EMC

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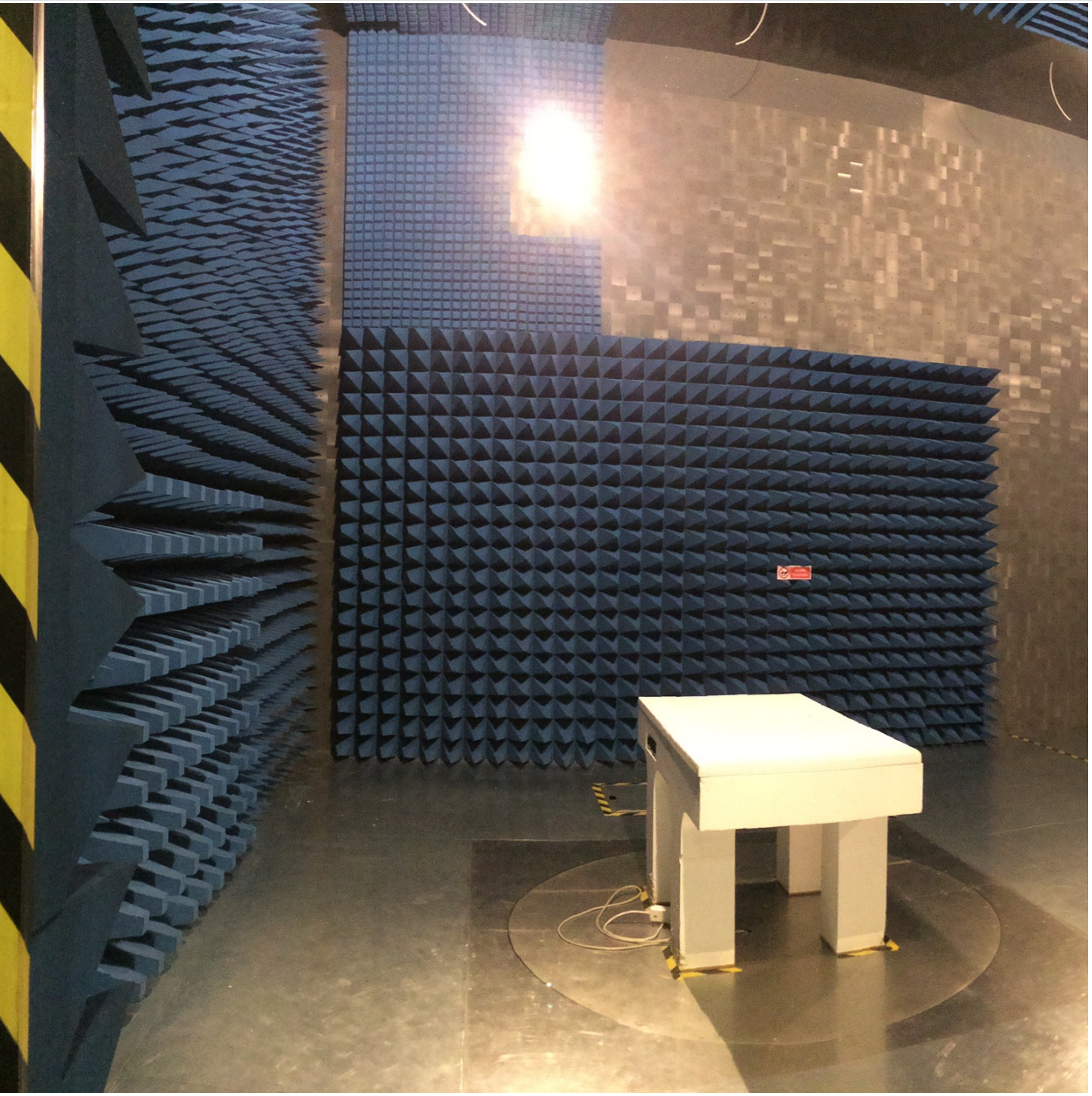
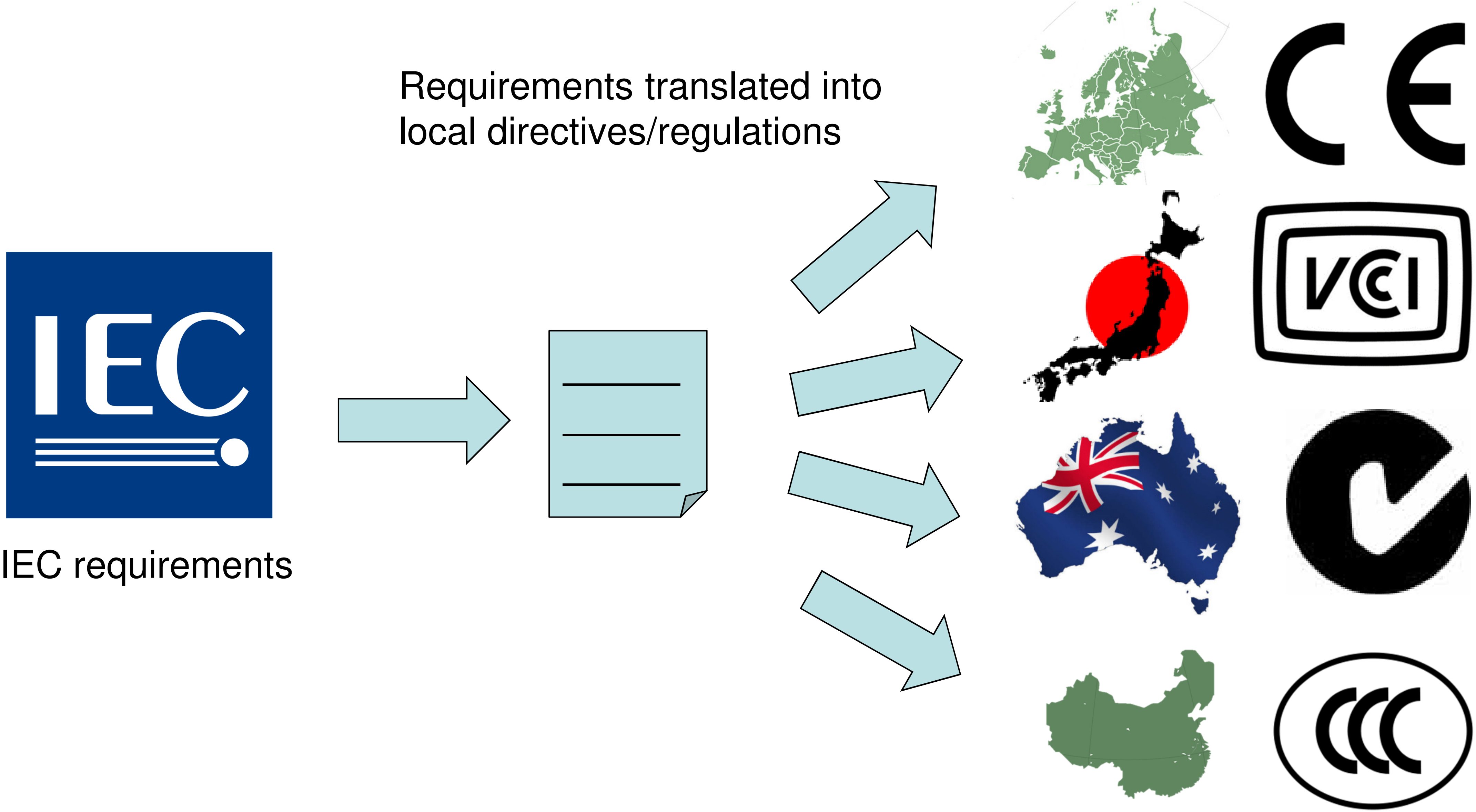
Würth Elektronik eiSos France



EMC

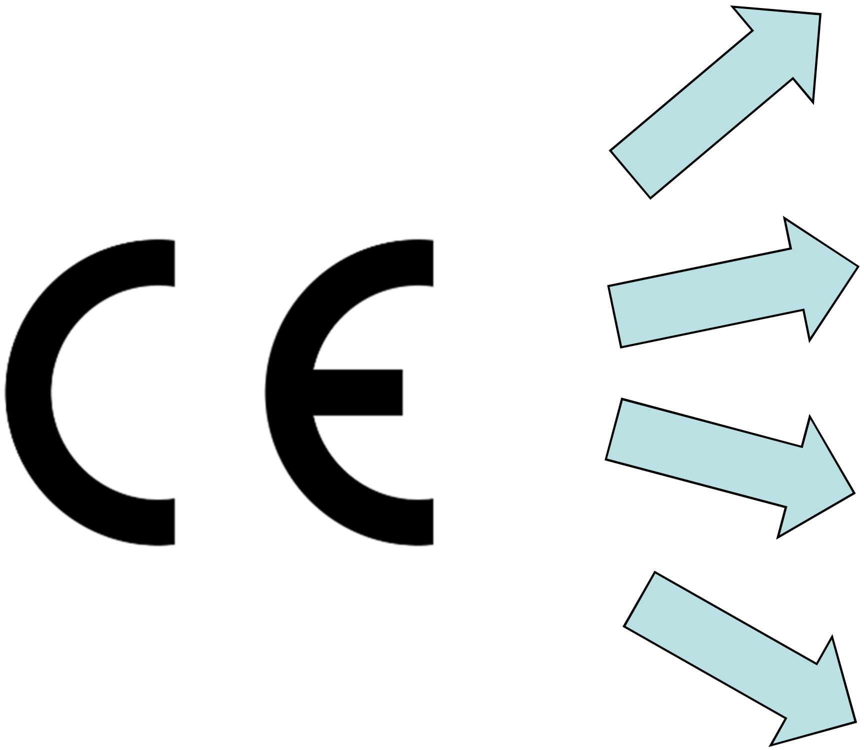
What is the meaning of EMC ?

Enabling global trade of electronic products



Enabling global trade of electronic products

Implies to follow
applicable directives



ElectroMagnetic Compatibility
2004/018/CE

ATEX 94/9/CE Explosive
Atmosphere

Elevator 1995/16/CE

Pyrothechnical article
2007/023/CE

…

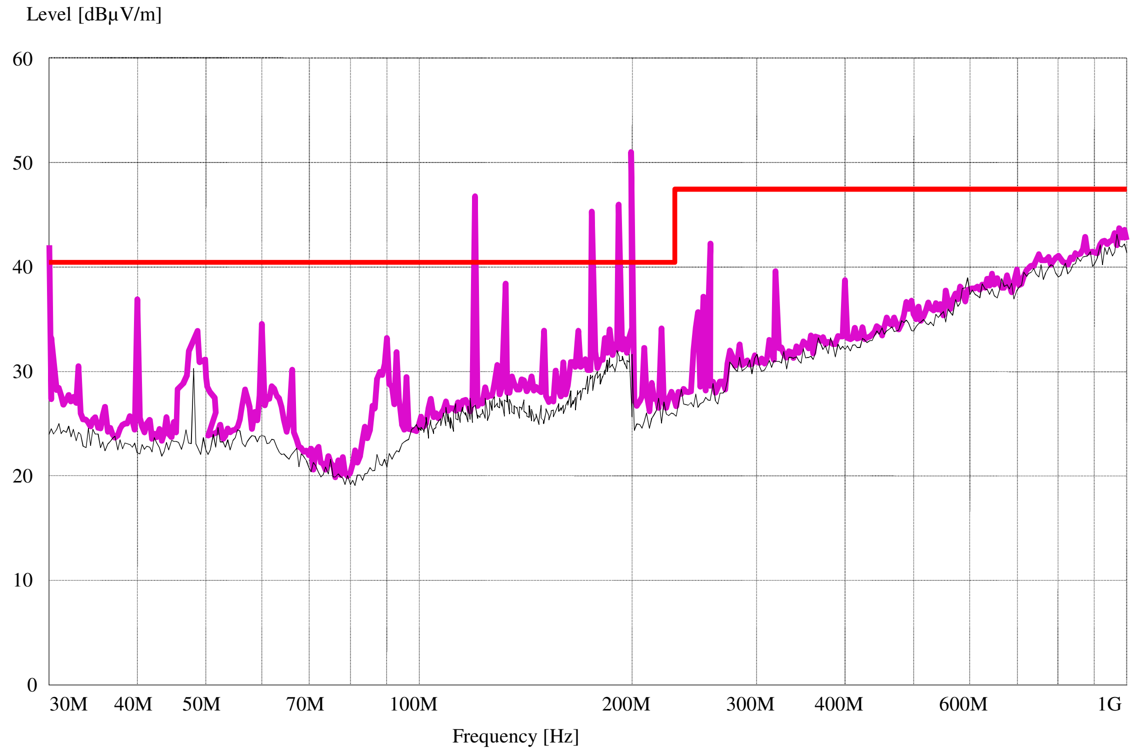
EMI vs EMC

Electromagnetic Interference vs.
Electromagnetic Compatibility

VS

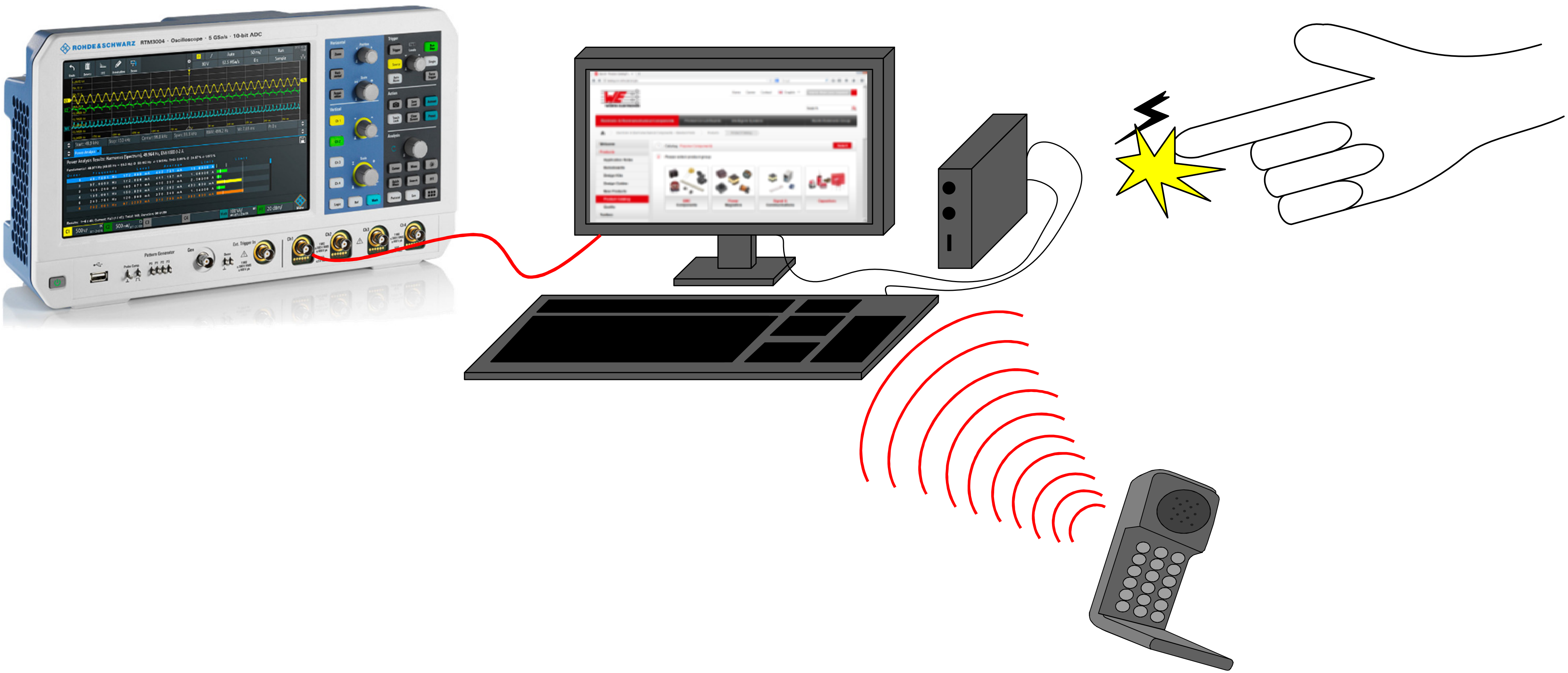
How is EMC defined?

