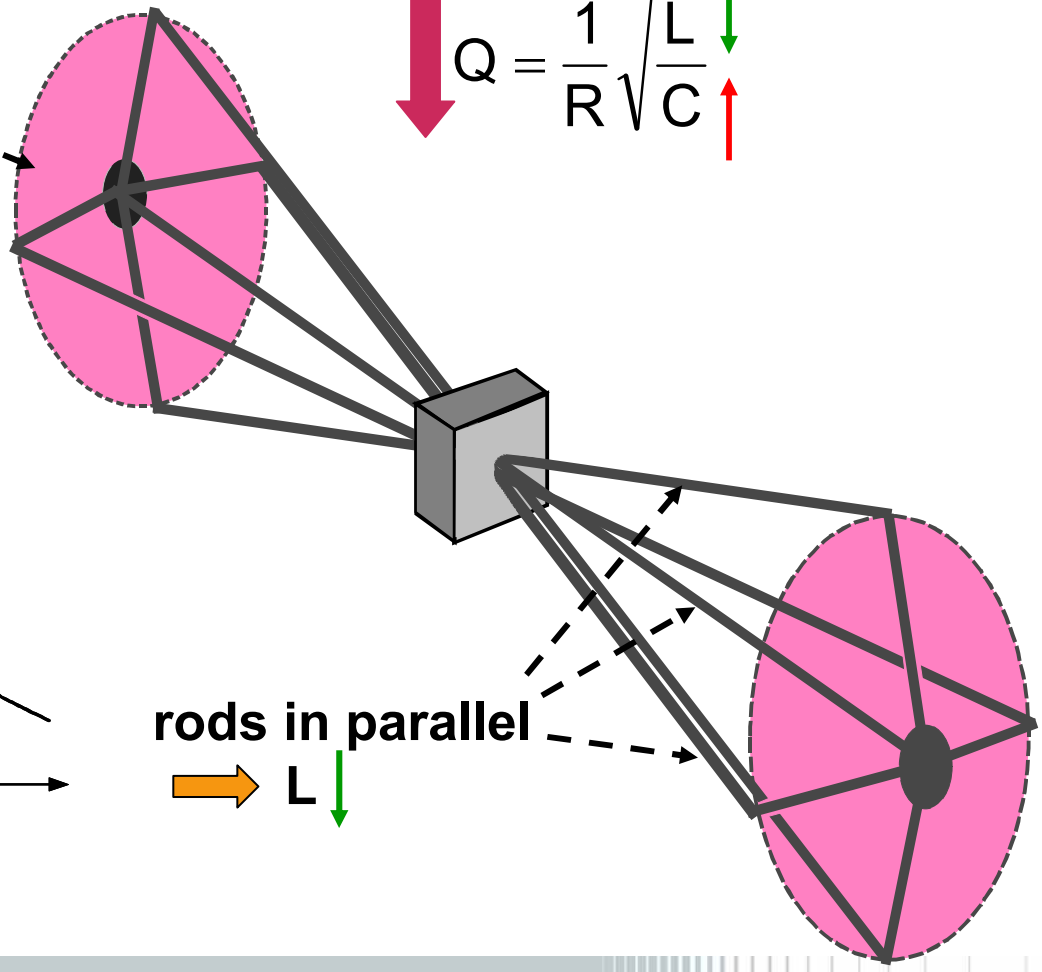
Biconicle antenna:
Increasing the bandwidth by reduction of Q-factor

capacitive area
C

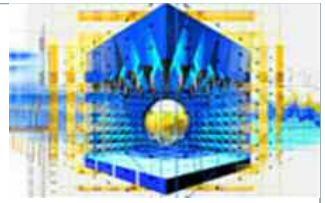
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$



