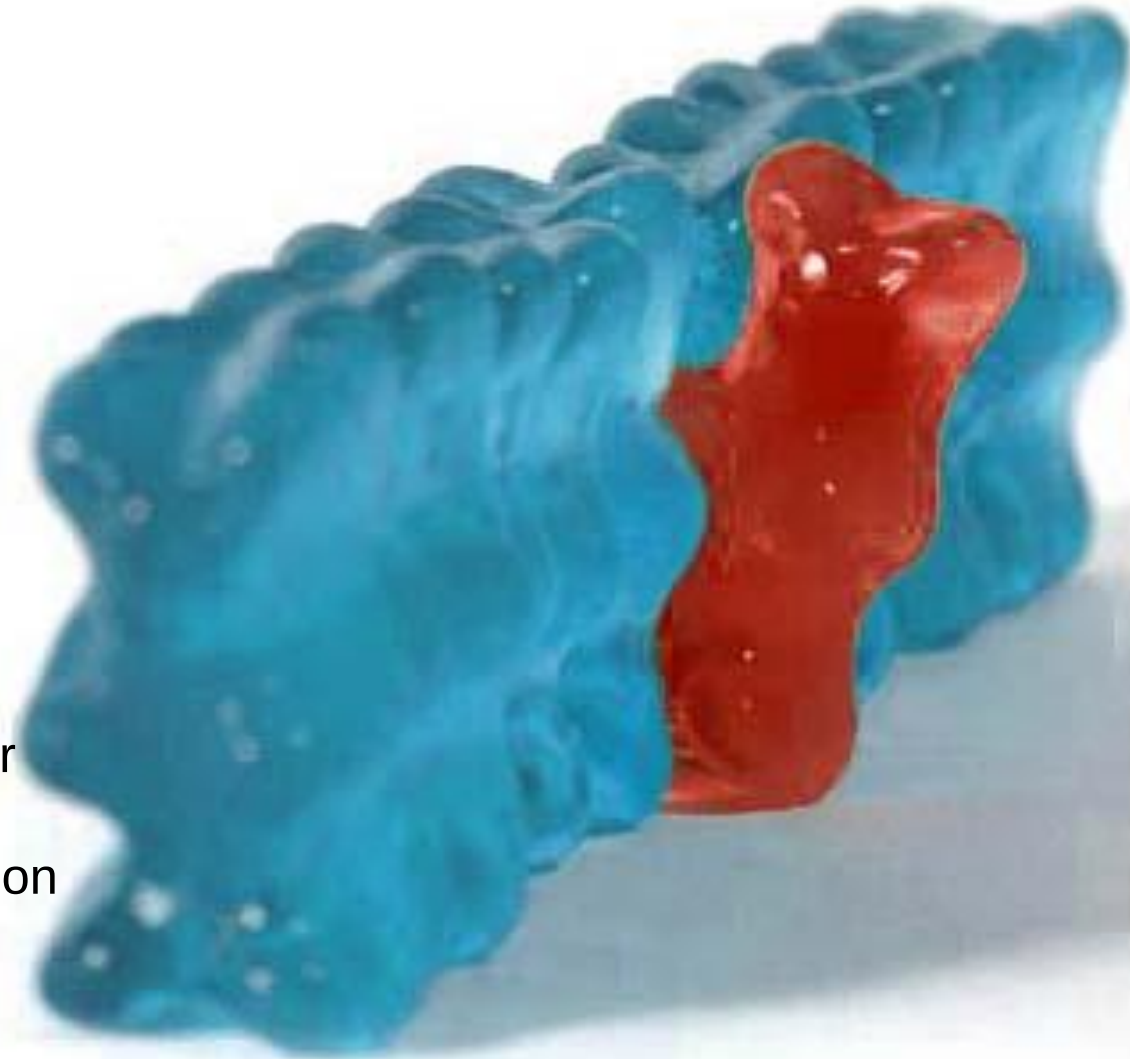


Agenda

- EMC- basics
- Magnetic field basics
- Filter & Signals
- Insertion loss calculation
- Filter topologies
- Simulation
- Live measuring with spectrum analyzer
- AC/DC how to pass Conducted Emission
- ESD & Layout tipps





EMC - basics

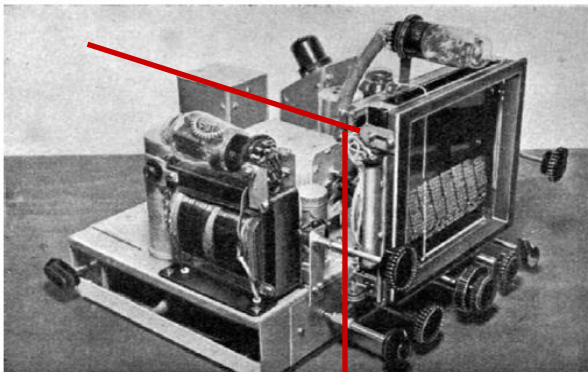
EMC - Definition



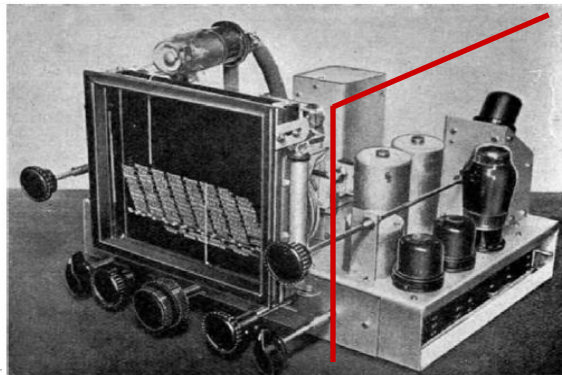
„Electro-Magnetic Compatibility“

Ability of electronic equipment and systems to operate in proximity of electromechanical devices, without causing or suffering unacceptable degradation in output or performance.

LF-area



HF/RF-area



EMC Directive 2004/108/EC



Main goals:

- To ensure that the electromagnetic disturbances produced by equipment does not affect the correct functioning of other apparatus as well as radio and telecommunications networks, related equipment and electricity distribution networks.
- To ensure that equipment has an adequate level of intrinsic immunity to electromagnetic disturbances to enable them to operate as intended.

Obviously, the goal of the essential requirements is not to guarantee absolute protection of equipment (e.g. zero emission level or total immunity). These requirements accommodate both physical facts and practical reasons. To ensure that this process remains open to future technical developments, the EMC Directive only describes the essential requirements along general lines.

In the “new” Directive essential requirements includes both protection requirements for equipment as well as specific requirements for installations.

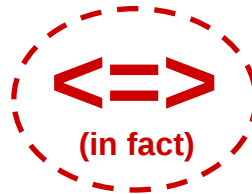
EMC - Definition

„Transmitter / Receiver“

- Apparatus which operate with other machinery in same electromagnetic environment.

Source / Transmitter

- Mobile base station
- Electro engine
- Hi power electronic
- Mobile device (Laptop, PDA, Mobile phones etc.)
- Discharge of static capacity
 - ESD (Electro Static Discharge – „Person“)
 - LEMP (Lighting Electro Magnetic Pulse)



Load / Receiver

- Receivers (TV, Radio, ...)
- White & Braun goods
- Computer systems
- Measuring, regulating systems (e.g. sensors)
- Medicine electronics (e.g. Heart pace maker)



EMC - requirement

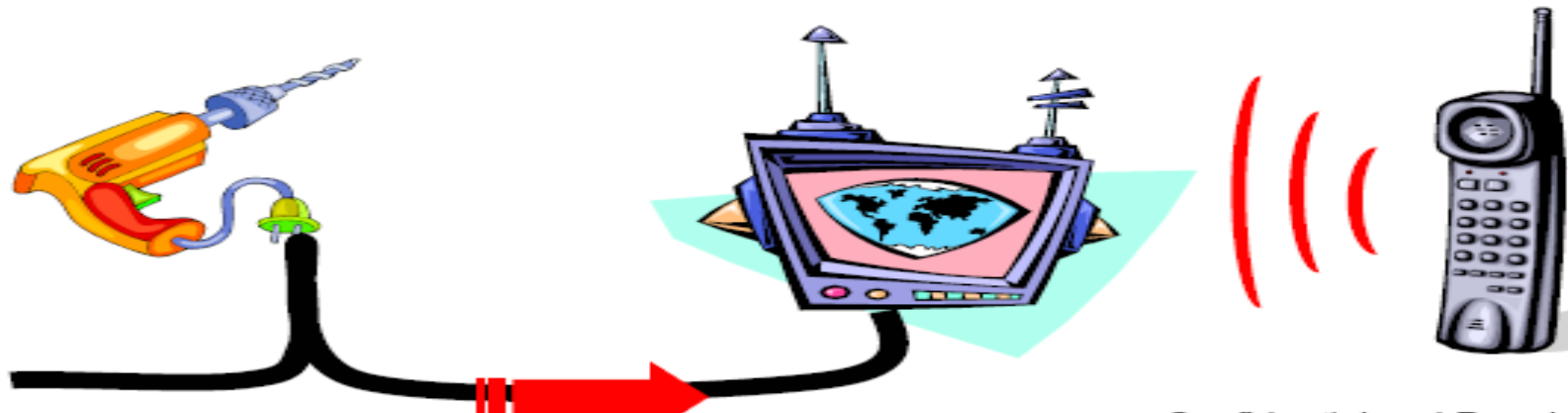
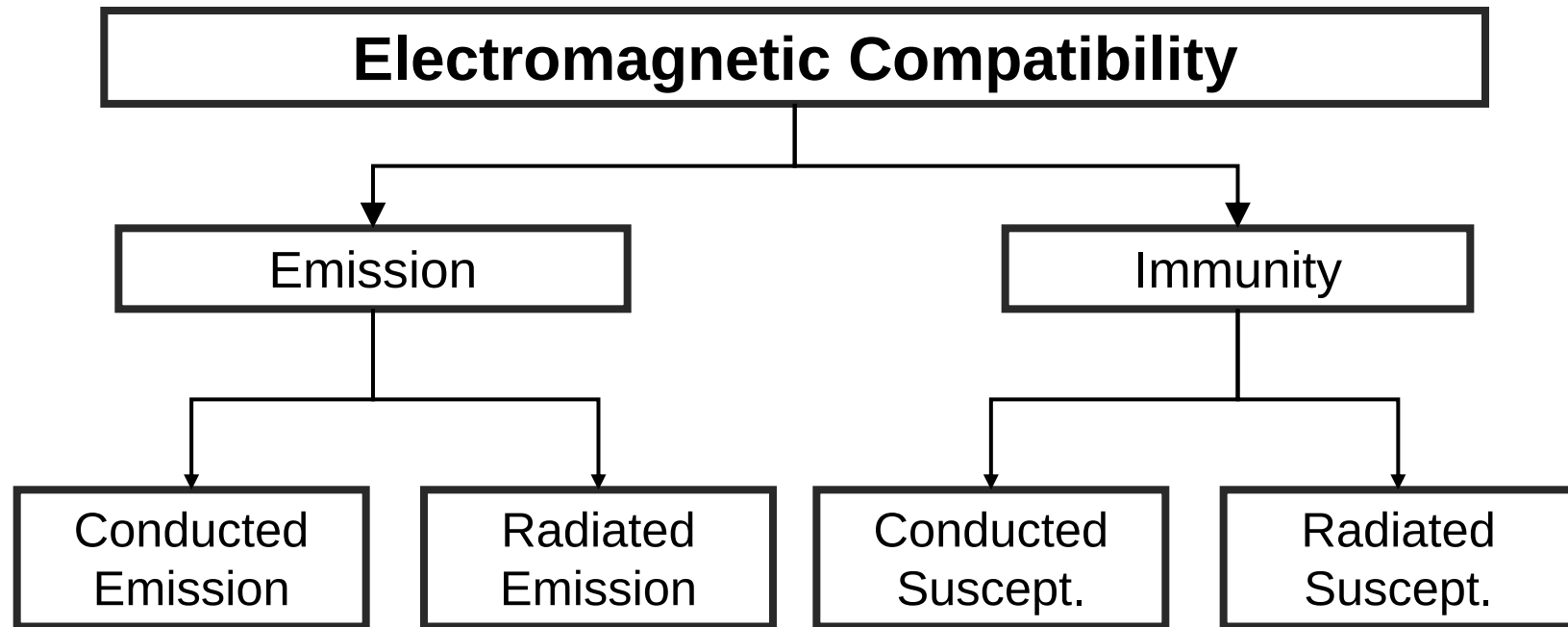
Beginning from definition

- an basic requirement to apparatus:

- | | | |
|---------------|---|--------------|
| 1) avoid | } | Emission |
| 2) prevent | | |
| 3) attenuated | | Interference |

Effective protection TO AND AGAINST other electronic devices

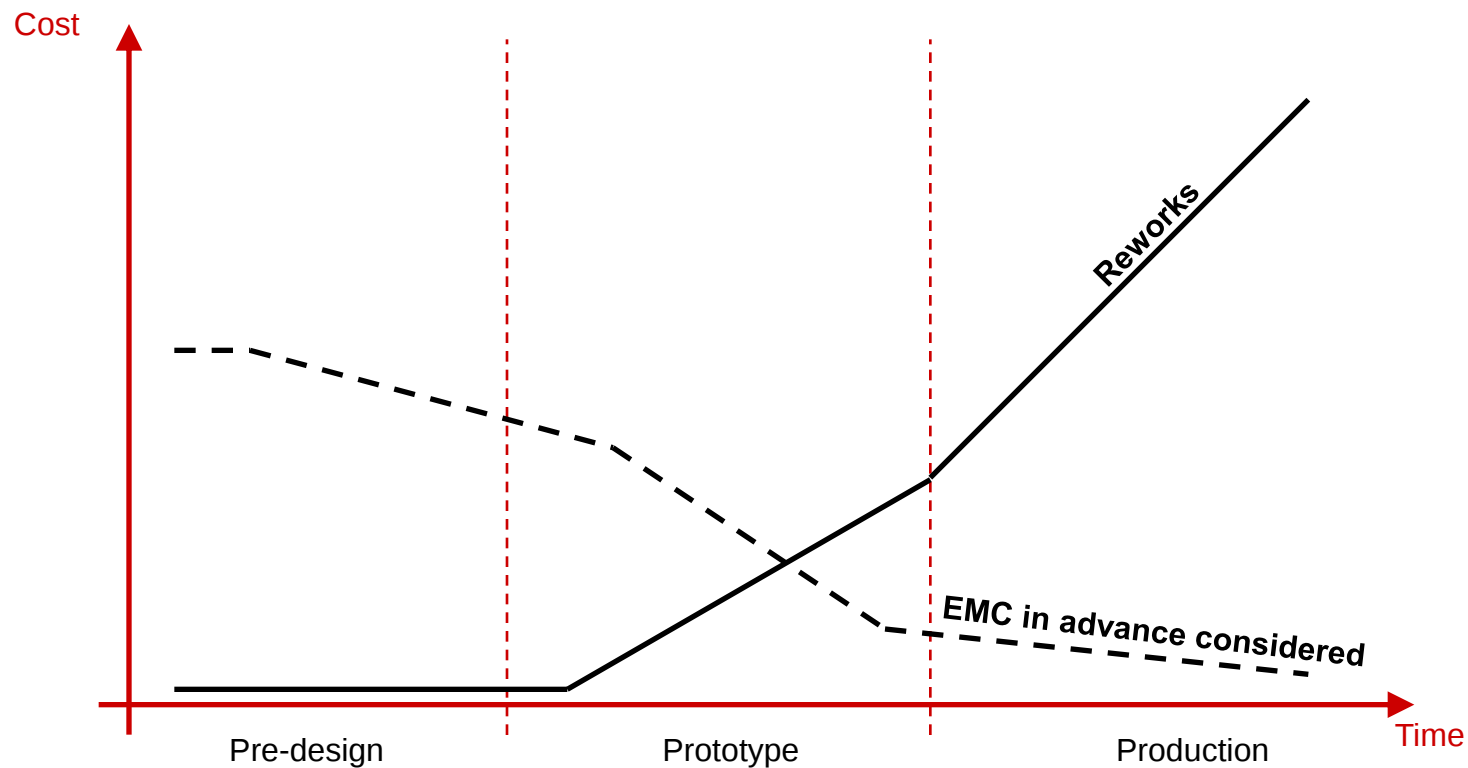
EMC – requirement directive 2004/108/EC



EMC - Affect

Economical point of view:

- Depends when you will start to design EMC conform



EMC - Coupling

...some time as intra system perturbation occurred

- Possibilities to avoid such EMC situations can be done at noise source, coupling way or at coupled load

→ Primary procedure

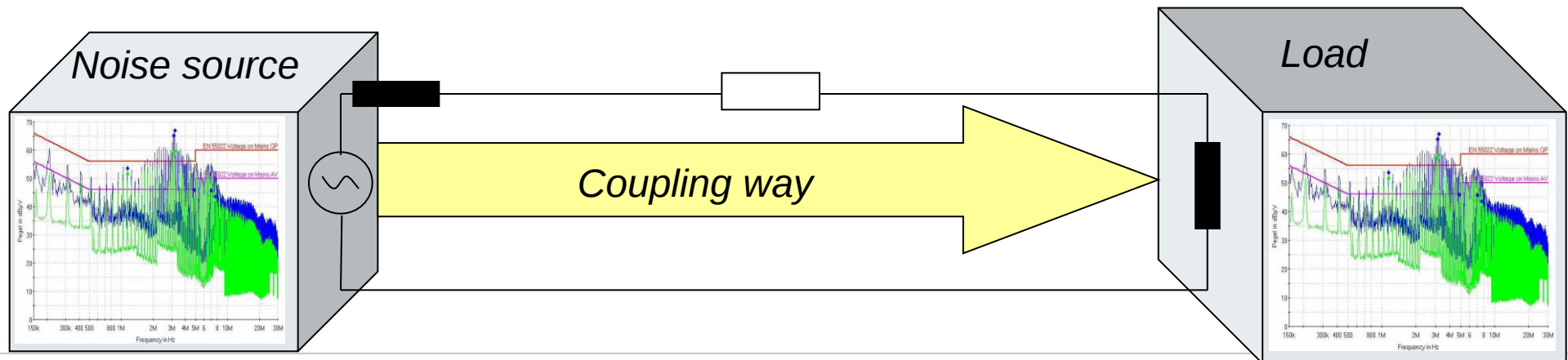
...to aim at source a low noise

→ Secondary procedure

... eliminate the noise thru interrupting the coupling way

→ Tertiary procedure

... increase the noise immunity at load





Basics



Whas is frequency?

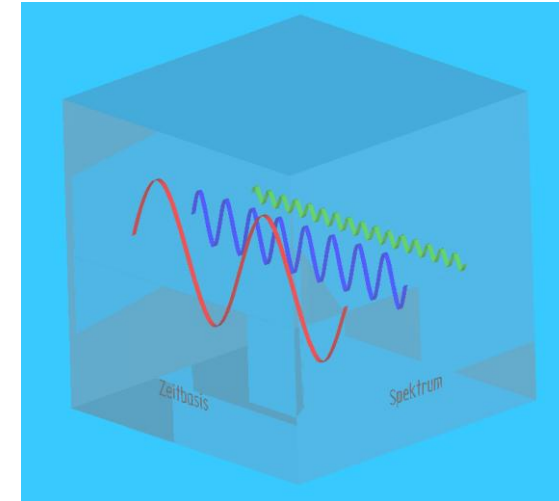
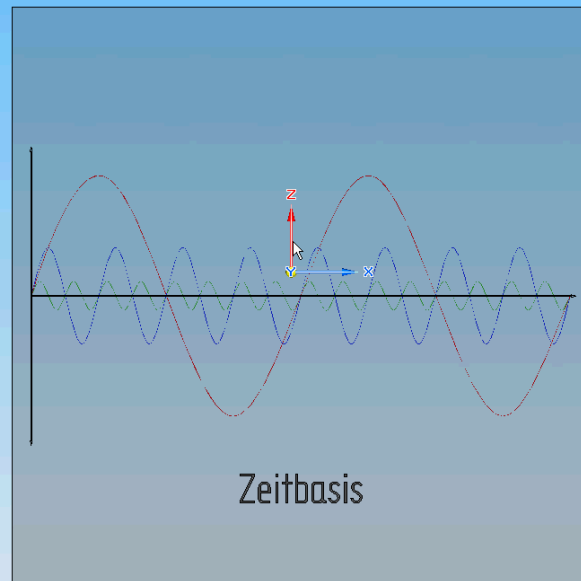
- lat. Frequentia = occurrence
- ...describe the numbers of incidents in a defined time
- all signal forms can be deducted from standard base oscillations (sin., cos.)
 - Fourier transformation
- if you overlay those base oscillation you will become new signal forms (vector addition)
 - Triangle, right angle, ...
- the unwanted interfering generate our disturbance signal
 - e.g. noise (a accidental signal with “constant” amplitude)
- the aim of EMC: reduce / filter those disturbances

What is frequency? What is spectrum?

- Fourier transformation

Transformation from time domain into spectrum

Unregistered HyperCam 2



What is frequency?

- Dependence of wave length -frequency

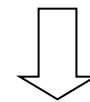


$$\lambda = \frac{c}{f} = \frac{c_0}{f \cdot \sqrt{\epsilon \cdot \mu}}$$

Example: for WLAN 2,4GHz

$$\lambda = \frac{3 \times 10^8 \cdot m \cdot s}{2,4 \times 10^9 \cdot s}$$

$$\lambda = 0,125m$$



$$\underline{\underline{\lambda / 4 = 3,125cm}}$$

What is an Inductor ? What is a coil?

...technical aspect:

→ a piece of wire wrapped on something

As a function:

- a Filter
- an energy-storage-part (for short-time)

What is the difference between Coil and Inductor?

Coil = **Inductor**
(many shapes) (just inductance)



What is an EMC ferrite?

.....technical aspect:

→ Sintered ferrite material applied to a wire

As a function

- RF-Absorber
- frequency dependant filter

Shapes:

Split ferrite

Toroid / sleeve ferrite

flat cores

ferrite plates

chip bead ferrite

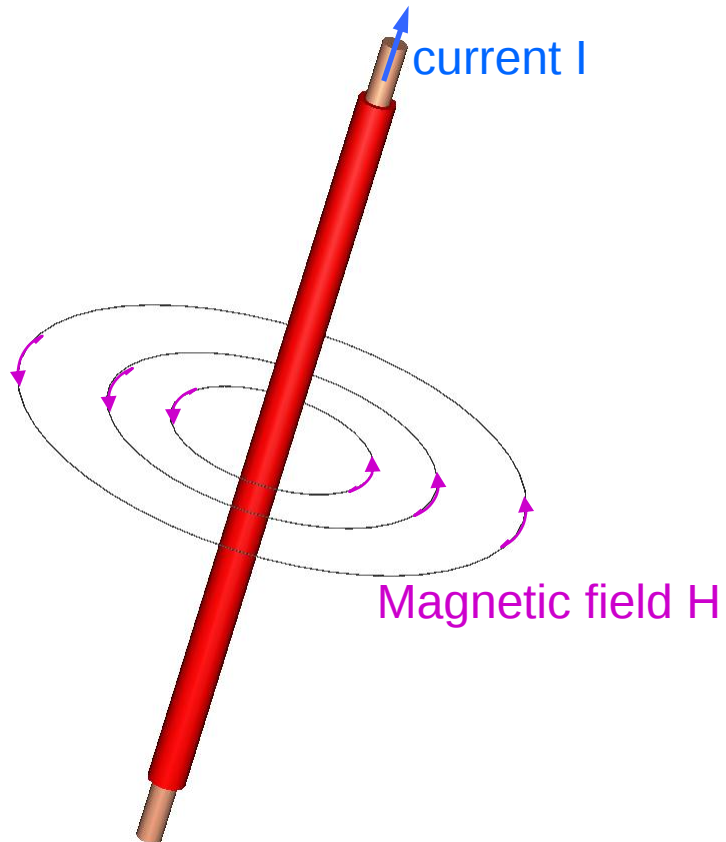
multi hole ferrite

ferrite beads



The magnetic field

Each electric powered wire generate a magnetic field

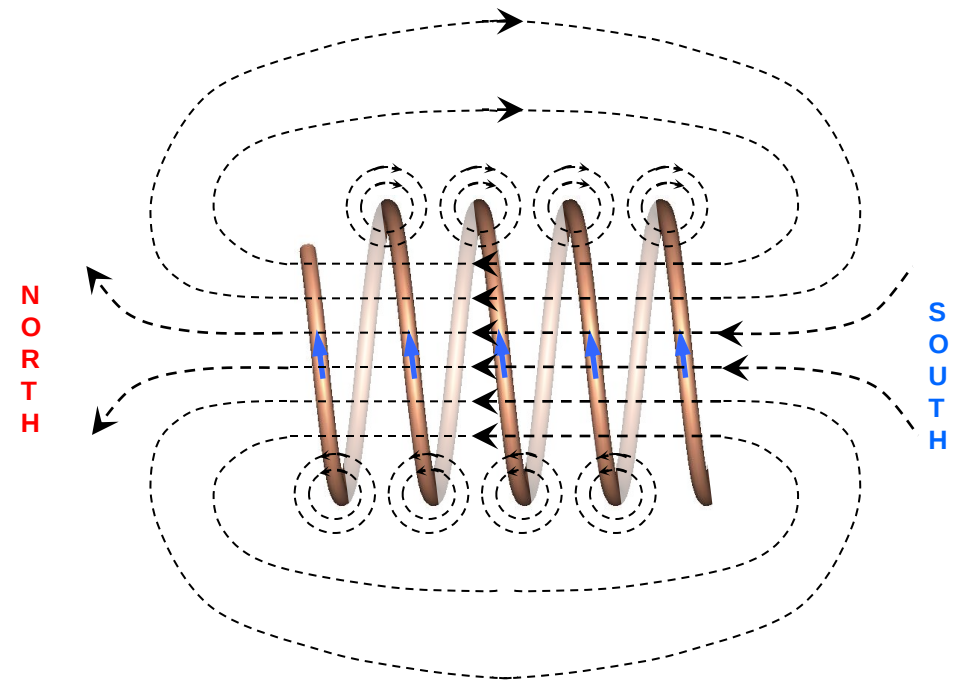
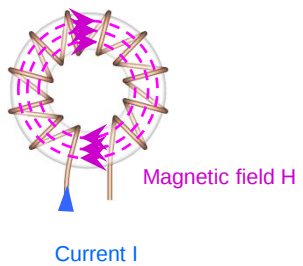
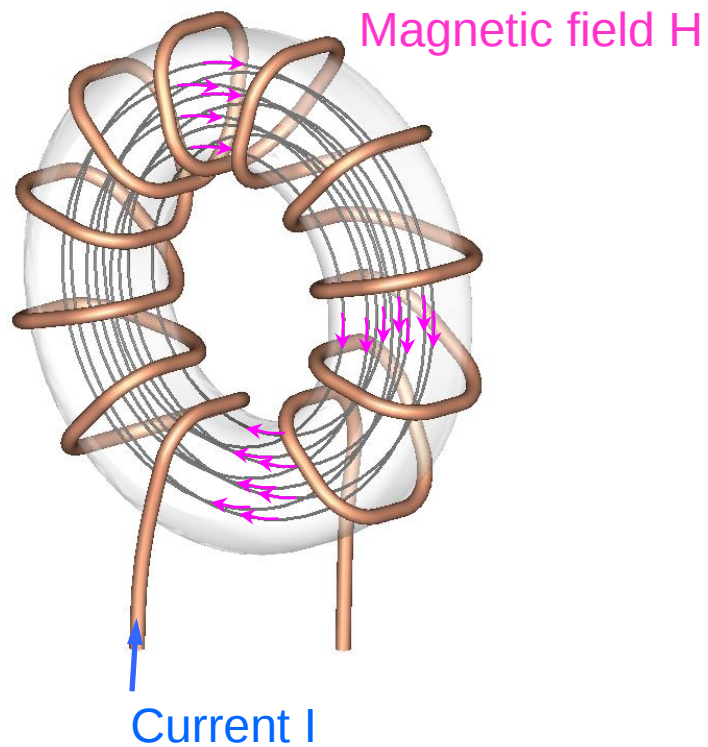


Field model



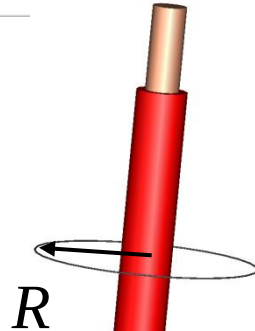
The magnetic field

Field model



The magnetic field

Straight wire

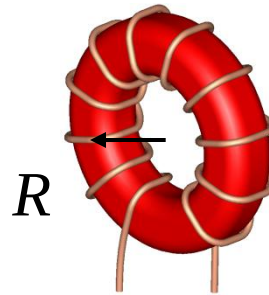


$$H = \frac{I}{2 \cdot \pi \cdot R}$$

The magnetic field strength is depending from:

- Geometries
- No. of turns
- Current

Toroidal

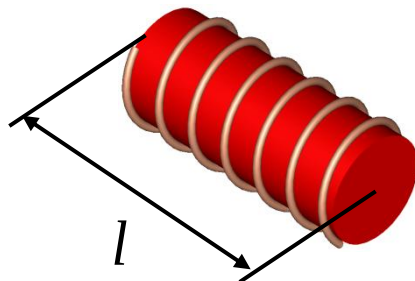


$$H = \frac{N \cdot I}{2 \cdot \pi \cdot R}$$

but

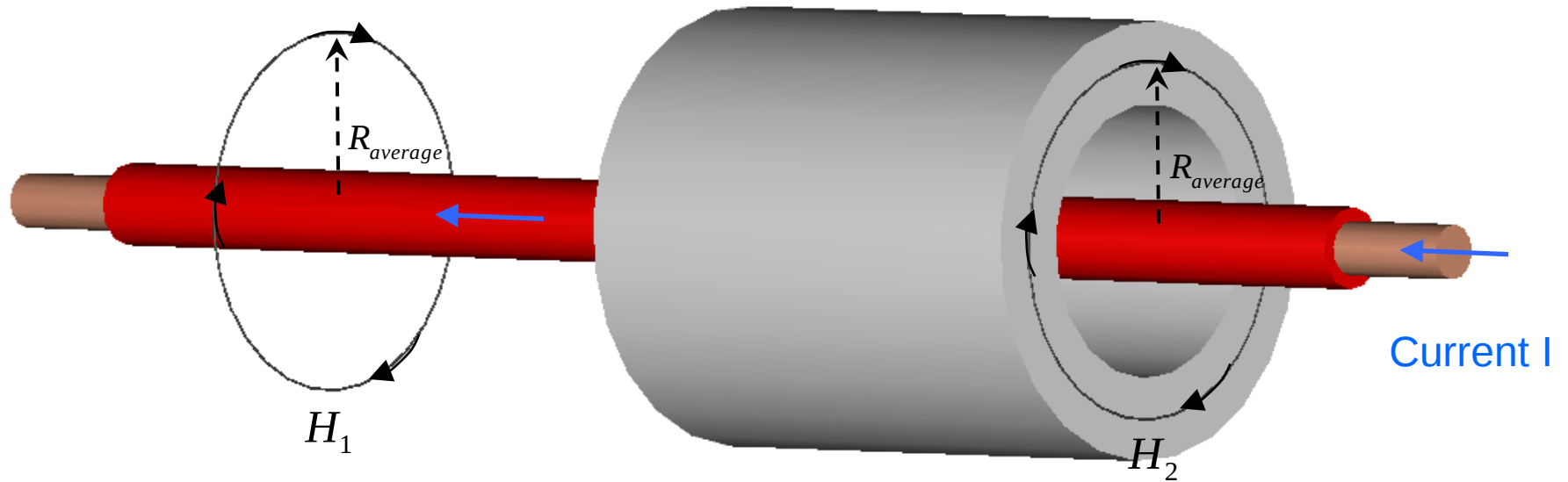
NOT ON MATERIAL

solenoid



$$H = \frac{N \cdot I}{l}$$

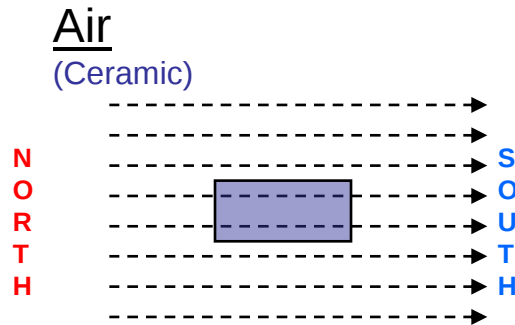
The magnetic field



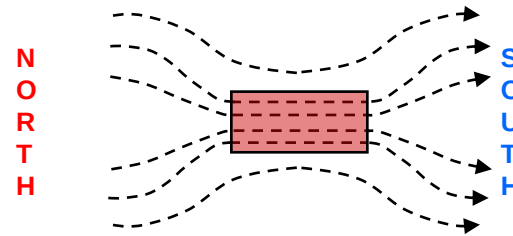
$$H_1 = H_2 = H = \frac{I}{2 \cdot \pi \cdot R_{average}}$$

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

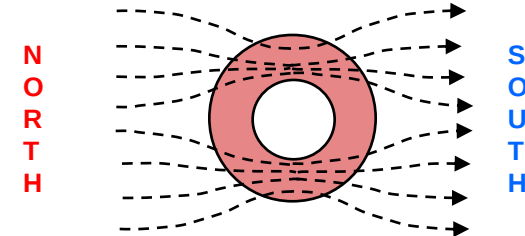
The magnetic field



Rod core ferrite



Ring core ferrite



Induction in air:

$$B = \mu_0 \cdot H$$

linear function, because $\mu_r = 1 = \text{constant!}$

Induction in a ferrite:

$$B = \mu_0 \cdot \mu_r \cdot H$$

**material-
frequency-
temperature-
current-
pressure-**

-dependant parameter

The relative permeability is a:

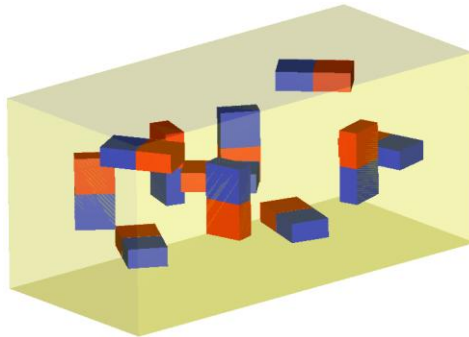
What is permeability?