EMISSIONS - the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended

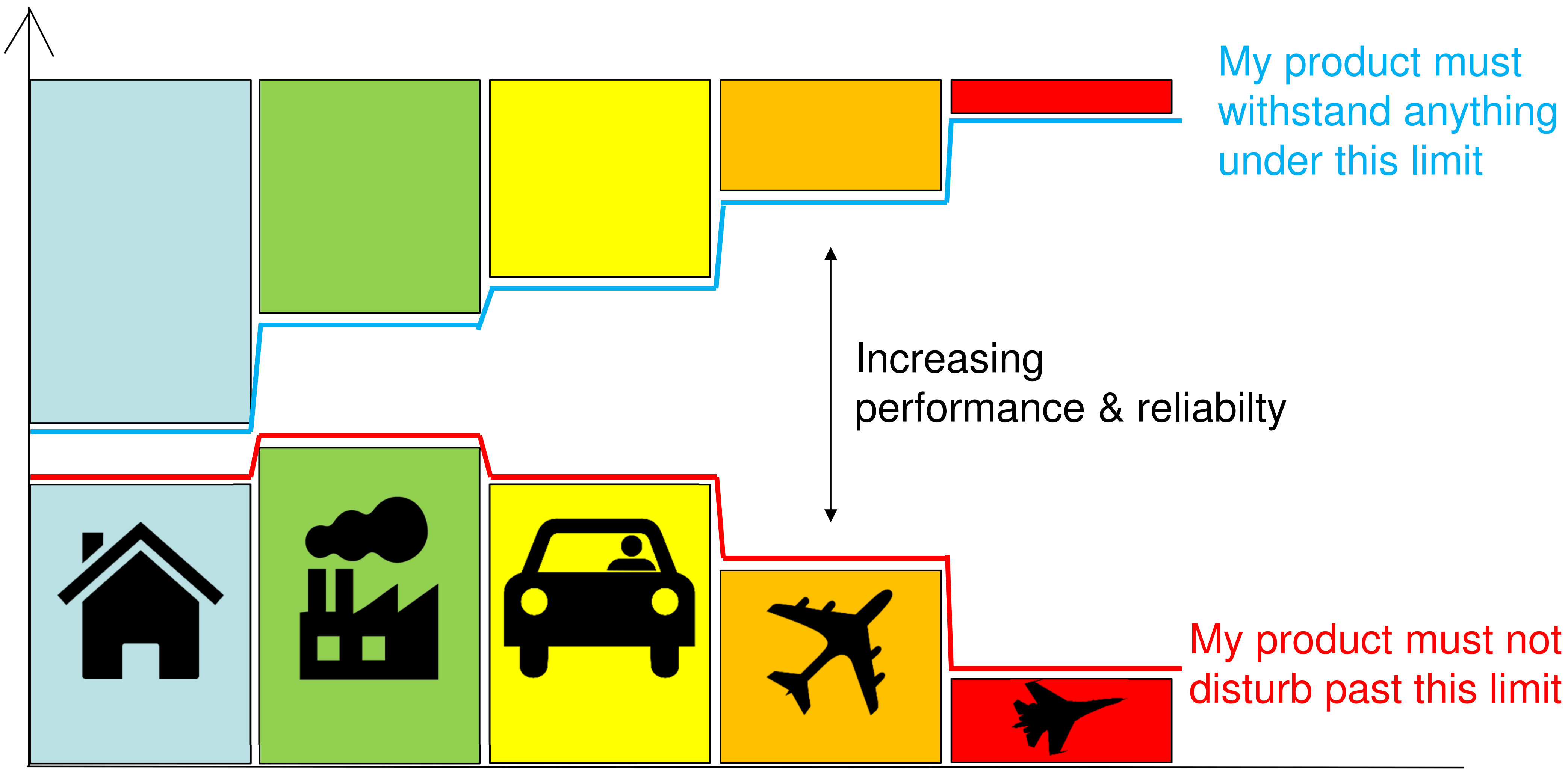


How is EMC defined?

IMMUNITY- it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.



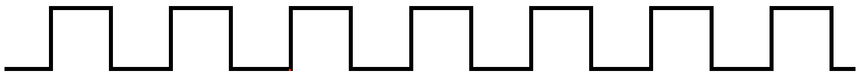
Emission - Immunity « gap »



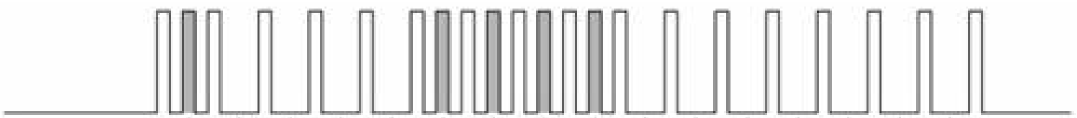
What causes EMI in a product?

- **Clock frequencies.** E.g Crystal 25MHz, CPU 2.6GHz

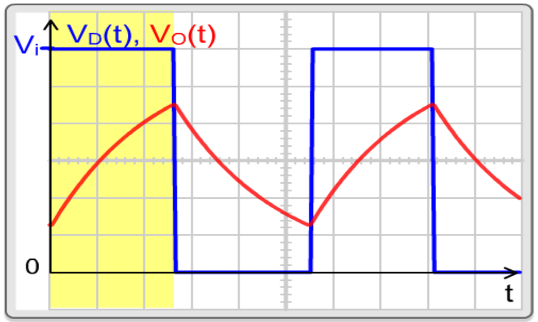
CLK

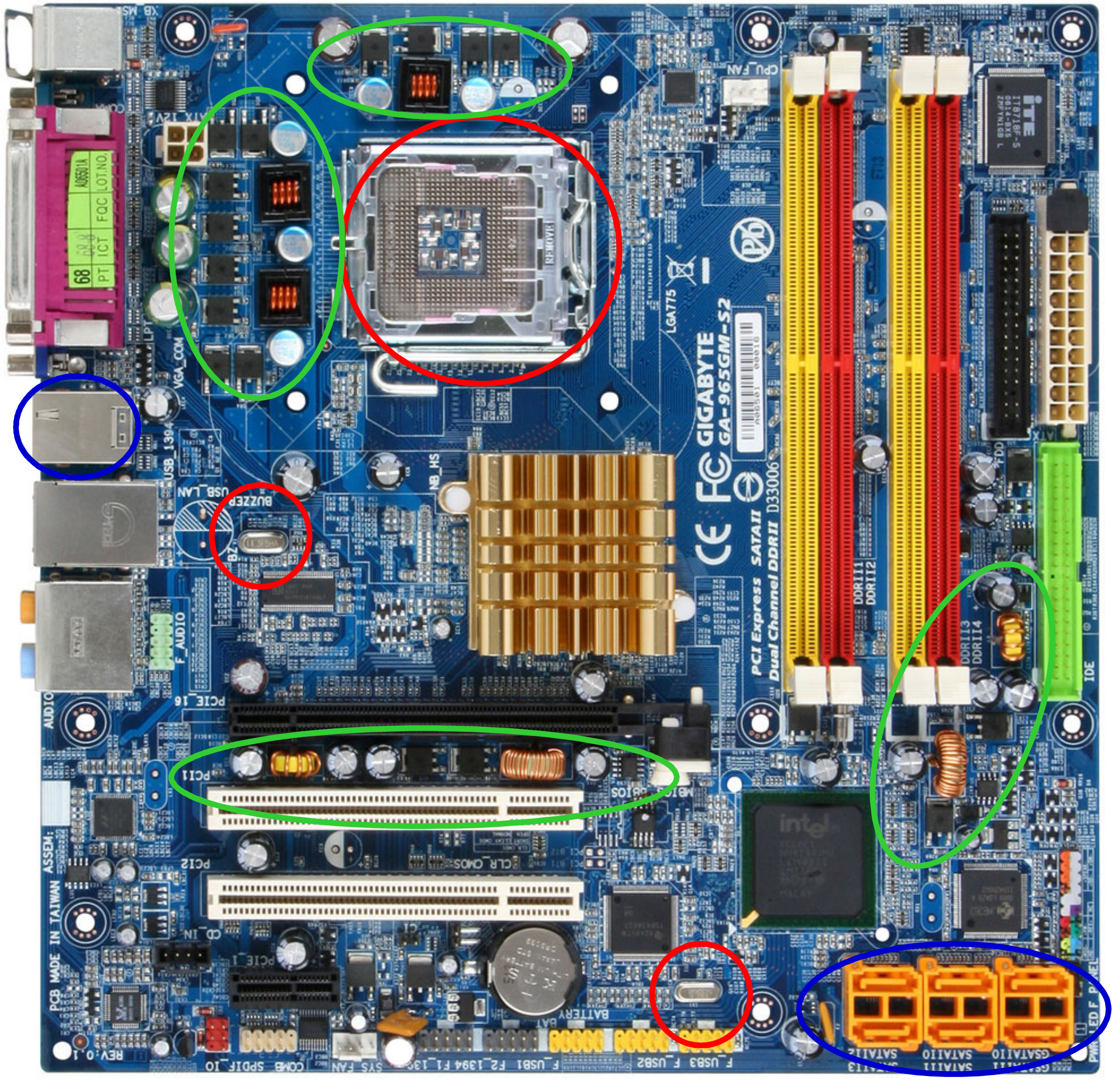


- **Data rates.** E.g USB 2.0 480Mbps, SATA II 300Mbps



- **DC/DC convertors** and Switch mode power supplies (**SMPS**) E.g 135kHz, 2MHz





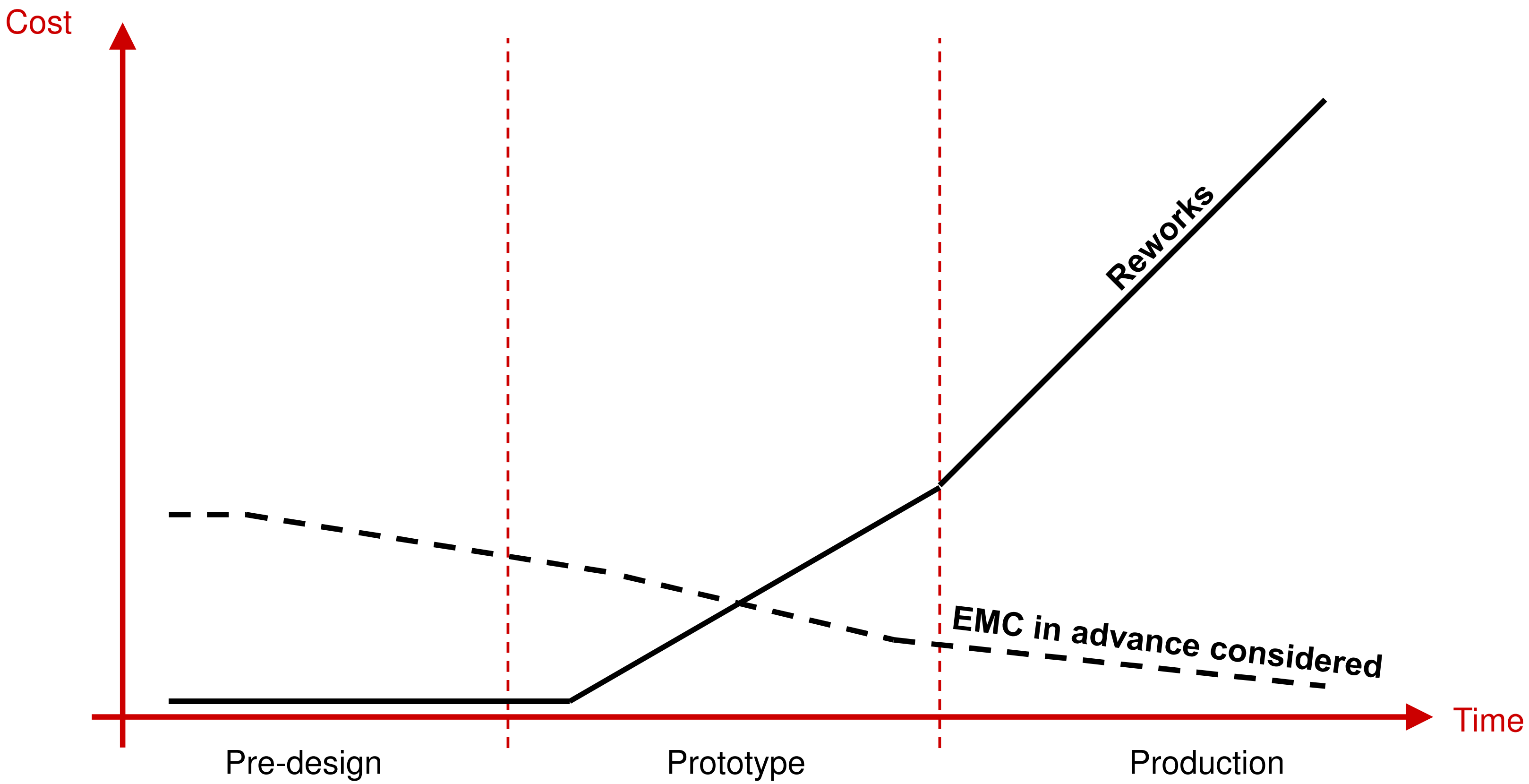
EMC Standards and tests are seen by developpers as