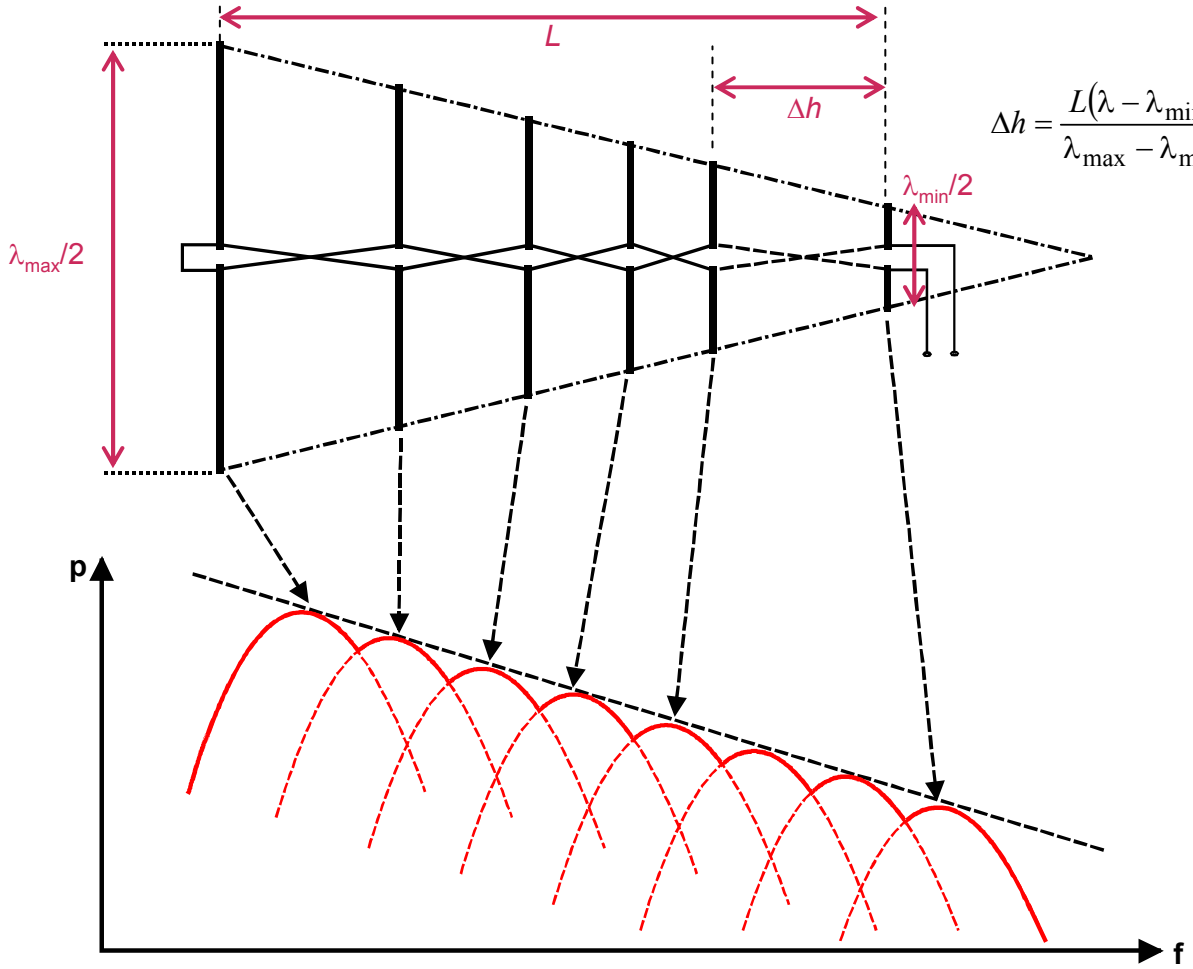
rods in parallel
L



EMI fieldstrength test: Broadband Antennas (2)

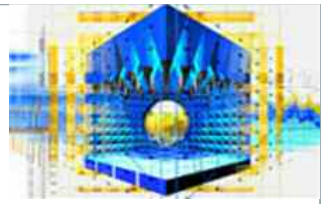


principle of
logarithmic-periodic broadband antenna



$$\Delta h = \frac{L(\lambda - \lambda_{min})}{\lambda_{max} - \lambda_{min}} = \frac{L\left(\frac{1}{f} - \frac{1}{f_{max}}\right)}{\frac{1}{f_{min}} - \frac{1}{f_{max}}}$$

EMI fieldstrength test: Diagnostic testing with probes



HZ-11 E and H near-field probes
with pre-amplifier
for **qualitative** measurements