Relative permeability

- describe the capacity of concentration of the magnetic flux in the material.
- it is a energy factor to magnetize the material

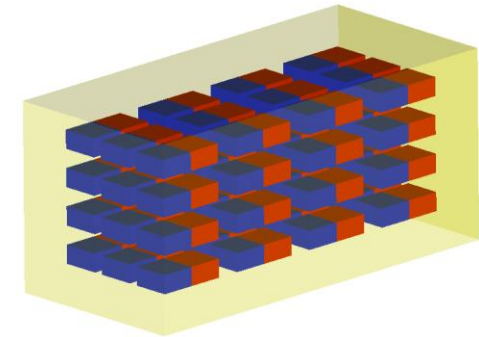
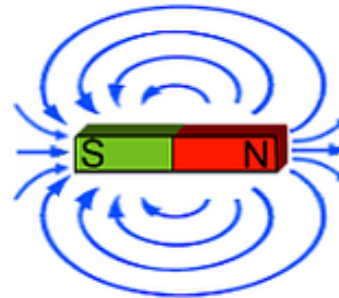
$$\mu_r = \frac{1}{\mu_0} \frac{\Delta B}{\Delta H}$$

Ferrite material



- un ordered (random position)
- soft magnetic

Permanent magnet



- ordered
- hard magnetic

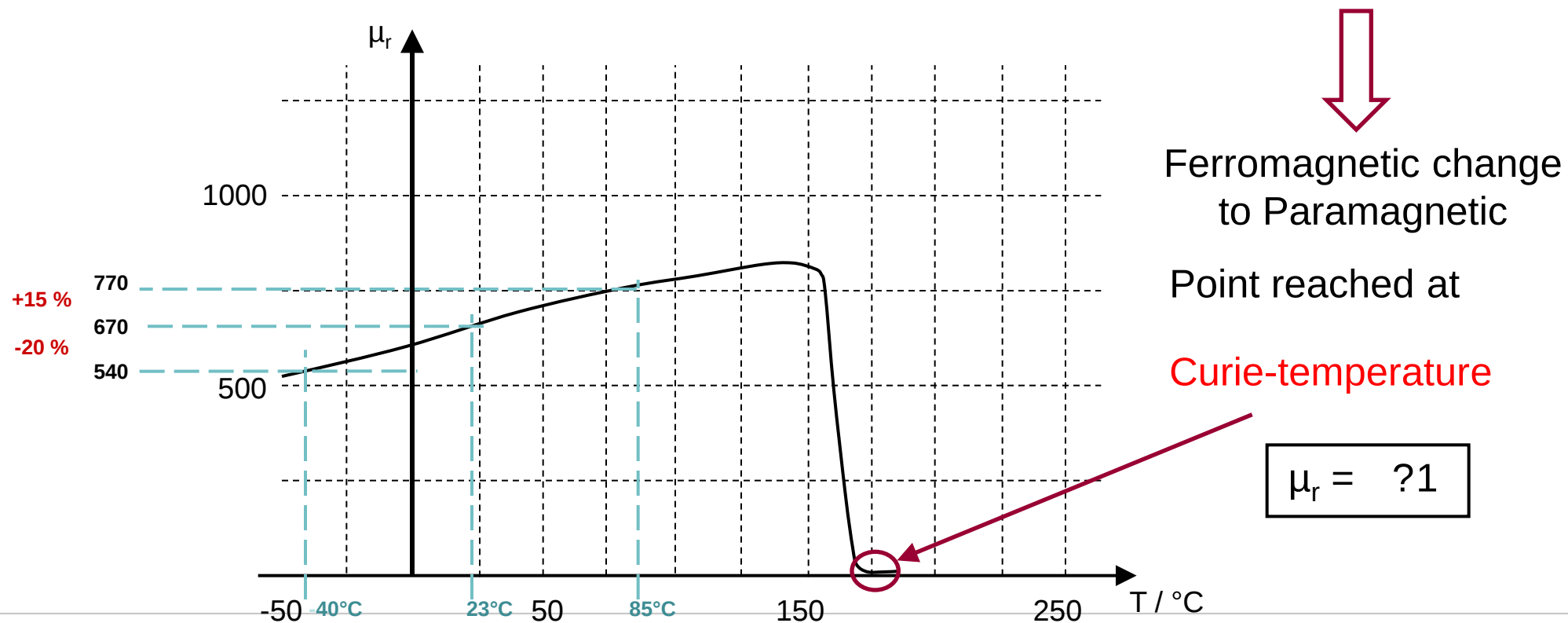
Typical permeability μ_r :

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

Permeability – Core material parameter

Temperature influence

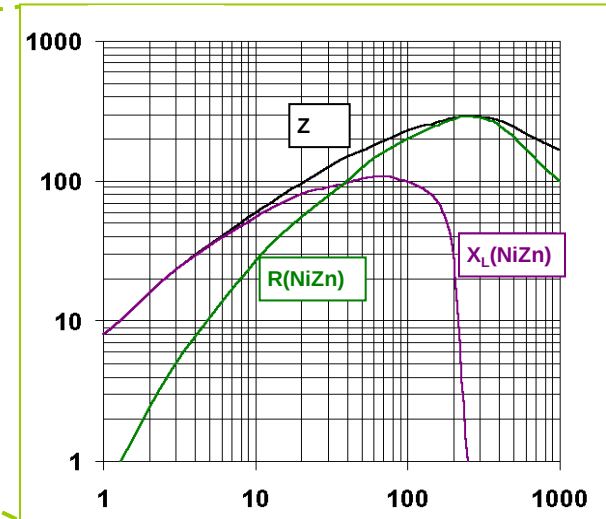
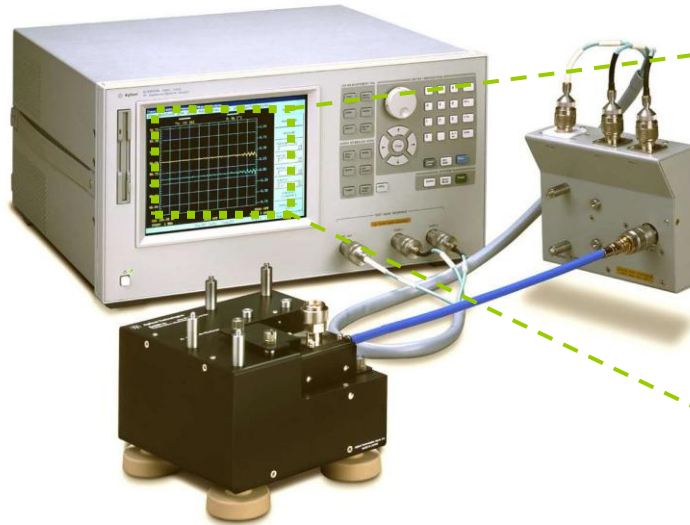
- The magnetization depends from the temperature



Permeability – complex permeability



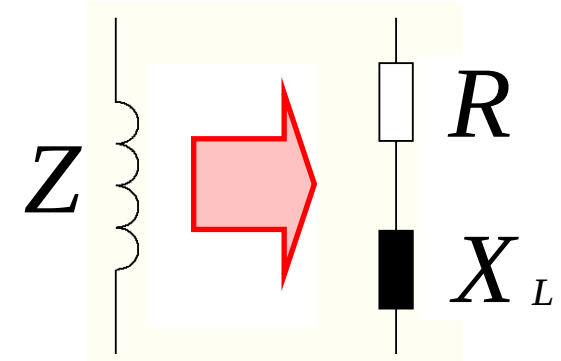
=1 turn



Core material-Parameter

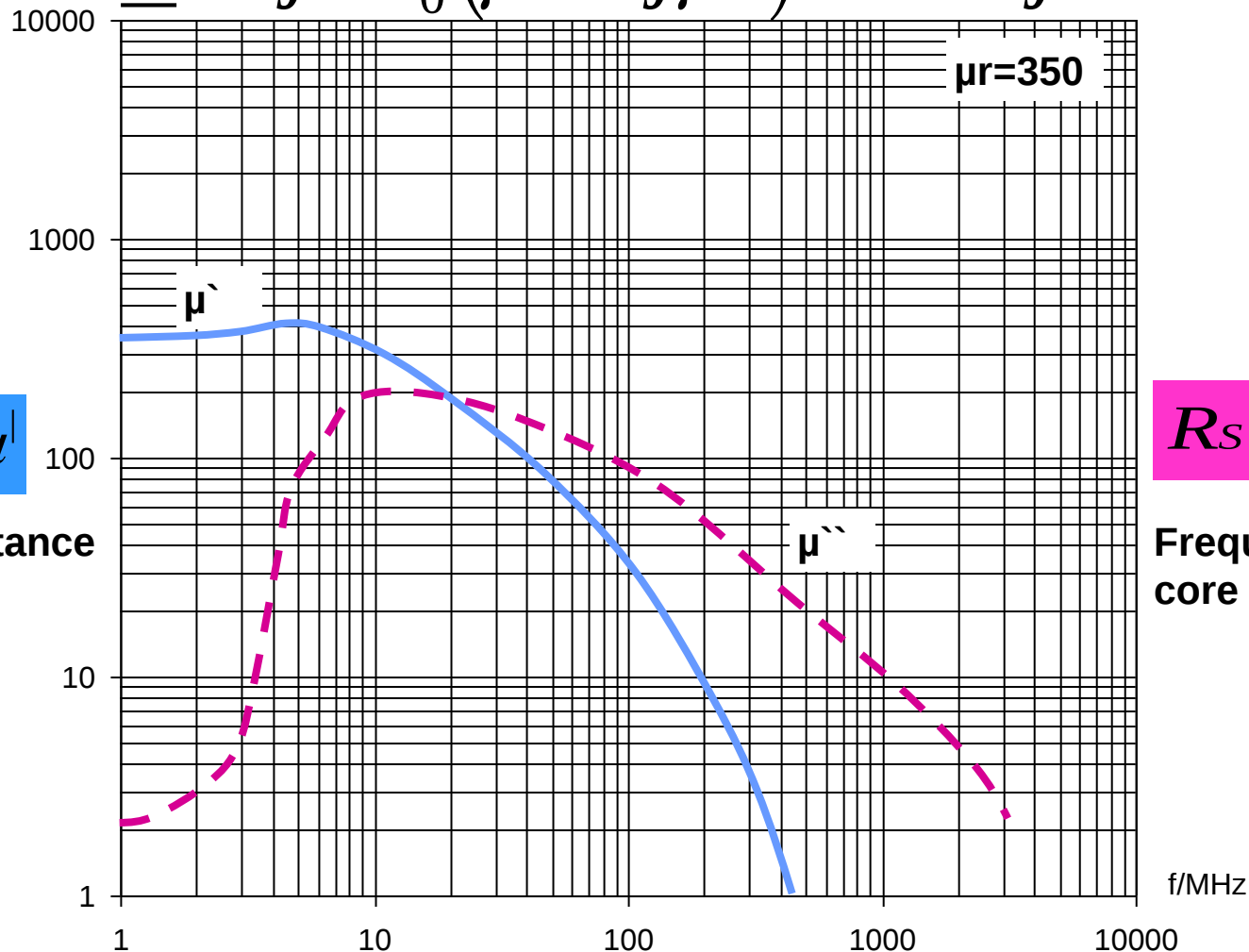
Replacement circuit

$$Z = \sqrt{R^2 + X_L^2}$$



Permeability – complex permeability

$$\underline{Z} = j\omega L_0 (\mu' - j\mu'') = R + jX$$



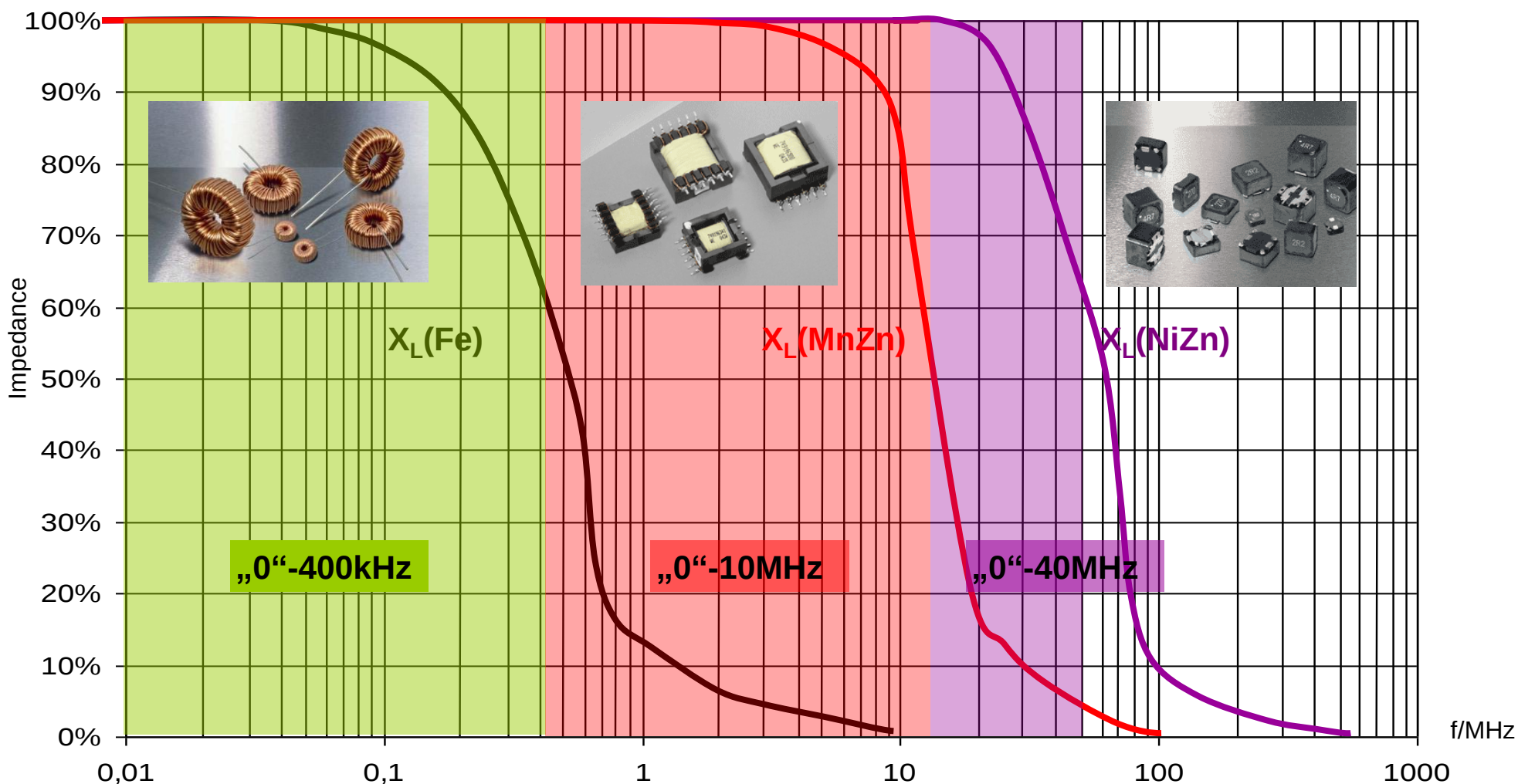
$$X_{LS} = \omega L_0 \mu'$$

Inductance reactance
(Magnetize ability)

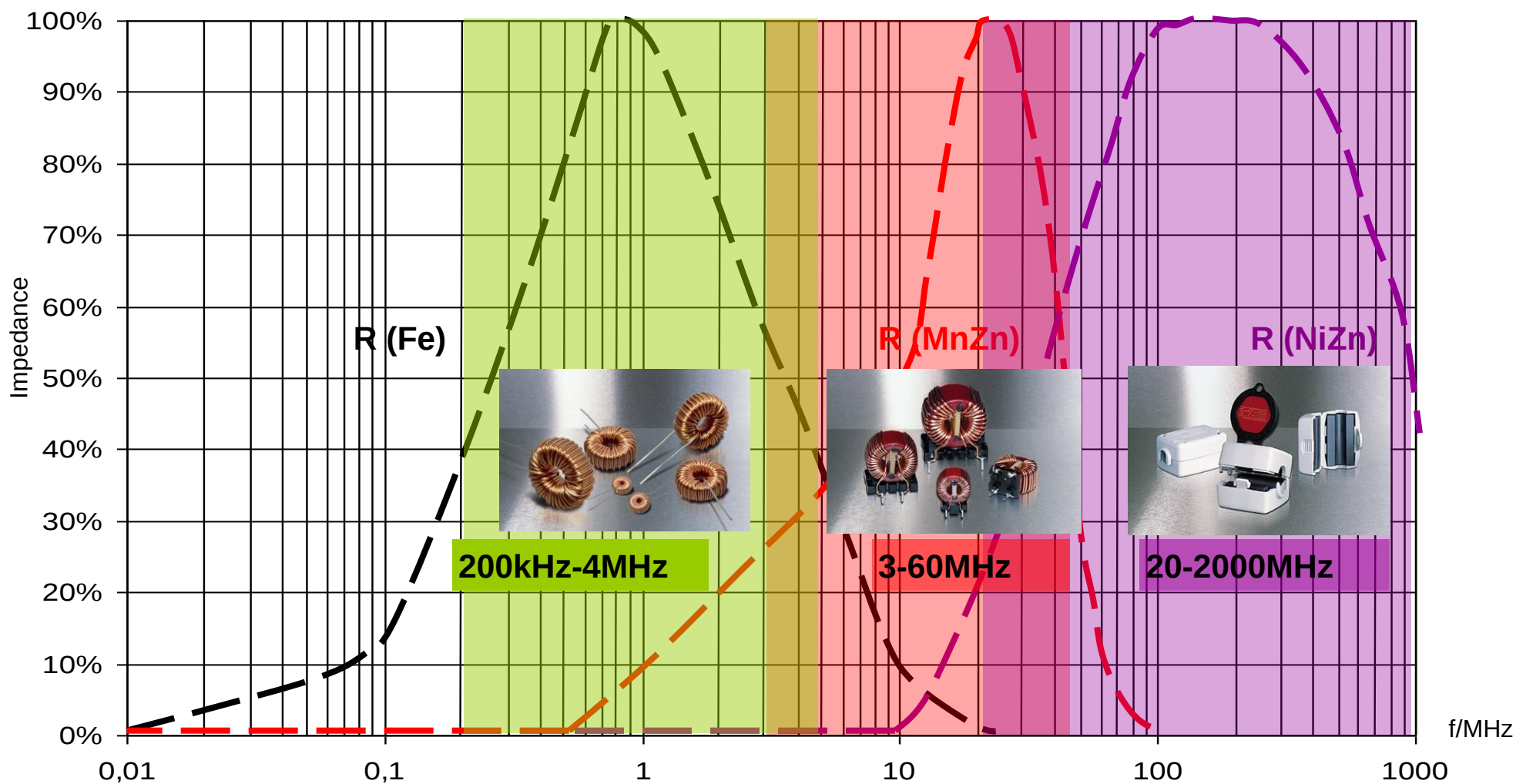
$$R_s = \omega L_0 \mu''$$

Frequency dependent core losses (hysteresis loss)

Core material – Inductors (Storage)



Core material – Choke (Filter)



Core material – Inductor / EMC-Ferrite

1. Application: **Storage inductor**

Request: - lowest possible core losses at switching frequency

2. Application: **Signal filter** for RF-stage

Request: - low losses to signal=> high Q

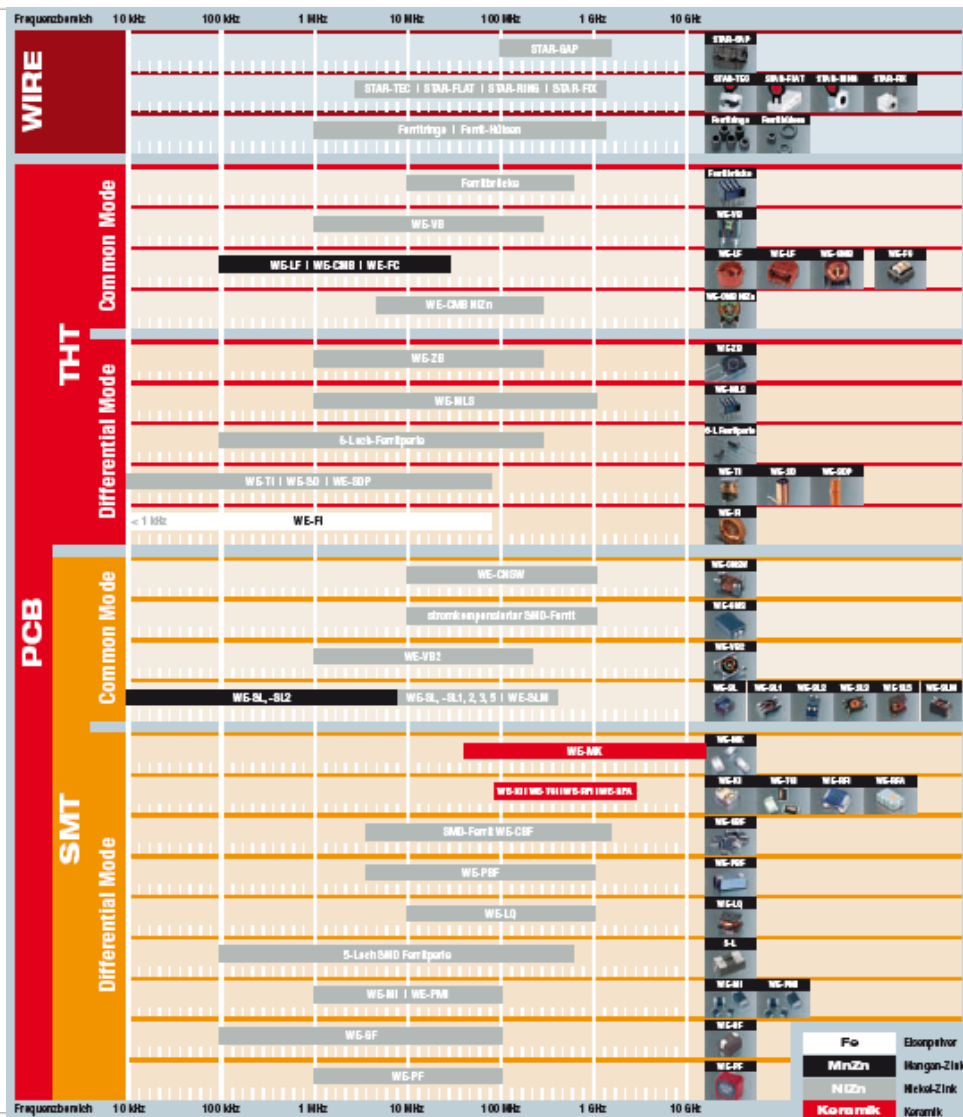
3. Application: **Absorber / Filter**

Request – highest possible core losses at application frequency

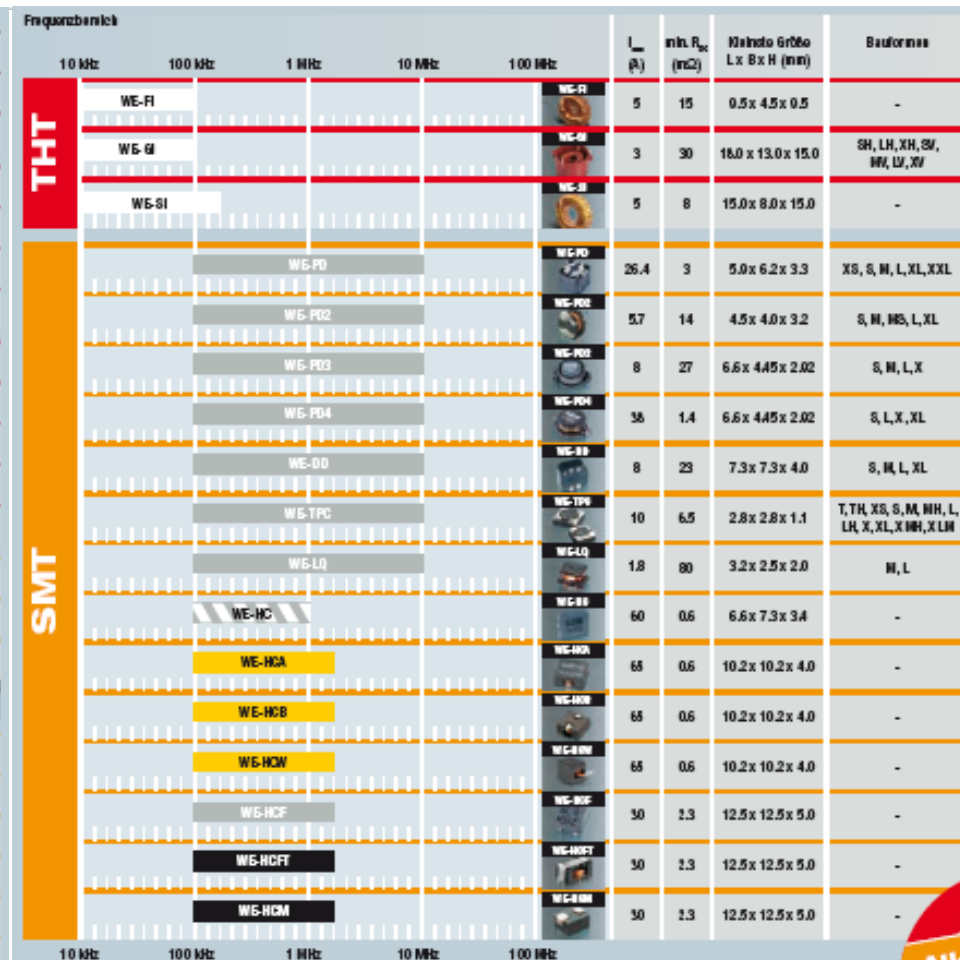
Core materials – Application



Filter



Storage inductor



Fe

Eisenpulver

MnZn

Mangan-Zink

NiZn

Nickel-Zink

Keramik

Keramik



FILTER & SIGNAL

Filter - basics

The energy can not disappear it will be just transformed into other energy form
→ energy conservation law

- e.g. electrical energy transformed into → thermal energy



- the core losses from ferrite transform the noise energy into heat

MAIN AIM:

Noise energy should not occur at all!

Filter - basics

What means filtering?

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

Complexity?

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

Structured interference suppression

- **Recognize the coupling mode:**
 - **common mode noise**
 - **differential mode noise**

How can we find out what interference we have?

Common mode or differential mode?

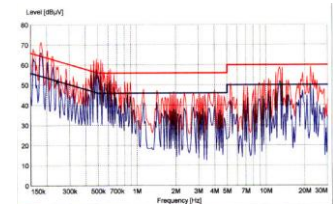
Take a Snap Ferrite and fix it on the cable
(both lines e.g. VCC and GND)

if noise is reduced or
noise immunity increase

you have Common Mode Interference

If not

you have Differential Mode Interference



e.g. Common mode
choke

e.g. chip bead ferrite

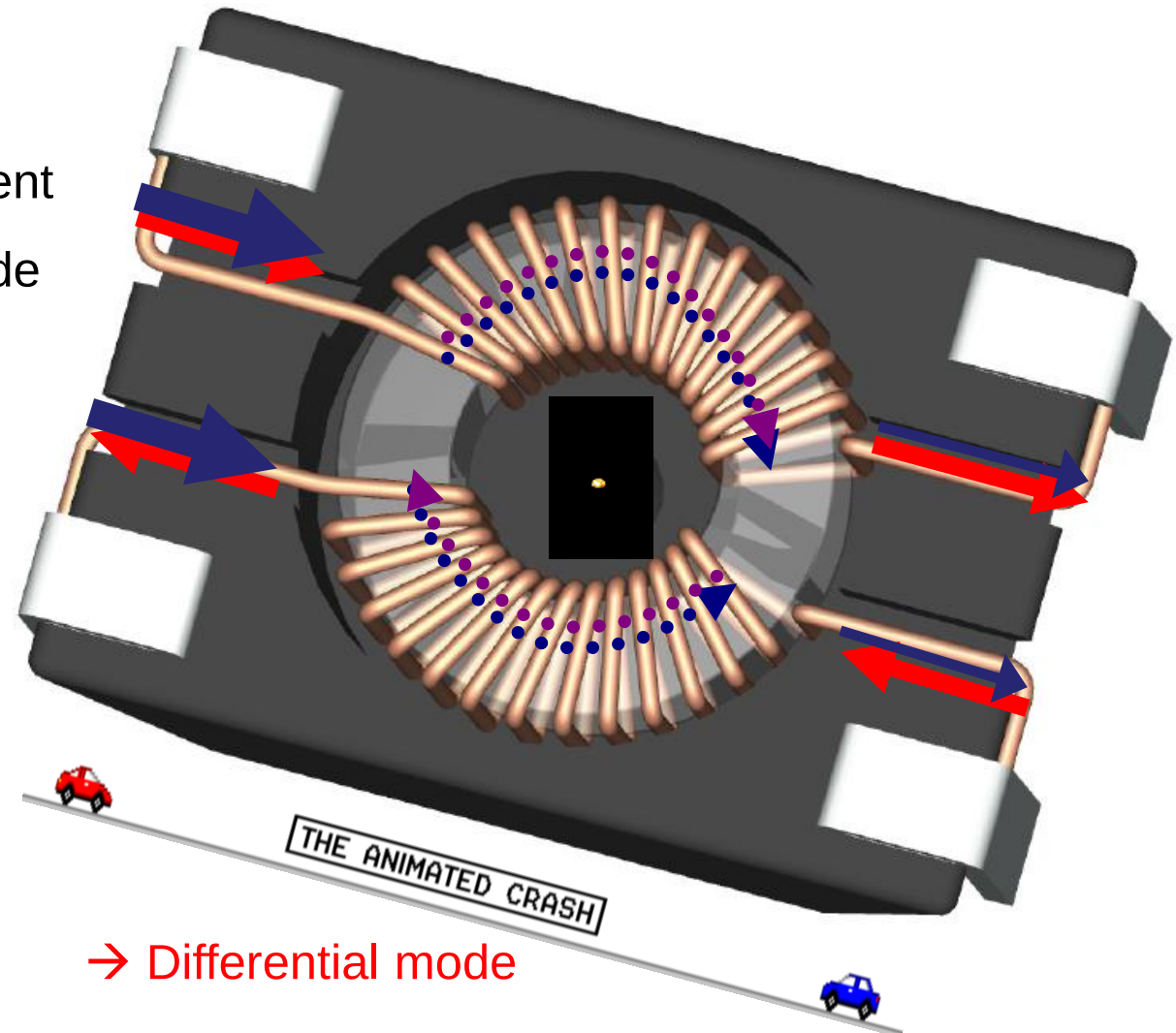
Common Mode Filter – Signal theories

Less noise

- From device to outside environment
- From outside environment to inside device

Conclusion:

- “almost” no affect the signal
- high attenuation to the noise



→ Differential mode

→ Common mode

Common mode choke - construction

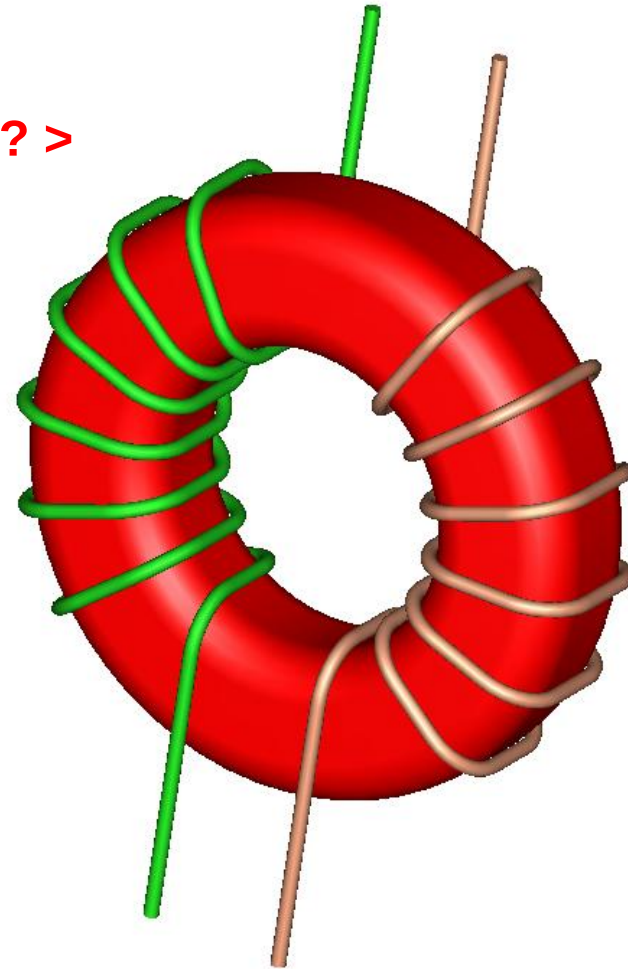
bifilar



$$L_{\text{leak}} \sim 0,01 \dots 0,1 \% * L_R$$

< ? Advantage ? >

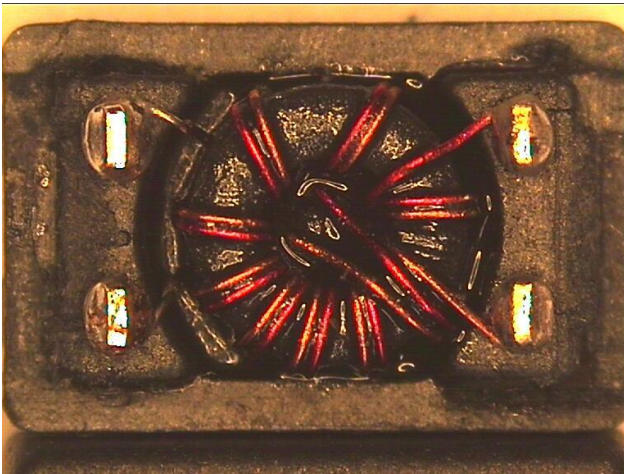
sectional



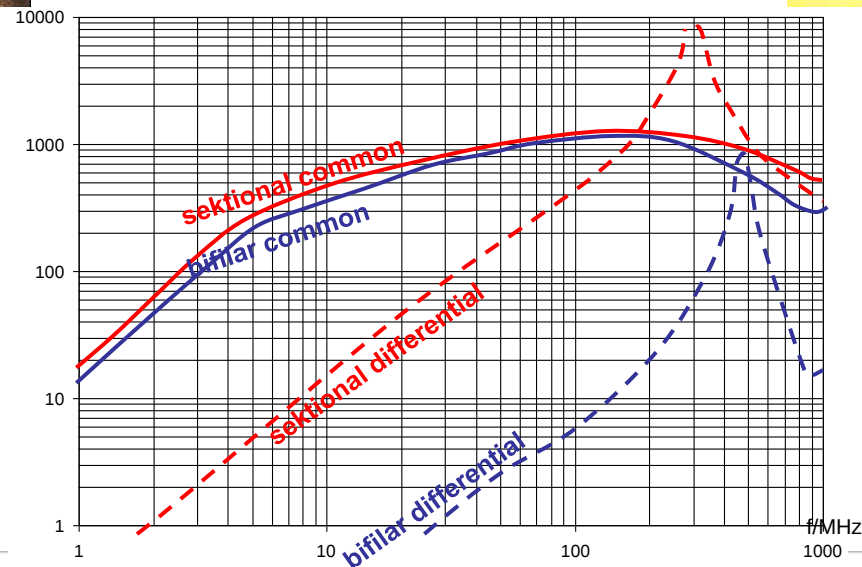
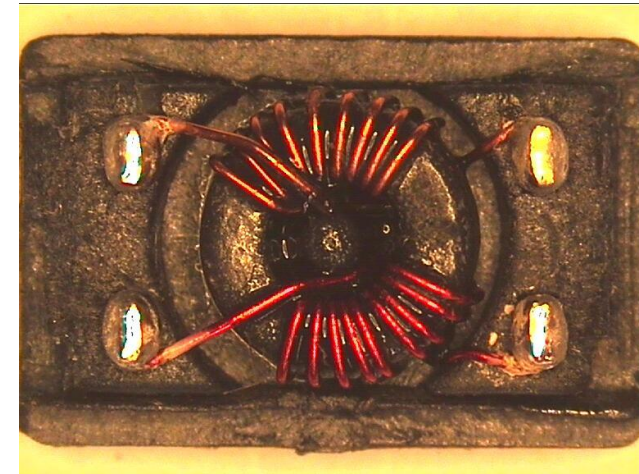
$$L_{\text{leak}} \sim 0,5 \dots 2\% * L_R$$

Common mode choke - construction

WE-SL2 744227
bifilar winding



WE-SL2 744227S
sectional winding



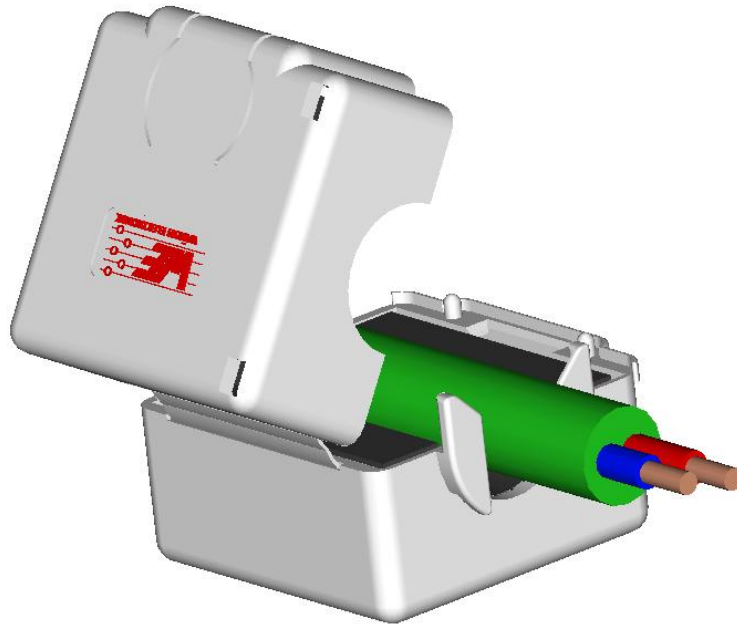
Common mode choke - construction

WE-Star TEC split ferrite → Is that an CMC?

- Yes, CMC with one winding

e.g. 74271712

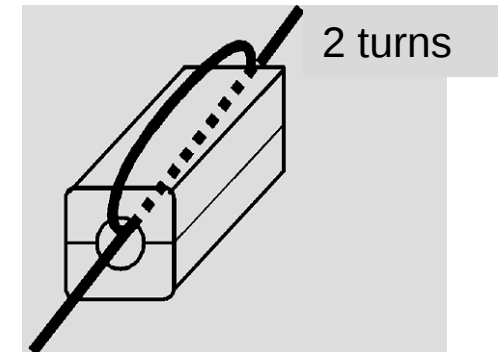
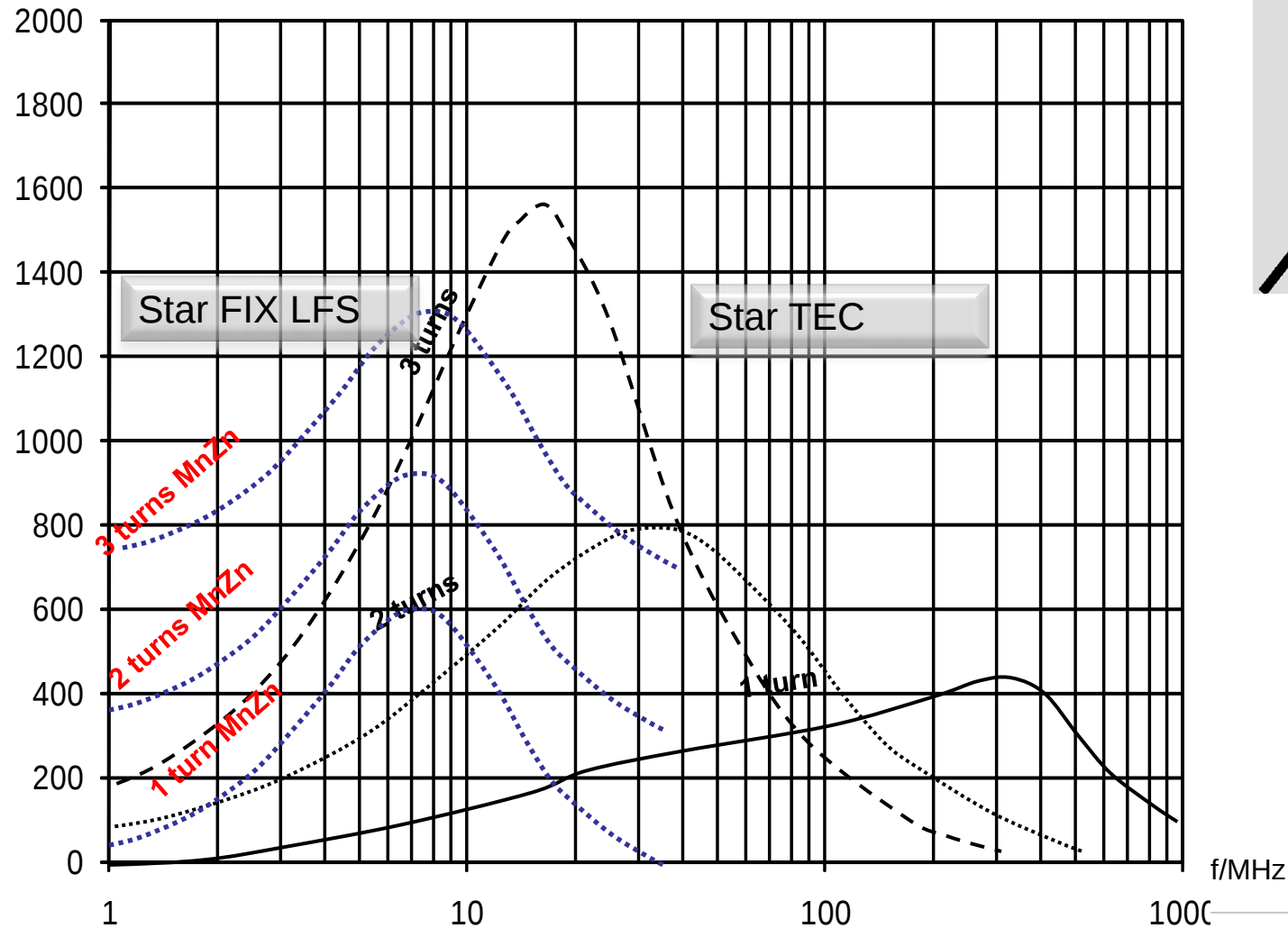
Comparable with bifilar winding CMC



- Both absorbs Common Mode Interferences

Common mode choke: ferrite core

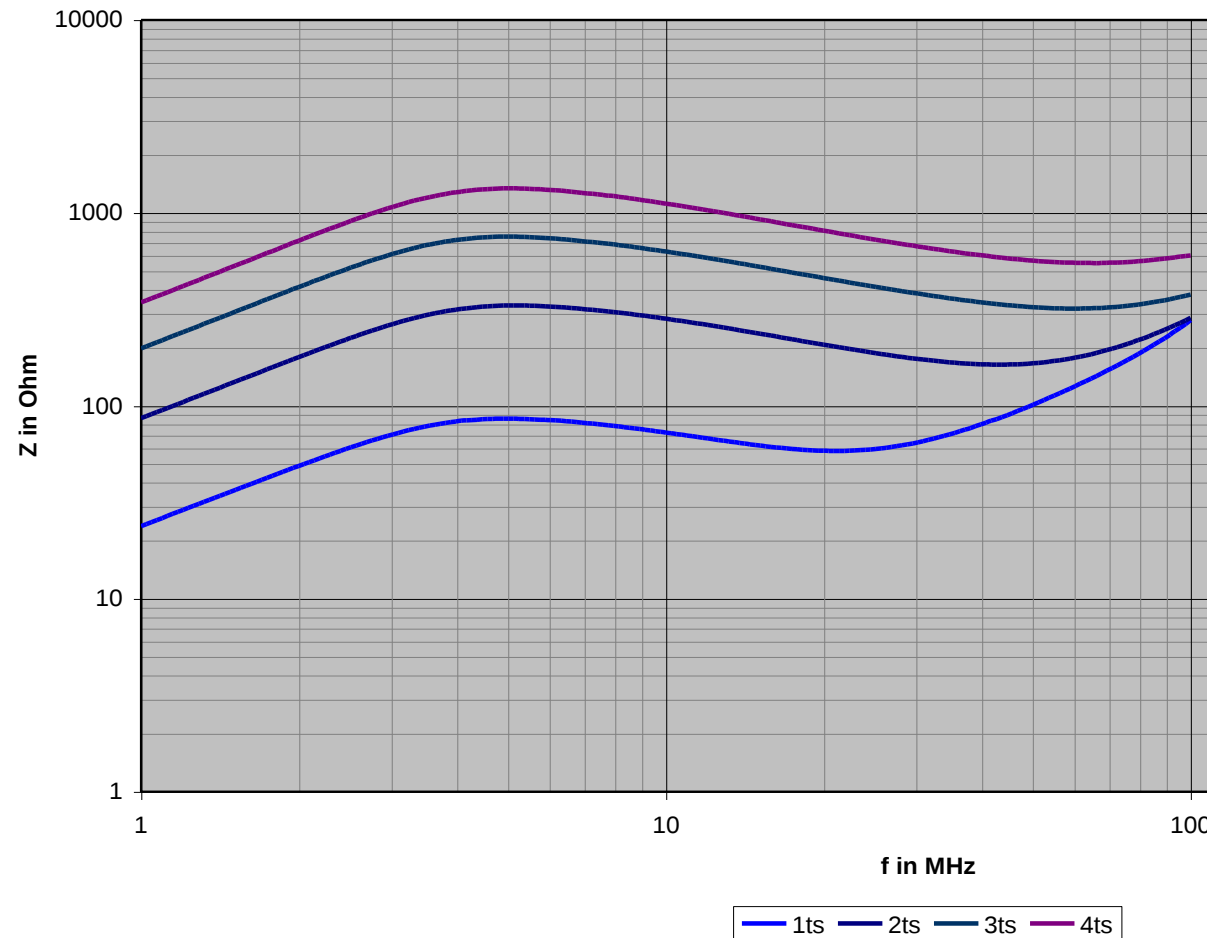
Increase the no. of turns means:



Snap ferrite Star FIX-LFS using MnZn core

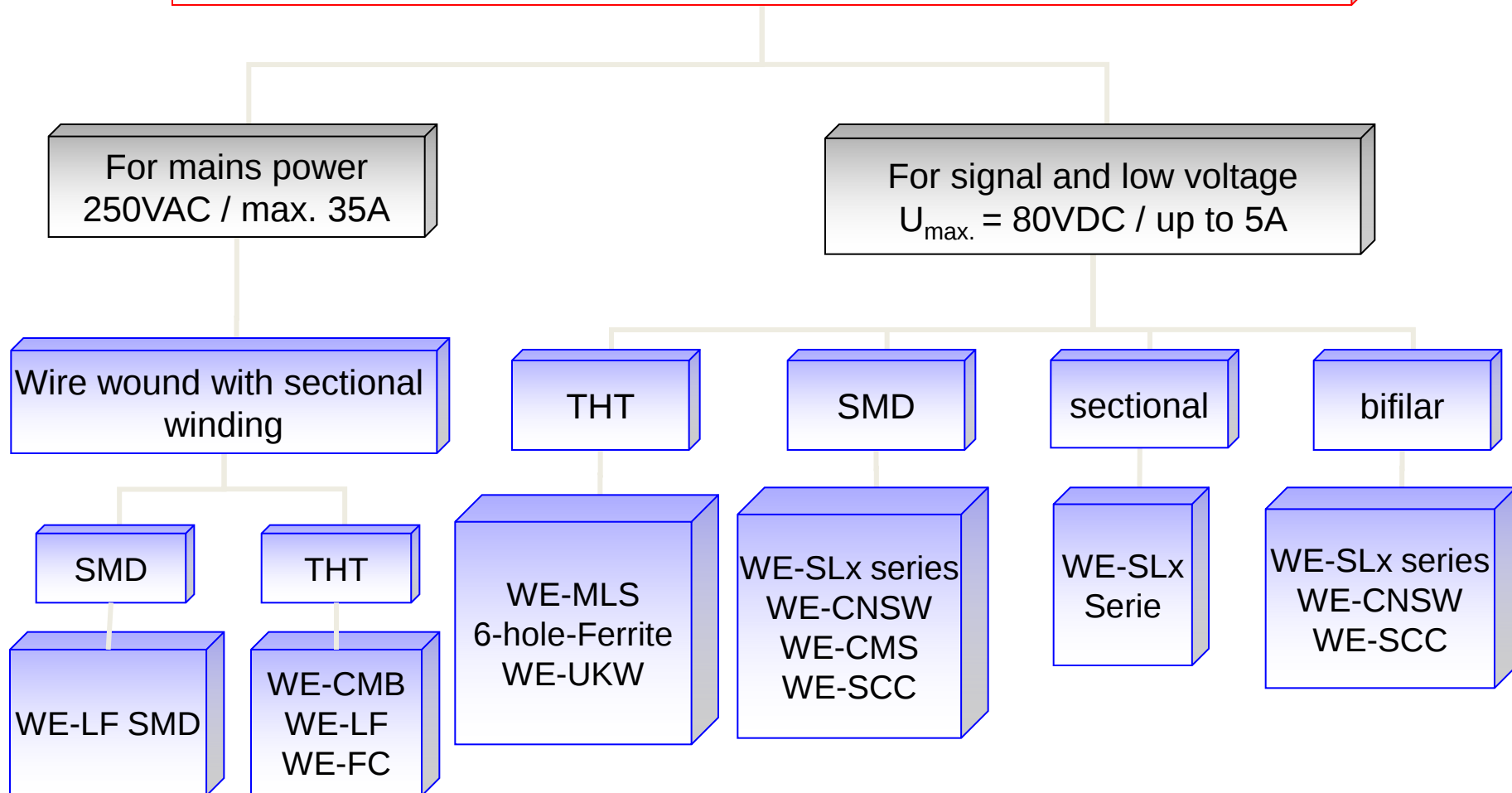
Impedance influence by increasing the no. of turns

74272733



Common Mode Chokes – line card

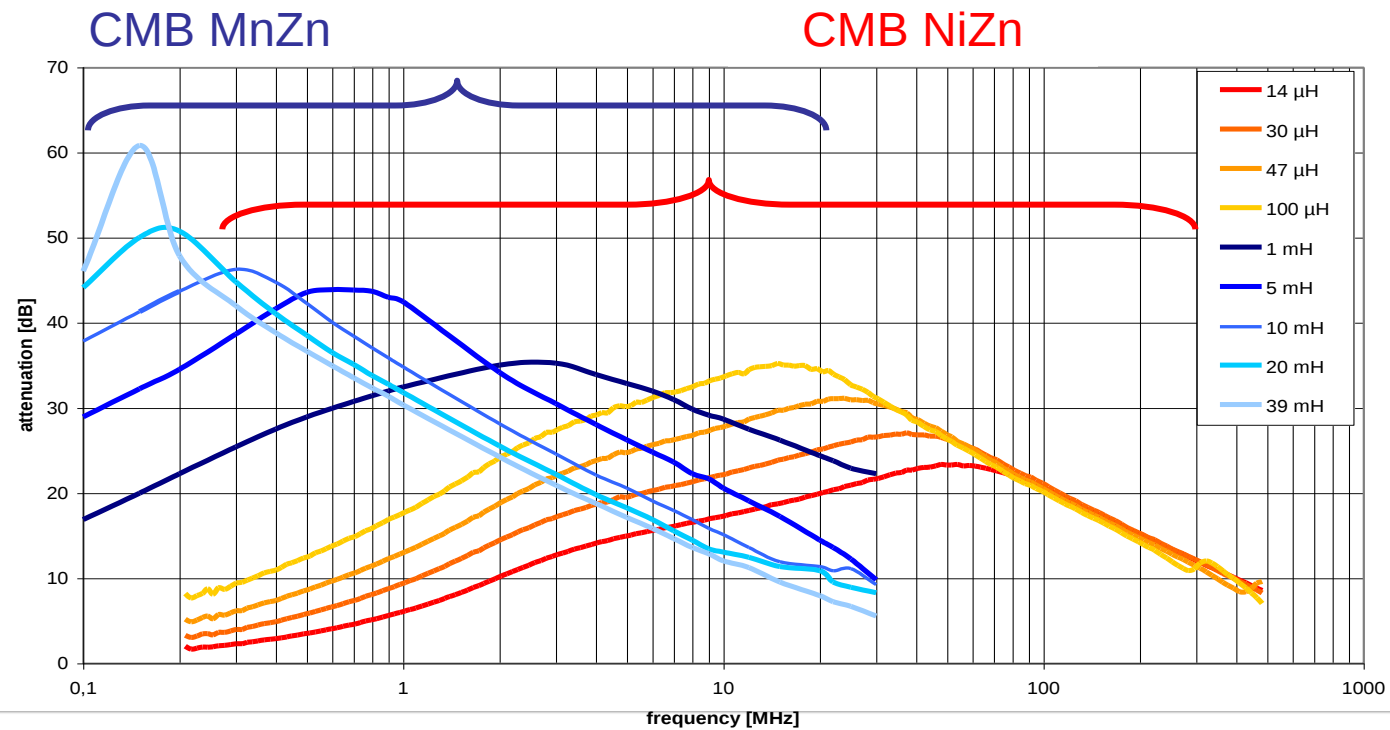
CMC produced by Würth Elektronik eiSos



Common mode chokes – line card



WE-CMB NiZn Type S

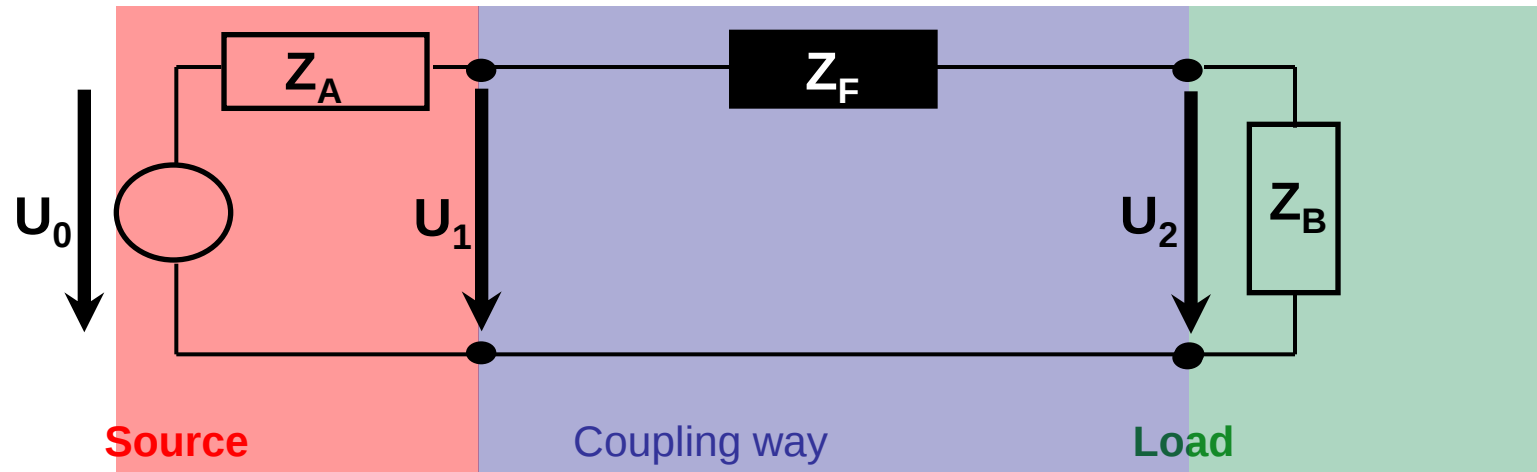




INSERTION LOSS

Insertion loss - Definition

Mathematic definition



- System attenuation

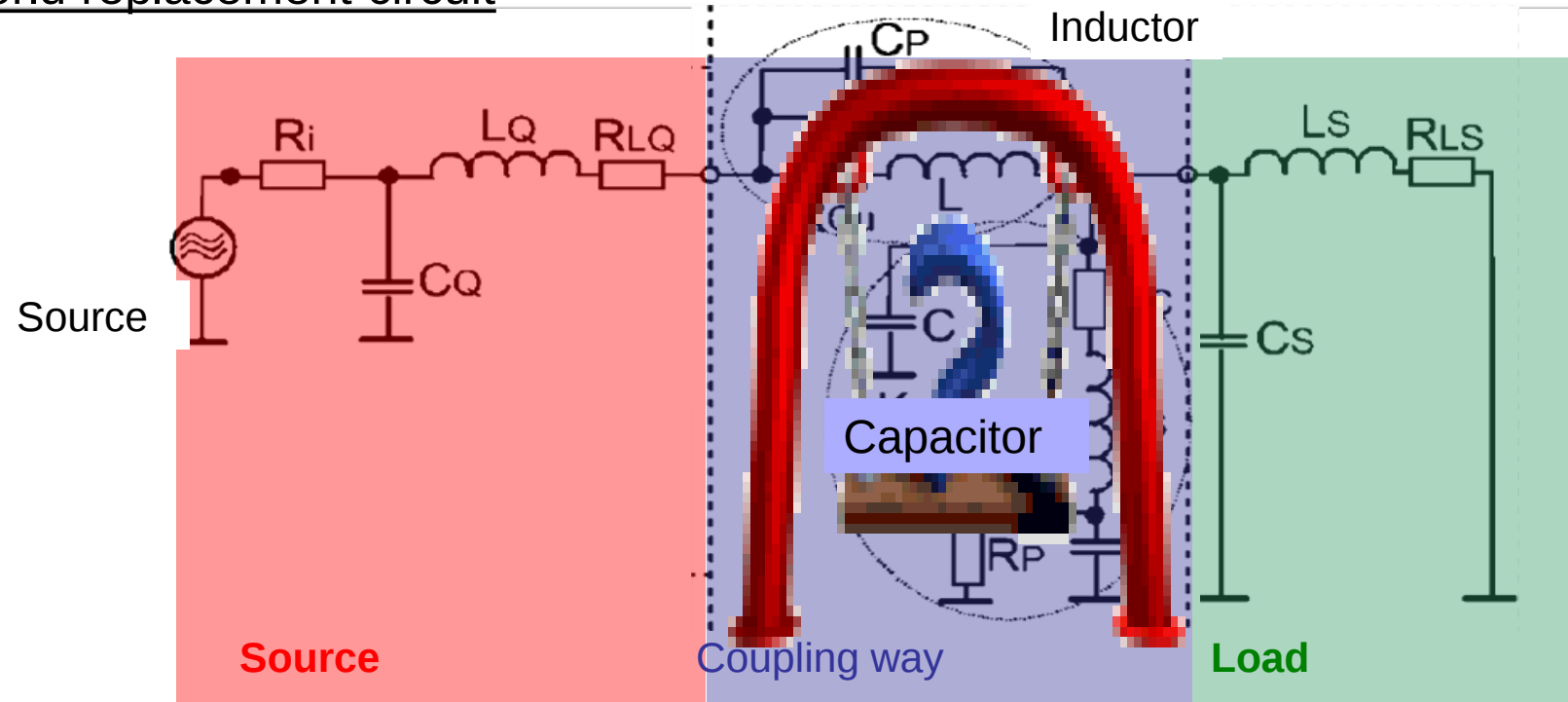
$$A = 20 \cdot \log \frac{Z_A + Z_F + Z_B}{Z_A + Z_B} \quad \text{in (dB)}$$

- Impedance

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

Insertion loss - Definition

The real world replacement circuit



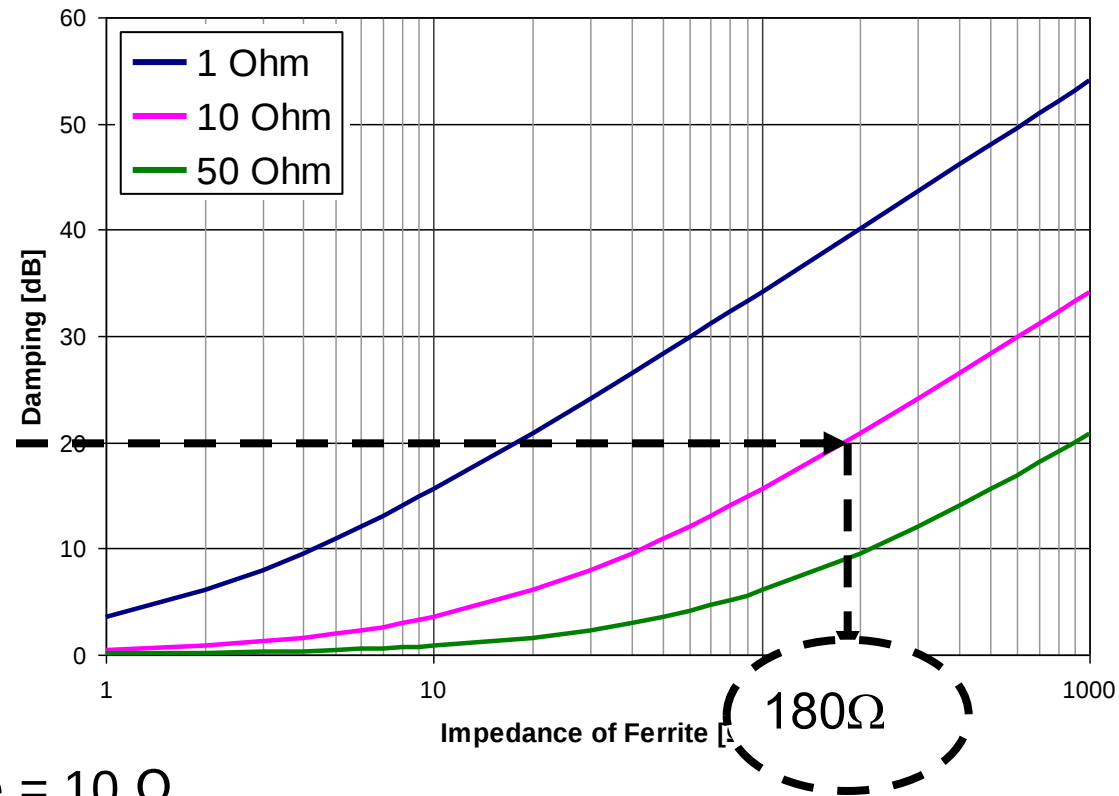
- Practical values for source and load impedance

→ Grounding planes	1 ... 2 Ω
→ Vcc distribution	10 ... 20 Ω
→ Video- /Clock- /Data line	50 ... 90 Ω
→ long data lines	90 ... >150 Ω