HUGE PROBLEMS

EMC Effect

Economical point of view:

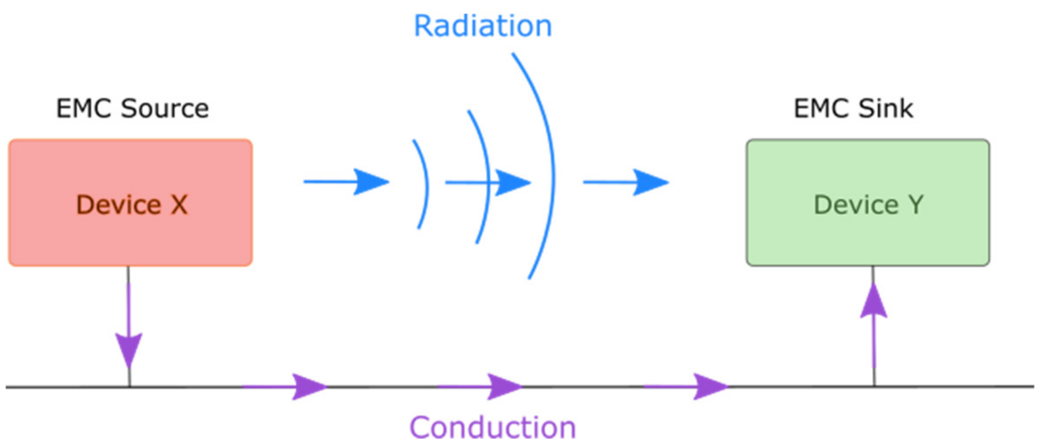
- dependent on when EMC conformity is considered in a design phase



EMC is required to sell products -> ok!

I will face EMI and I need to make my device compatible…
But practically, what are EMI ???

What are EMI ?



Radiative coupling

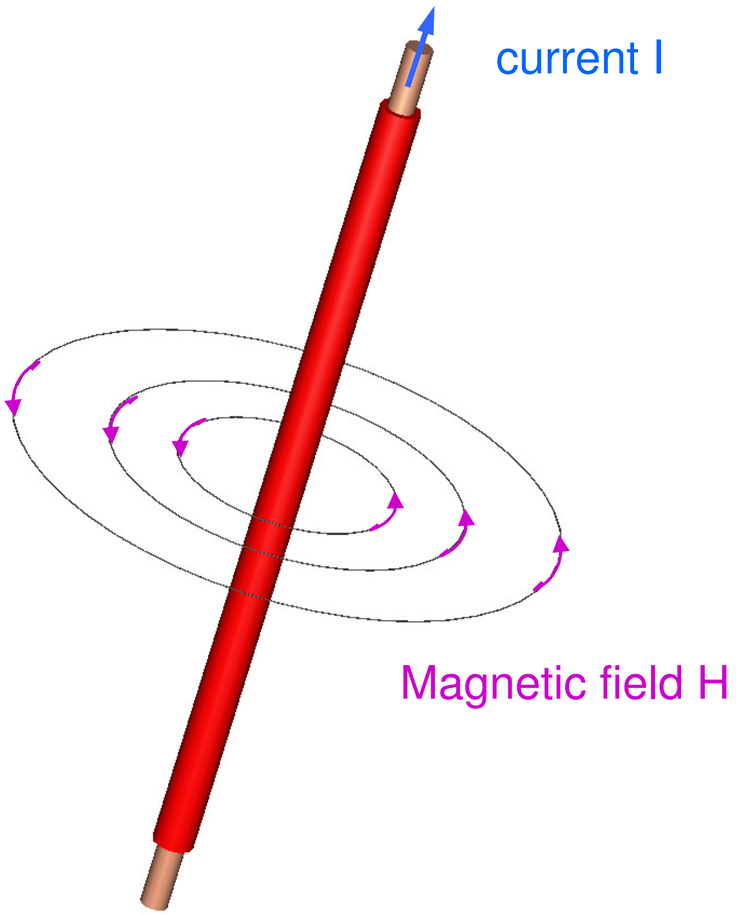
- Through the air
- Electrical field, Magnetic field, Electromagnetic field, …

Conductive coupling

- Through any conductive wires
- Common impedance, Capacitive or Inductive coupling, …

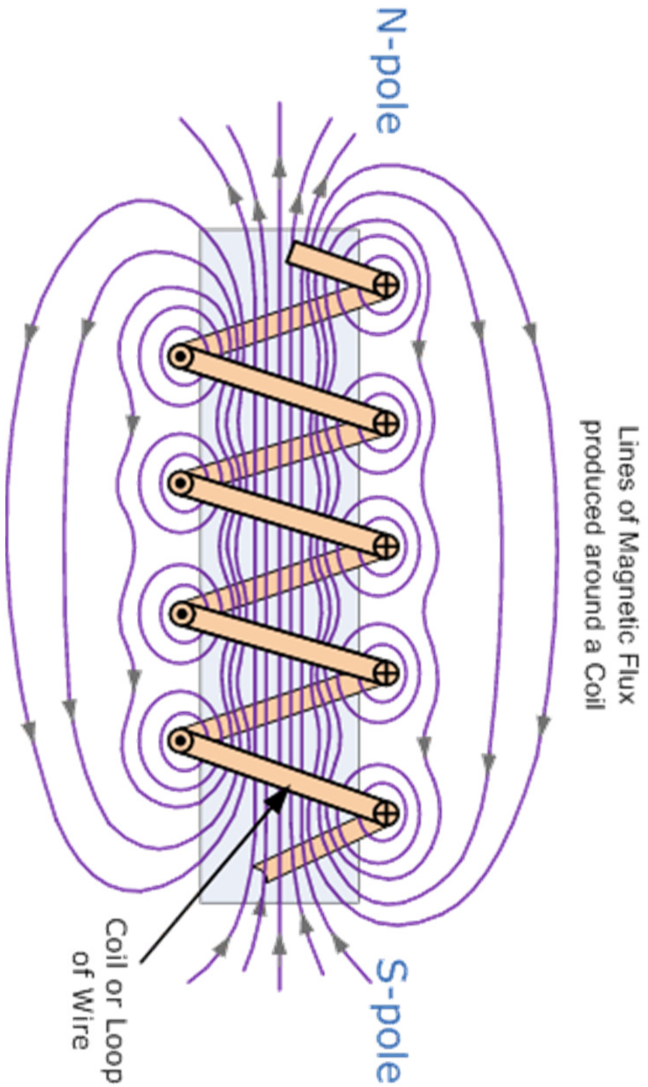
The magnetic field

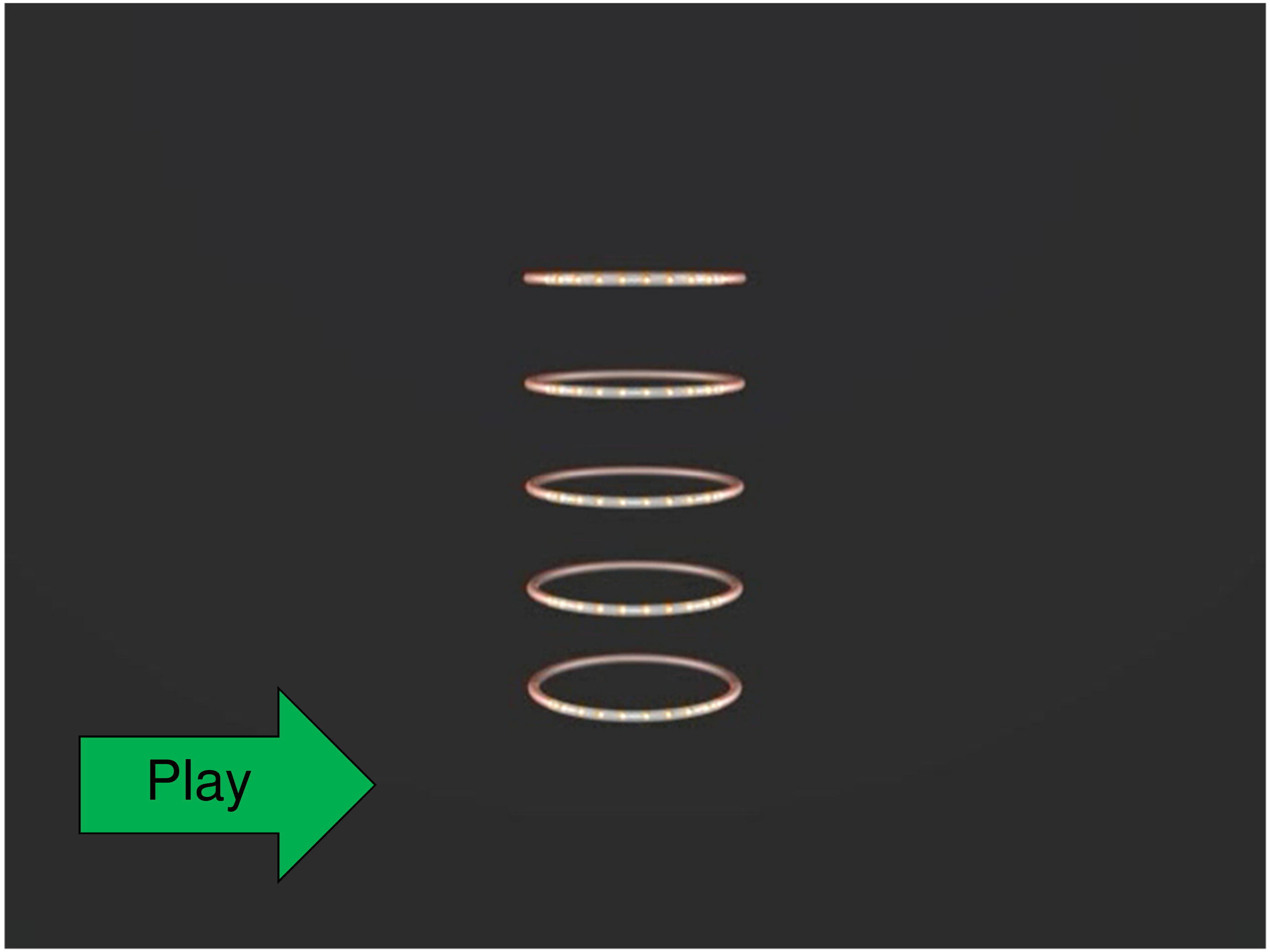
Each electric powered wire generates a magnetic field



Field model

Magnetic Fields – The magnetic field





EMC is required to sell products -> ok!

I understand what is EMI -> ok!

So now, how to make them disappear ?

Filter

What does filtering mean?

- useful to reduce coupling of noise from device A to device B
- reduce noise emissions
- increase noise immunity
- the intentional signal should not be affected

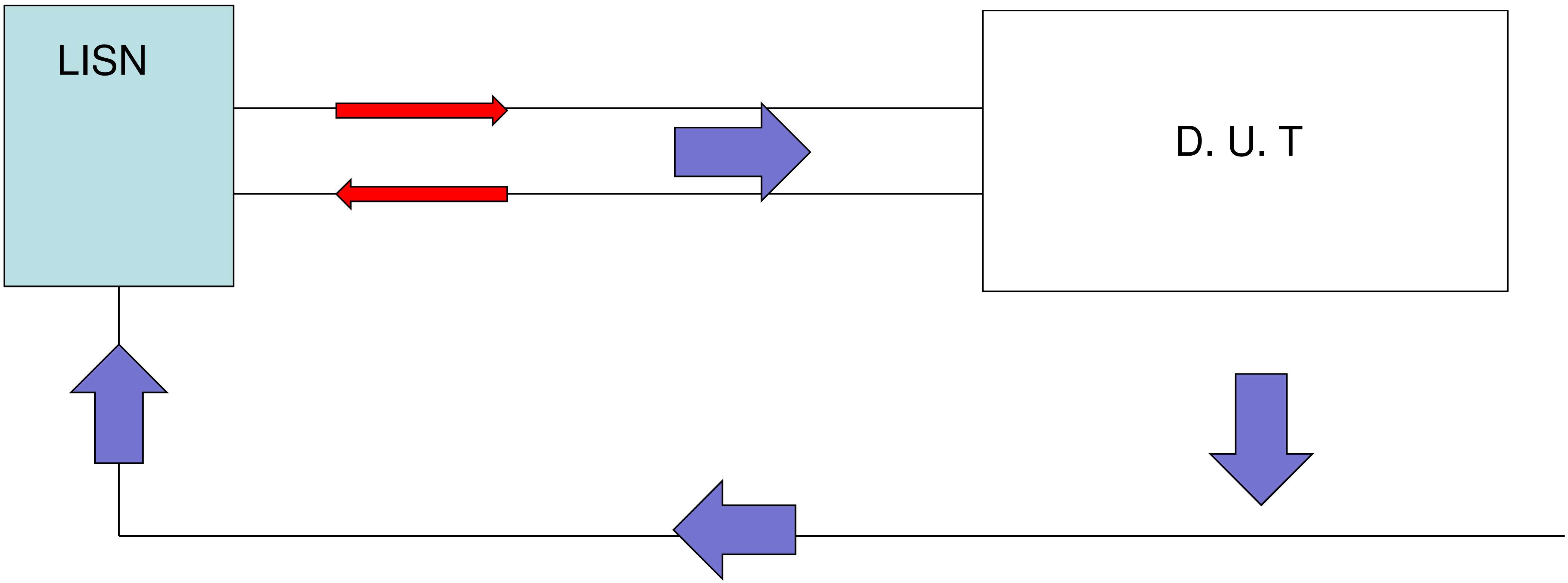
Complexity?