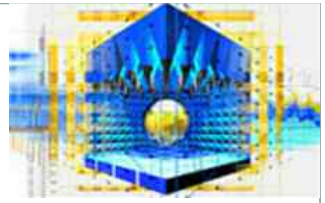
frequency range 100 kHz to 2 GHz

HZ-14 E and H near-field probes
with pre-amplifier
for **quantitative** measurements

frequency range 9 kHz to 1 GHz
„calibration adapter“ to check function

Gigahertz Transverse ElectroMagnetic Cell

or GTEM cell

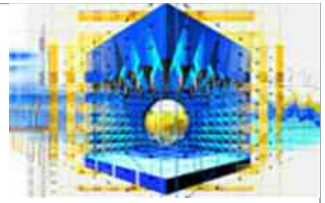


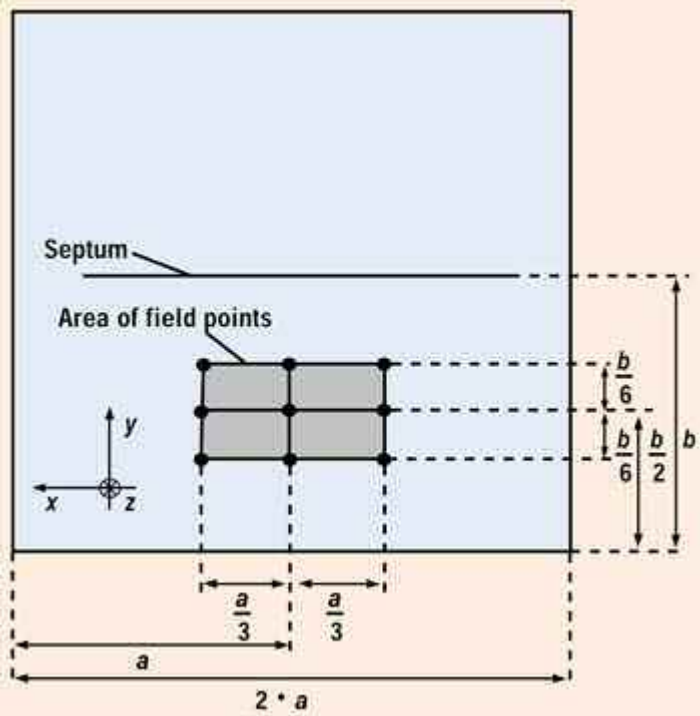
GTEM Cell:

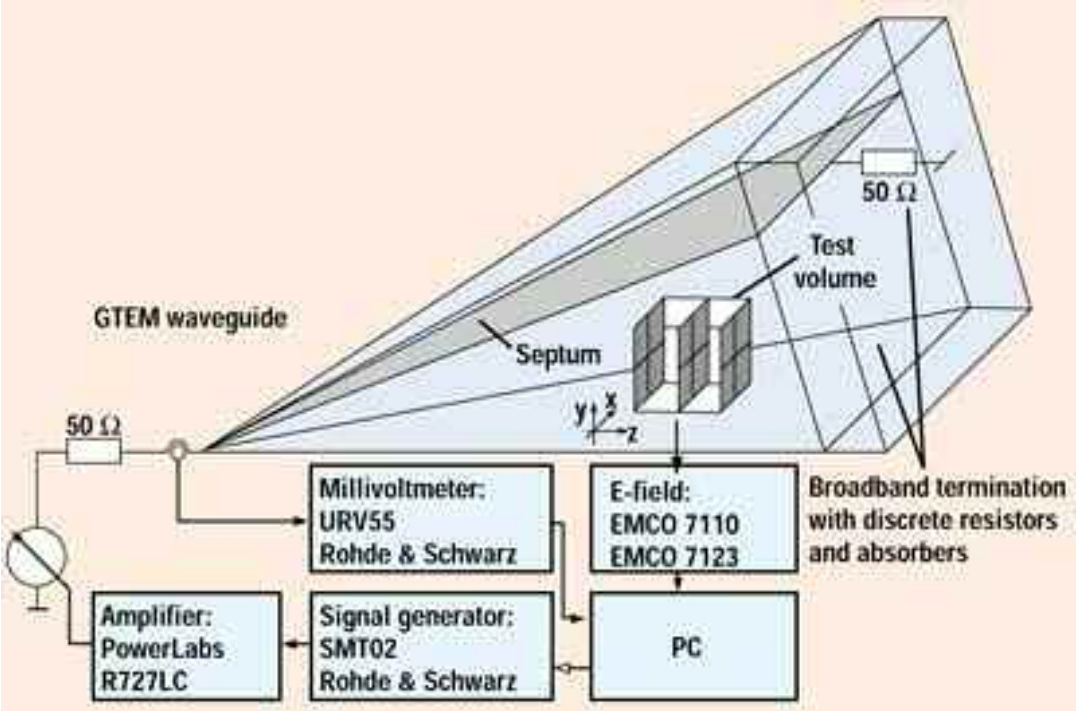
- Suitable for smaller devices
- For both Emission & Immunity measurements
- DC to 20 GHz
- Available in different sizes, 1,2 to about 10 meter length
- Cost-effective solution when compared to Anechoic chambers