Insertion loss - example

→ Application: power supply

→ 20dB @ 200 MHz

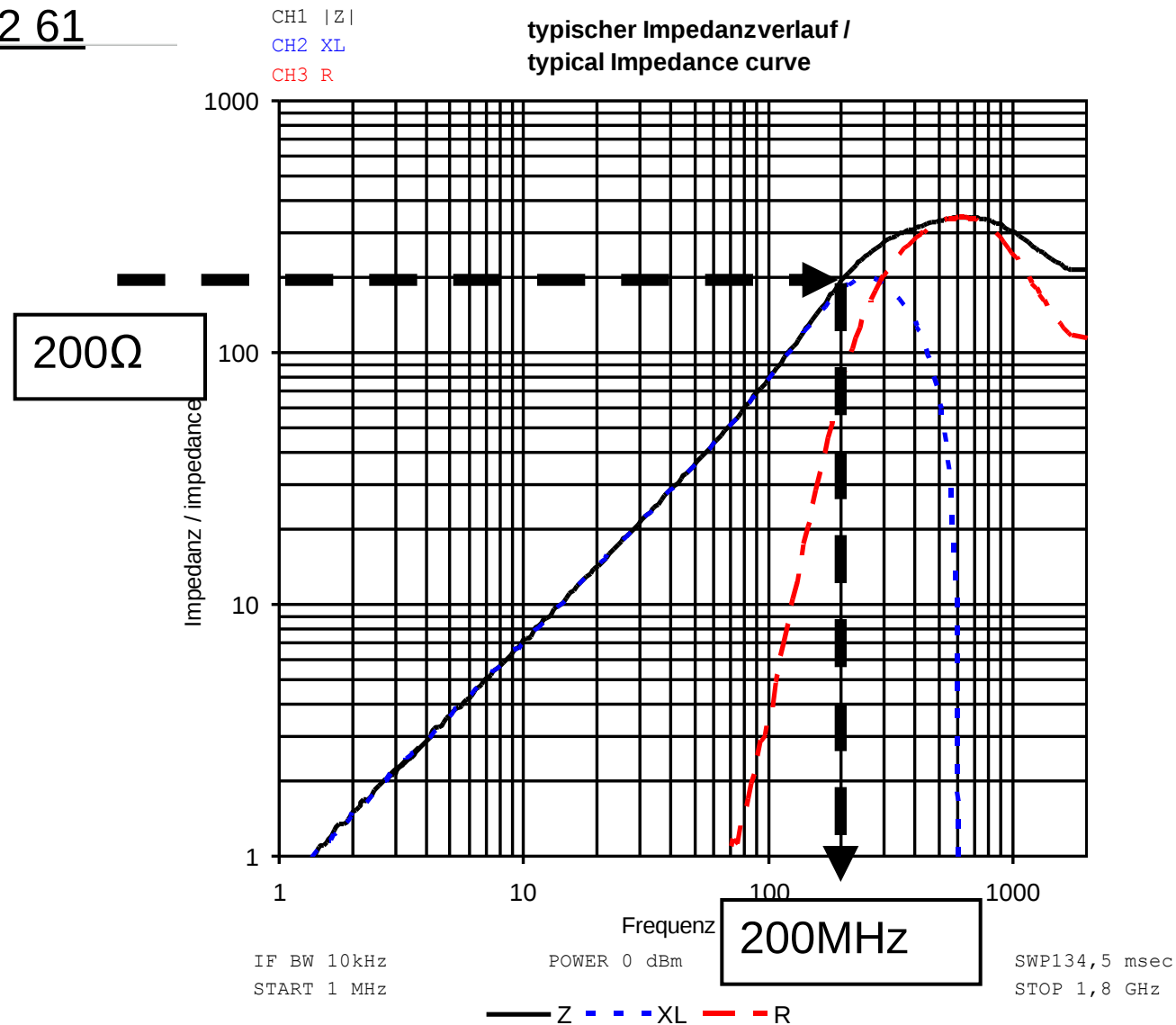


- System impedance = 10 Ω

→ Catalog: WE-CBF 742 792 61

Insertion loss - example

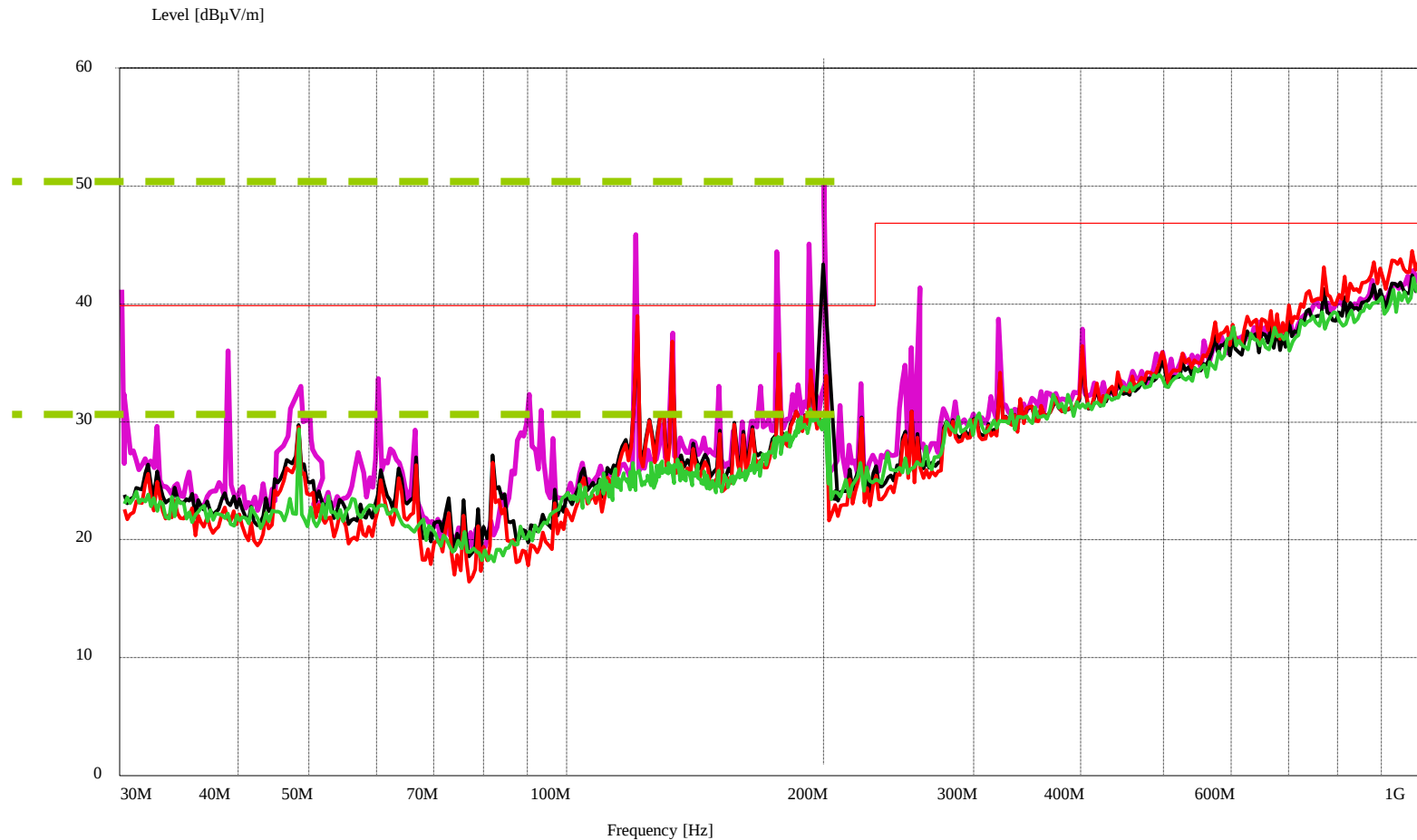
WE-CBF 742 792 61



Insertion loss - example

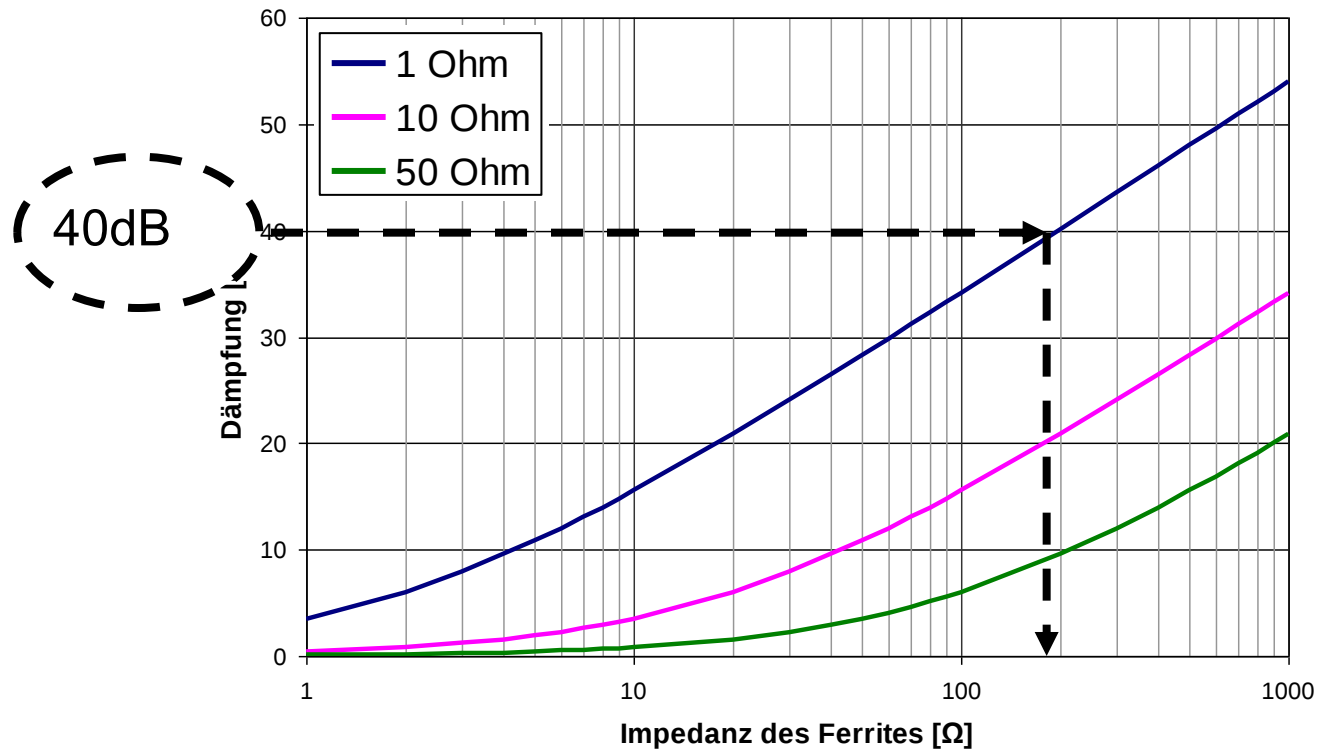
- Check the results

→ Measuring the emission and compare with the solution



Insertion loss - example

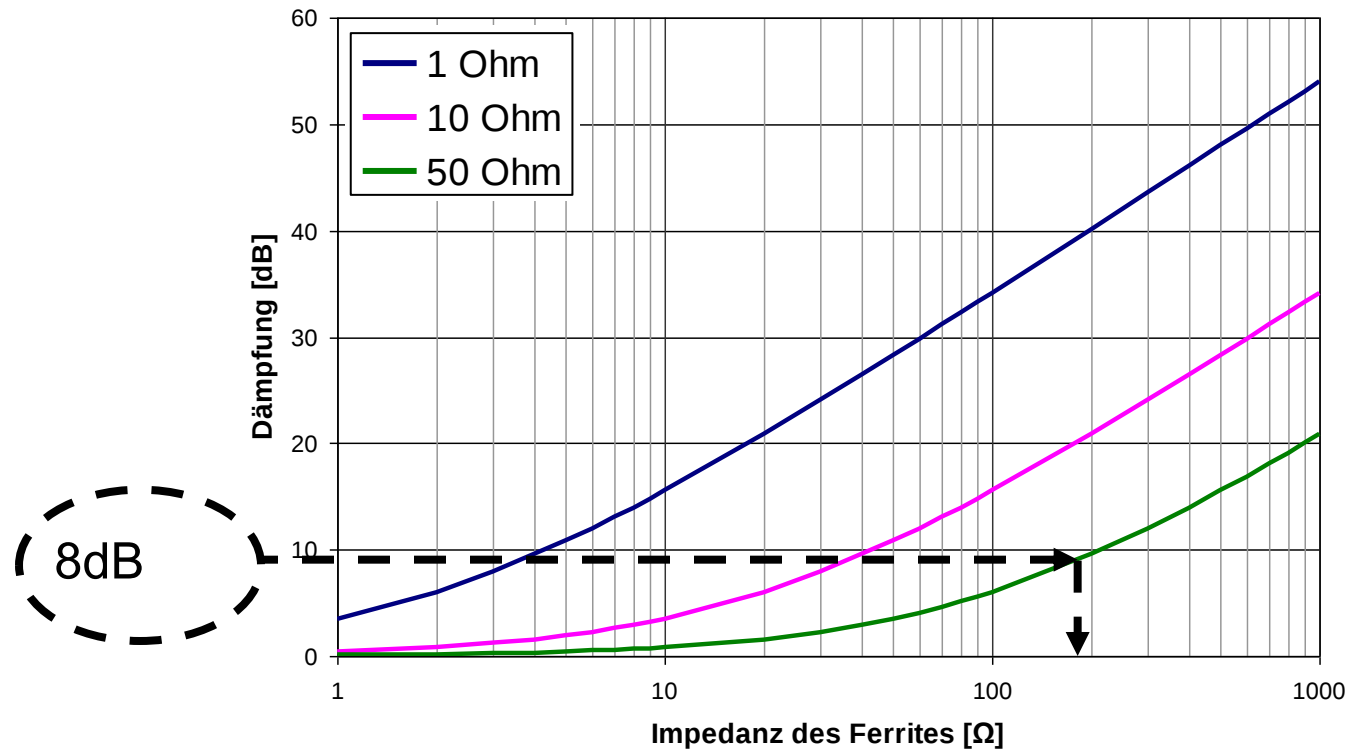
- Possibility 1: too high attenuation?



- Could be because of wrong system impedance
- reduce the impedance of ferrite

Insertion loss - example

- Possibility 2: to low attenuation

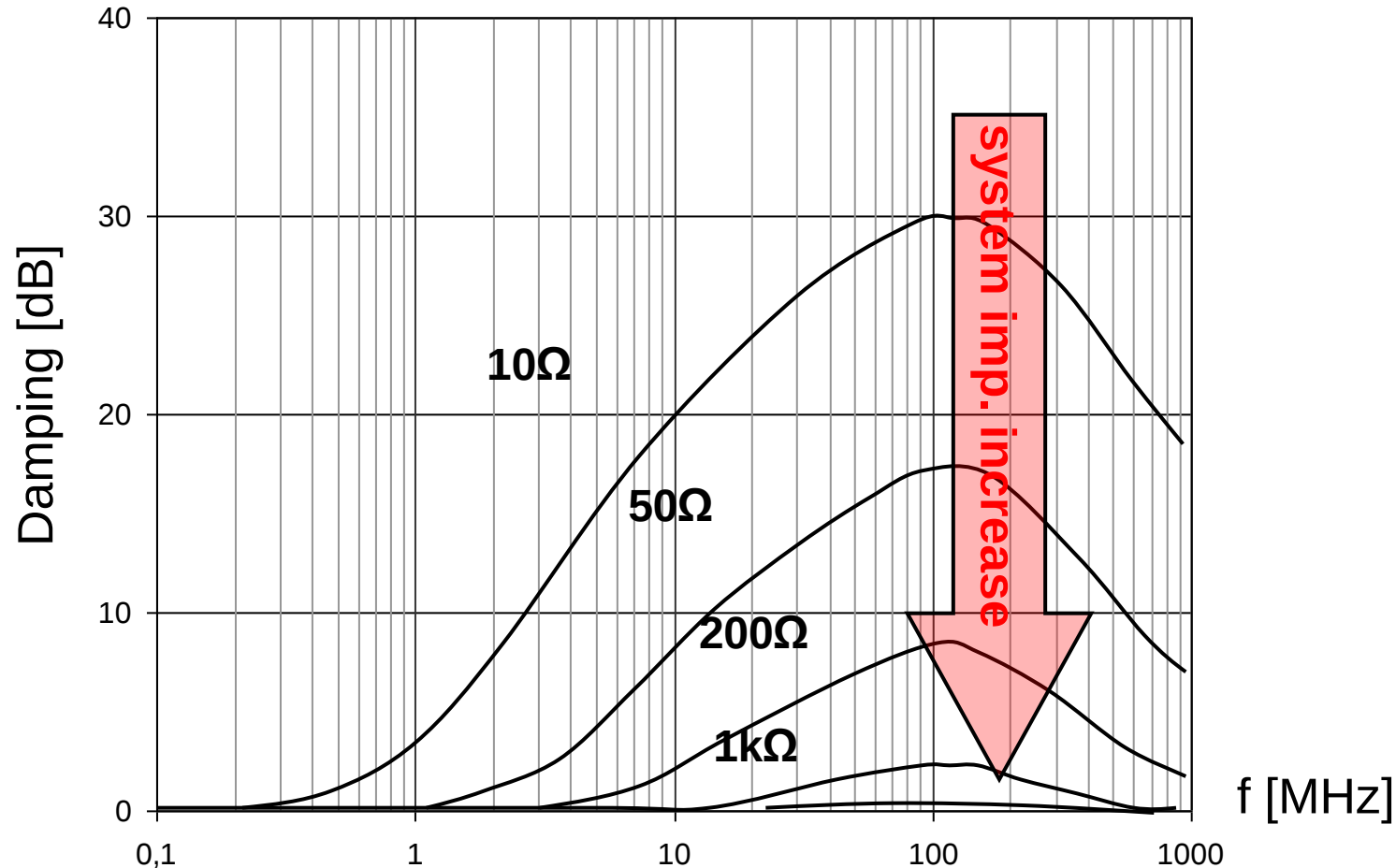


- Could be because of wrong system impedance
→ increase the impedance of ferrite ($Z_F \sim 1000 \Omega$)

Insertion loss - example

- Dependency of system impedance (Source/Load) vs. Damping

→ High system impedance generate low attenuation



→ Filtering just to a certain system impedance possible



FILTER TOPOLOGIES

Insertion loss – recommended filter topology

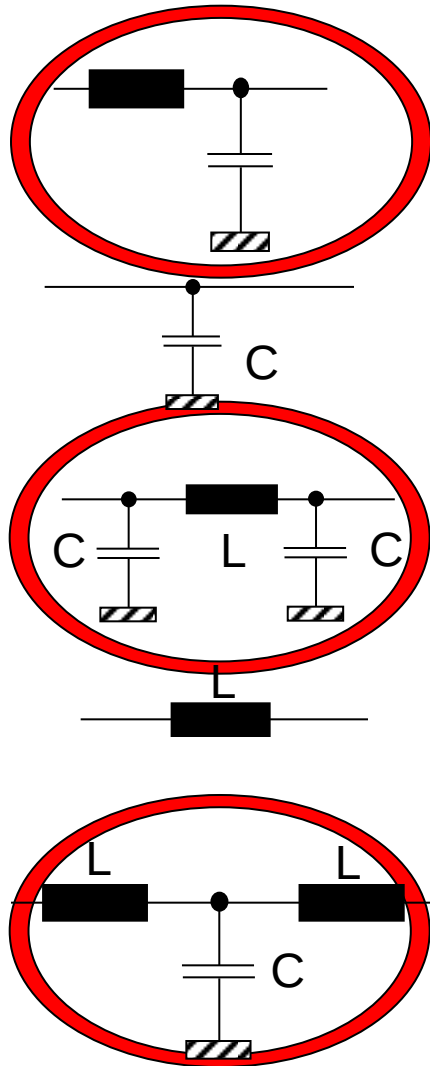
Source Impedance

low

high

high or
unknown

low

low or
unknown

Load Impedance

high

high

high or
unknown

low

low or
unknown

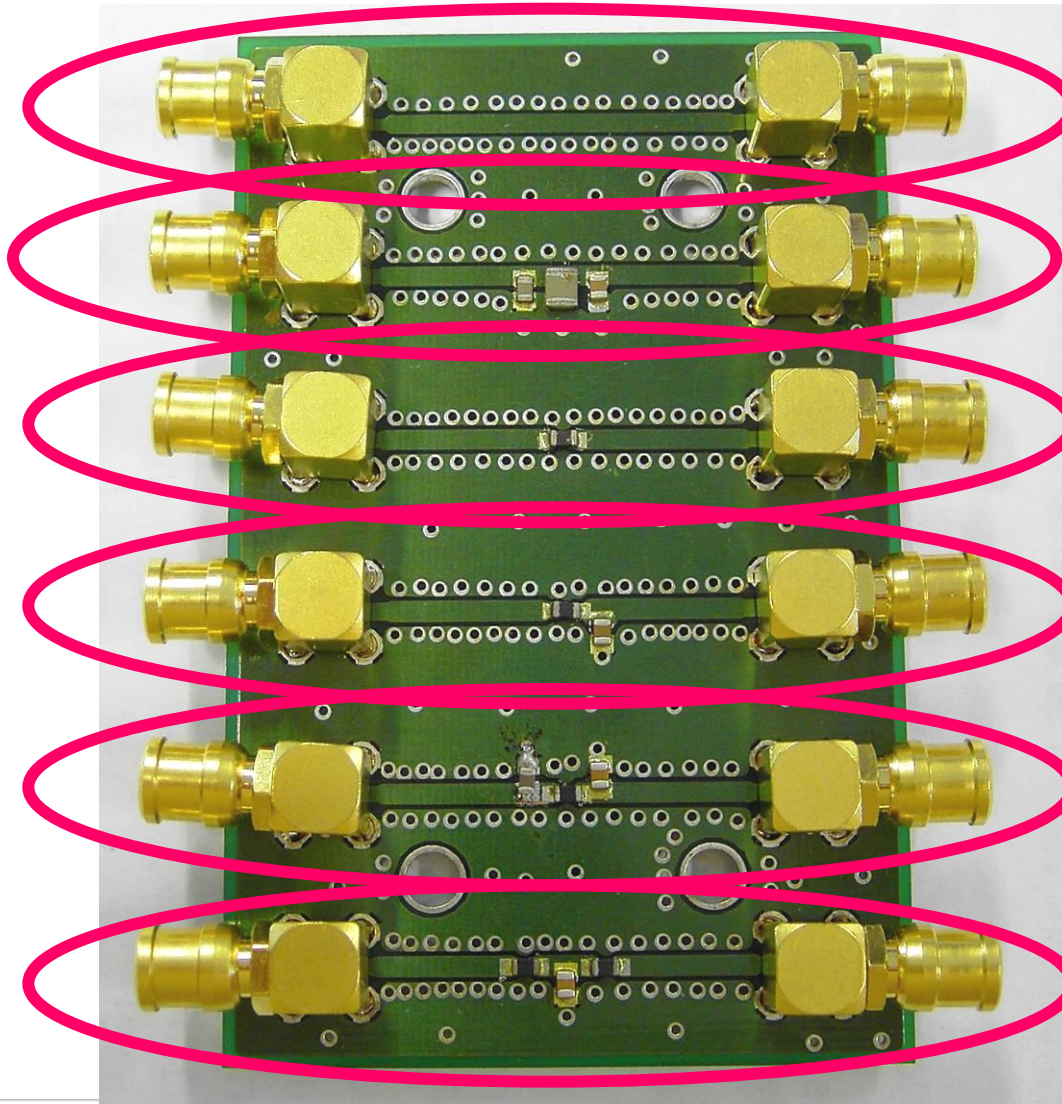
→ small C = higher SRF

Choose ferrite bead or inductors L which
 = build no resonance with C
 = wideband filter

Pay attention to:

SRF of used components

Filter topologies



50 Ohm Ref. Line

3xC Capacitance Filter

„L“ Filter with SMD
Ferrite

„L-C“ Filter with SMD
Ferrite & Capacitor

„PI“ Filter

„T“ Filter

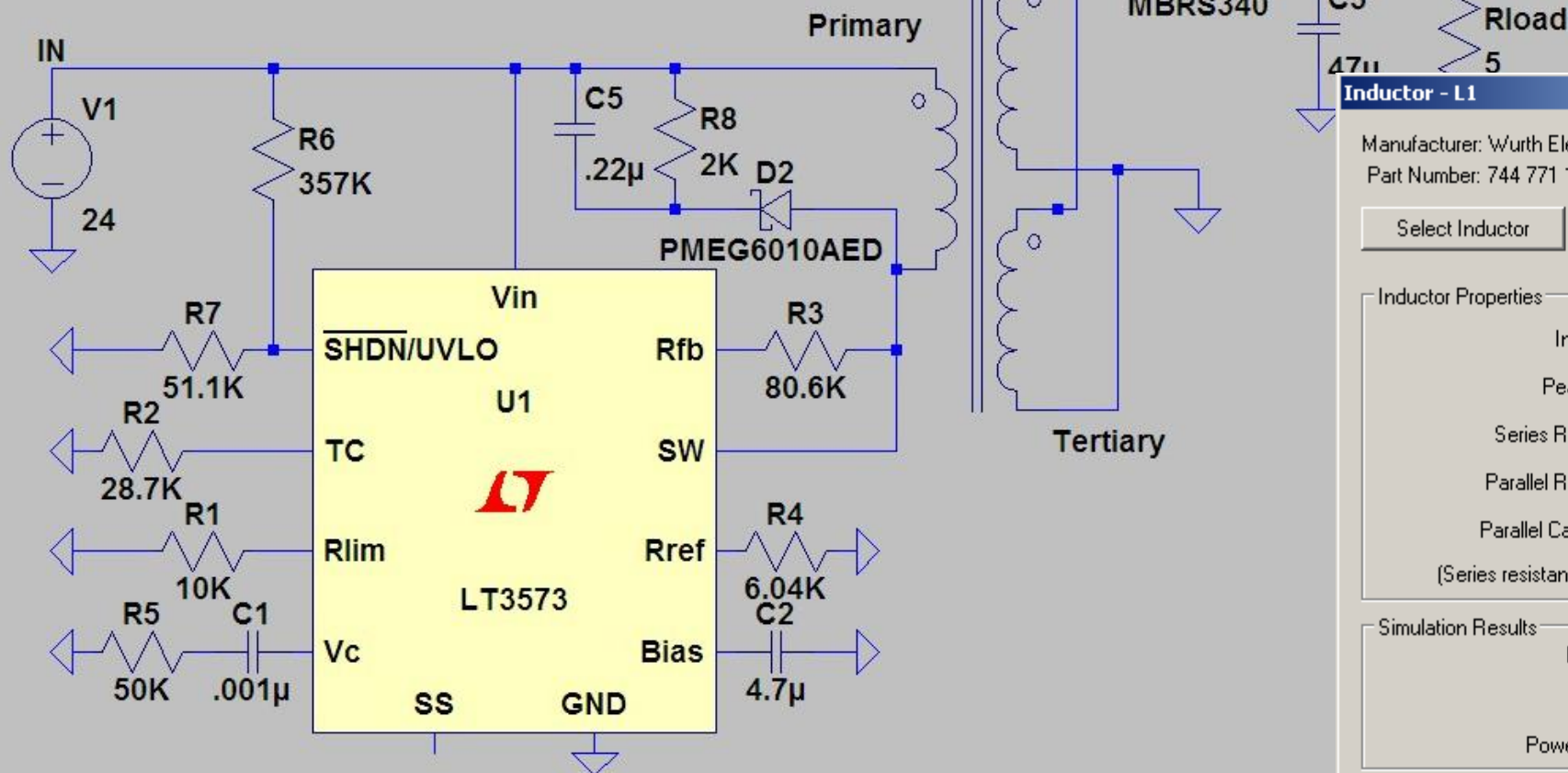
LTspice - FREEWARE

afo]



750310471

LT3573 - Isolated Flyback Converter Without an Opto-Coupler
 Input: 24V Output: 5V @ 1A



Inductor - L1

Manufacturer: Würth Elektronik
 Part Number: 744 771 10

Select Inductor

Show Phase Dot ☐

Inductor Properties

Inductance[H]: 10μ

Peak Current[A]: 5.6

Series Resistance[Ω]: 0.021

Parallel Resistance[Ω]: 13768

Parallel Capacitance[F]: 5.767p

(Series resistance defaults to 1mΩ)

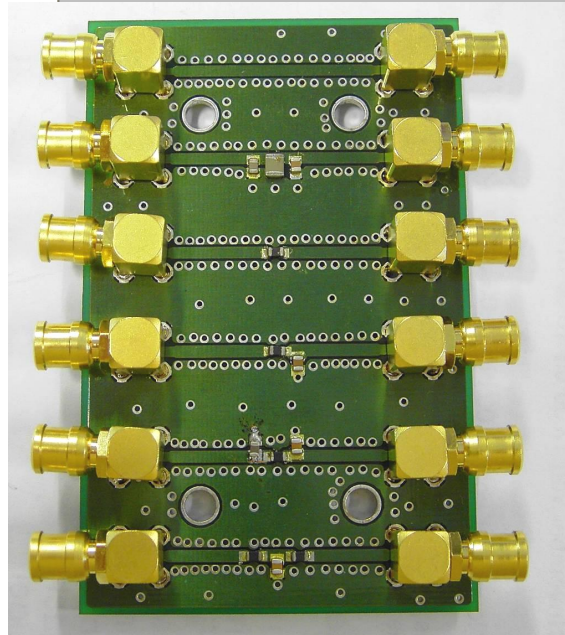
Simulation Results

Peak Current: 1.12A

RMS Current: 1A

Power Dissipation: 21.6mW

LTspice - Simulation



Linear Technology LTspice/SwitcherCAD III - [FilterEMVseminar.asc]

File Edit Hierarchy View Simulate Tools Window Help

The circuit diagram shows an AC voltage source V1 (AC 1v, Rser=0.1) connected to a network of resistors (R1-R6, R7-R12), capacitors (C1-C7), and inductors (L1-L5). The circuit includes several filter topologies: a C-Filter (R5, C1, C2, C3, R7), a Ferrit-Filter (R4, L1, R8), an LC-Filter (R3, L2, C4, R9), a Pi-Filter (R2, C5, L3, C6, R10), and a T-Filter (R1, L4, C7, L5, R11). A reference resistor R12 is also shown.

Ferrite Bead

Würth Elektronik eiSos
742 792 093

Select Ferrite Bead

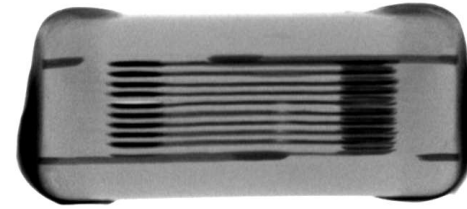
Inductor Properties

Inductance[H]:	3.42μ
Series Resistance[Ω]:	0.6
Parallel Resistance[Ω]:	2780
Parallel Capacitance[F]:	970f
Peak Current[A]:	0.2
Impedance @ 100MHz[Ω]:	2579.8
Max Impedance[Ω]:	2778.7
Freq of Max. Impedance[MHz]:	87

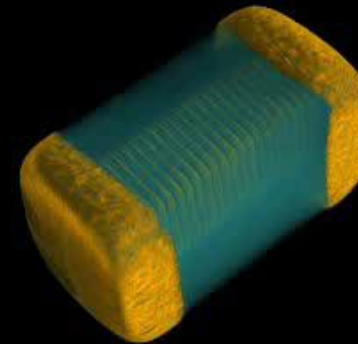
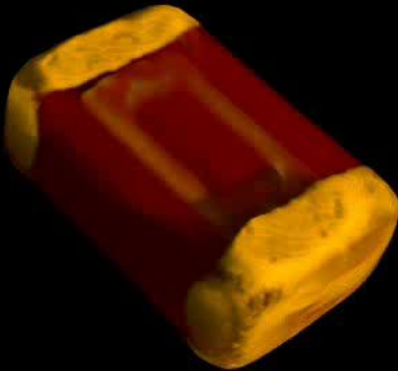
(Series resistance defaults to 1milliOhm)

OK Cancel

L Filter SMD-Ferrite WE-CBF



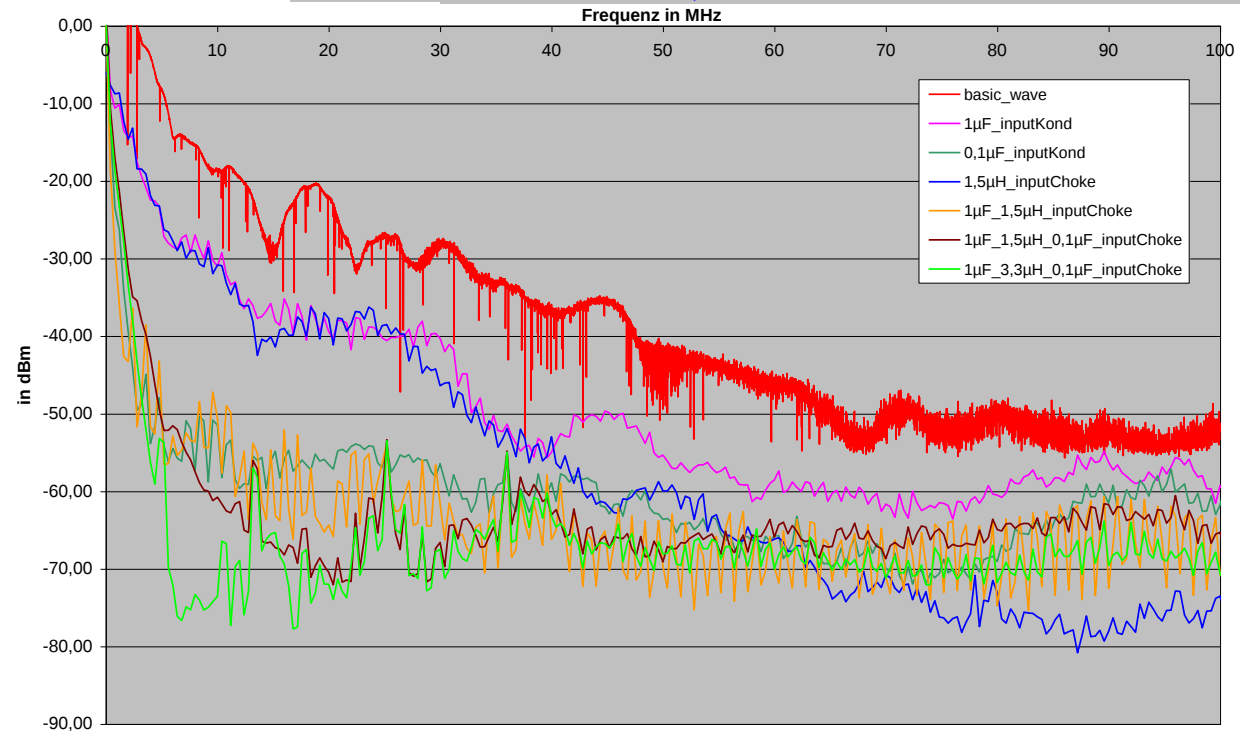
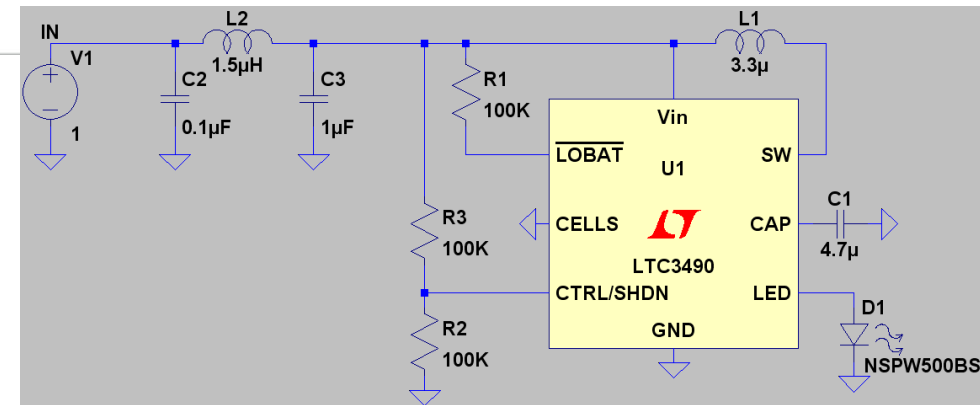
- Using the core losses $R=f(f)$
- Transform differential noise energy into heat



Simulation – LED driver LTC3490



- Filtering the reflected switching power
- First solution capacity to GND
- Second/third solutions
- → L-Filter & PI-Filter