- filtering can be very difficult if intentional signal and noise frequency are close to each other
- if intentional signal and noise frequency are far away from each other, then a filter design is very easy

Recognizing the transmission mode

- common mode noise?
- differential mode noise?

Common/Differential mode

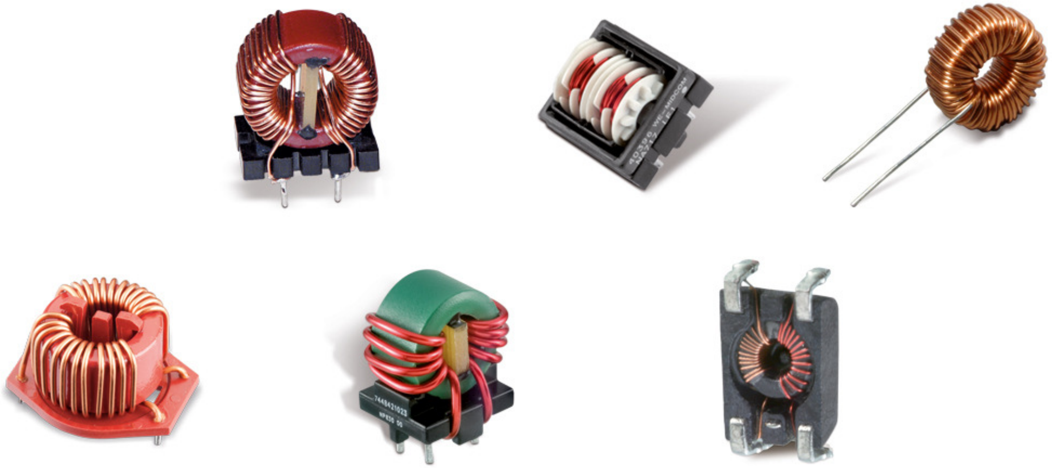


INDUCTIVE EMC SOLUTIONS BASICS

What about inductances?

… technical aspect

- a piece of wire wrapped on something



We also see inductance …

- in different shapes (shielded, round, square, …)

  or

- as parasitic effects

What is an EMC ferrite?

… technical aspect

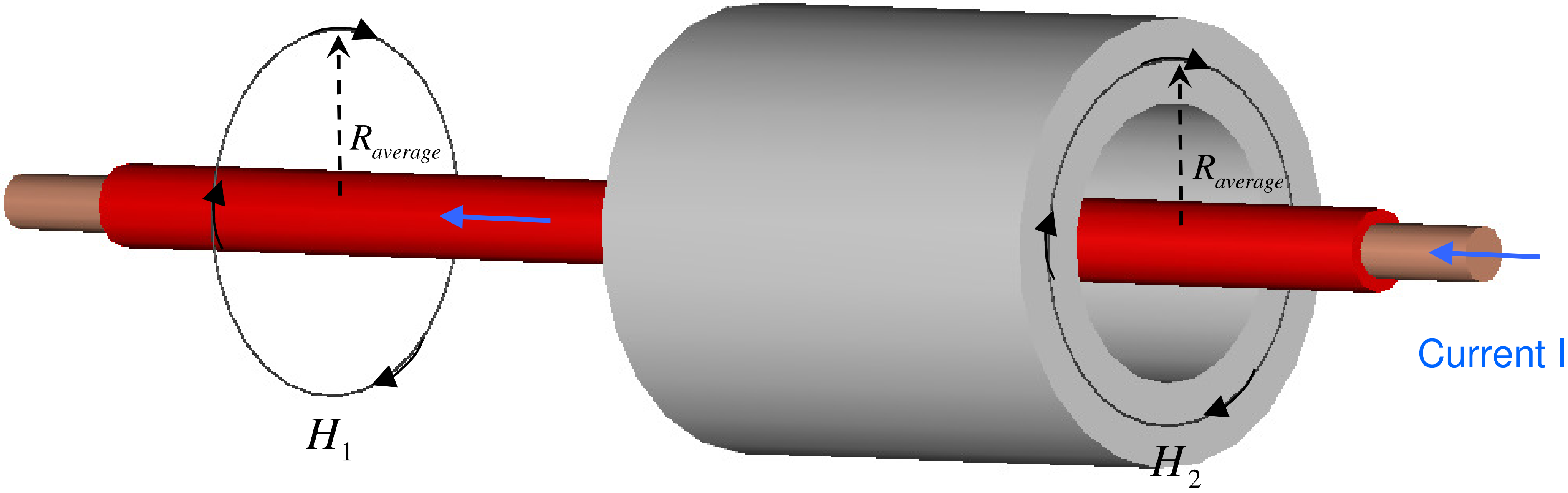
- Sintered ferrite material applied to a wire

As a function

- RF-Absorber
- frequency dependent filter

… in different forms

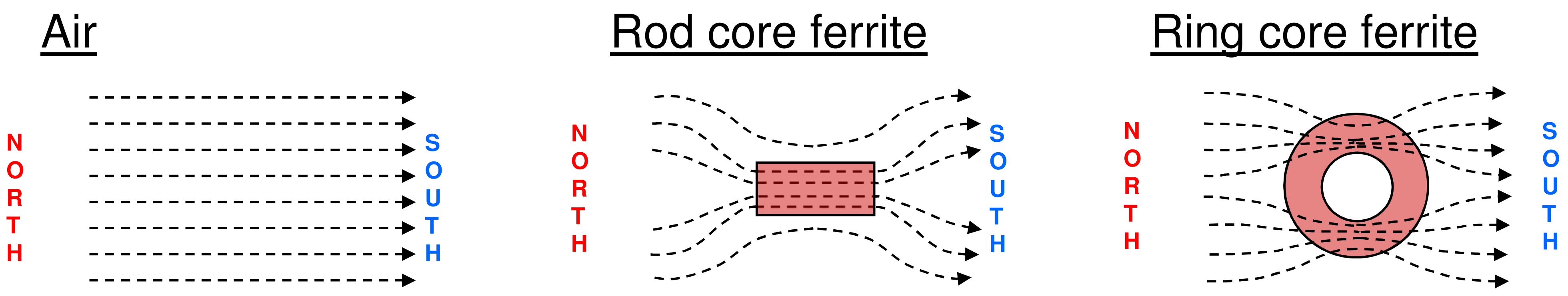
The magnetic field



$$H_1 = H_2 = H = \frac{I}{2 \cdot \pi \cdot R_{average}}$$

$$B_1 \; \boxed{\begin{matrix} \neq \\ ? \\ = \end{matrix}} \; B_2$$

The magnetic field



Induction in air:

$$B = \mu_0 \cdot H$$

linear function, because µr = 1 = constant!

Induction in a ferrite:

$$B = \mu_0 \cdot \boxed{\mu_r} \cdot H$$

The relative permeability is a: **material- frequency- temperature- current- pressure-** **-dependent parameter**

What is permeability?

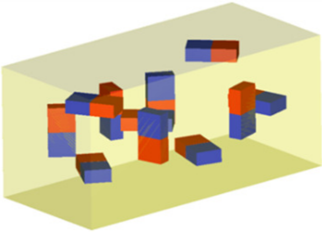
Relative permeability

- describes the capacity of concentration of the magnetic flux in the material

$$\mu_r = \frac{1}{\mu_0}\frac{\Delta B}{\Delta H}$$

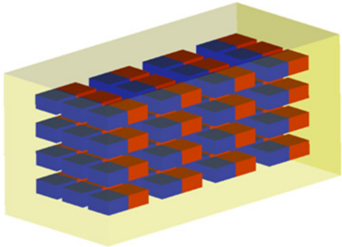
Ferrite material

- unordered (random position)
- soft magnetic



Permanent magnet

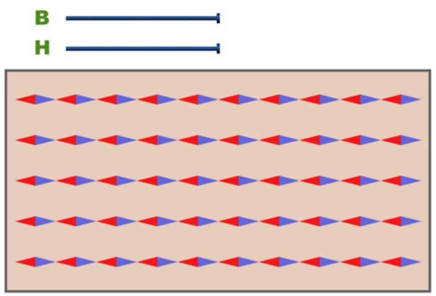
- ordered
- hard magnetic



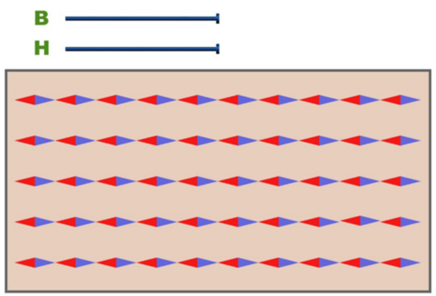
Typical permeability μ_r:

- Iron Powder/ Superflux: 50 ~ 150
- Nickel Zinc (NiZn): 40 ~ 1500
- Manganese Zinc (MnZn): 300 ~ 20000

Magnetic Fields – Magnetic Domains Simulation

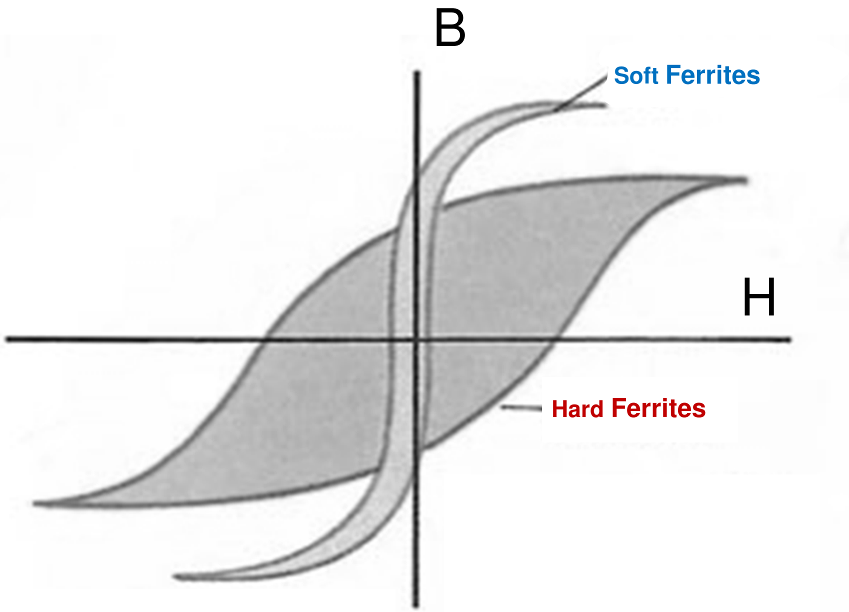


Linear hysteresis loop

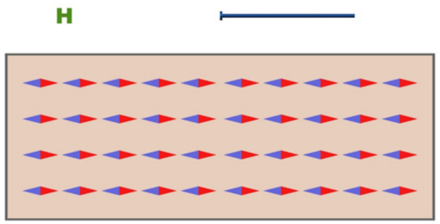


Rectangular hysteresis loop

Hard Ferrites:
Iron Powder



Soft Ferrites:
MnZn and NiZn

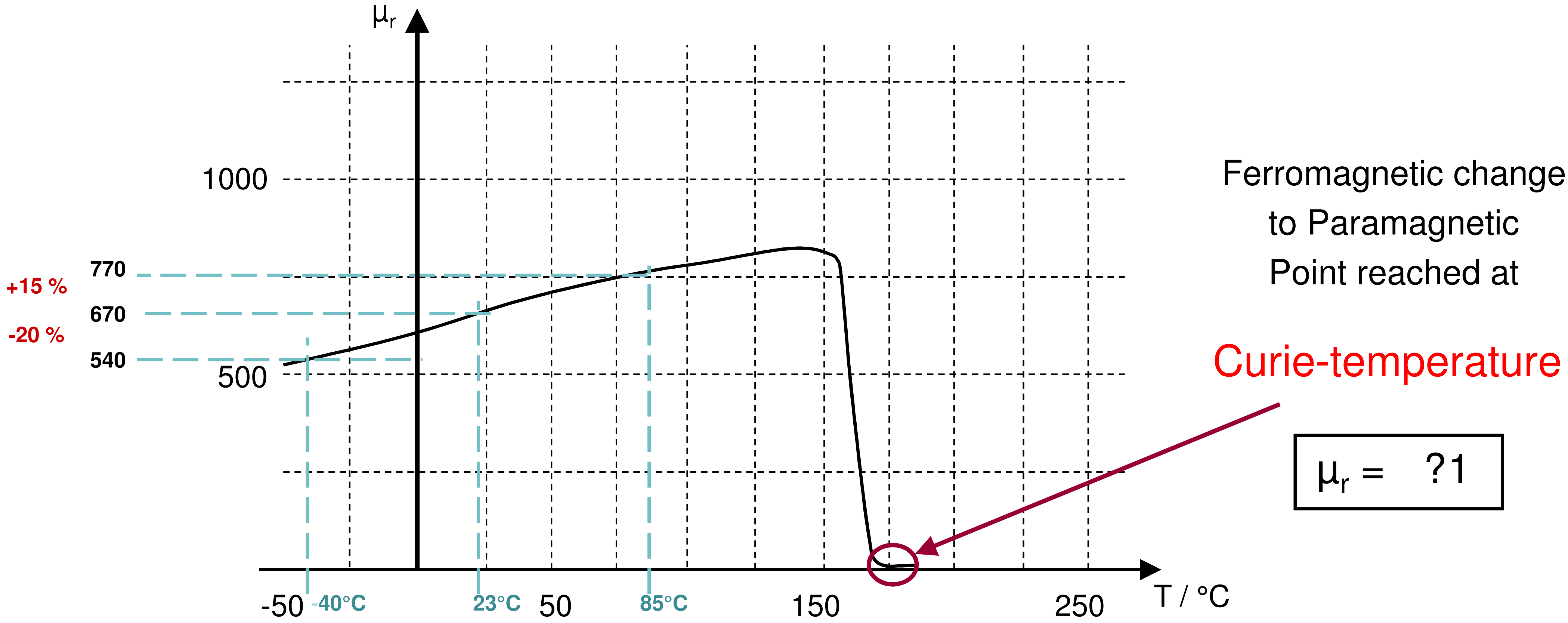


Magnetostriction

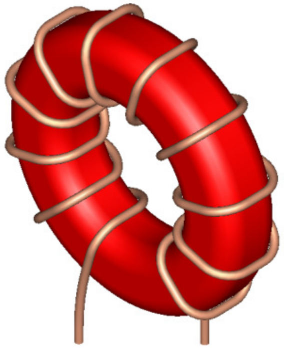
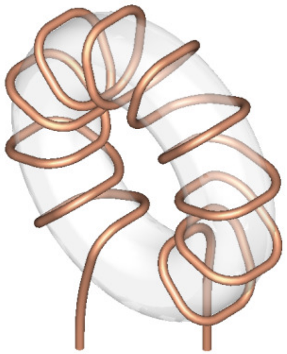
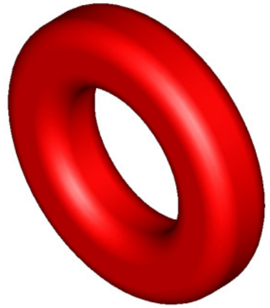
Permeability – core material parameter