Gigahertz Transverse ElectroMagnetic Cell

GTEM principle







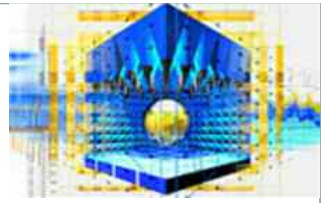
The GTEM cell is, in principle, a tapered coaxial line (offset septum plate), from a coaxial feeding point, having an air dielectric and a characteristic impedance of Z = 50 Ω.

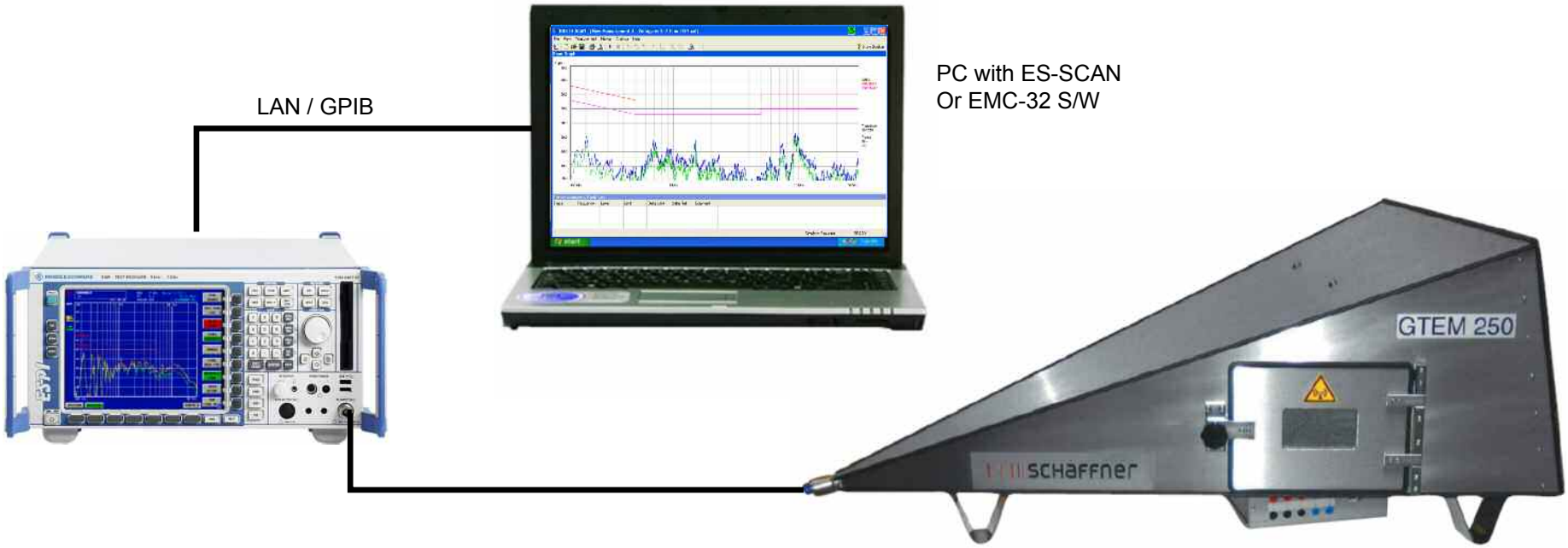
This coaxial line is terminated by a combination of discrete resistors and RF absorbers to achieve a broadband match.

The outer conductor of this “coax line” is created by the metal walls of the cell which provide screening for both internal and external electromagnetic fields.

Gigahertz Transverse ElectroMagnetic Cell

Typical Emission setup

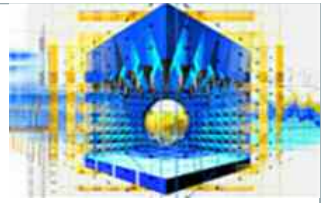




- The EUT is measured in the directions x, y and z in a GTEM cell.
- The respective results are referred to as Vx, Vy and Vz.
- Then a correlation algorithm is used to compare the data with the measured electrical field of an open-area test site (OATS).
- Based on Vx, Vy and Vz the interfering power of the test item is calculated depending on the GTEM dimensions.