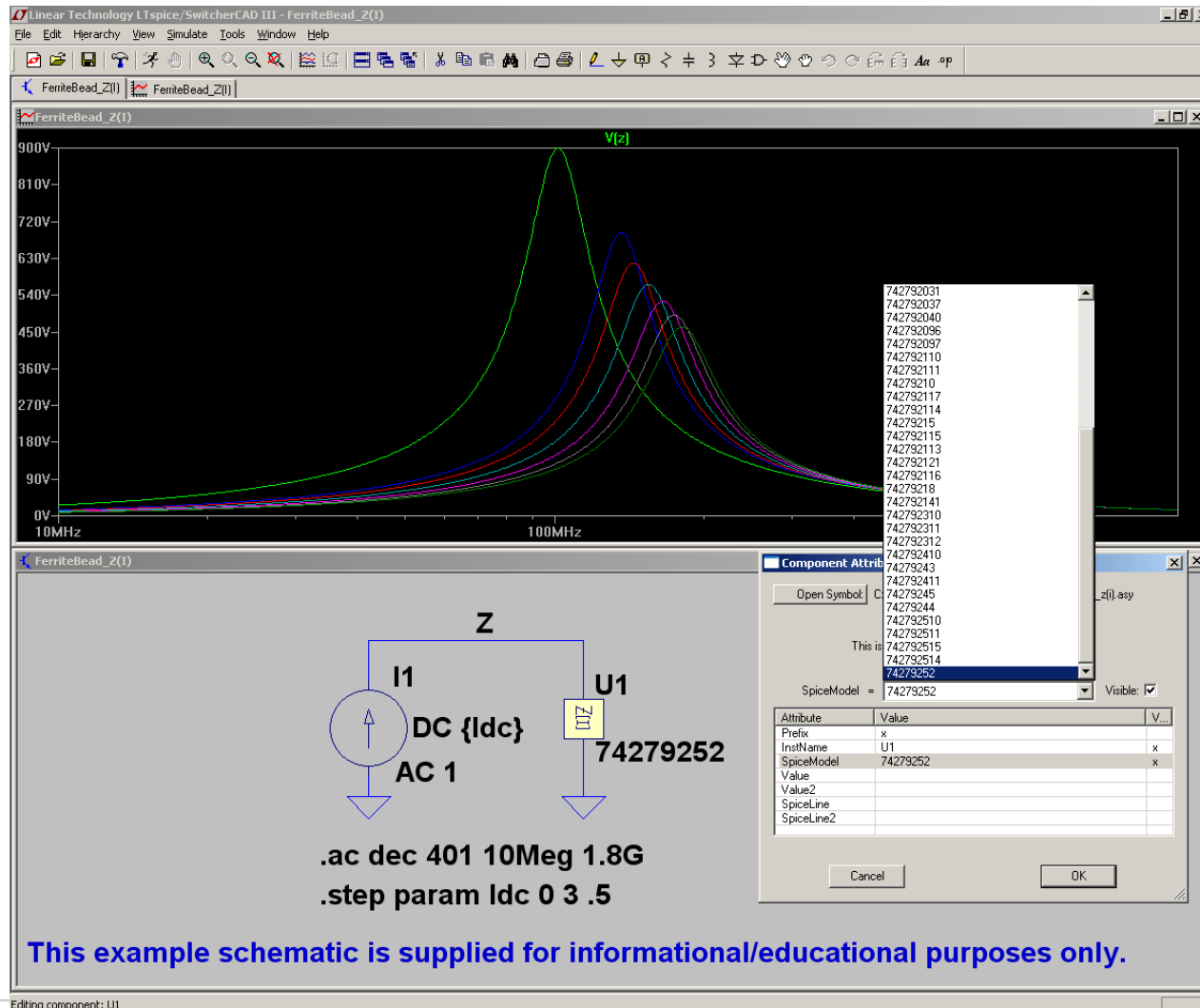
SIMULATION



Simulation – LTSpice IV

- <http://ltspice.linear.com/software/LTspiceIV.exe>

FREEWARE



Select Stock Inductor

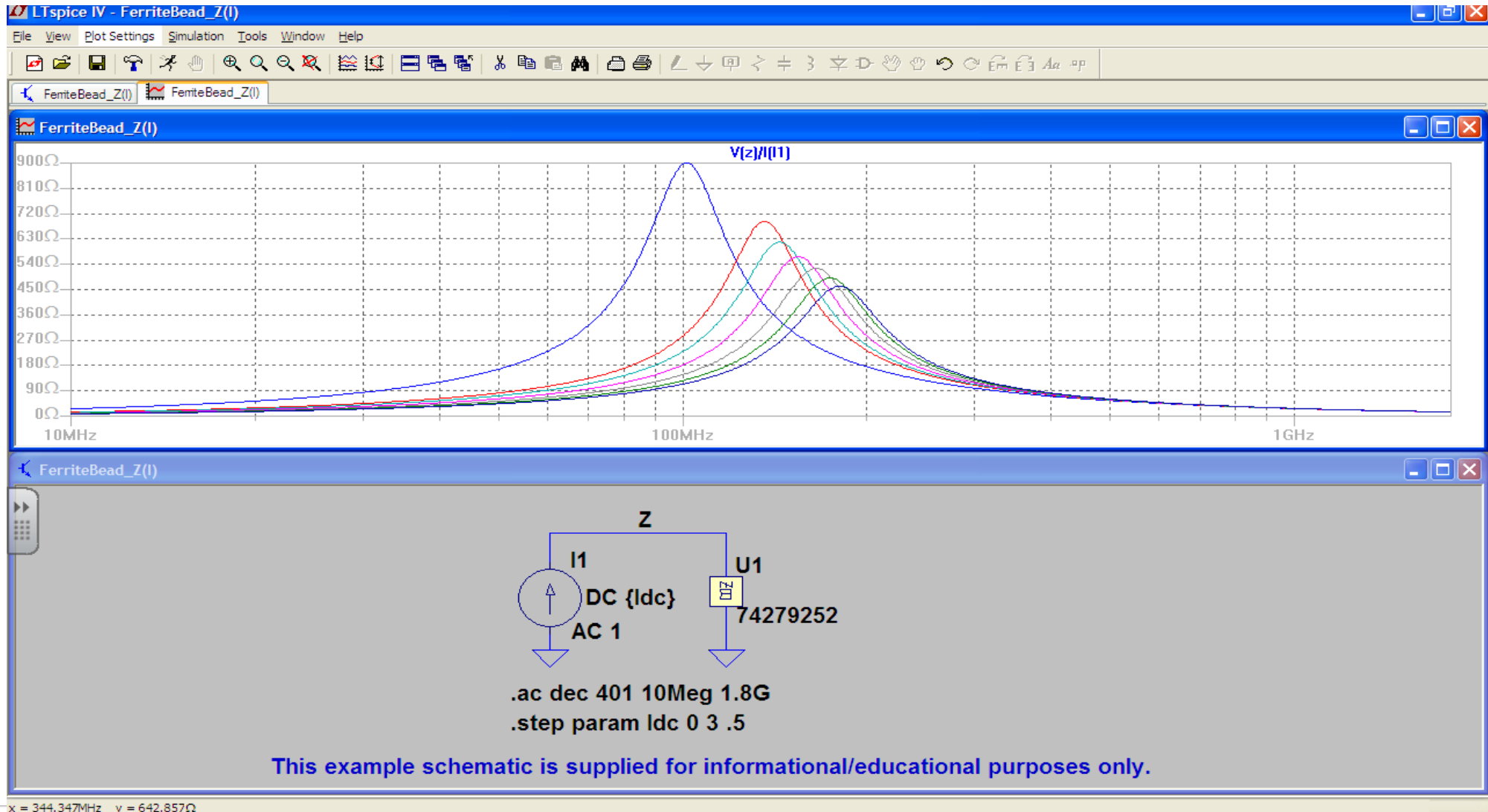
Quit and Edit Database OK

List All Inductors in Database Cancel

L[μH]	Mfg.	Part No.	Ipk[A]	Rser[Ω]
6.8	Würth Elektronik	744029006 WE-TPC	0.650	0.290
10.0	Würth Elektronik	744029100 WE-TPC	0.500	0.390
1.2	Würth Elektronik	744030001 WE-TPC	1.100	0.088
2.2	Würth Elektronik	744030002 WE-TPC	0.800	0.136
3.3	Würth Elektronik	744030003 WE-TPC	0.720	0.180
4.7	Würth Elektronik	744030004 WE-TPC	0.500	0.230
6.8	Würth Elektronik	744030006 WE-TPC	0.430	0.230
10.0	Würth Elektronik	744030100 WE-TPC	0.350	0.510
22.0	Würth Elektronik	744030220 WE-TPC	0.250	1.150
1.5	Würth Elektronik	744031001 WE-TPC	1.550	0.035
2.5	Würth Elektronik	744031002 WE-TPC	1.250	0.045
3.6	Würth Elektronik	744031003 WE-TPC	1.100	0.065
4.7	Würth Elektronik	744031004 WE-TPC	0.900	0.085
6.8	Würth Elektronik	744031006 WE-TPC	0.750	0.125
10.0	Würth Elektronik	744031100 WE-TPC	0.560	0.165
100.0	Würth Elektronik	744031101 WE-TPC	0.180	2.050
15.0	Würth Elektronik	744031150 WE-TPC	0.450	0.230
22.0	Würth Elektronik	744031220 WE-TPC	0.360	0.360
33.0	Würth Elektronik	744031330 WE-TPC	0.320	0.545
47.0	Würth Elektronik	744031470 WE-TPC	0.250	0.800
1.0	Würth Elektronik	744042001 WE-TPC	2.600	0.020
1.8	Würth Elektronik	7440420018 WE-TPC	2.400	0.050
2.7	Würth Elektronik	7440420027 WE-TPC	2.200	0.050
3.3	Würth Elektronik	744042003 WE-TPC	1.800	0.050
3.9	Würth Elektronik	7440420039 WE-TPC	1.700	0.050
4.7	Würth Elektronik	744042004 WE-TPC	1.650	0.070
5.6	Würth Elektronik	744042005 WE-TPC	1.350	0.080
6.8	Würth Elektronik	744042006 WE-TPC	1.250	0.080
8.2	Würth Elektronik	744042008 WE-TPC	1.100	0.100
10.0	Würth Elektronik	744042100 WE-TPC	1.100	0.130
100.0	Würth Elektronik	744042101 WE-TPC	0.300	1.170
12.0	Würth Elektronik	744042120 WE-TPC	0.950	0.150
15.0	Würth Elektronik	744042150 WE-TPC	0.750	0.190
18.0	Würth Elektronik	744042180 WE-TPC	0.700	0.270
22.0	Würth Elektronik	744042220 WE-TPC	0.600	0.280
1.2	Würth Elektronik	7440430012 WE-TPC	2.800	0.015
1.8	Würth Elektronik	7440430018 WE-TPC	2.450	0.020
2.2	Würth Elektronik	7440430022 WE-TPC	2.350	0.027
2.7	Würth Elektronik	7440430027 WE-TPC	1.950	0.028
3.3	Würth Elektronik	744043003 WE-TPC	1.800	0.030
3.9	Würth Elektronik	7440430039 WE-TPC	1.650	0.050
4.7	Würth Elektronik	744043004 WE-TPC	1.700	0.050
5.6	Würth Elektronik	744043005 WE-TPC	1.300	0.070
6.8	Würth Elektronik	744043006 WE-TPC	1.250	0.080
8.2	Würth Elektronik	744043008 WE-TPC	1.050	0.090
10.0	Würth Elektronik	744043100 WE-TPC	1.000	0.095
100.0	Würth Elektronik	744043101 WE-TPC	0.290	0.550
12.0	Würth Elektronik	744043120 WE-TPC	0.950	0.100
15.0	Würth Elektronik	744043150 WE-TPC	0.750	0.120
18.0	Würth Elektronik	744043180 WE-TPC	0.700	0.150
22.0	Würth Elektronik	744043220 WE-TPC	0.700	0.160
220.0	Würth Elektronik	744043221 WE-TPC	1.008	0.095
33.0	Würth Elektronik	744043330 WE-TPC	0.550	0.163
47.0	Würth Elektronik	744043470 WE-TPC	0.500	0.218
58.0	Würth Elektronik	744043680 WE-TPC	0.400	0.310
1.2	Würth Elektronik	7440520012 WE-TPC	3.500	0.020
1.8	Würth Elektronik	7440520018 WE-TPC	3.000	0.030
2.5	Würth Elektronik	744052002 WE-TPC	2.700	0.040
3.0	Würth Elektronik	744052003 WE-TPC	2.400	0.040
3.9	Würth Elektronik	7440520039 WE-TPC	2.100	0.050
5.0	Würth Elektronik	744052005 WE-TPC	1.800	0.070

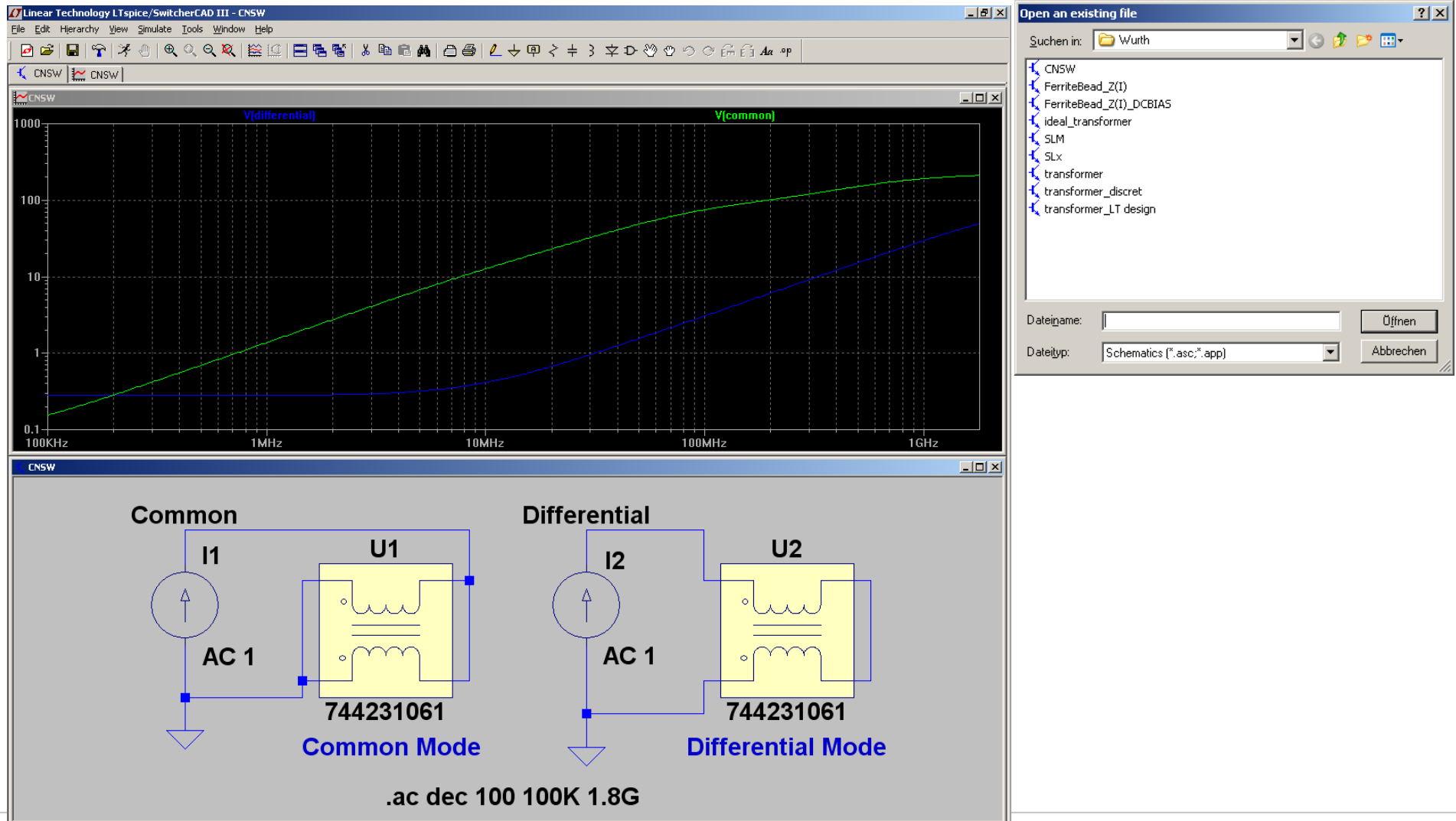
Simulation – LTSpice IV

- SMD-Ferrite Impedance vs. DC Bias $Z(I)$



Simulation - LTSpice

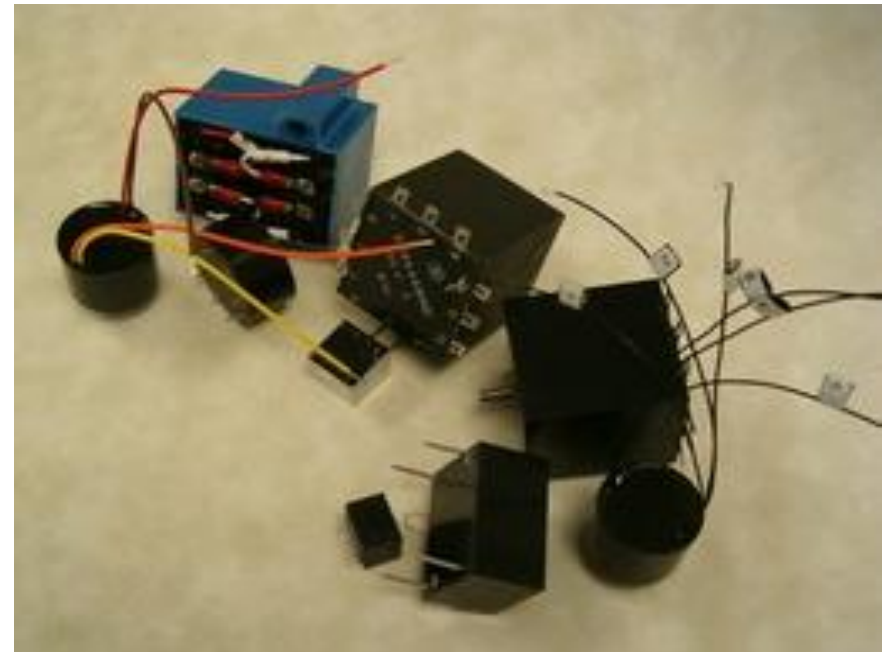
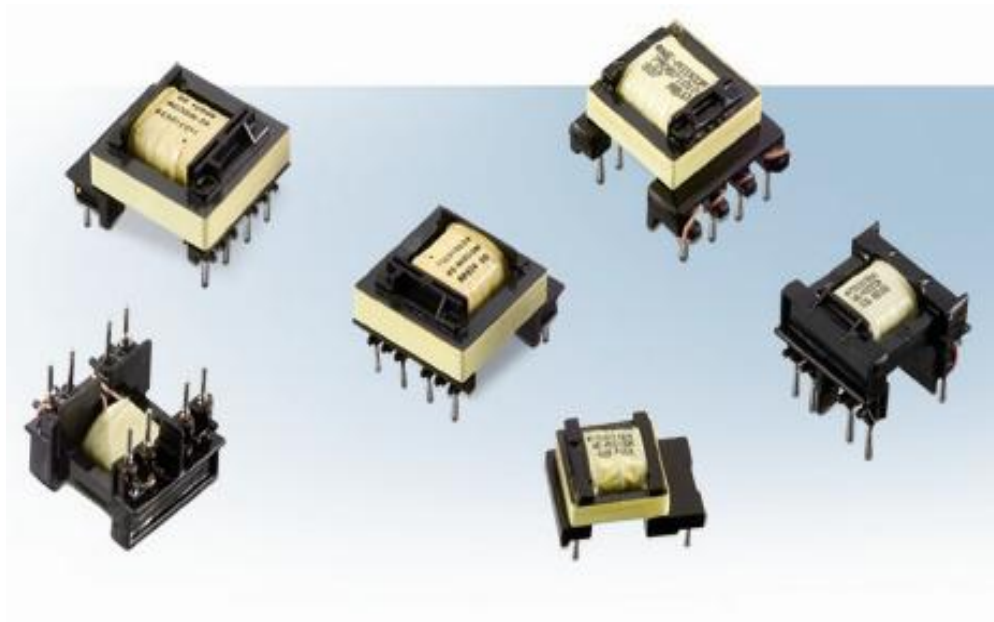
CommonMode-Chokes





AC/DC CONVERTER EMI

Transformers for EMC – What to choose?



Transformers for EMC – No Antennas please!

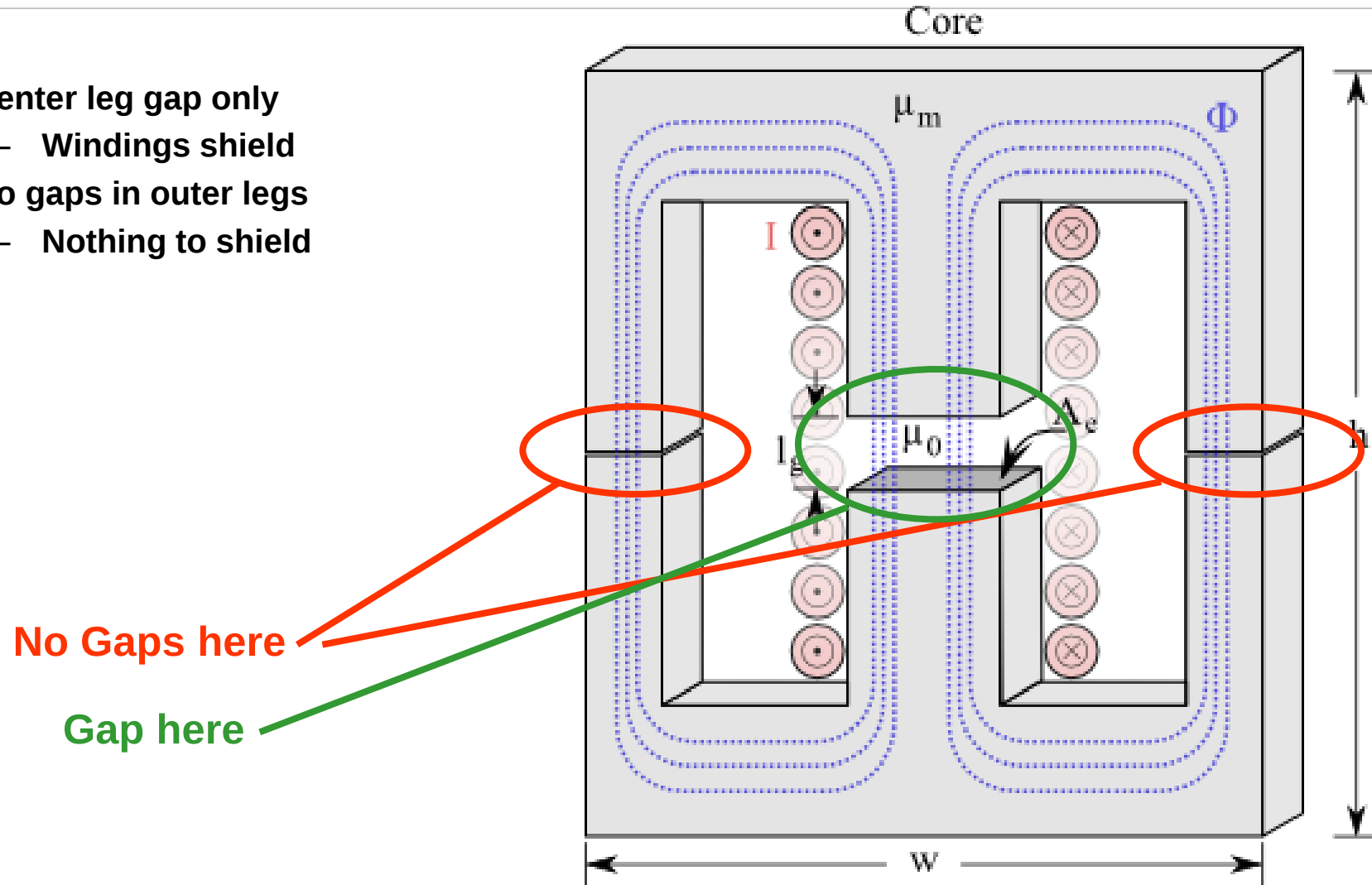
Enough Said!



Flying Leads Make Great Antennas.

Transformers for EMC – No external gaps

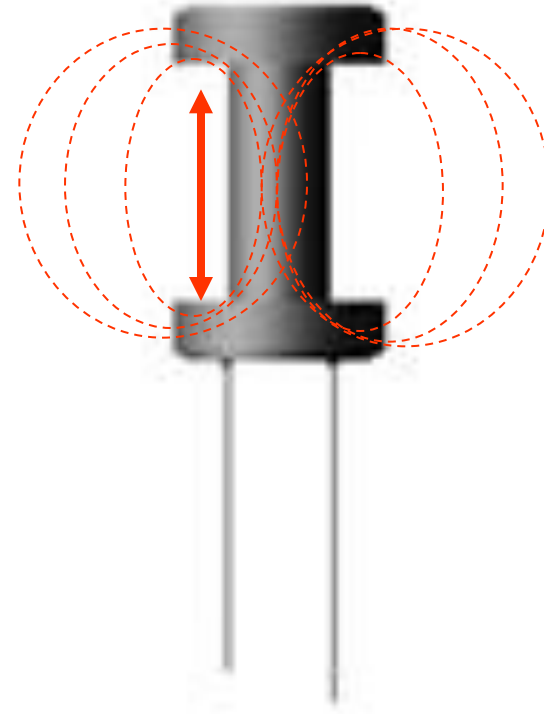
- Center leg gap only
 - Windings shield
- No gaps in outer legs
 - Nothing to shield



Transformers for EMC – No drum cores

- Drum core style
- Very large gap
- Much radiation

Not a good solution!

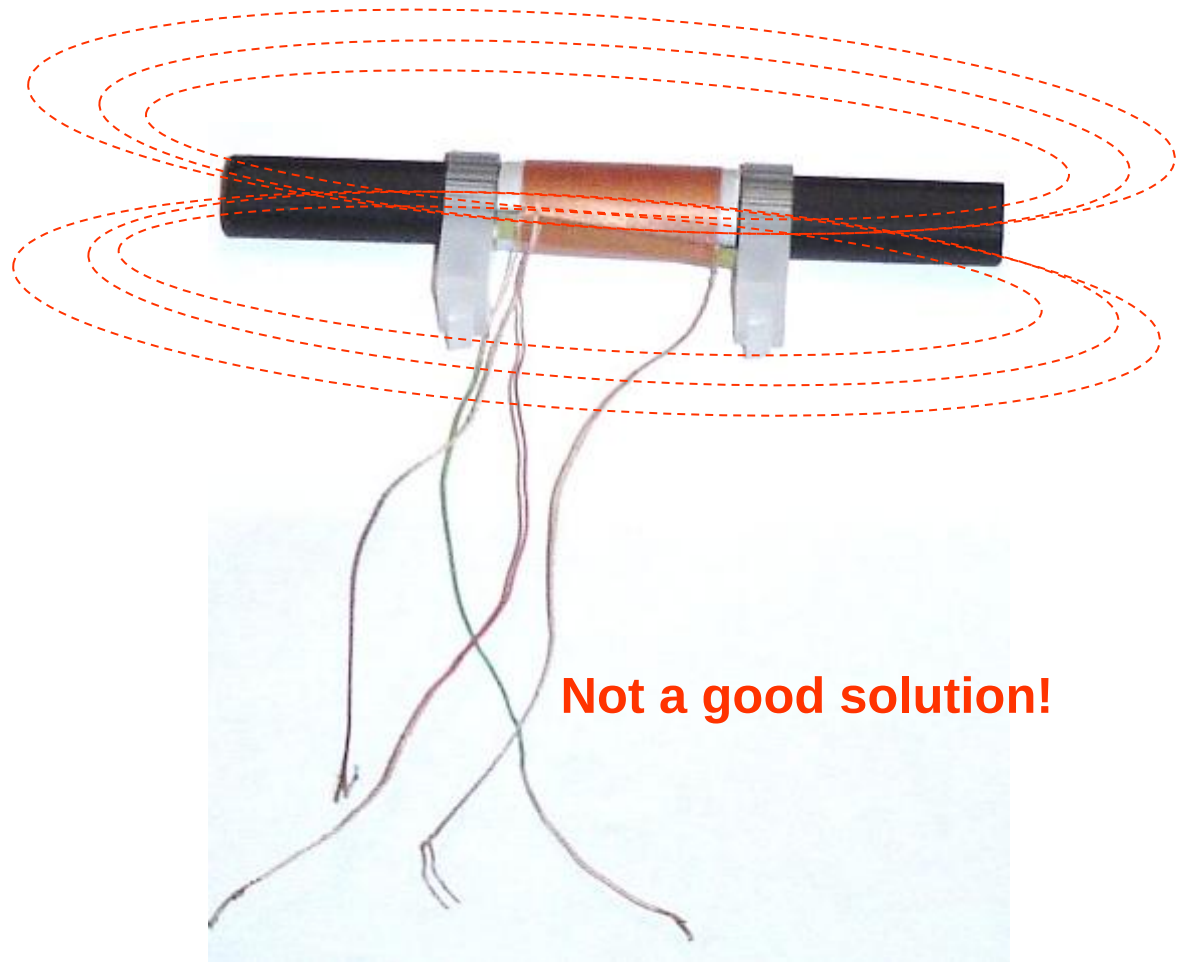


Transformers for EMC – No rod cores

- Rod core style
- Huge gap – much radiation
- This is an AM antenna

So where is the gap?

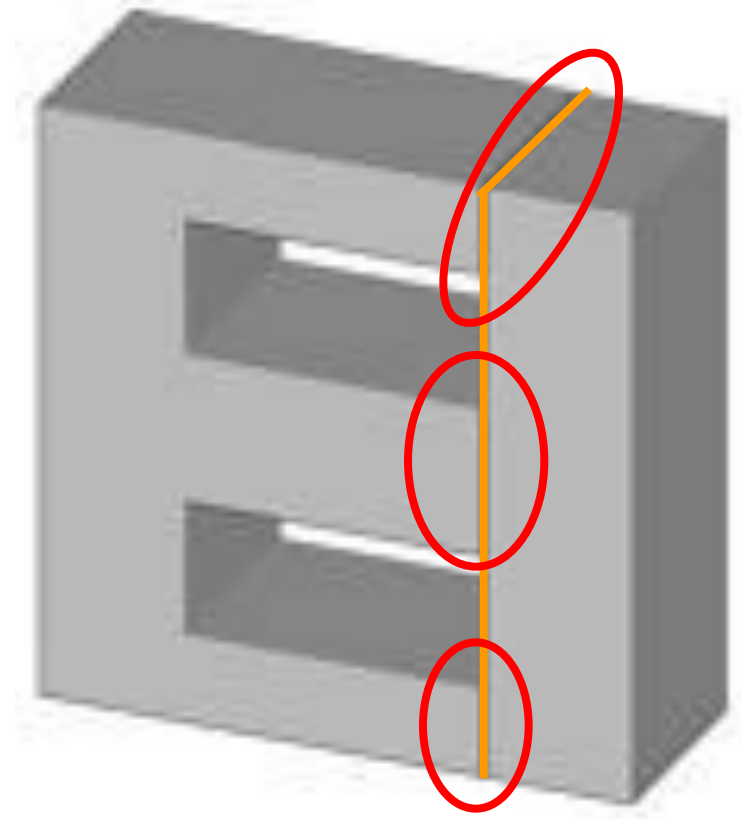
What is this?



Transformers for EMC – No EI core

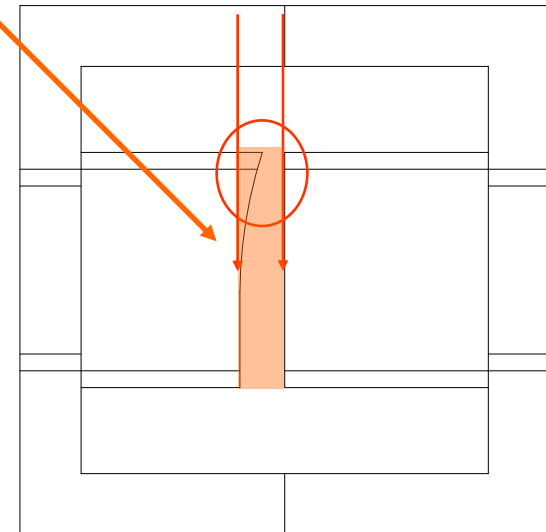
- EI core style
- Mylar or tape used for gap
- Three unshielded gaps

Not a good solution!