Temperature influence

- Relative permeability is dependent on temperature

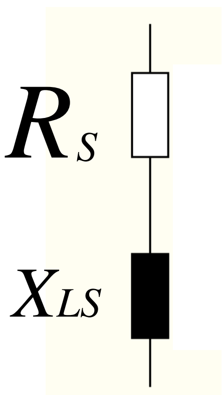


Permeability – complex permeability

 =  * 

Impedance from core and windings = **Impedance of winding w/o core** * **core material**

$$\underline{Z} = j\omega L_0 * (\mu' - j\mu'')$$



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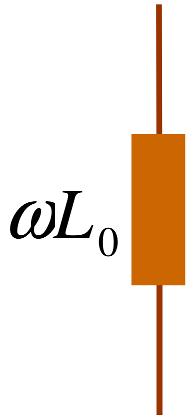

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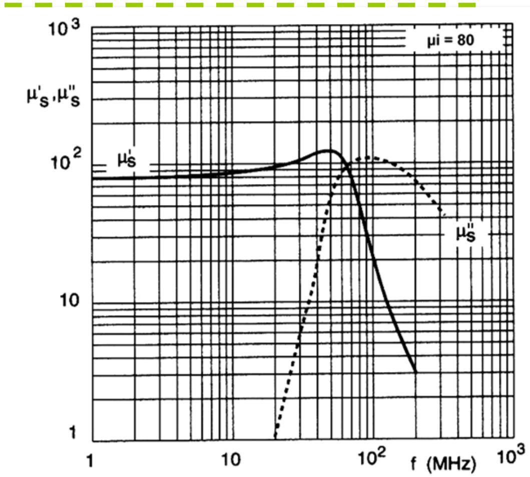
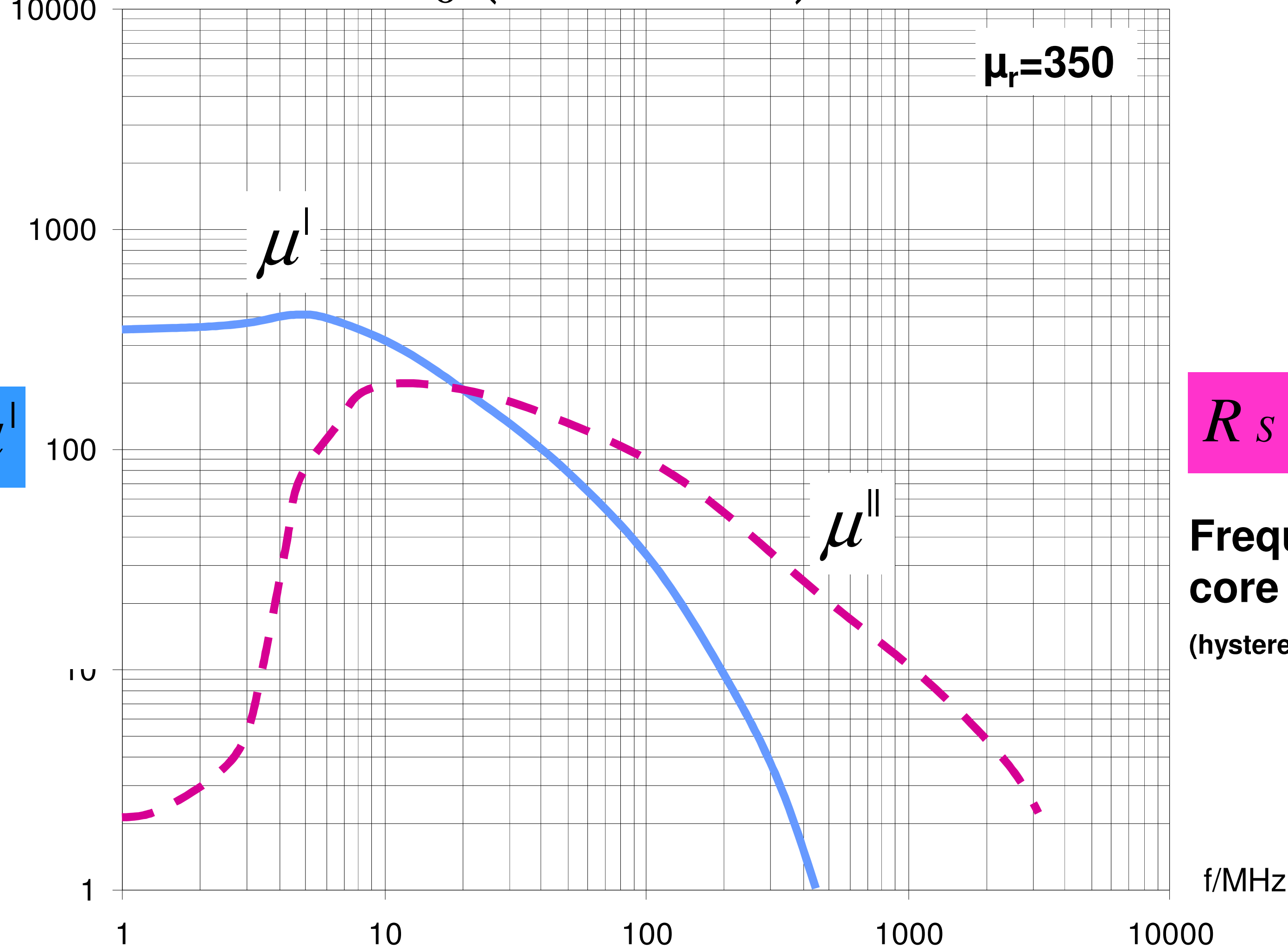


Permeability – complex permeability

$$\underline{Z} = j\omega L_0\left(\mu^{\prime} - j\mu^{\prime\prime}\right) = R + jX$$



$$X_{LS} = \omega L_0 \mu^{\prime}$$

Inductance reactance

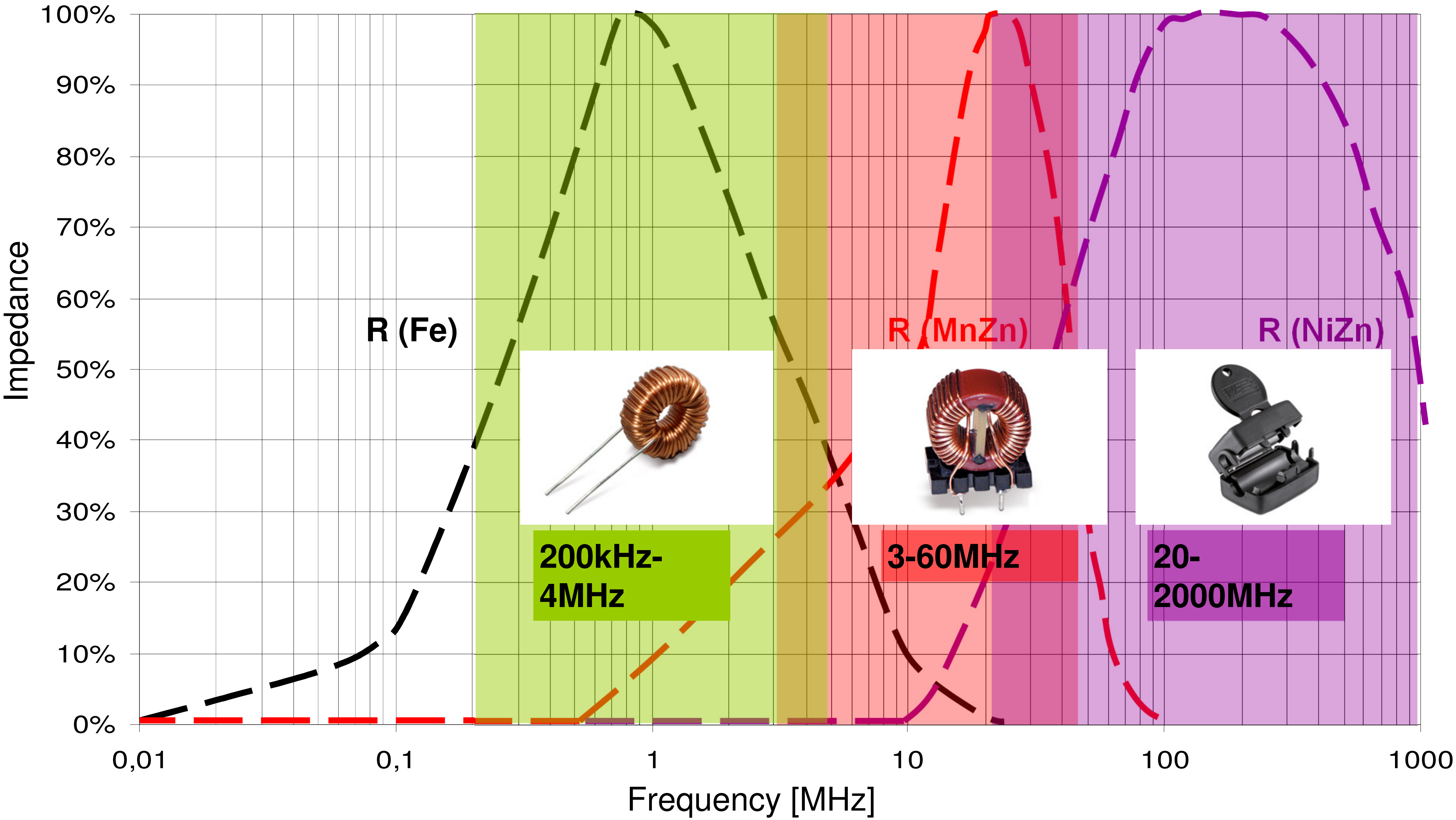
(Magnetize ability)