EMI fieldstrength: Precompliance Solutions

From Rohde & Schwarz and Hameg



ESPI

FSV

HMS3000

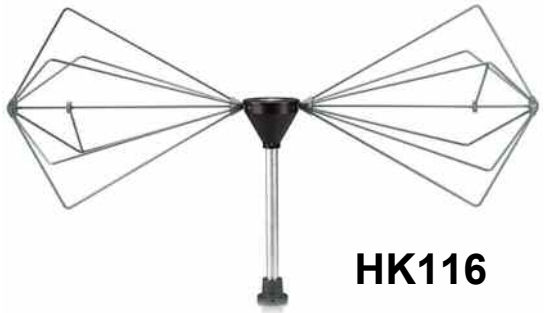
ESL / FSL

HM020

HL562

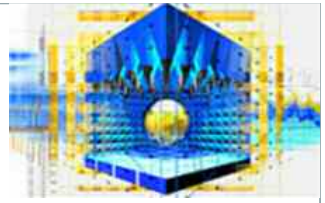
HZ11

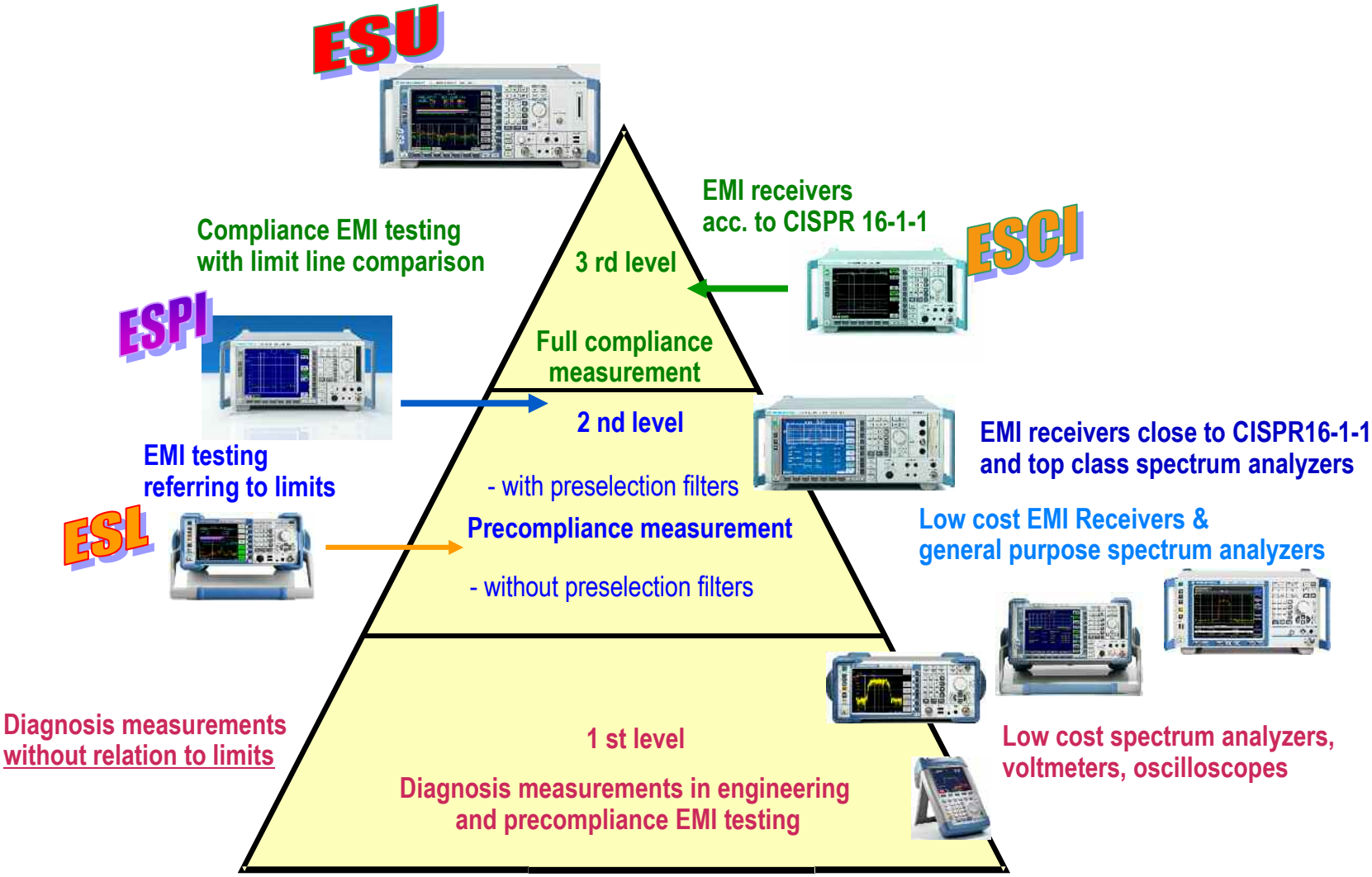
HL223



HK116

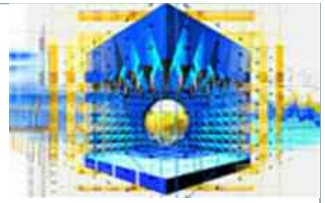
R&S EMI receiver performance pyramid





EMI precompliance testing

Spectrum Analyzer overview



R&S FSV 3/7/13/30/40

R&S FSP 3/7/13/30/40

R&S FSL 3/6/18

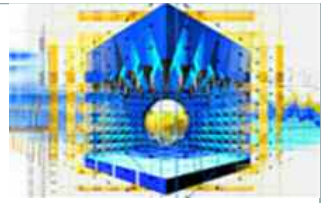