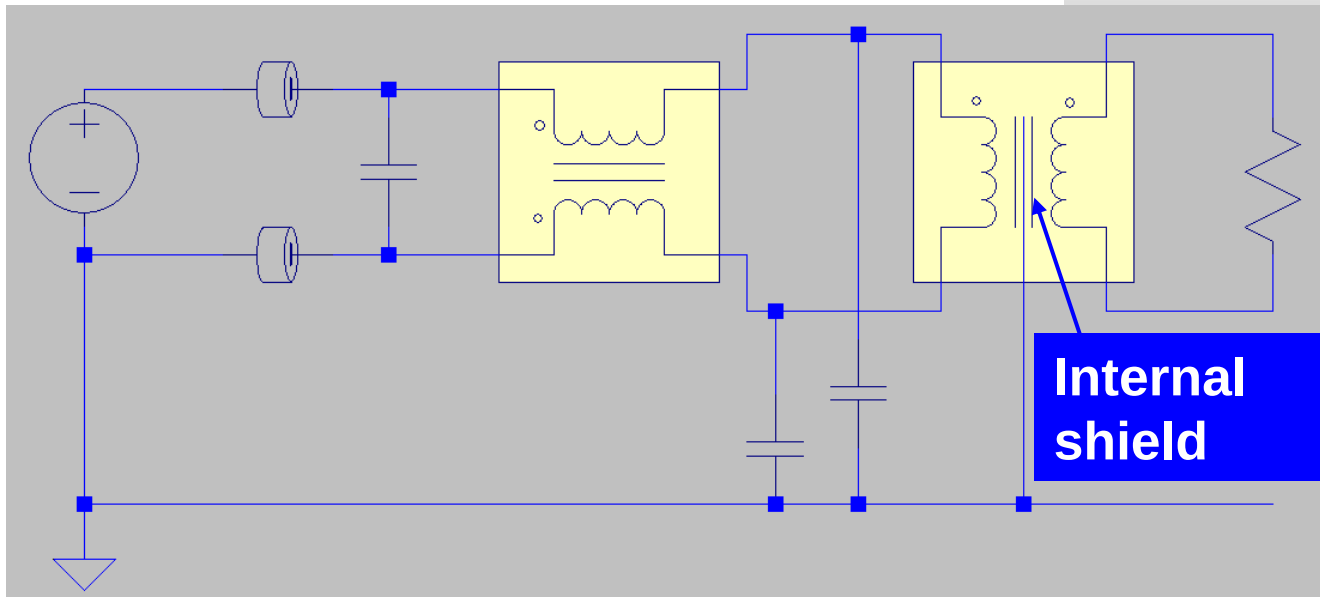
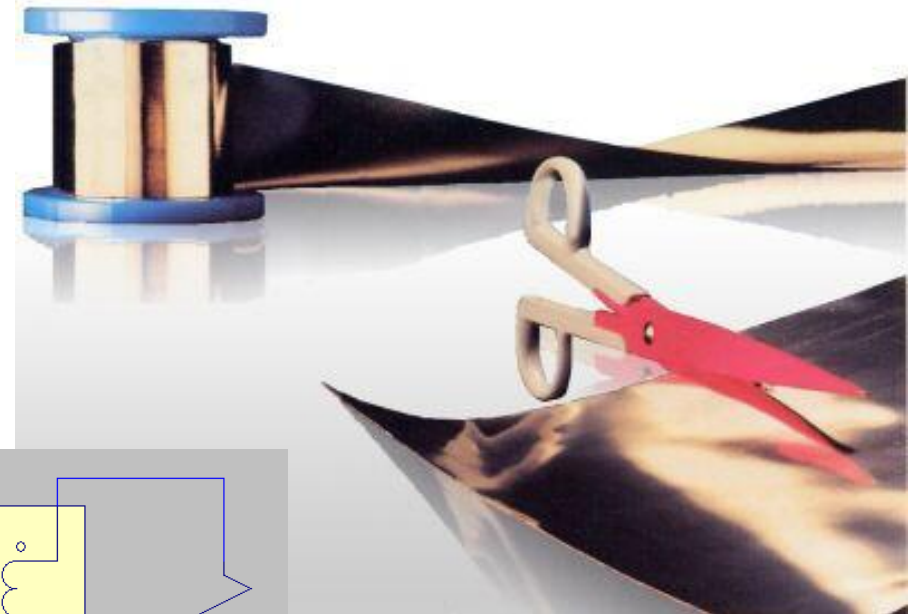
Transformers for EMC – Gap

- Gap must be perpendicular to flux lines
 - Here only one side is gapped
- Uneven gaps are inefficient. => **Why?**
 - Core saturates at minimum gap.
 - Requires a larger gap
- Also larger gap – More potential EMI



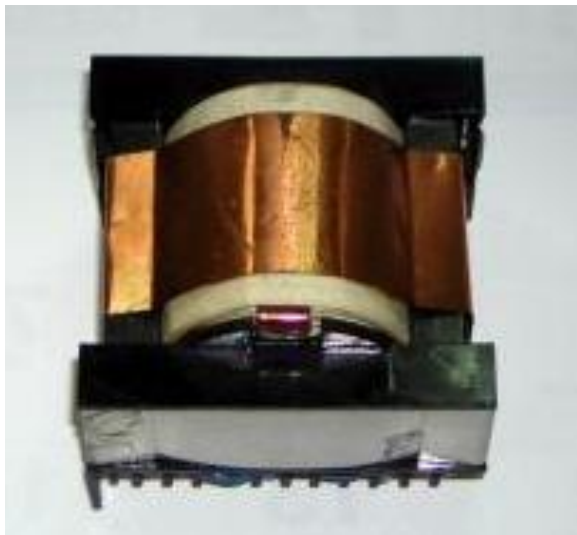
Transformers for EMC – Internal shields

- Shield both conducted and radiated noise
- **Copper foil or wound magnet wire?**
- Copper foil shields – Expensive, => **Why?**
 - Must build shield
 - Must be covered with tape
 - Winding machine stopped to apply
- All shields take away from winding area

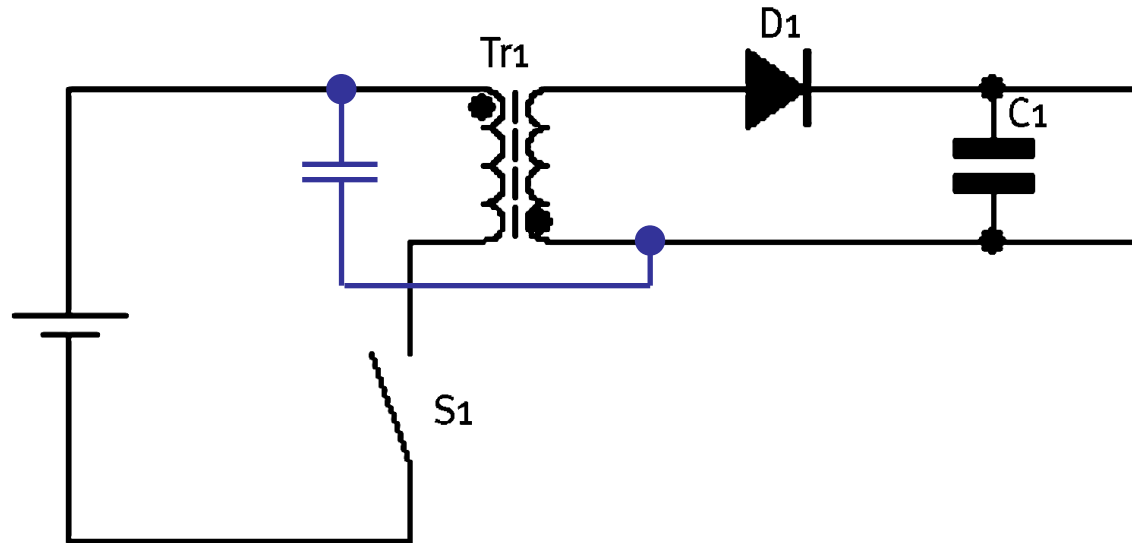


Transformers for EMC – External shields

- How do external shields differ from internal shields?
- Shield radiate noise only!
- As expensive as internal shields



Transformers for EMC – Y-Cap termination



- Noise couples through the transformer via C_{ww}
 - Noise seeks path to primary circuit
 - Without path, noise may become conducted emissions

What Can We Do?

- Y-Cap across transformer reduces noise
 - Tune the capacitor for optimum loss vs. noise reduction

Decrease C_{ww}?

- Capacitor usually in the 470pF to 4.7nF range
- Y-Caps to transformer terminals not on switch nor on diode
- Close to transformer as possible

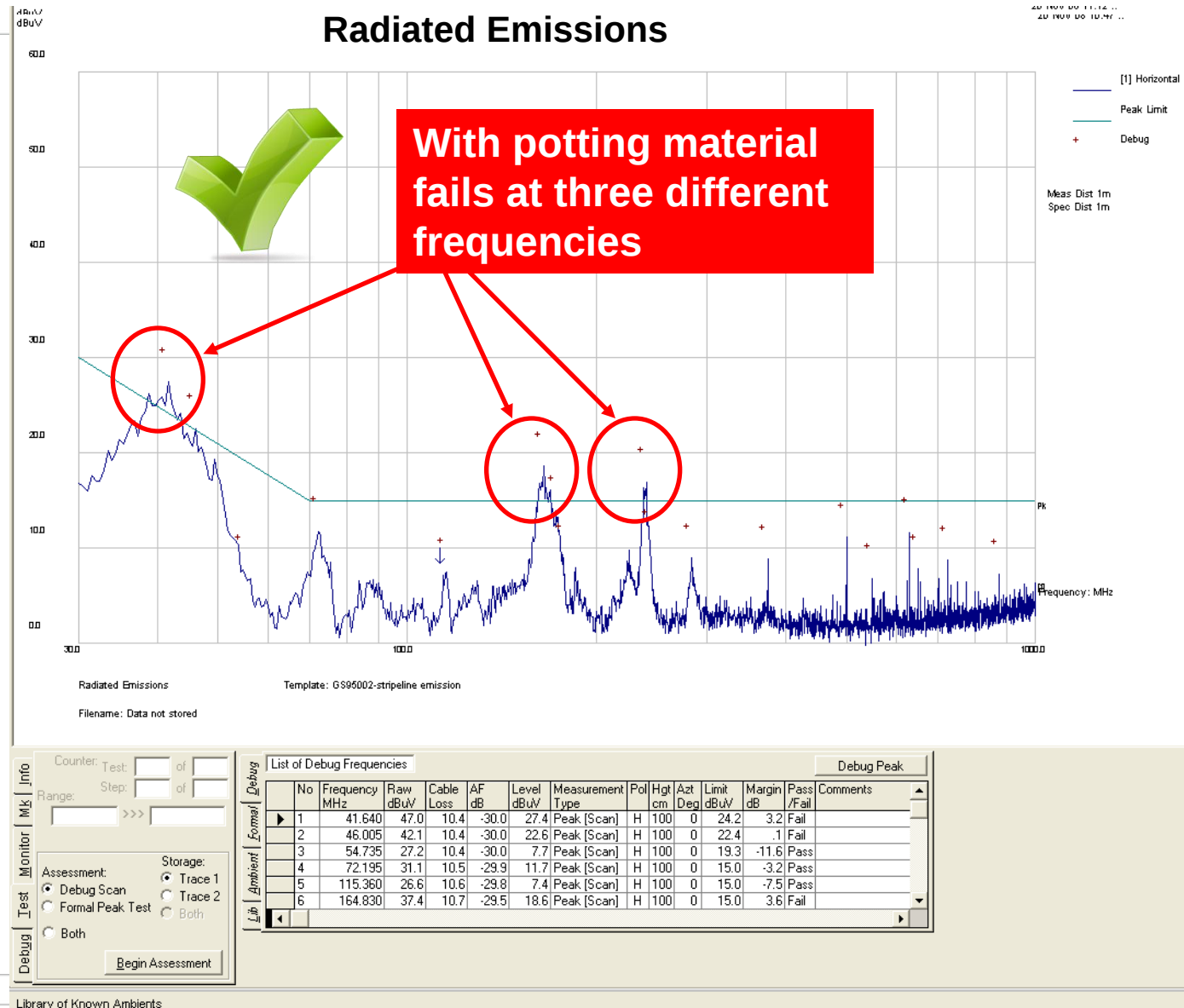
What Else Can We Do?

Transformers for EMC – Reducing C_{ww}

- High C_{ww} causes conducted emissions
- May reduce C_{ww} , but what happens?
- Leakage inductance increases
- L_{LKG} can be controlled by Snubber but efficiency and cost suffer
- Balance between C_{ww} and L_{lkg}



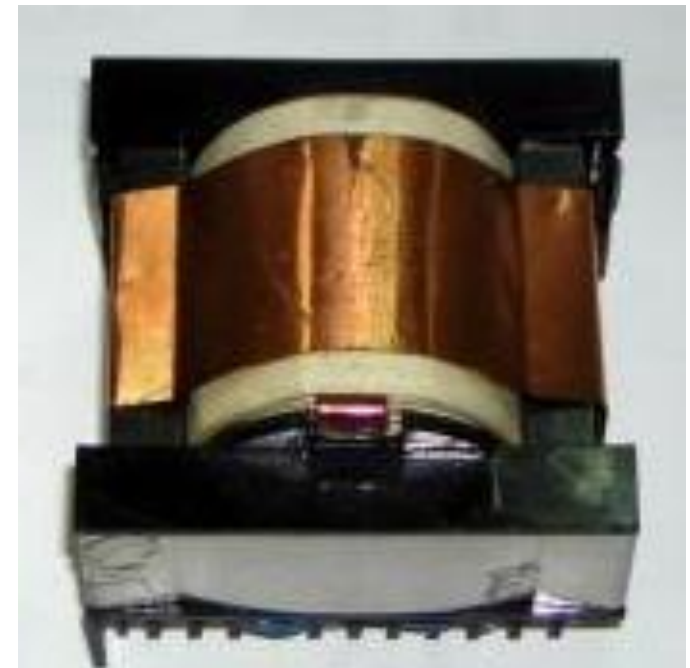
Transformers for EMC – No varnish or potting



Transformers for EMC - Small designs

Why build smaller designs?

- Build smaller more compact transformers
- Smaller transformers have less parasitic
 - Less capacitance
 - Smaller leads (e.g. smaller antennas)
 - Smaller gaps
 - Less leakage inductance
- Less conducted and less radiated noise



Transformers for EMC – Power Supply

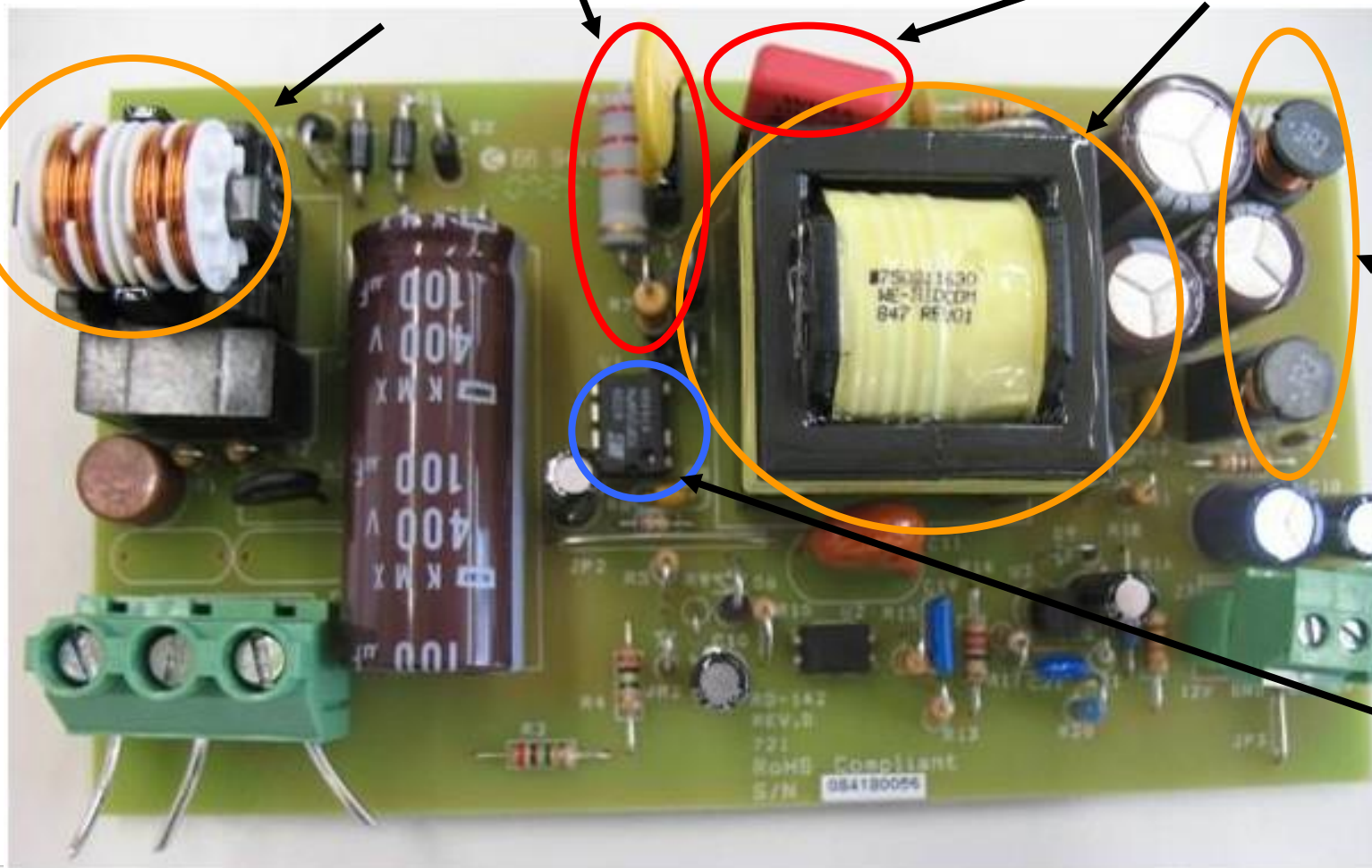
Current Compensated
Choke WE-FC

Snubber

Y-Cap
Transformer

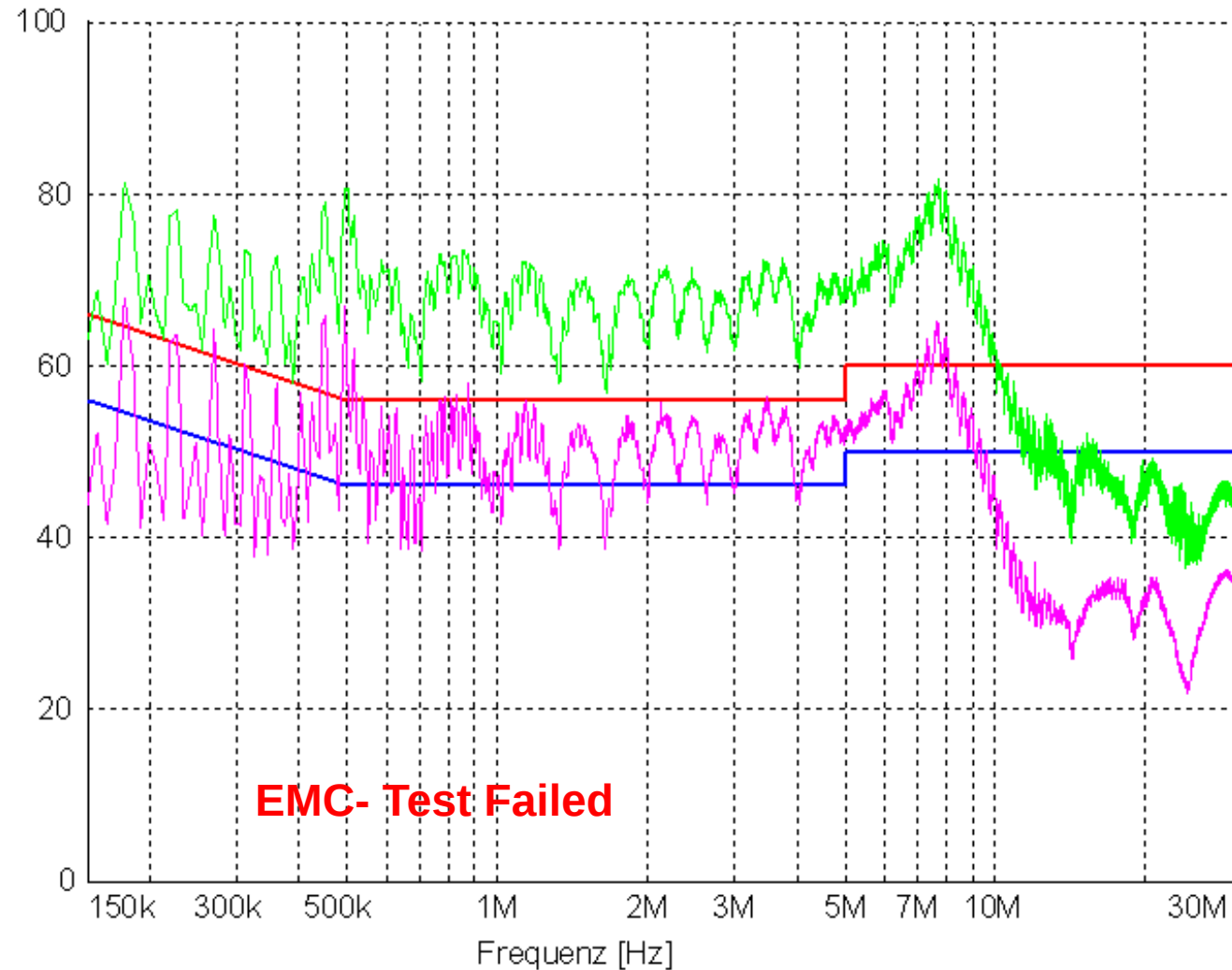
Output filter
WE-TI

Switch



Transformers for EMC – Example 1

Pegel [dB μ V]



- Without common mode choke
- With adjusted Snubber
- Without adjusted Y-Cap

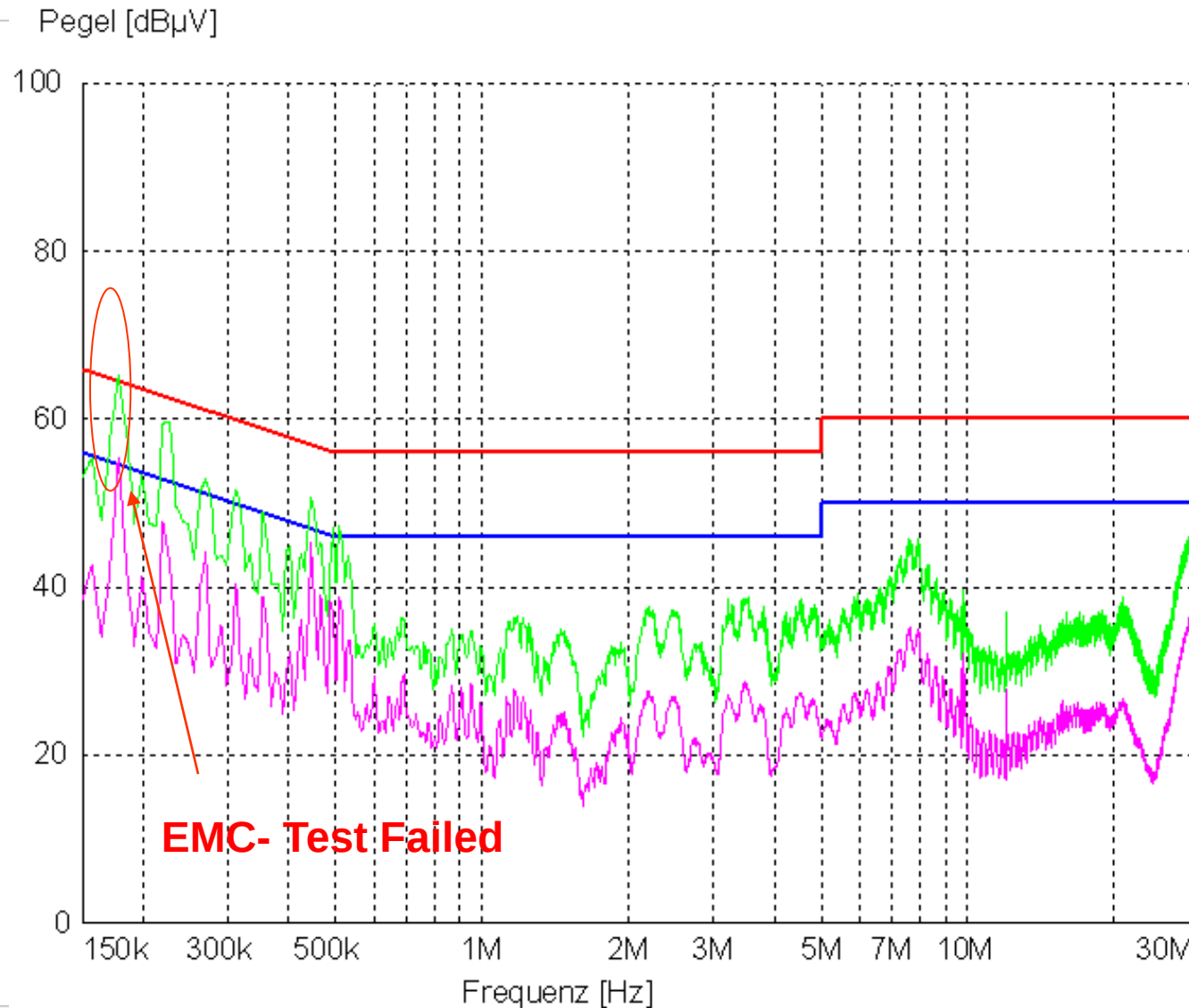
QPeak

Avg.

Peak

Avg.

Transformers for EMC – Example 2



- With common mode choke
- With adjusted Snubber
- Without adjusted Y-Cap

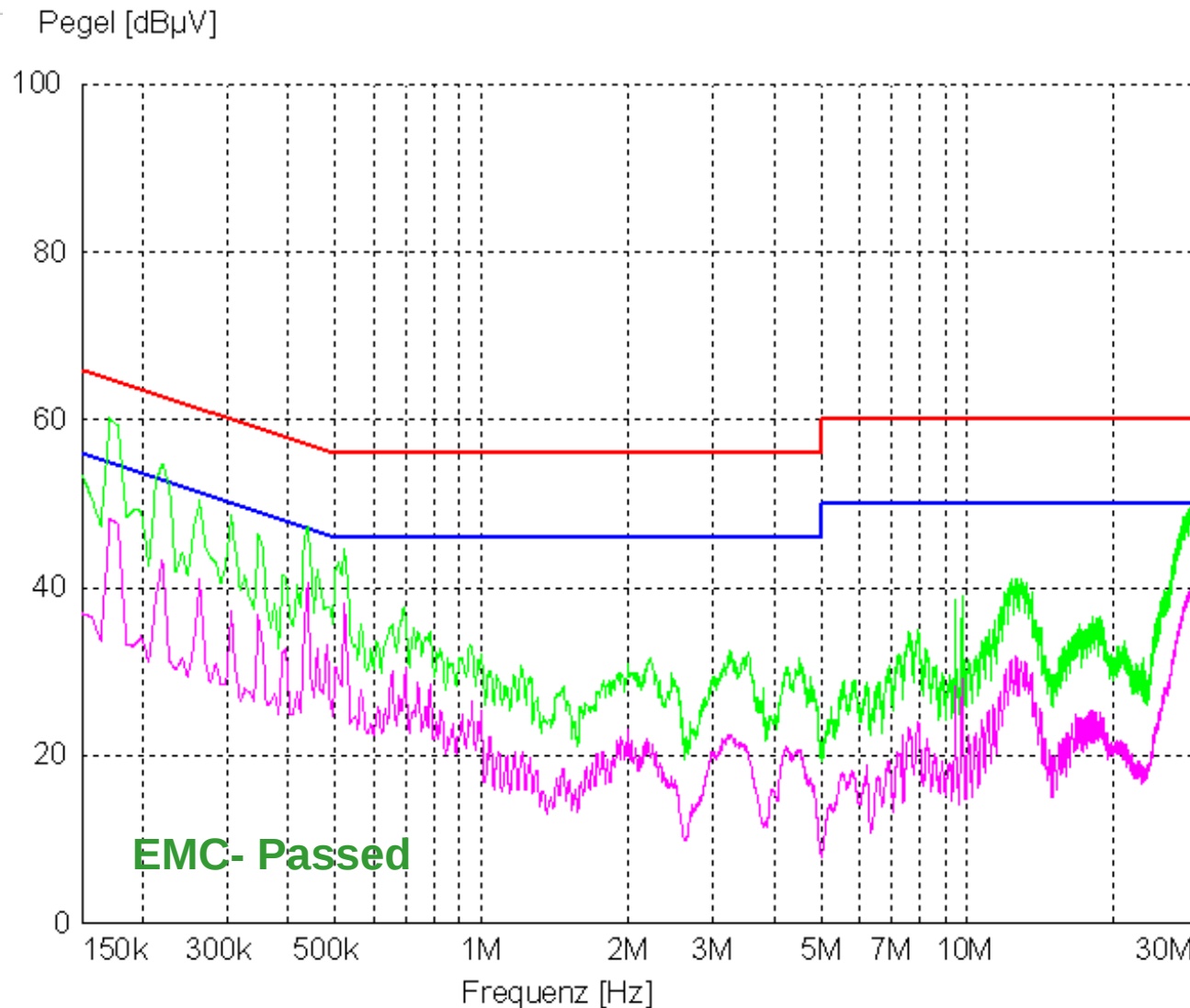
QPeak

Avg.

Peak

Avg.

Transformers for EMC – Example 3



- With common mode choke
- With adjusted Snubber
- With adjusted Y-Cap

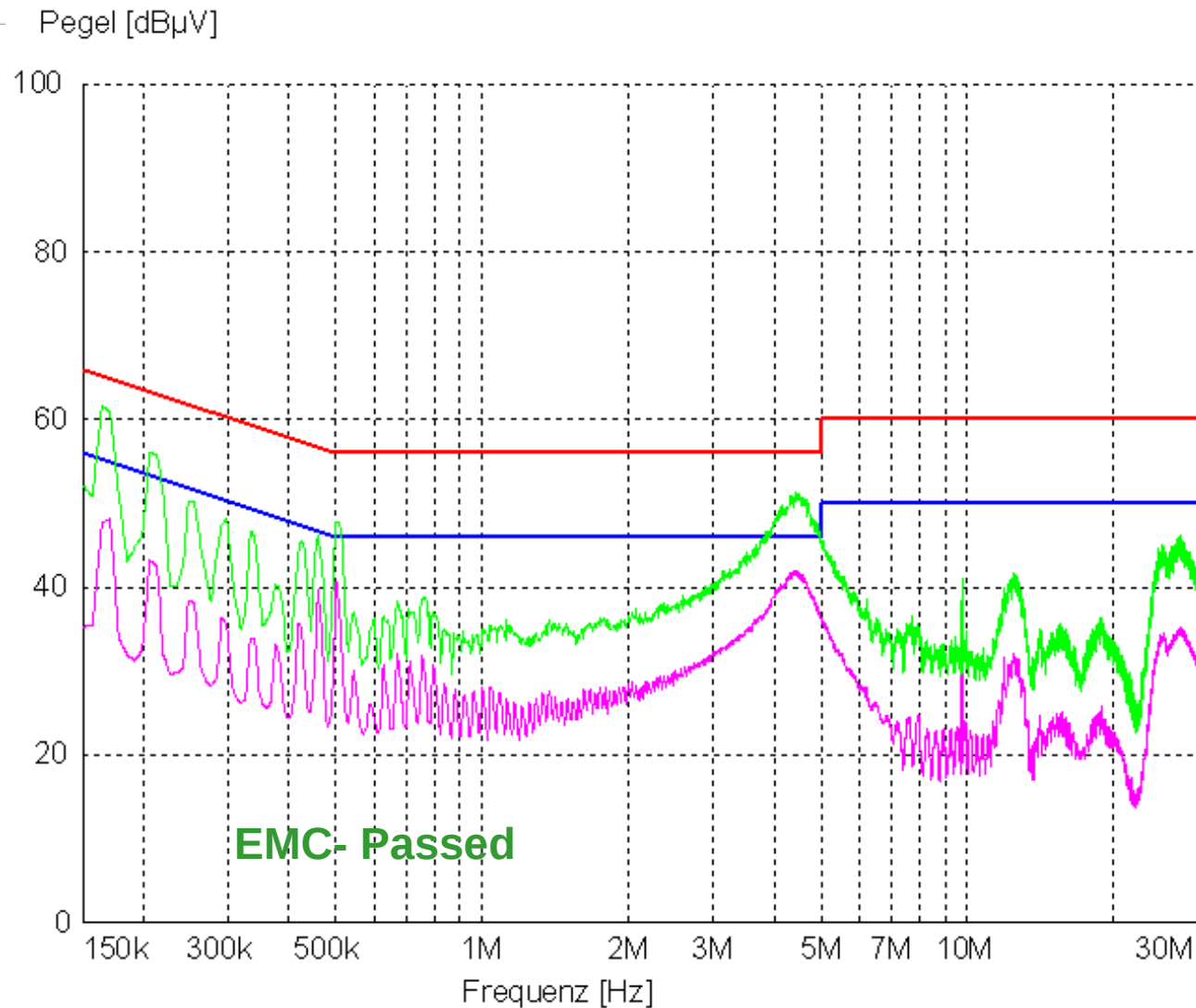
QPeak

Avg.

Peak

Avg.

Transformers for EMC – Example 4



- With common mode choke
- Without adjusted Snubber
- With adjusted Y-Cap

QPeak

Avg.

Peak

Avg.