$$R_S = \omega L_0 \mu^{\prime\prime}$$

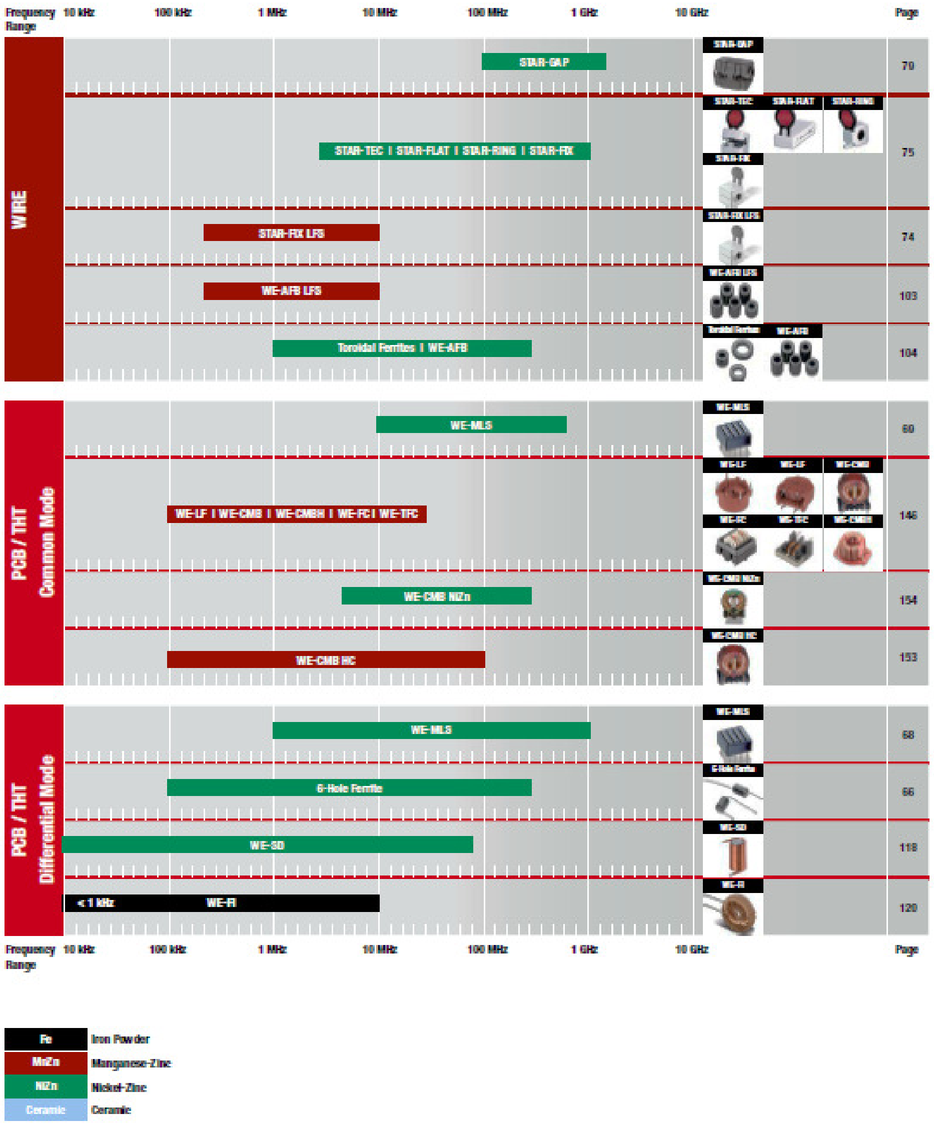
Frequency dependent core losses

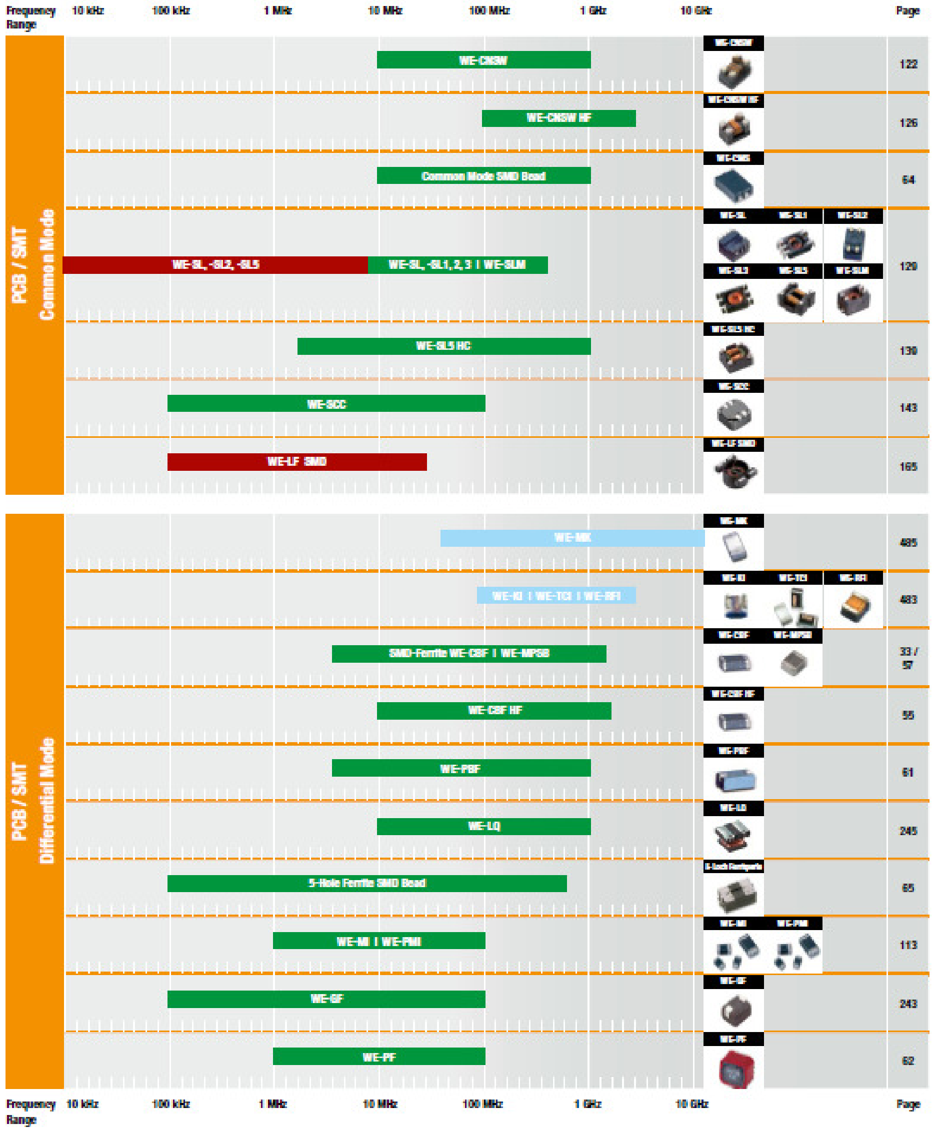
(hysteresis loss)

Core material – Choke (filter)



Core material – Filter application





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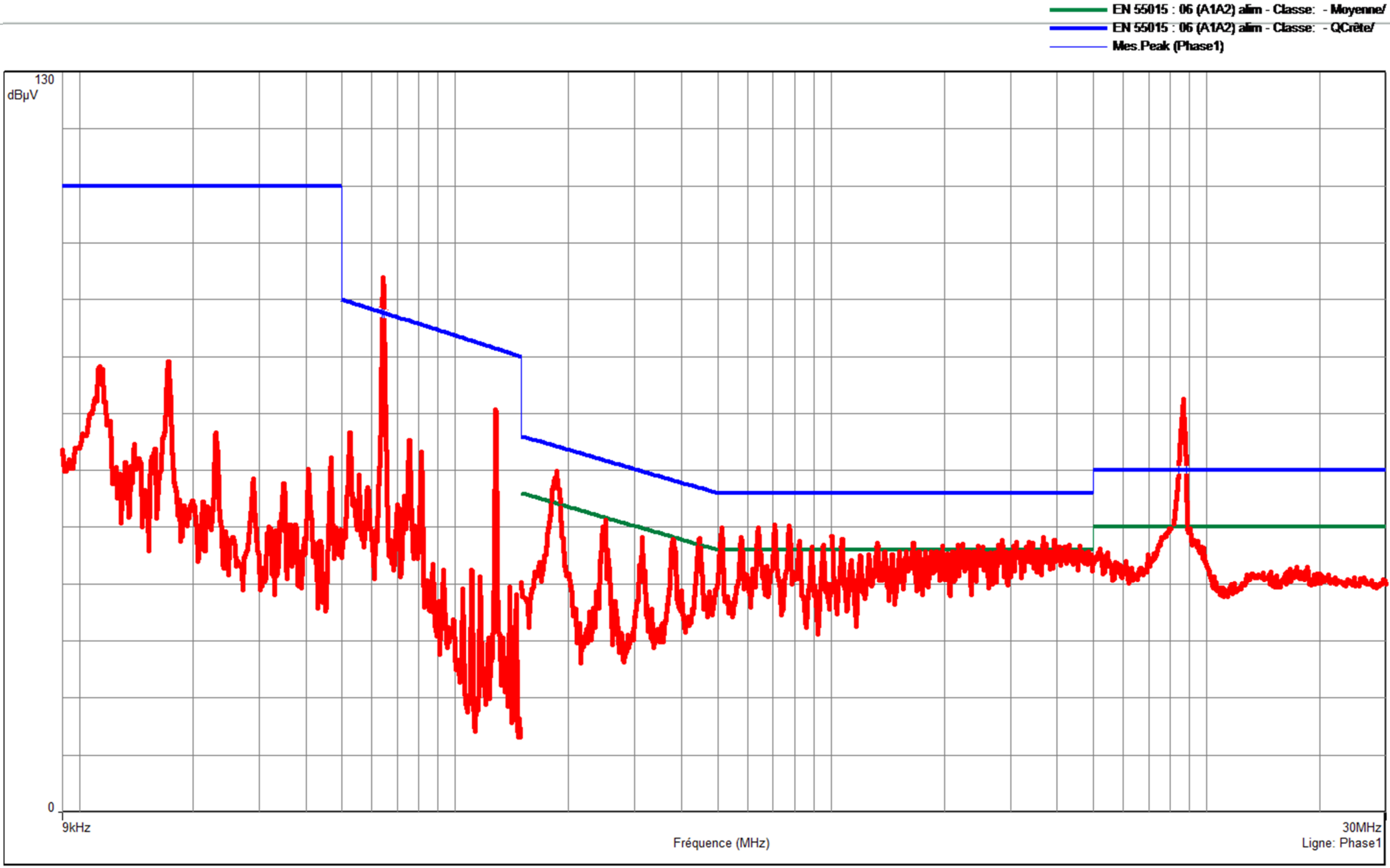
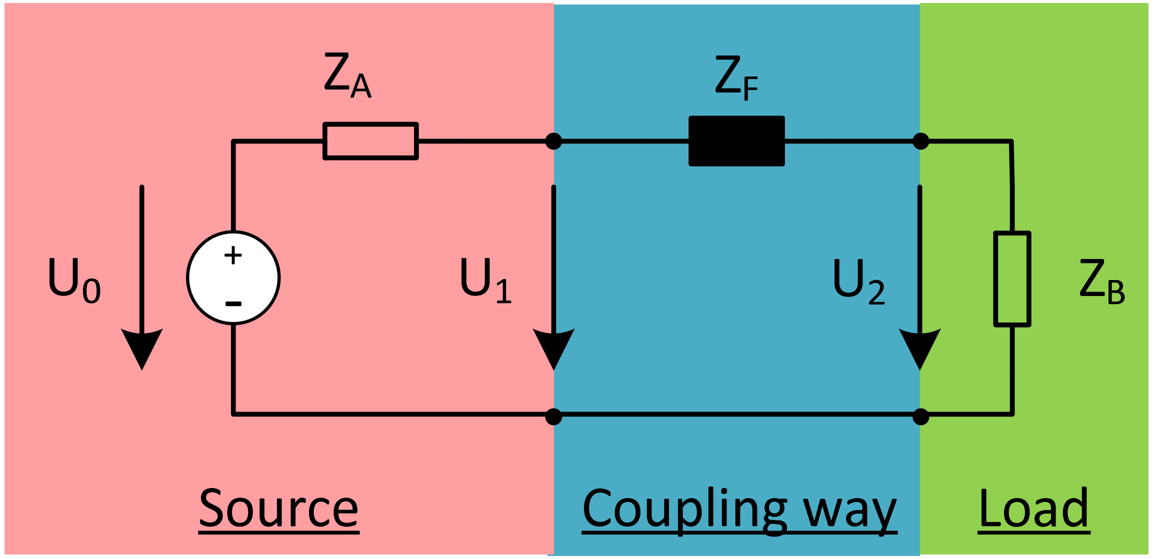
INSERTION LOSS OF INDUCTIVE SOLUTIONS

The problem(s)



Insertion Loss – Definition



- System attenuation

$$A = 20 \cdot \log \frac{Z_A + Z_F + Z_B}{Z_A + Z_B} \quad in\ (dB)$$

- Impedance

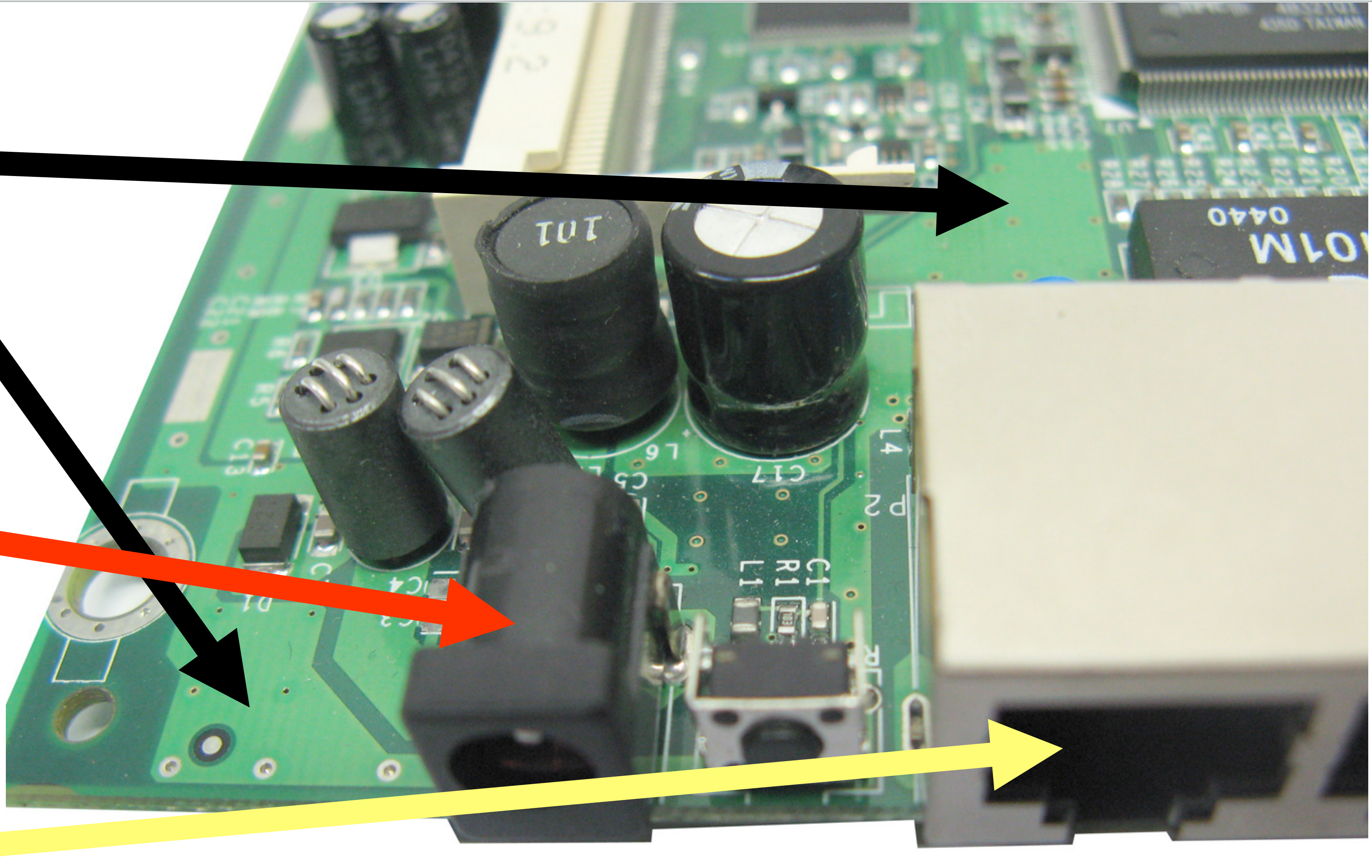
$$Z_F = \left[10^{\frac{A}{20}} \cdot (Z_A + Z_B) \right] - (Z_A + Z_B) \quad in\ (\Omega)$$