R&S FSH 4/8/18

Hameg HMS 3000/3010

Performance

EMI precompliance testing

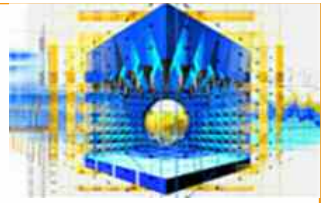
EMI Test Receiver overview



R&S ESPI 3/7

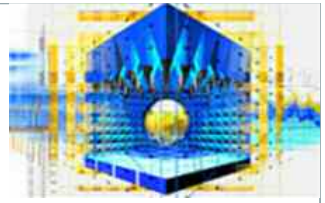
R&S ESL 3/6

Performance



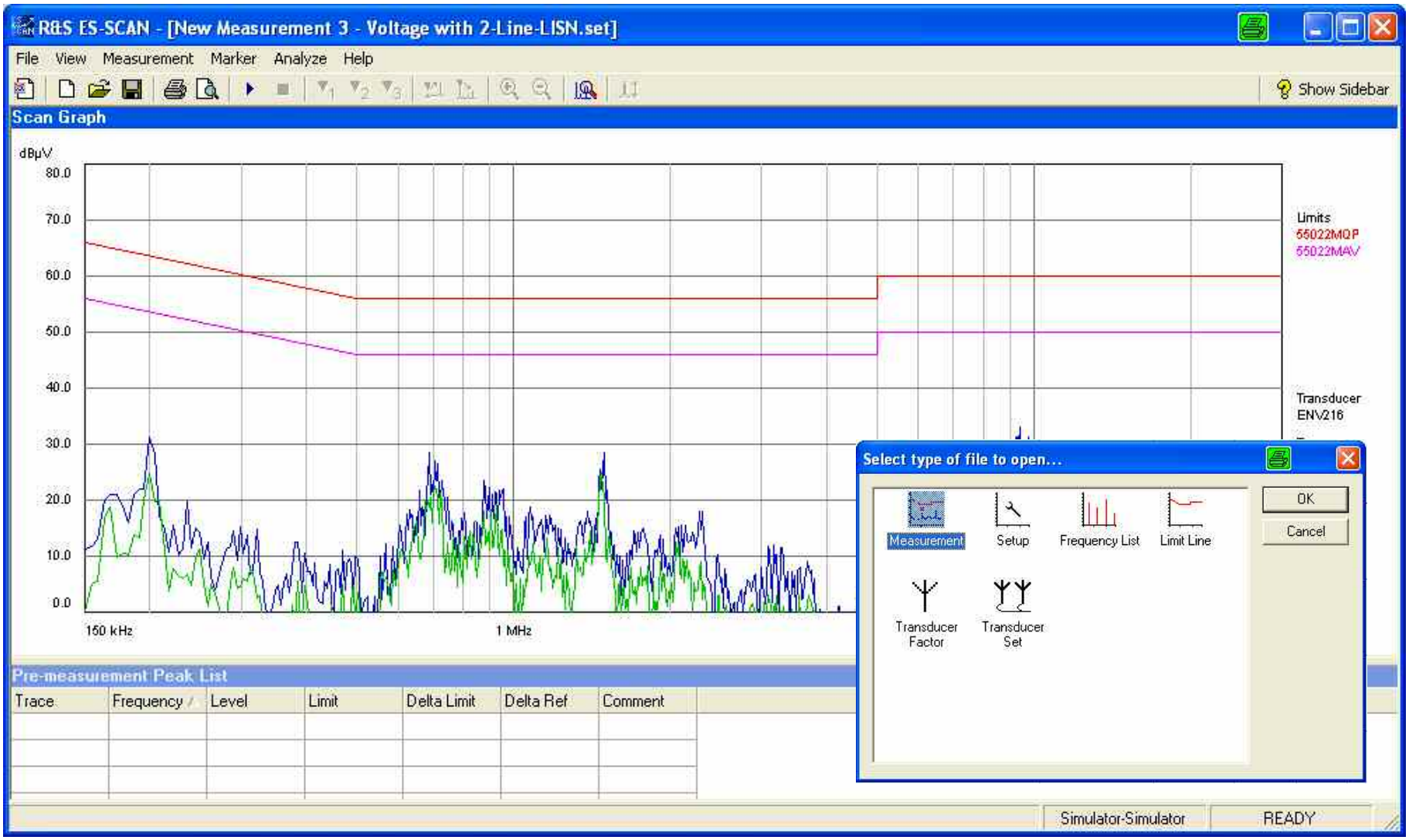
EMI Precompliance Software
R&S ES-SCAN

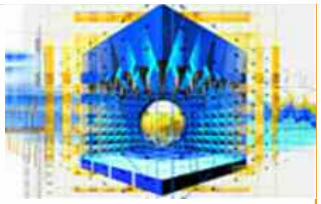
R&S ES-Scan at a glance



- Cost effective 32-bit application for EMI precompliance testing to commercial standards
- Specially designed for development-accompanying and pre-certification EMI testing
- Modern MS Windows look & feel for high user friendliness
- Supports remote control via GPIB and LAN
- Remote control of LISNs (via test receiver user port); no turntable/antenna mast control
- Works with the R&S ESPI, R&S ESCI and R&S ESL EMI receivers and the R&S FSL, R&S FSV and R&S FSP spectrum analyzers. The R&S ZVL Network Analyzer with K1 (Spectrum Analyzer option) can be used as well.
- Hardlock copy protected (iKey)