Transformer for EMC – Conclusion for this power supply



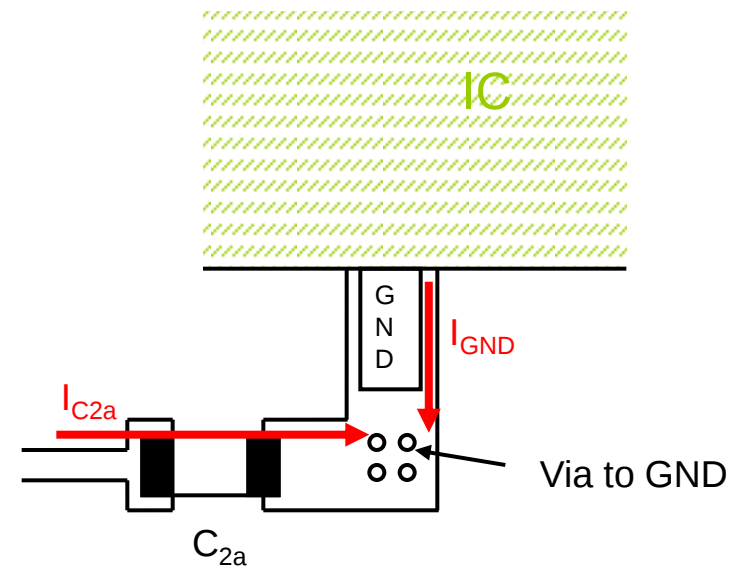
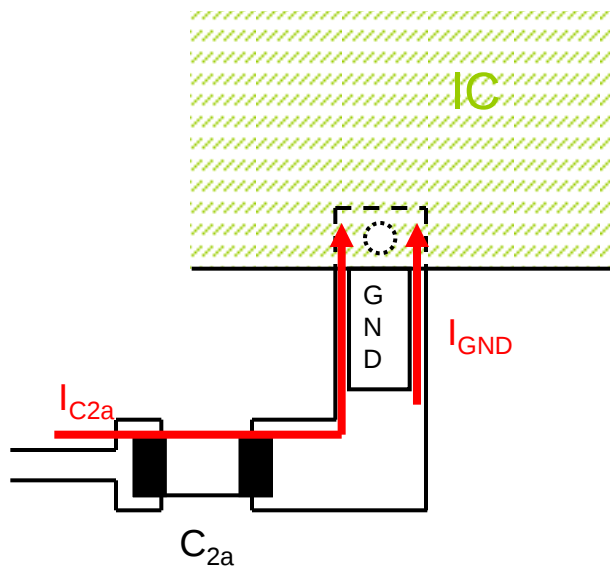
- Necessary to pass EMI:
 - Current compensated Choke (CMC)
 - Y-Caps
- Not necessary to pass EMI
 - Optimized Snubber



LAYOUT DESIGN

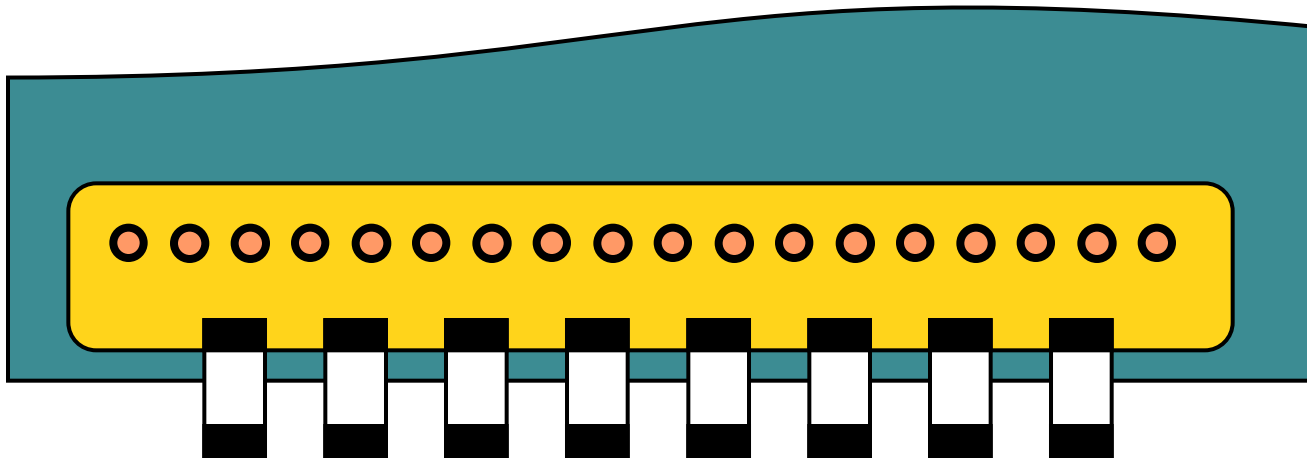
Layout design – set absolute reference for GND

- Common Impedance Coupling



Layout design – set absolute reference for GND

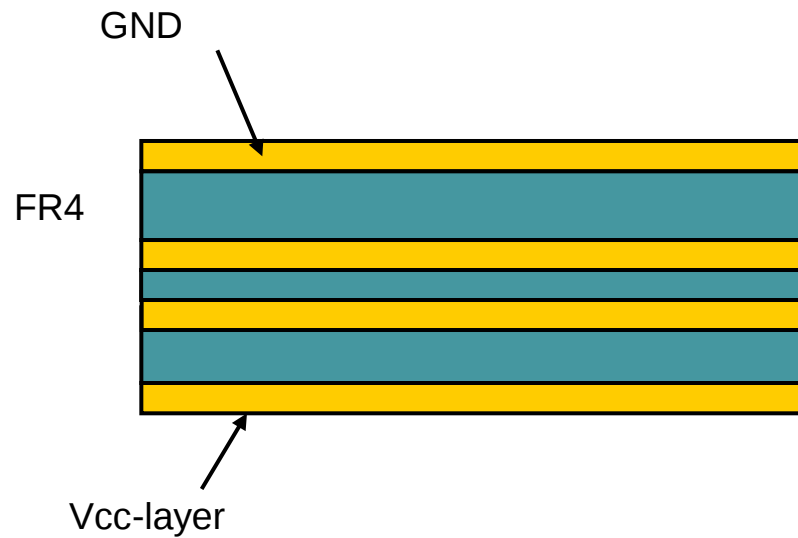
- GND reference plane
- create an low impedance GND point



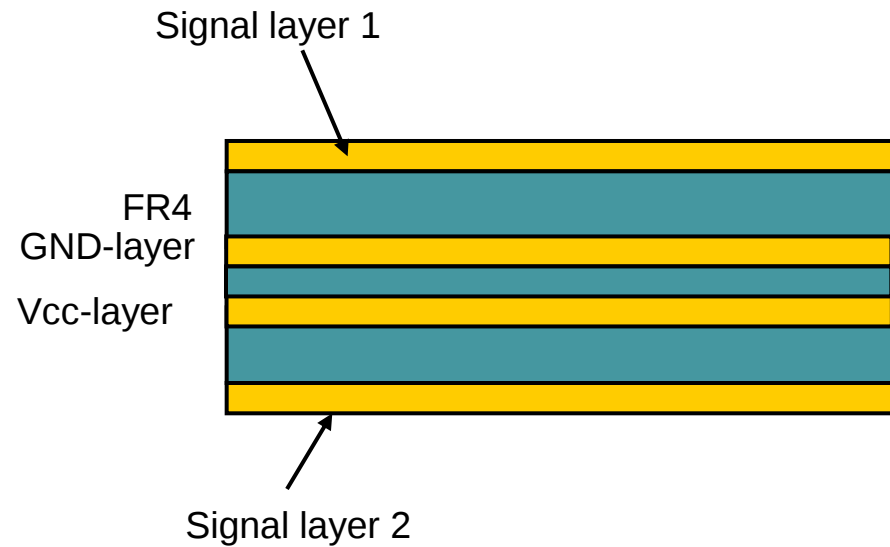
Layout design – set absolute reference for GND

- Layer design

undesirable



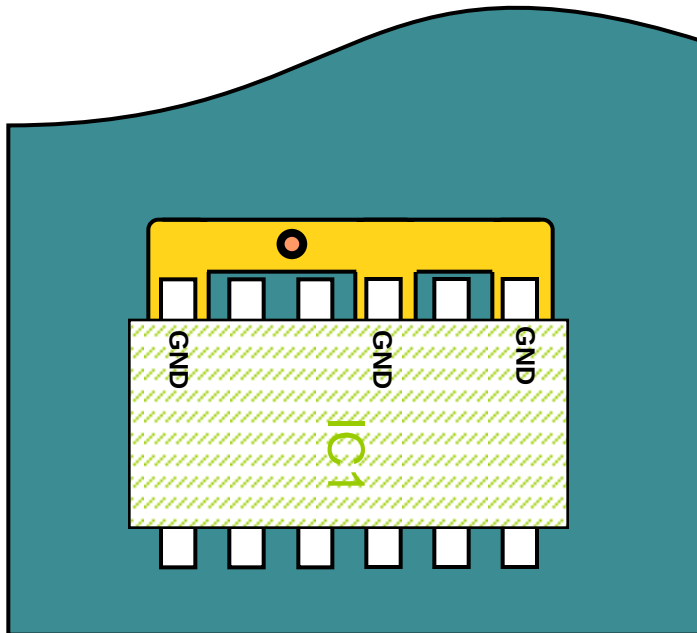
desired



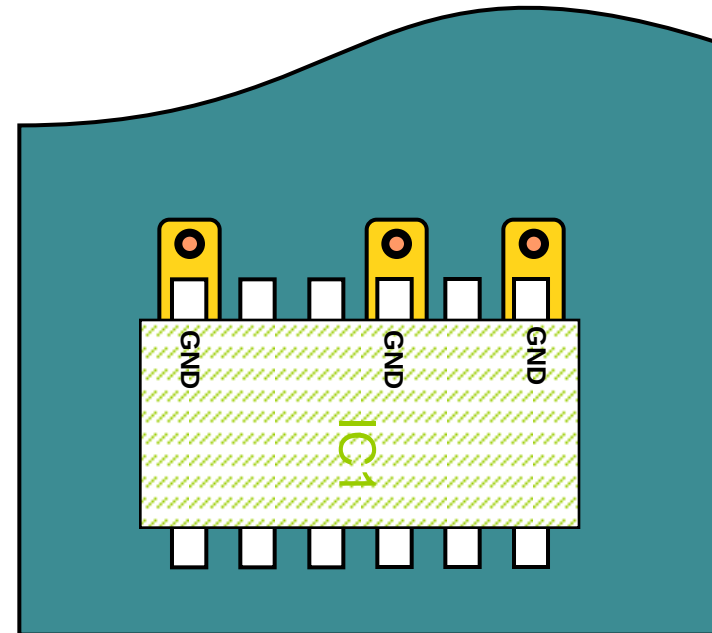
Layout design – set absolute reference for GND

- GND design for digital devices

WRONG



RIGHT





ESD

Surge protection

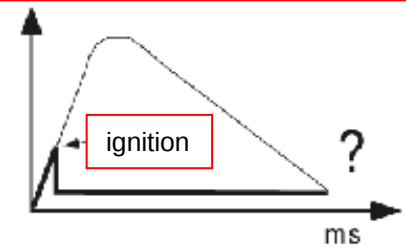
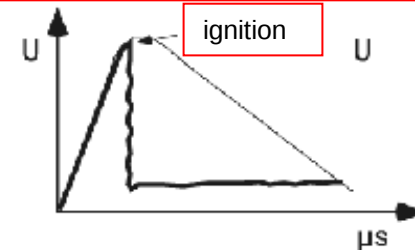
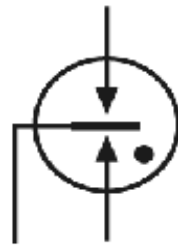


over voltage from fast transients

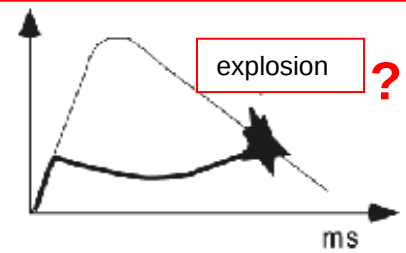
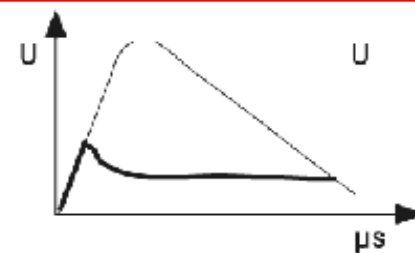
Over voltage from high energy

Components:

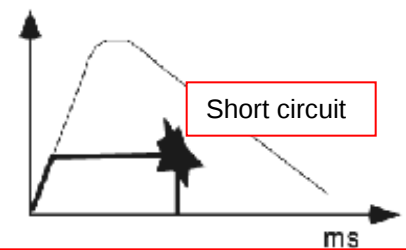
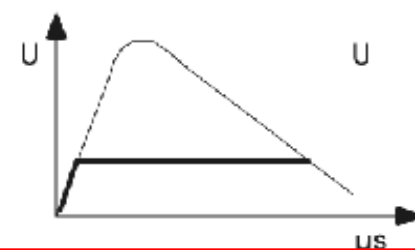
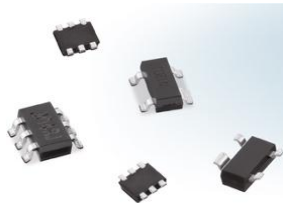
Gas discharger
(Trisil)



Varistor

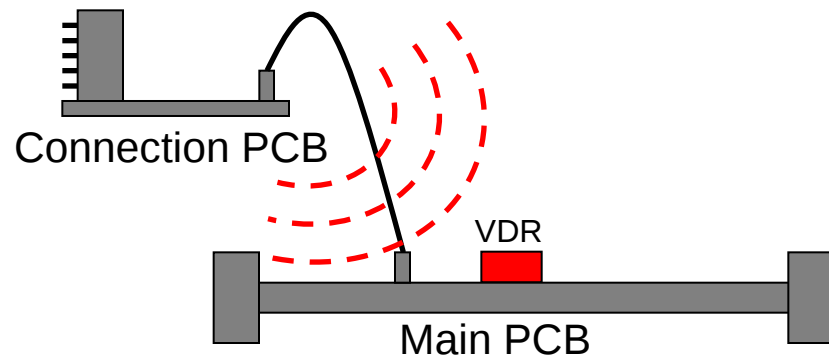


Diode
(Suppressor, Transil)
like a Zener-Diode with
higher current

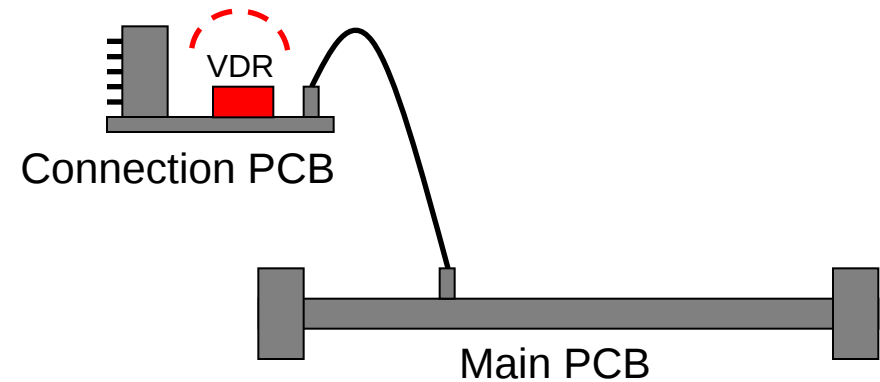


Where to place the varistors

Wrong

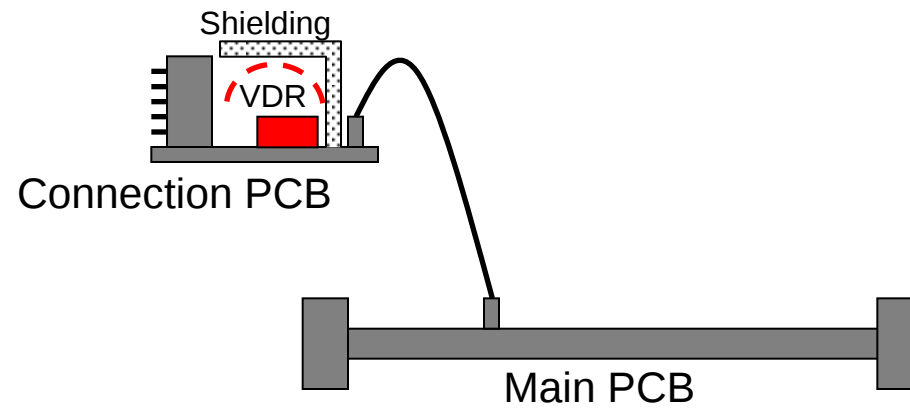


Right



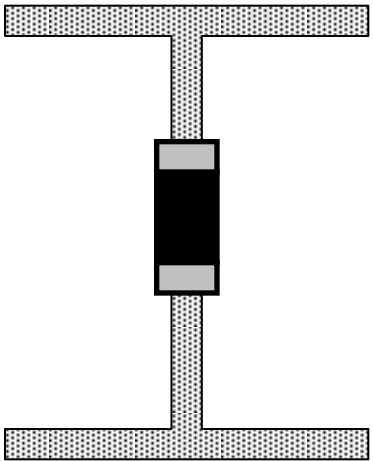
Where to place the varistors

Perfect

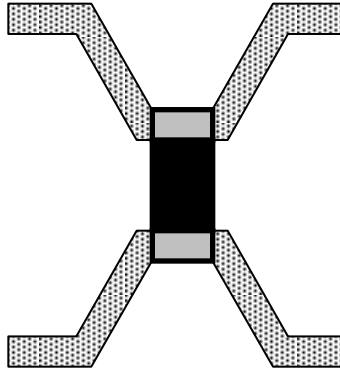


Layout design

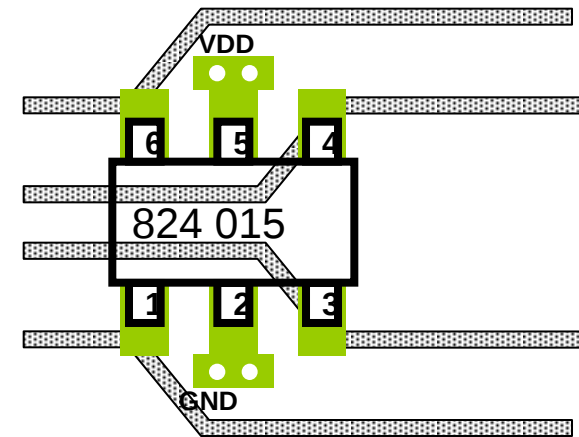
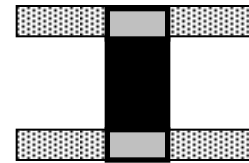
undesired



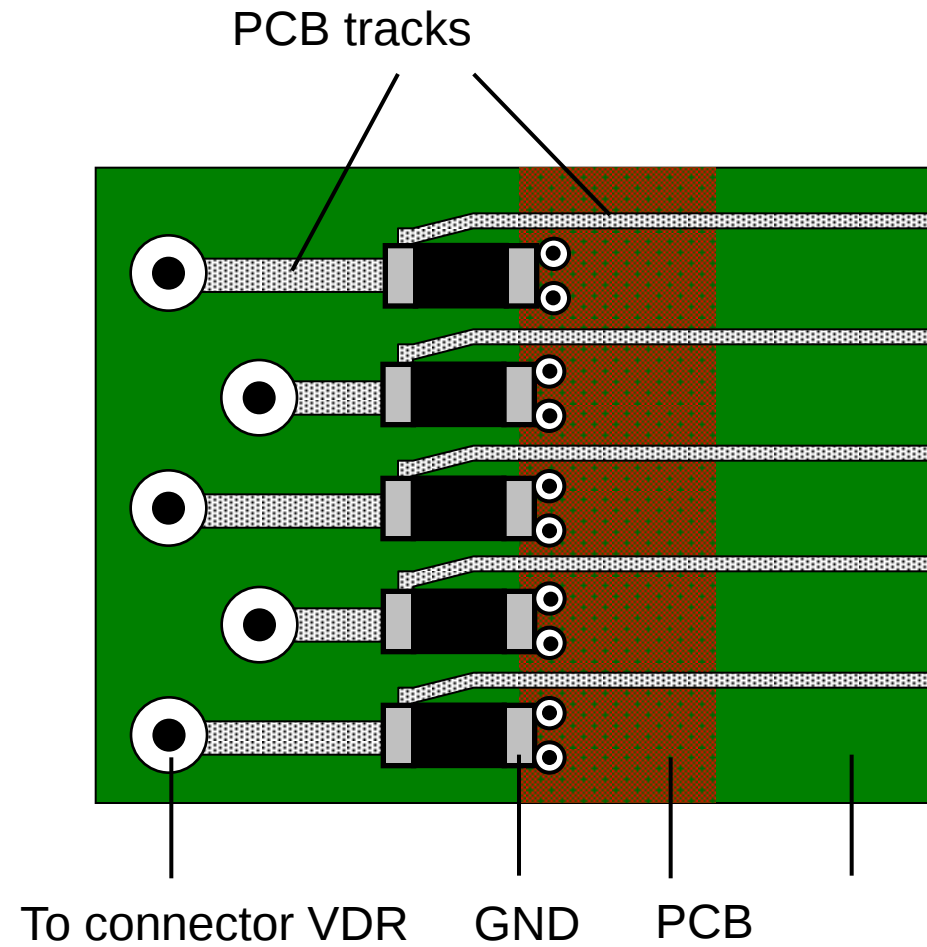
good



better

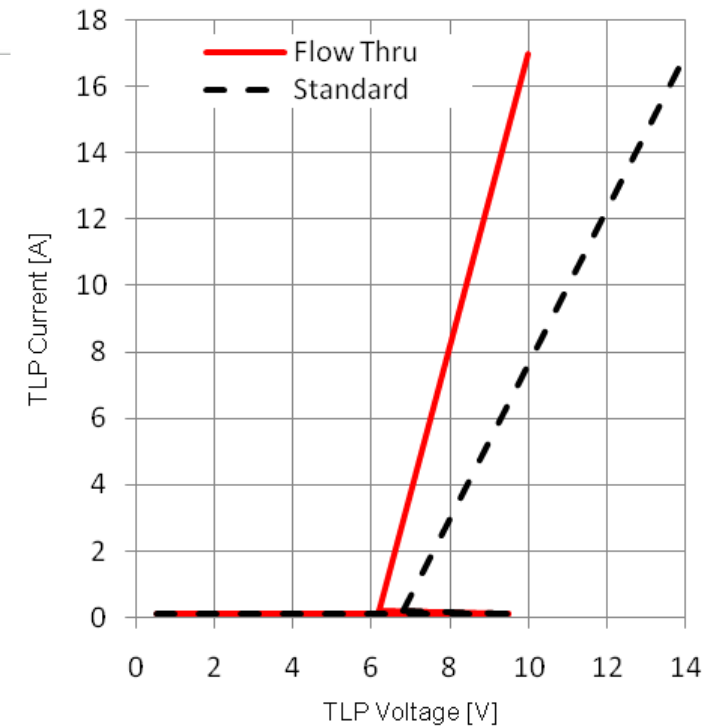
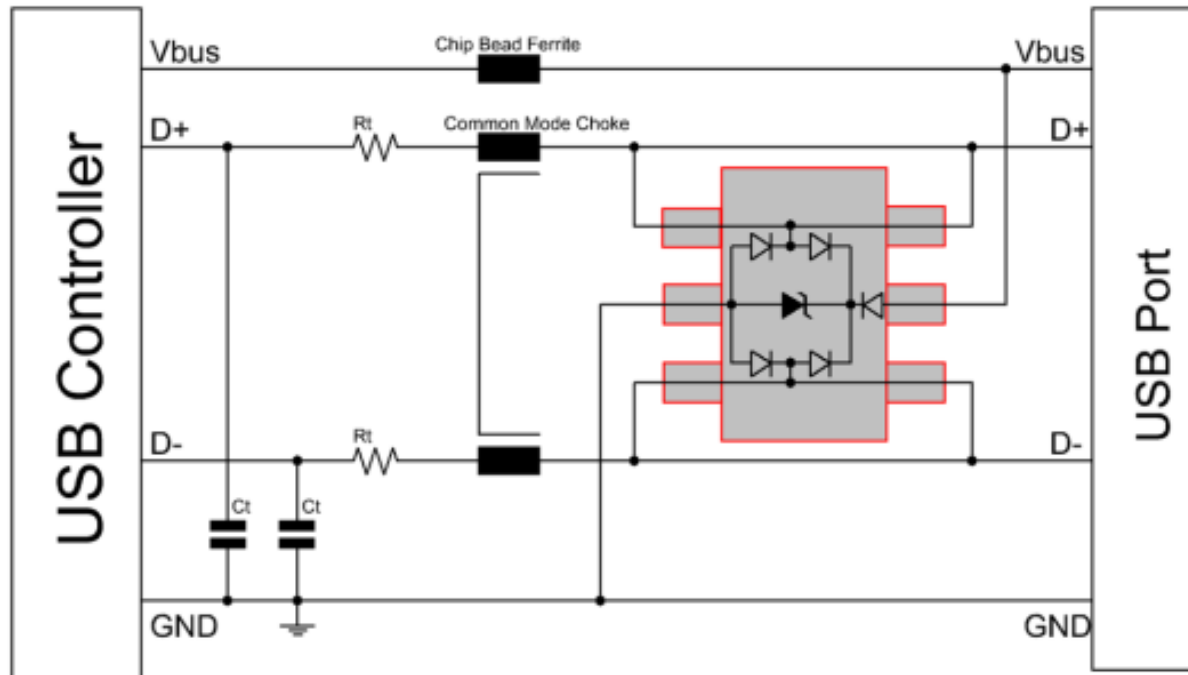


Layout design suggestion for varistors

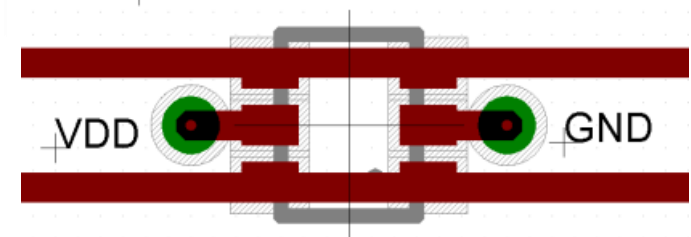




USB 2.0 Flow-Thru Design (ESD-EMI solution)

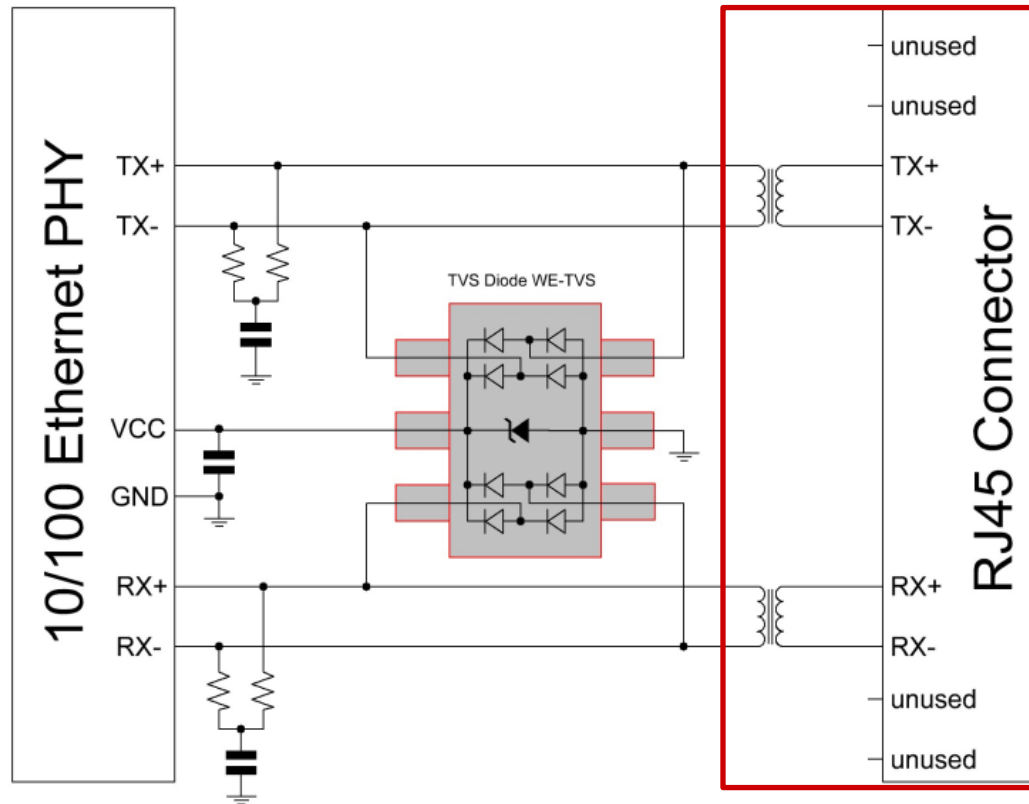


WE-TVS: 824 001x

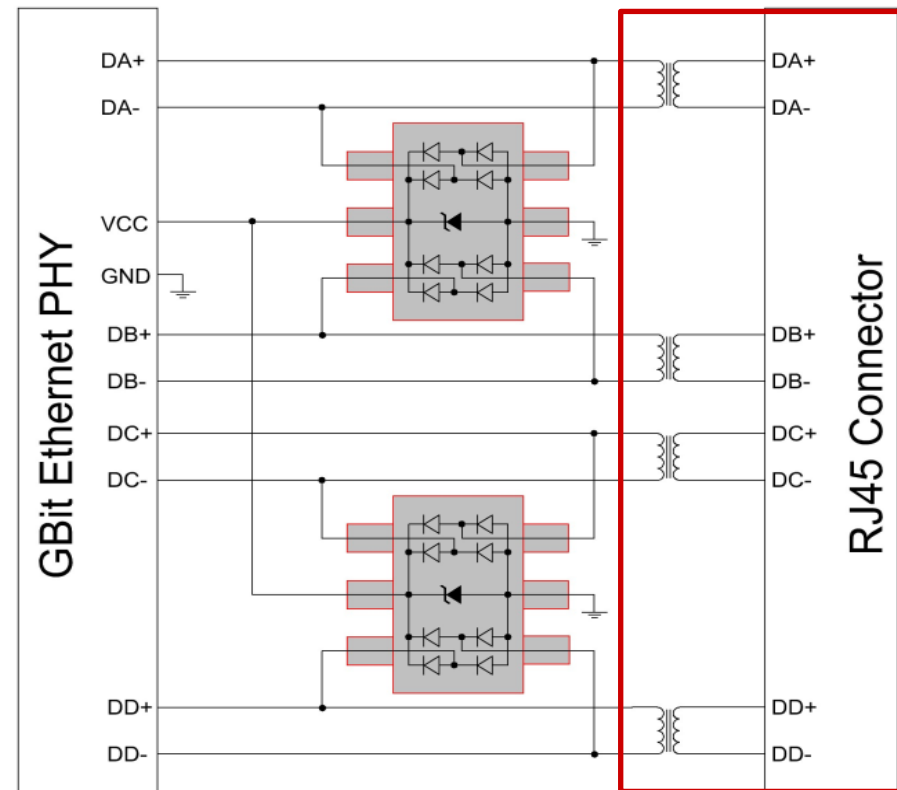


LAN ESD-solution

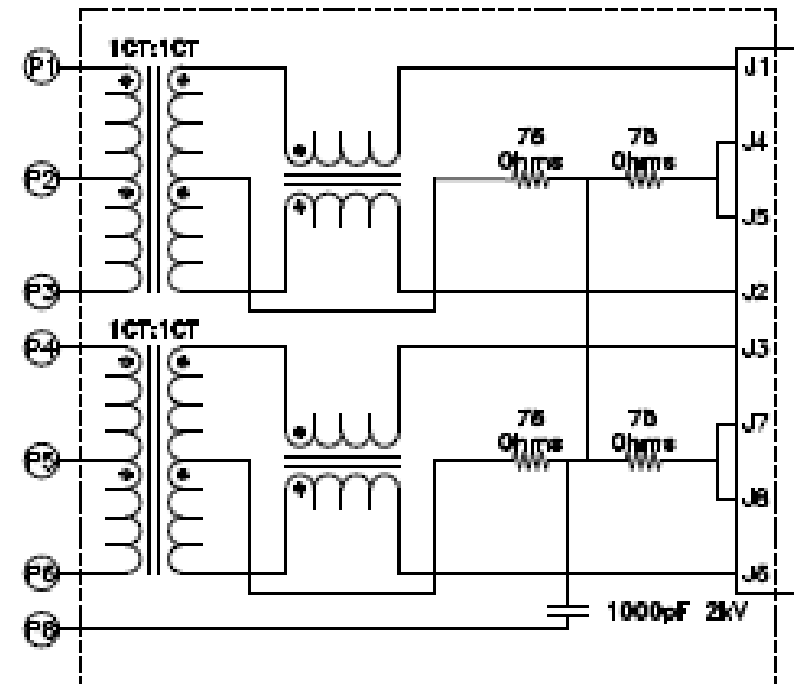
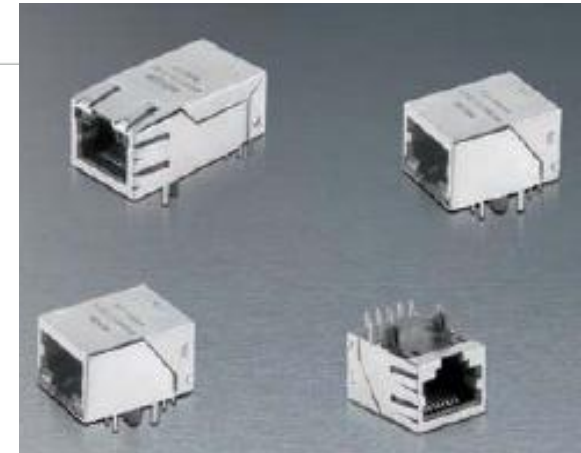
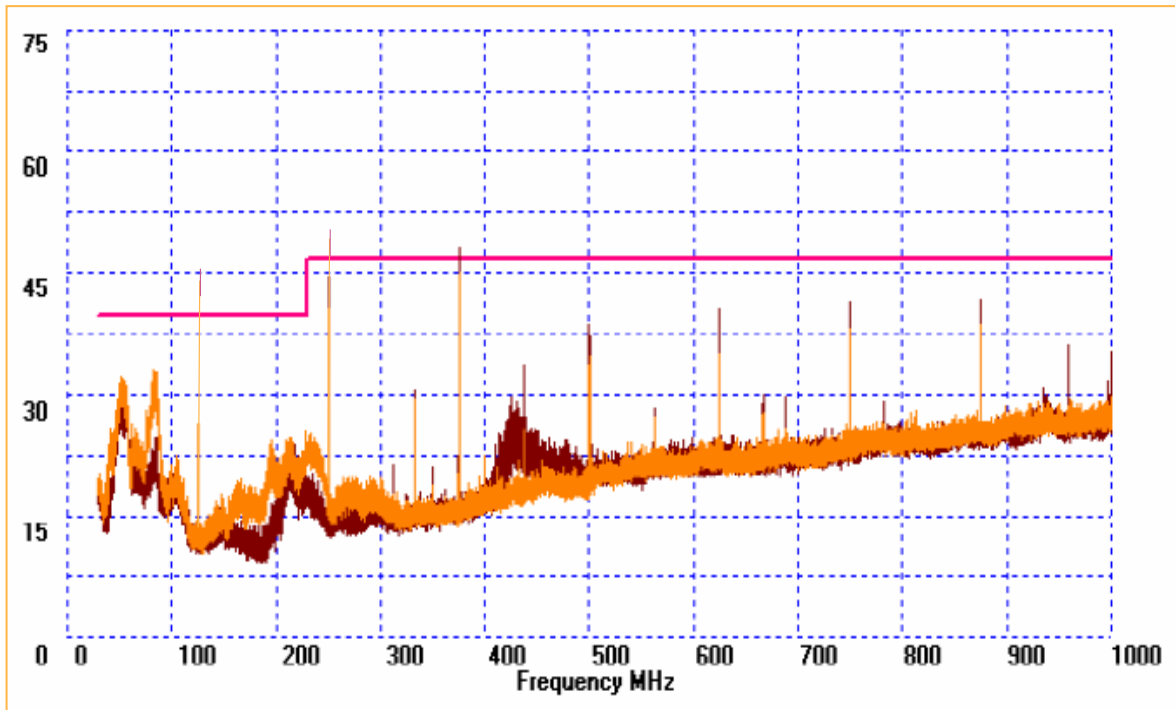
Ethernet 100MBit