System impedances

1 Ω

10 Ω

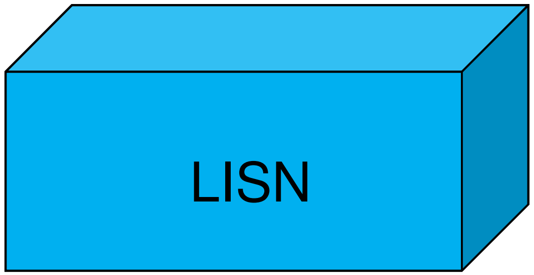
>90 Ω

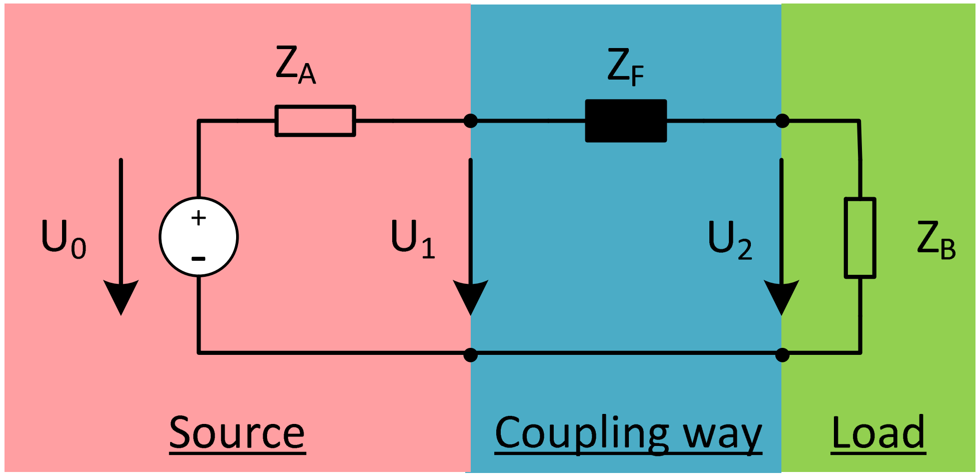


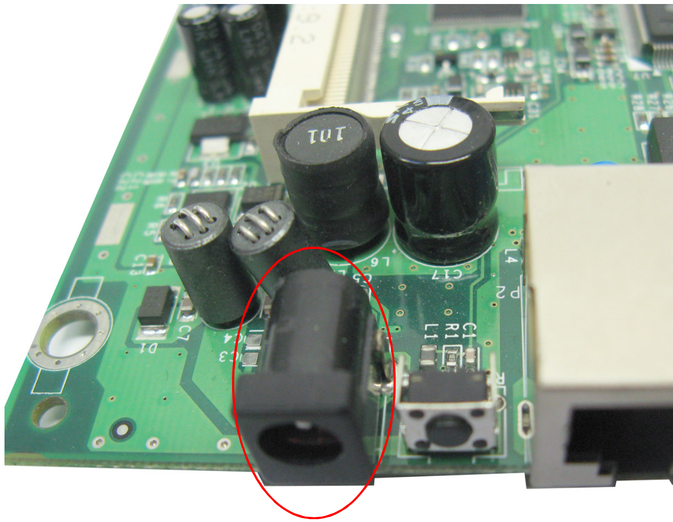
Complete solution

$$Z_F = \left[10^{\frac{A}{20}} \cdot (Z_A + Z_B)\right] - (Z_A + Z_B)$$

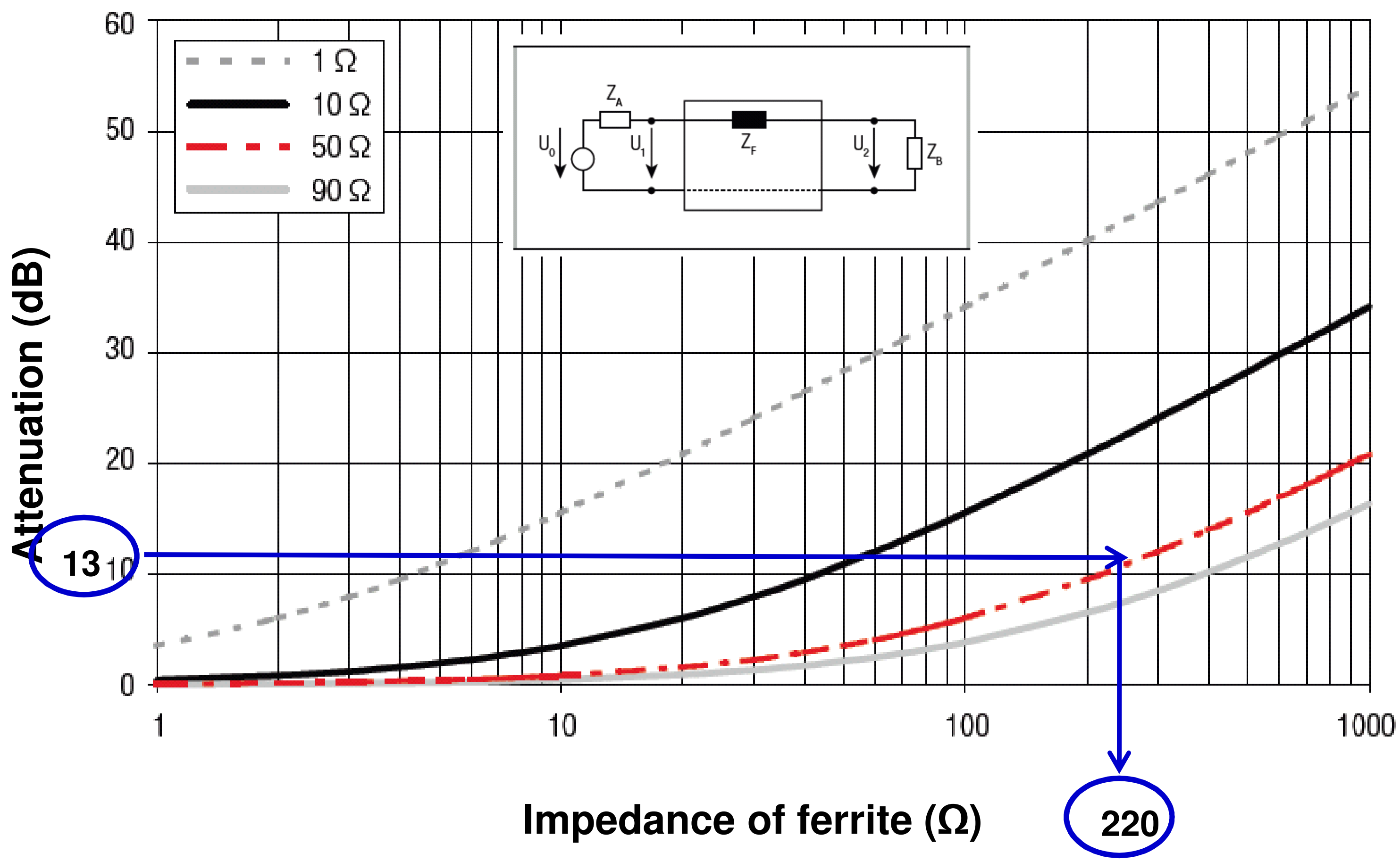
$$Z_F = \left[10^{\frac{13}{20}} \cdot (50 + 10)\right] - (50 + 10) = 208\,\Omega$$







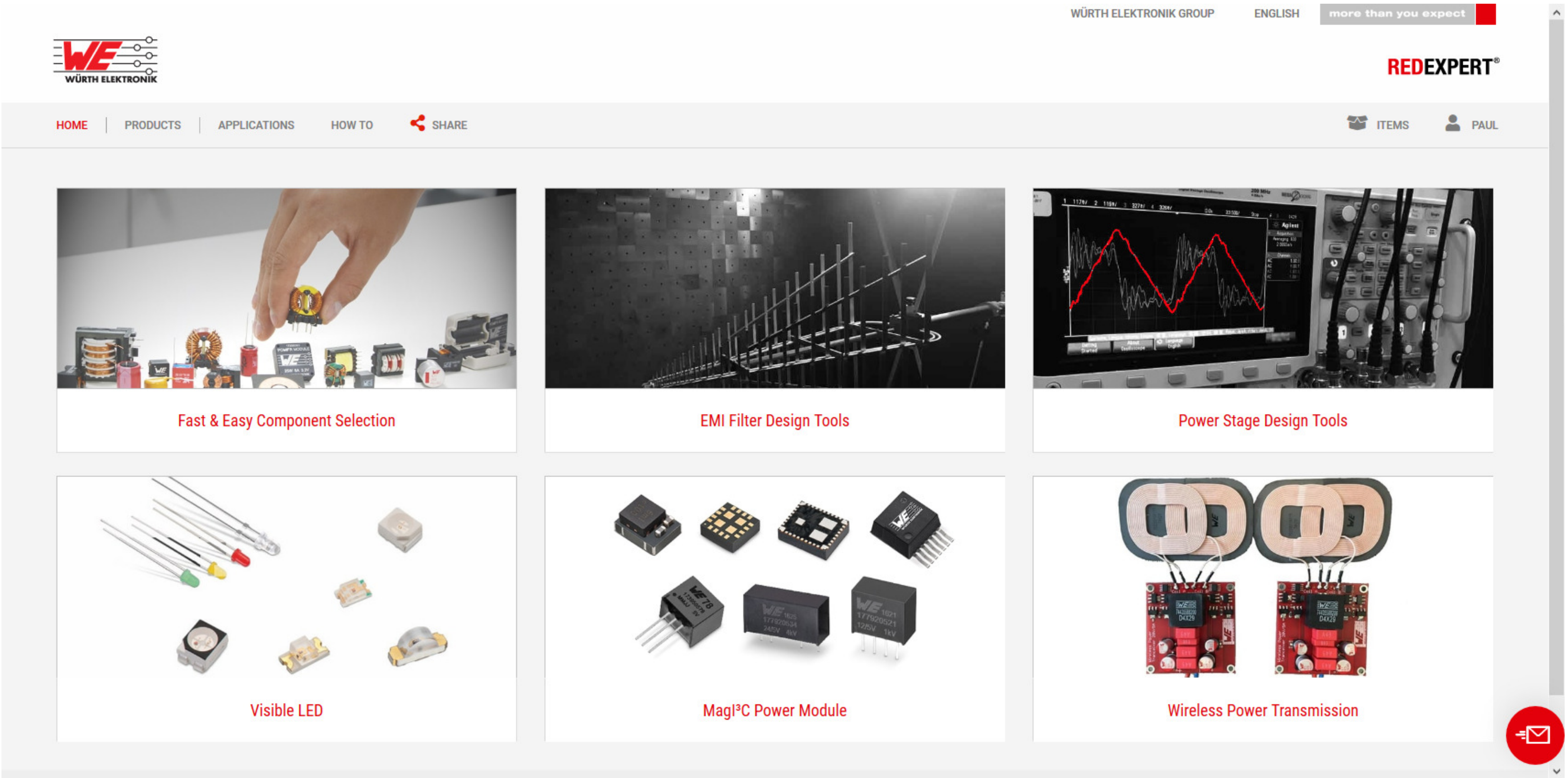
Quick solution

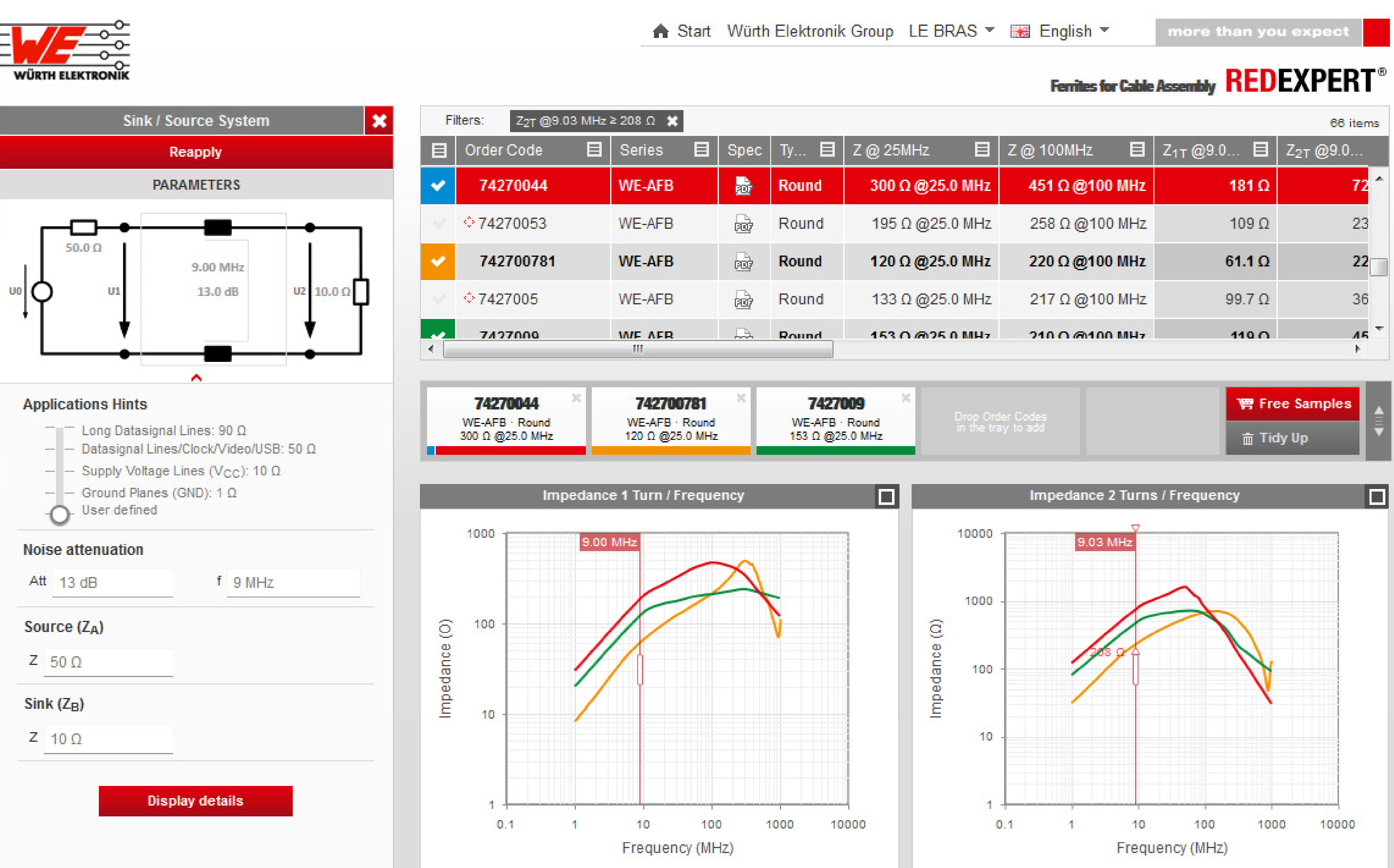


1. 1.Require 13dB of attenuation at 9 MHz
2. Know that it is a signal port
3. Signal port has 50 Ω impedance