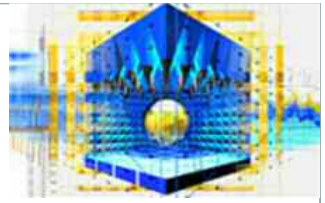
R&S ES-Scan: Graphical example





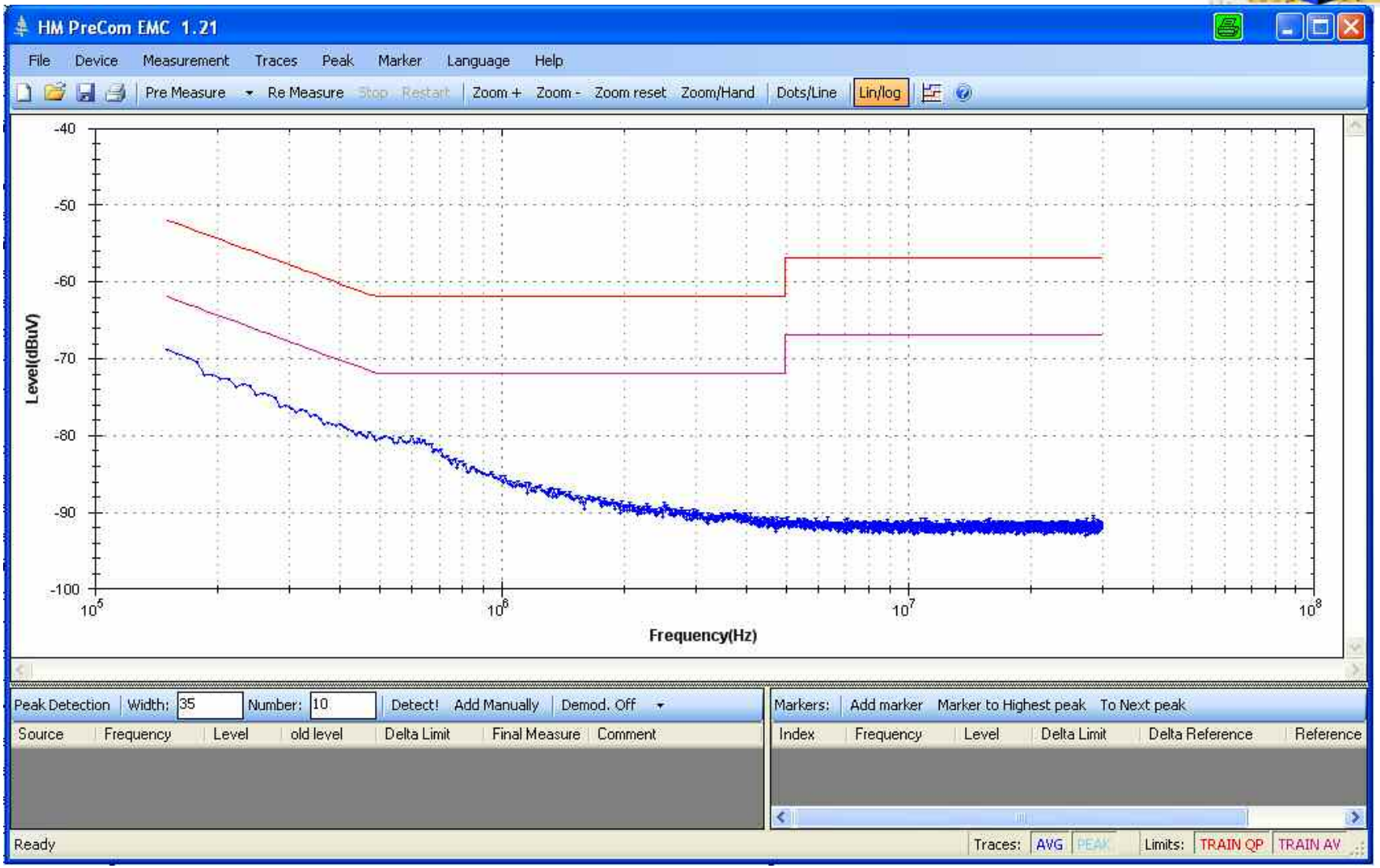
EMI Precompliance Software Hameg HM PreCom EMC

Hameg HM PreCom EMC at a glance



- Simple, cost effective solution for EMI precompliance testing to commercial standards.
- Designed for development-accompanying and pre-certification EMI testing
- Modern MS Windows application
- Supports remote control via USB and LAN
- Works with the Hameg HMS1000/1010 and Hameg HMS3000/3010 spectrum analyzers.
- Can be downloaded and used free of charge from www.hameg.com

Hameg PreCom: Graphical example



Thank you for your attention.

Please ask your questions.

Inspirationsseminar Glostrup, Sønderborg & Aalborg

Signal Integrity – Time Domain – Capture the Unseen

Rohde & Schwarz Glostrup

Tirsdag den 3. maj kl. 9 – 13.00
Rohde & Schwarz, Ejby Industrivej 40,
2600 Glostrup

Syddansk Universitet Sønderborg

Onsdag den 4. maj kl. 9 – 13.00
Syddansk Universitet, Alsion 2,
6400 Sønderborg

Rohde & Schwarz Aalborg

Torsdag den 5. maj kl. 9 – 13.00
Rohde & Schwarz, Gasværksvej 26,
9000 Aalborg

Seminaret henvender sig specifikt til personer, som beskæftiger sig med elektronikudvikling inden for signal analyse, fejlfinding og afprøvning.

Undervisningsformen er et miks af teoretisk og praktisk gennemgang af tidsdomæne-udstyr såsom digitale oscilloskoper og realtids-analyseudstyr.

Præsentationen vil berøre følgende emner:

- Introduktion til signal integritet og fundamentale elementer i transmissionsliniers adfærd i moderne elektronik
- Timings problematikker og "usynlige signalfejl"
- Begrebet "blind time" og detektering af "glitches"
- Probe / Interface udfordringer – hvilken probe skal jeg bruge?
- Præsentation af næste generations oscilloskoper og realtidsanalysatorer
- Indsigt i FFT baserede analyseværktøjer
- Praktiske måleeksempler

Vi afrunder dagen med en let frokost.

Kontakt evt. salgsafdelingen på tel. 4343 6699 for yderligere information.