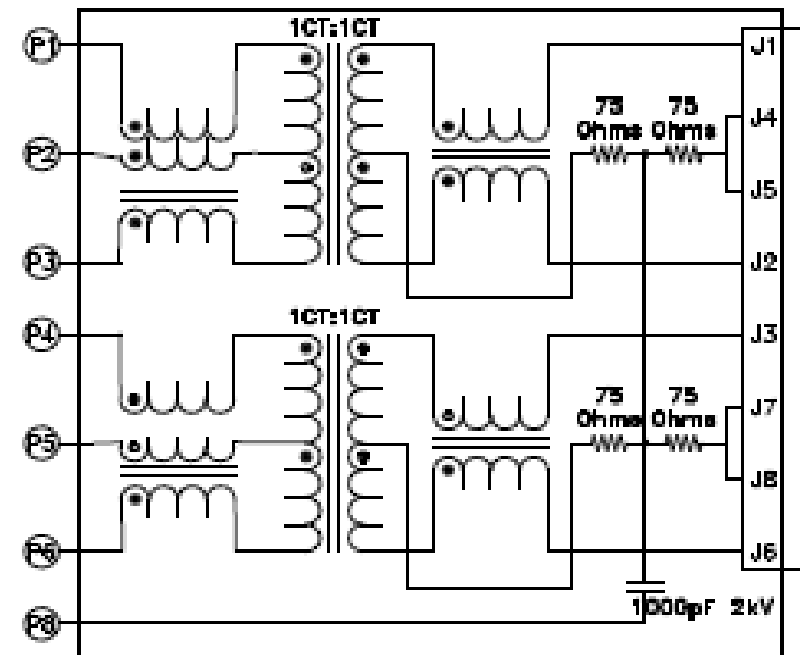
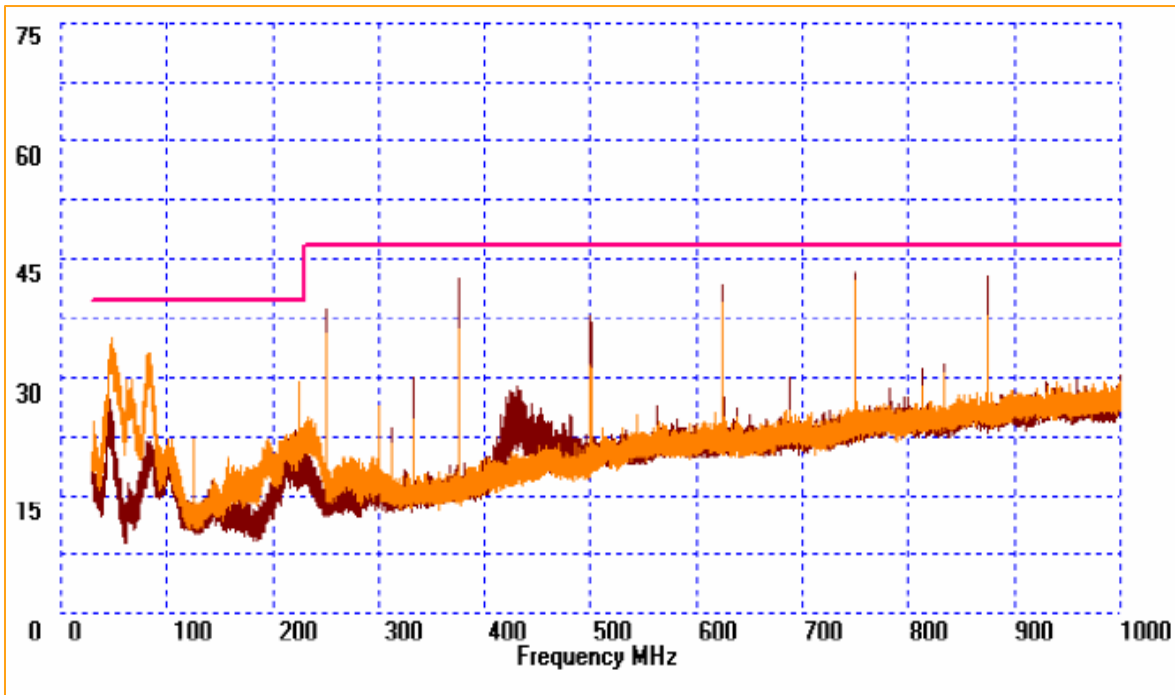
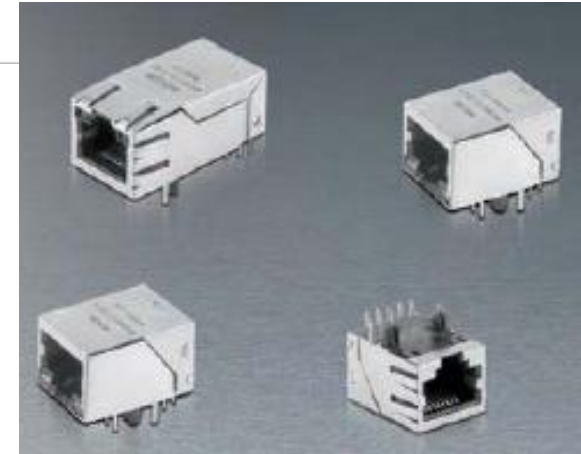
Ethernet 1GBit



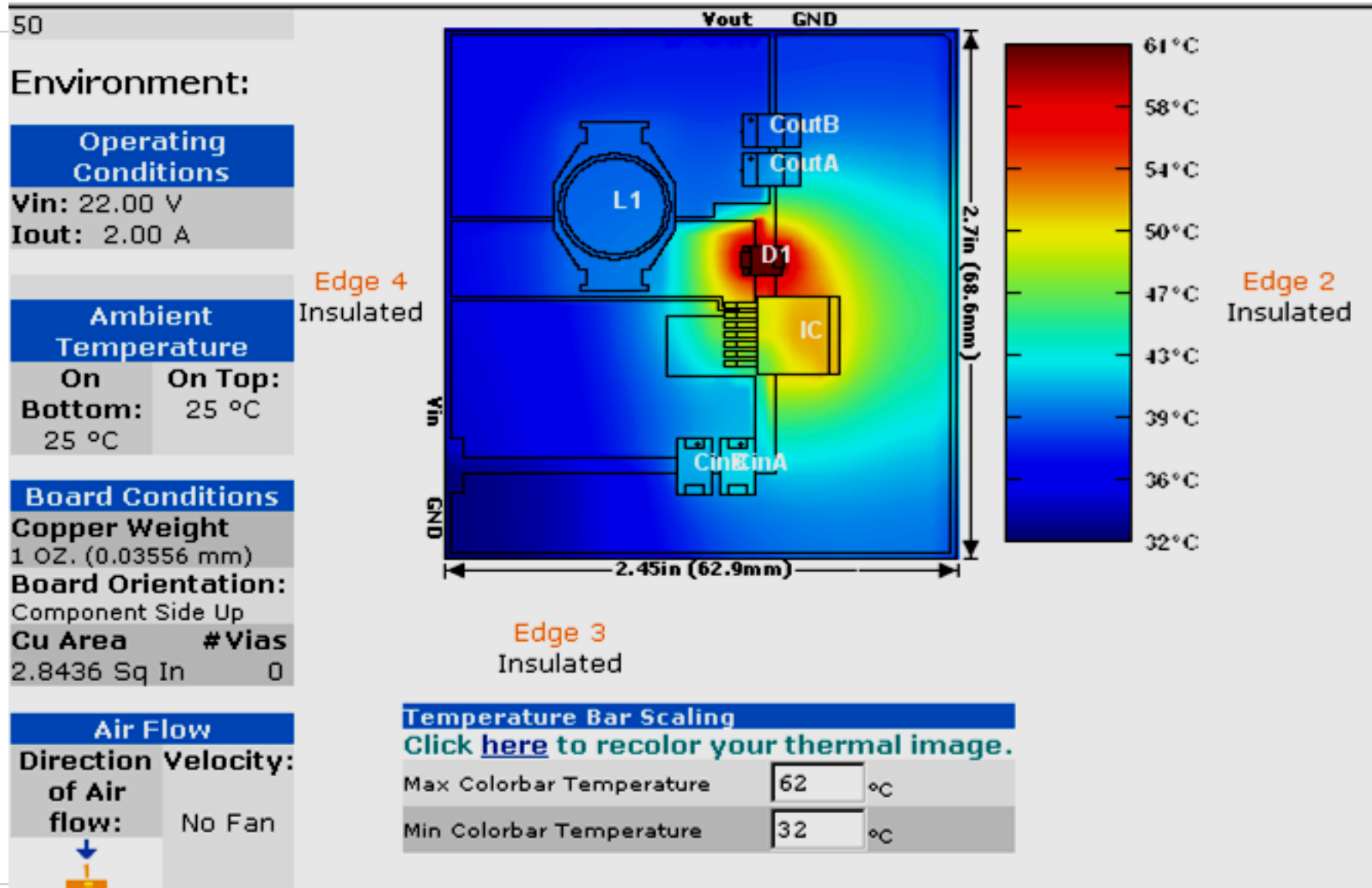
Ethernet EMI solution



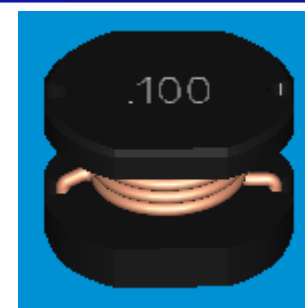
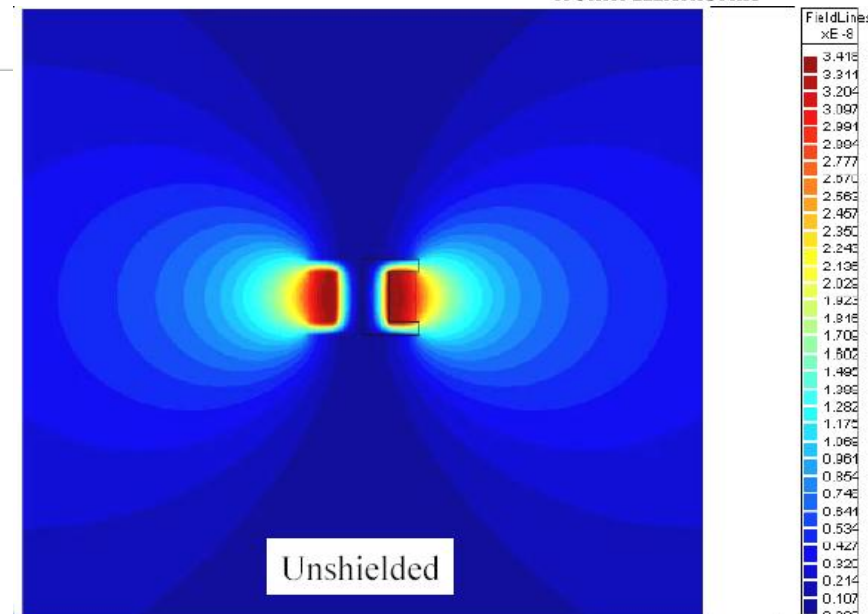
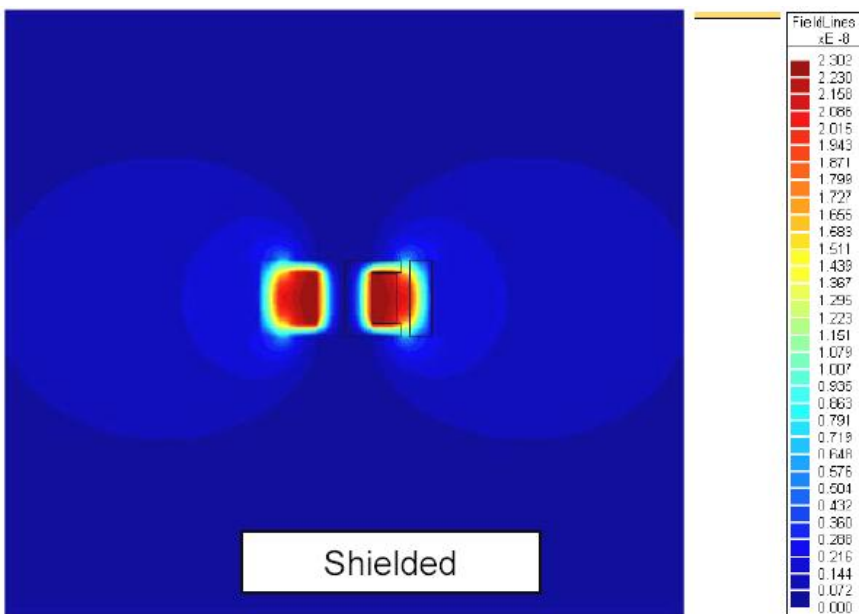
Ethernet EMI solution: WE-RJ45 HPLE



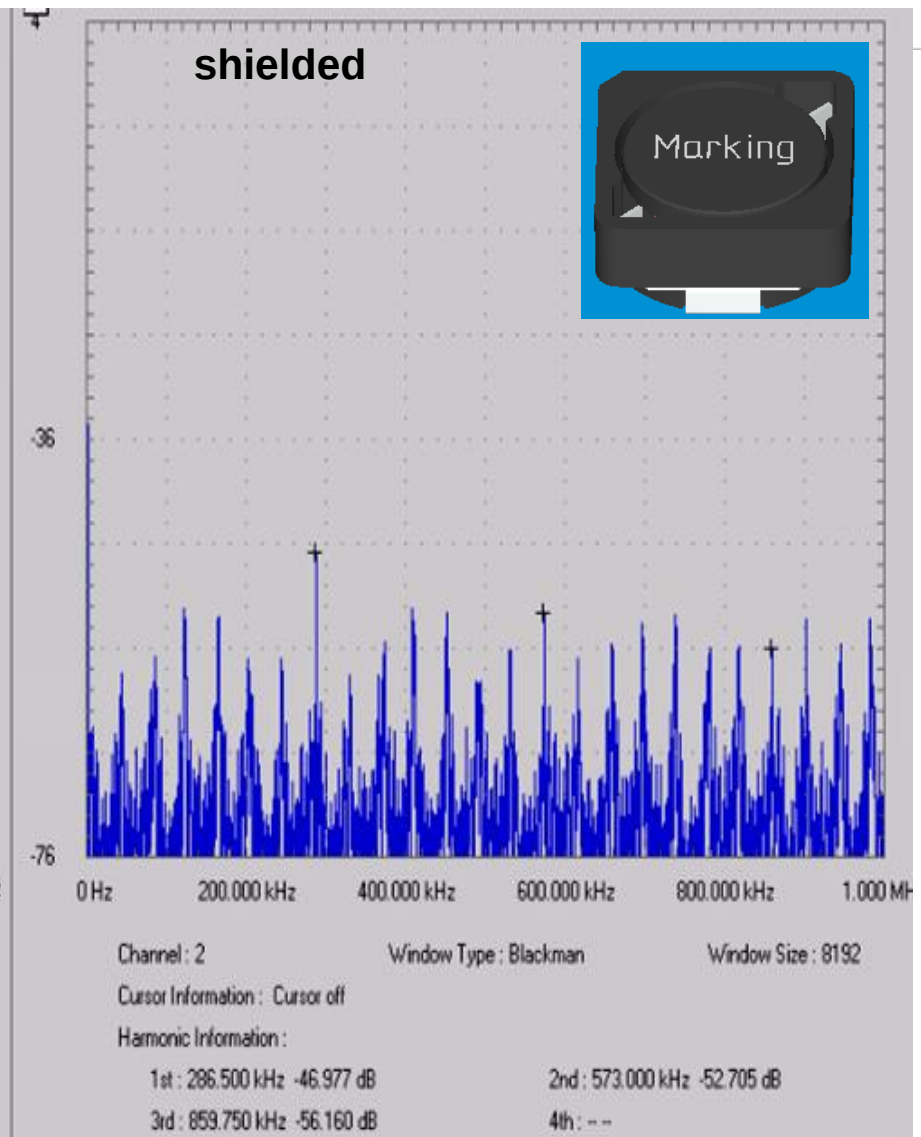
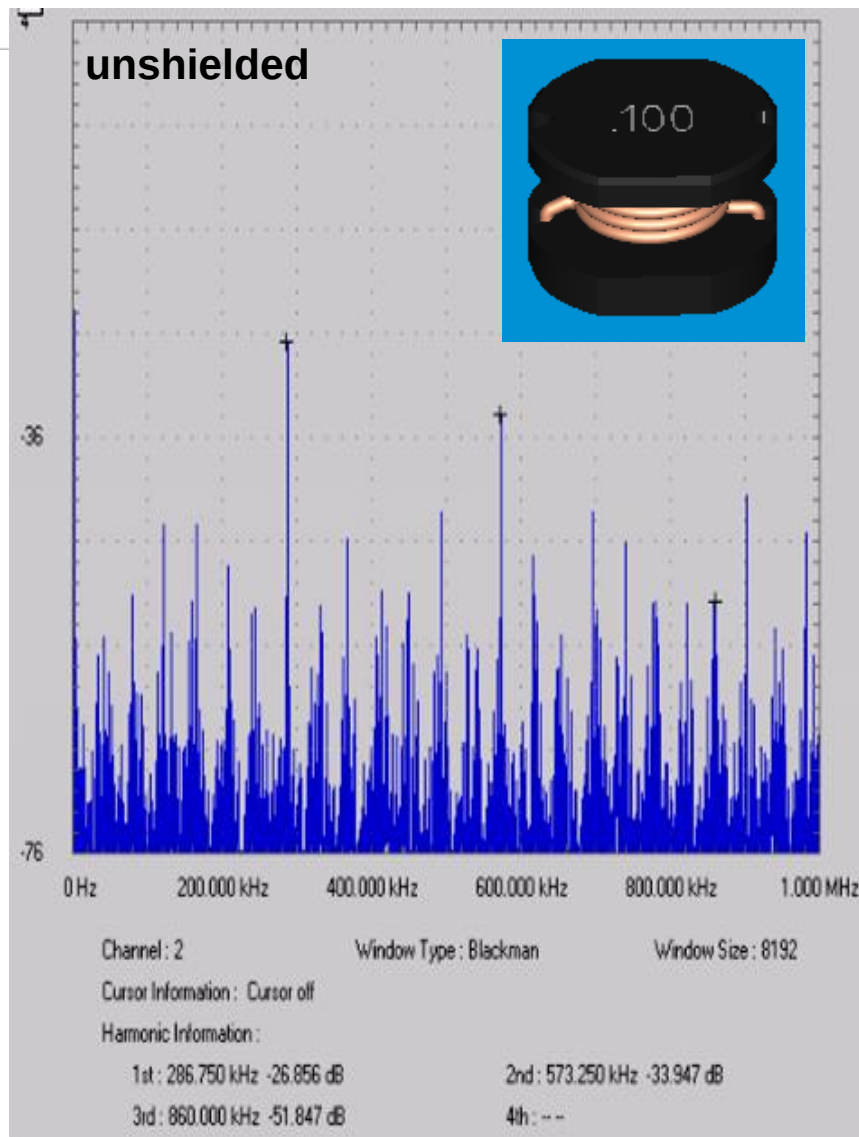
Where are the losses?



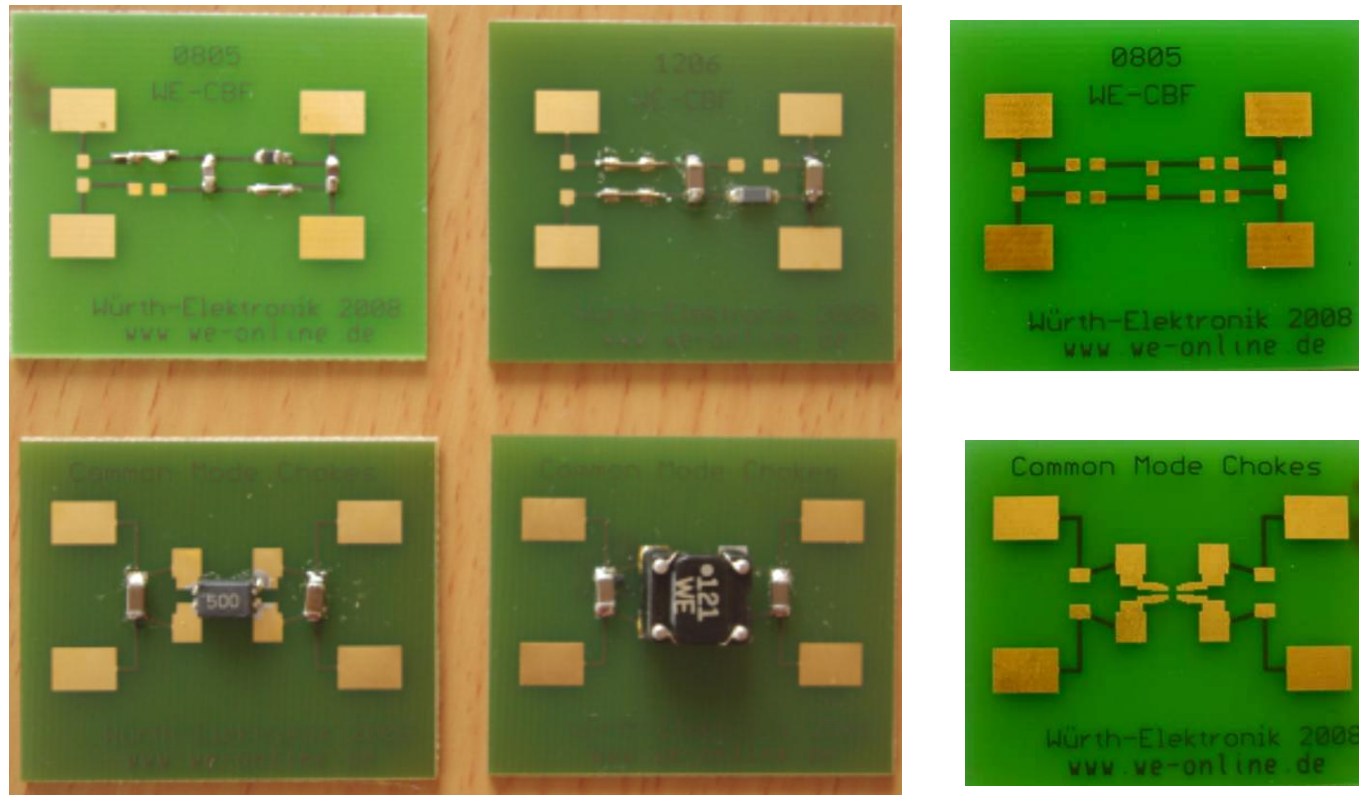
Magnetic leakage shielded vs. unshielded



Magnetic leakage shielded vs. unshielded



Application demo boards



P/N:

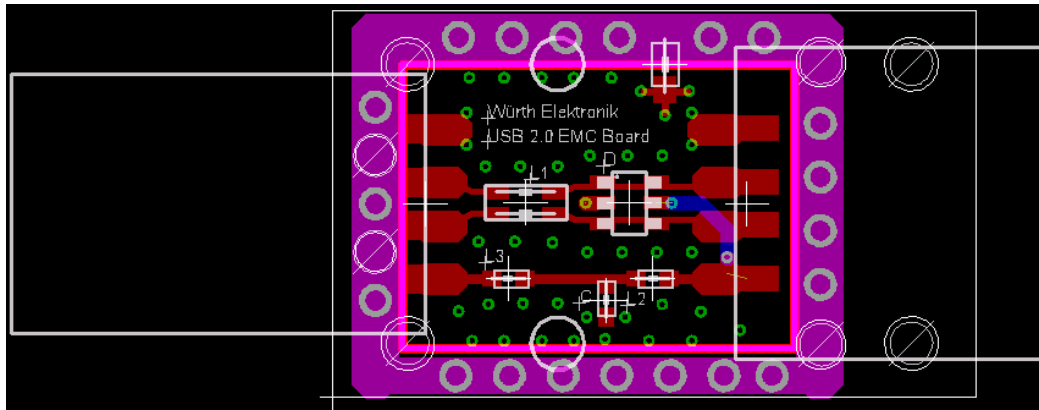
EP-CBF-0805 → SMD Ferrite 0805

EP-CBF-1206 → SMD Ferrite 1206

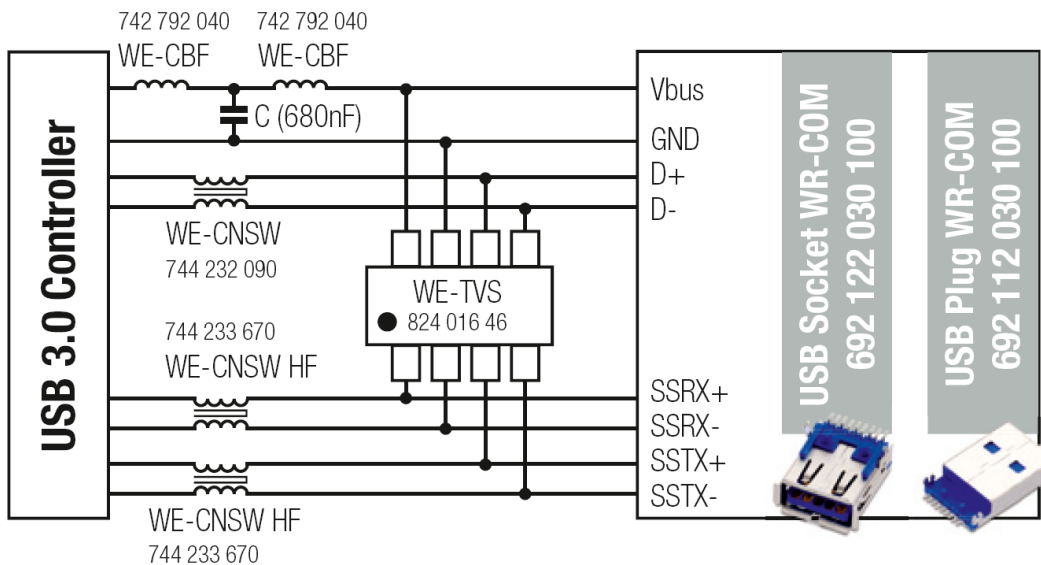
EP-STROKO → WE-SLxy... Series SMD common mode chokes

VPE 12 pcs. → Price 20,- € inclusive P&P

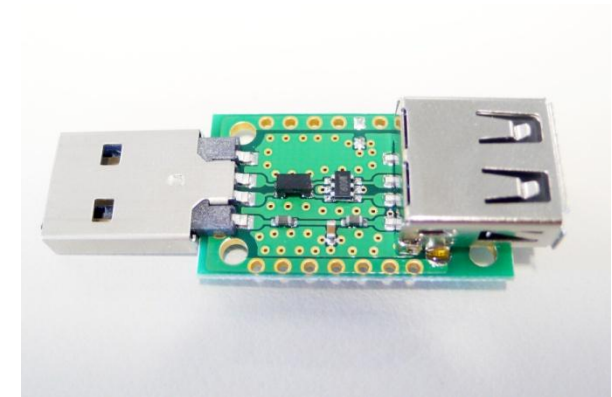
Application demo boards



USB 2.0:
P/N:829999



USB 3.0:
P/N:829993



More information online: www.we-online.com



More than you expect
and every day, worldwide

We promise this to our customers all over the world and work toward keeping that promise every day. Innovative products and solutions and always new, surprising services are our path to success.

 **About us**

Printed Circuit
Boards

Intelligent
Systems

Passive
Components

Electromechanical
Components

Photovoltaics

Welcome to Würth Elektronik

 **About us**

 **News**

TRILOGY OF MAGNETICS

DESIGN GUIDE
for EMI filter design,
SMPS & RF circuits

4th extended and revised edition


[Welcome](#)
[Products](#)
[Toolbox](#)
[Service](#)
[About us](#)
[News](#)
[Events](#)
[Job Offers](#)
[Contact](#)

-  [News](#)
-  [Events](#)
-  [Forms](#)
-  [Application Notes](#)
-  [Contact](#)



Toolbox for Engineers & Purchasers



Software

- > [Magnetic Builder](#)
- > [WEBENCH®](#)
- > [Component Selector](#)
- > [LTspice Simulator](#)



Search Tools

- > [Application Guide](#)
- > [Product Finder - One Click Selection Guide](#)
- > [RF Product Finder](#)
- > [Product Matrix](#)
- > [Product & Application Overview Passive Components](#)
- > [Product & Application Overview Electromechanical Components](#)
- > [Crossreference](#)
- > [IC Reference Designs](#)
- > [Search Engine for Passive Components](#)
- > [Search Engine for Electromechanical Components](#)

EMC LAB SEARCH ENGINE



Get quick access to the EMC test lab you are looking for.

> [Run the search](#)

> [Add your EMC lab](#)

COMPONENT SEARCH ENGINE



The search engine for passive components!

> [Run the search](#)



You can reach us:

Tel: +49 (0)7942-945-0

Fax: +49 (0)7942-945-5000

eiSos-hotline@we-online.com

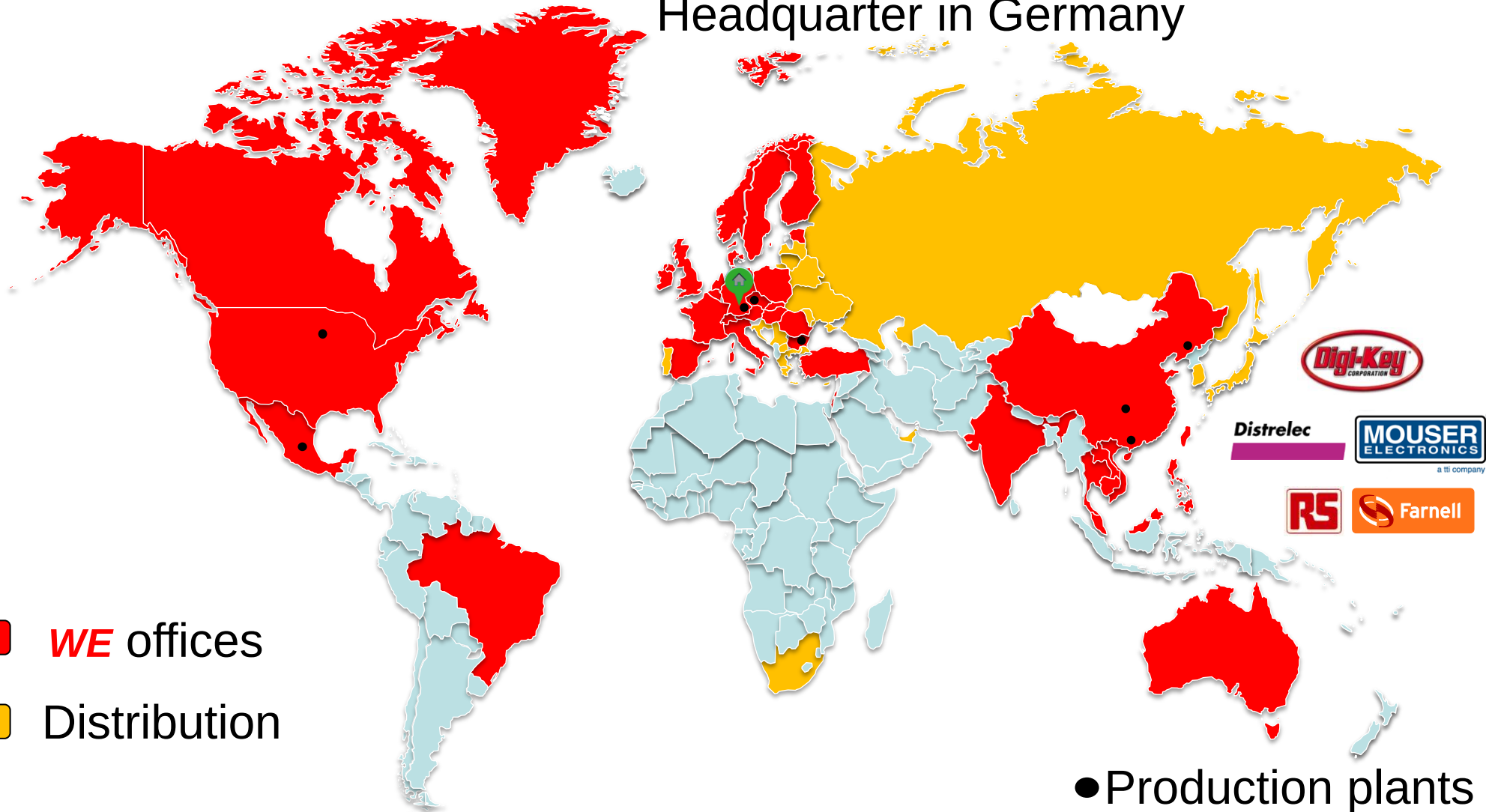
www.we-online.com



Globally available. Locally present!



Headquarter in Germany



WE does not mean Wireless Earthing !



... when all that did not helps:



Source: Kontakt Chemie