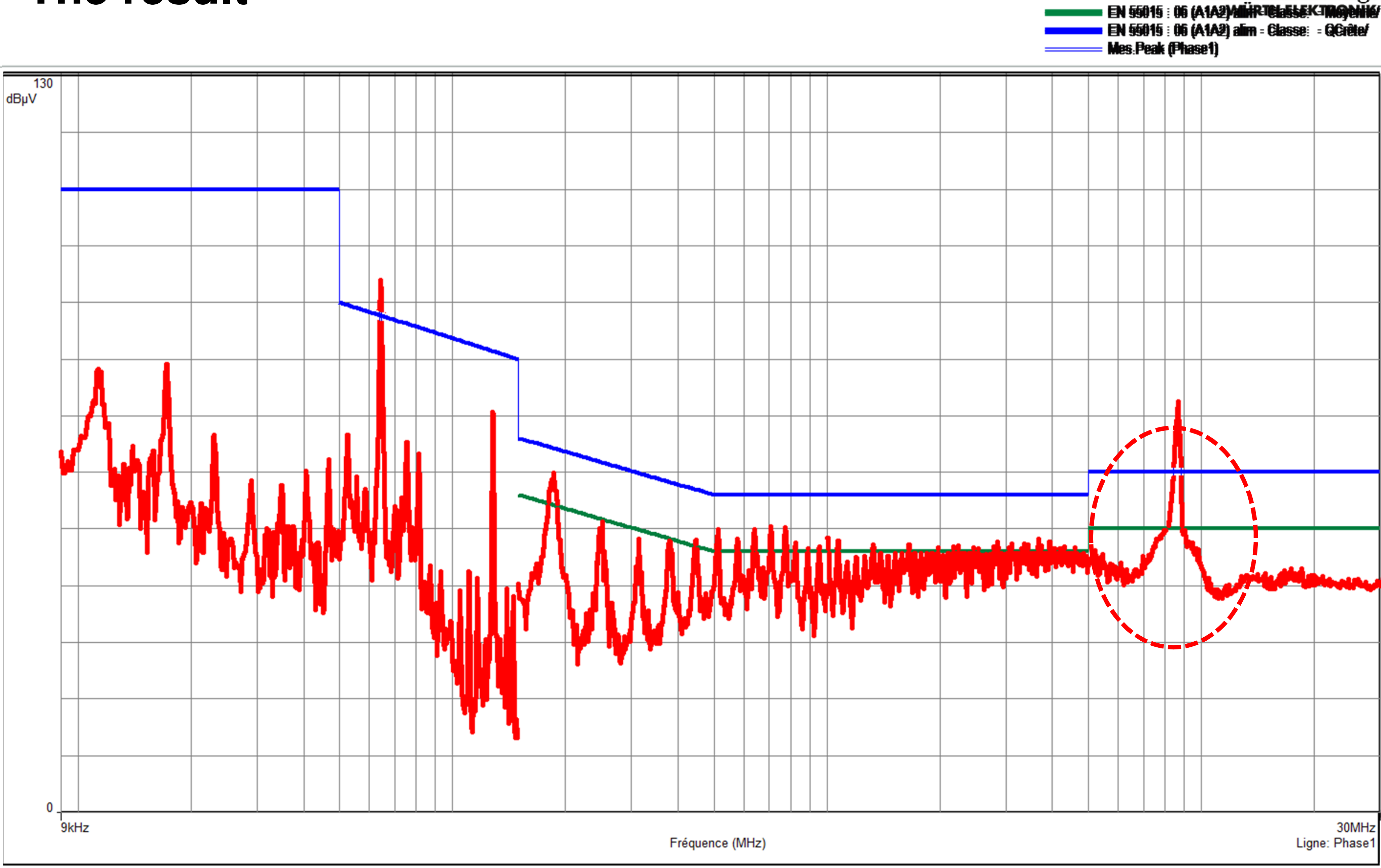
- Result is a minimum impedance of 220Ω

Finding inductive solution



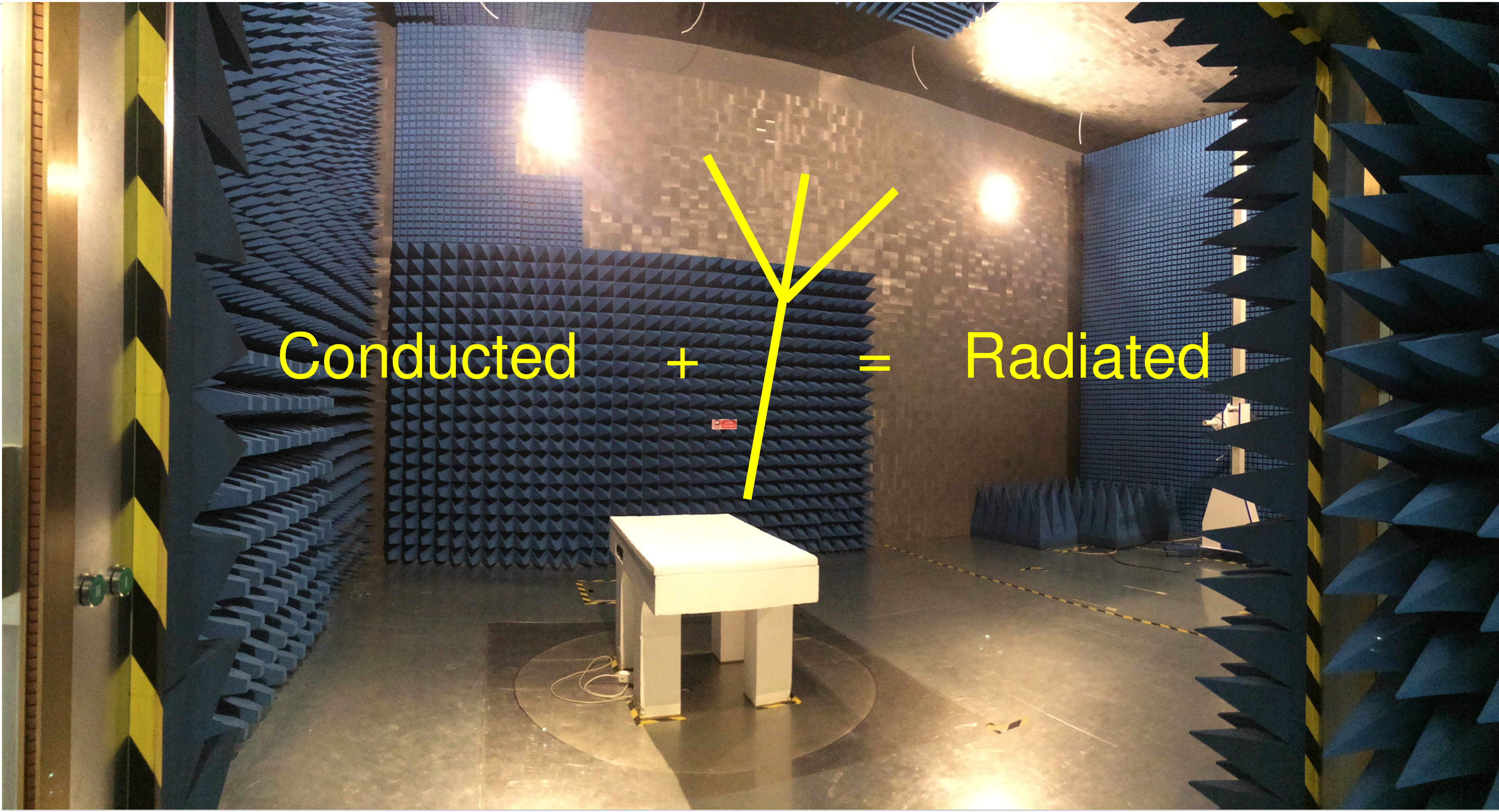

WÜRTH ELEKTRONIK
Start
Würth Elektronik Group
LE BRAS
English
more than you expect
Ferrites for Cable Assembly
REDEXPERT®
Sink / Source System
Reapply
PARAMETERS
50.0 Ω
9.00 MHz
13.0 dB
10.0 Ω
U0
U1
U2
Applications Hints
Long Datasignal Lines: 90 Ω
Datasignal Lines/Clock/Video/USB: 50 Ω
Supply Voltage Lines (VCC): 10 Ω
Ground Planes (GND): 1 Ω
User defined
Noise attenuation
Att 13 dB
f 9 MHz
Source (ZA)
Z 50 Ω
Sink (ZB)
Z 10 Ω
Display details
Filters: Z2T @9.03 MHz ≥ 208 Ω
66 items
Order Code
Series
Spec
Ty...
Z @ 25MHz
Z @ 100MHz
Z1T @9.0...
Z2T @9.0...
74270044 WE-AFB Round 300 Ω @25.0 MHz 451 Ω @100 MHz 181 Ω 72
74270053 WE-AFB Round 195 Ω @25.0 MHz 258 Ω @100 MHz 109 Ω 23
742700781 WE-AFB Round 120 Ω @25.0 MHz 220 Ω @100 MHz 61.1 Ω 22
7427005 WE-AFB Round 133 Ω @25.0 MHz 217 Ω @100 MHz 99.7 Ω 36
74270044
WE-AFB · Round
300 Ω @25.0 MHz
742700781
WE-AFB · Round
120 Ω @25.0 MHz
7427009
WE-AFB · Round
153 Ω @25.0 MHz
Drop Order Codes in the tray to add
Free Samples
Tidy Up
Impedance 1 Turn / Frequency
9.00 MHz
Impedance (Ω)
Frequency (MHz)
Impedance 2 Turns / Frequency
9.03 MHz
208 Ω

The result

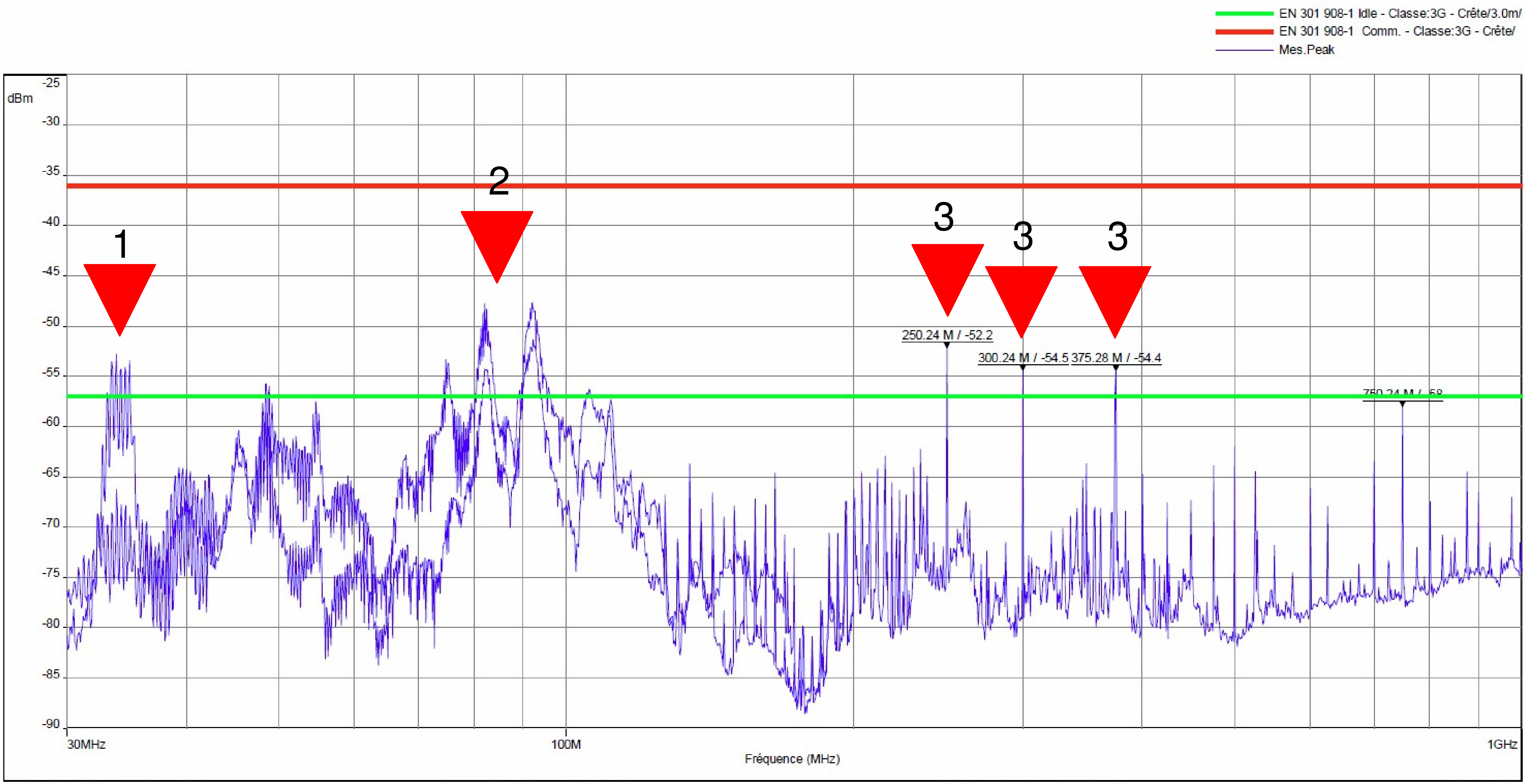

EN 55015 : 06 (A1A2) alim - Classe: - Moyenne/
EN 55015 : 06 (A1A2) alim - Classe: - QCrête/
Mes.Peak (Phase1)
130
dBµV
0
9kHz
30MHz
Fréquence (MHz)
Ligne: Phase1

RADIATED EMC

Radiated EMC



Radiated EMC



250.24 M, -52.2 dBm : 300.24 M, -54.5 dBm : 375.28 M, -54.4 dBm : 750.24 M, -58 dBm :

WÜRTH ELEKTRONIK

Thank you for your attention!
Any questions?