DIGITAL WE DAYS 2023

ELECTROMAGNETIC SHIELDING – BASICS & SOLUTIONS FOR DEVELOPERS

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

TODAY'S SPEAKERS

PRESENTATION
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MODERATION
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Marketing Department

INFORMATION ABOUT THE WEBINAR

You are muted during the webinar.
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Duration of the presentation	30 Min
Q&A:	10 – 15 Min

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AGENDA

- Introduction
- Basics
- Apertures
- Shielding Solutions

INTRODUCTION

INTRODUCTION

What does „electromagnetic shielding“ mean?

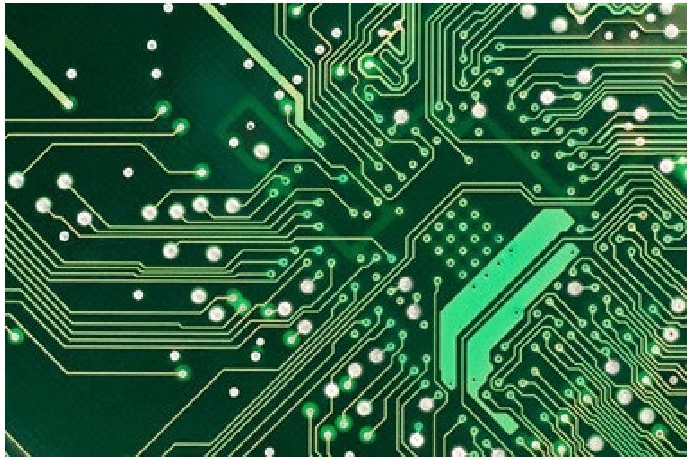
BASICS

BASICS

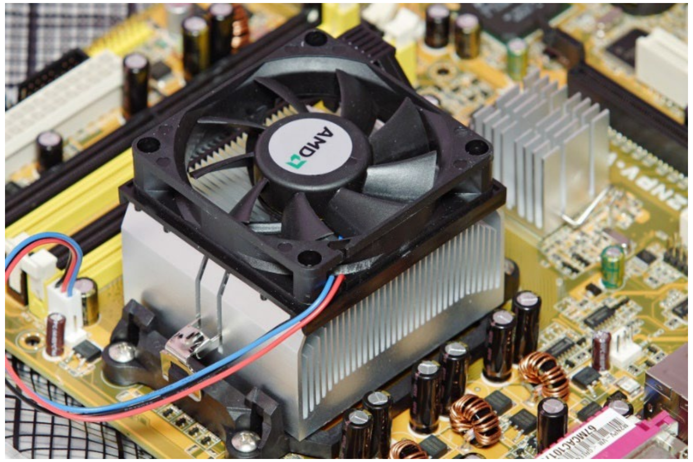
Unintended Antennas

- Electromagnetic fields are transmitted from or received by electrically conducting structures.
- Unintended antennas can be:

Cables, interfaces, apertures



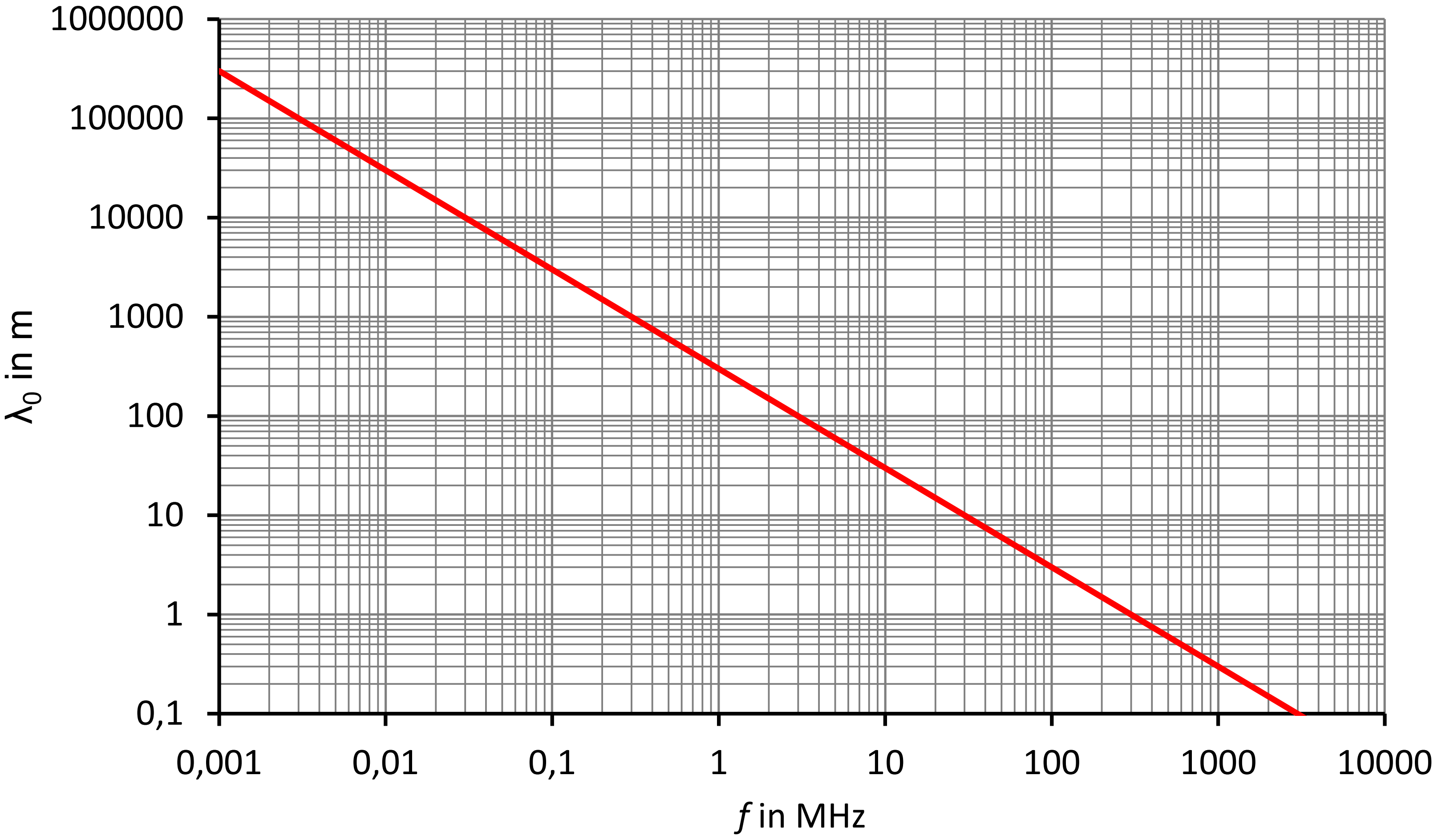
Traces, groundplanes, vias, slits



Components, heatsinks, integrated circuits

BASICS

Wavelength



- Relation between frequency and wavelength:

$$\lambda_0 = \frac{c_0}{f}$$

- Examples:

$f = 500\text{kHz} \rightarrow \lambda_0 = 600\text{m}$

$f = 8\text{MHz} \rightarrow \lambda_0 = 37{,}5\text{m}$

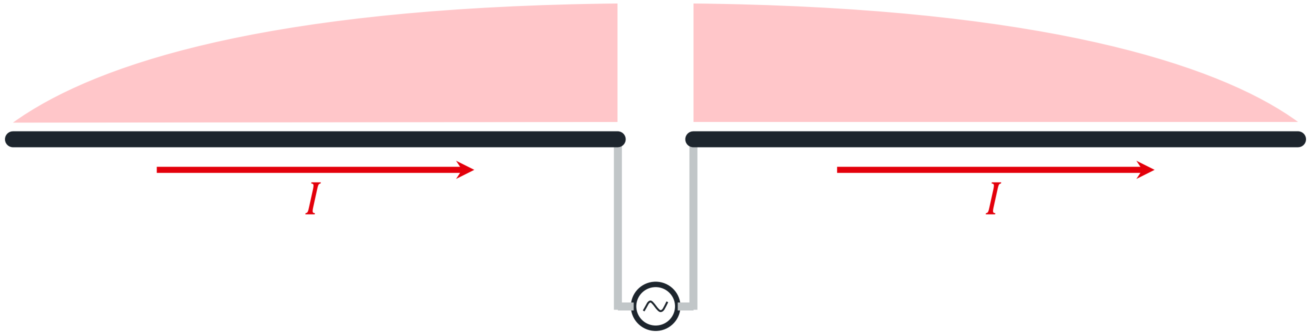
$f = 100\text{MHz} \rightarrow \lambda_0 = 3\text{m}$

$f = 2{,}45\text{GHz} \rightarrow \lambda_0 = 12{,}5\text{cm}$

BASICS

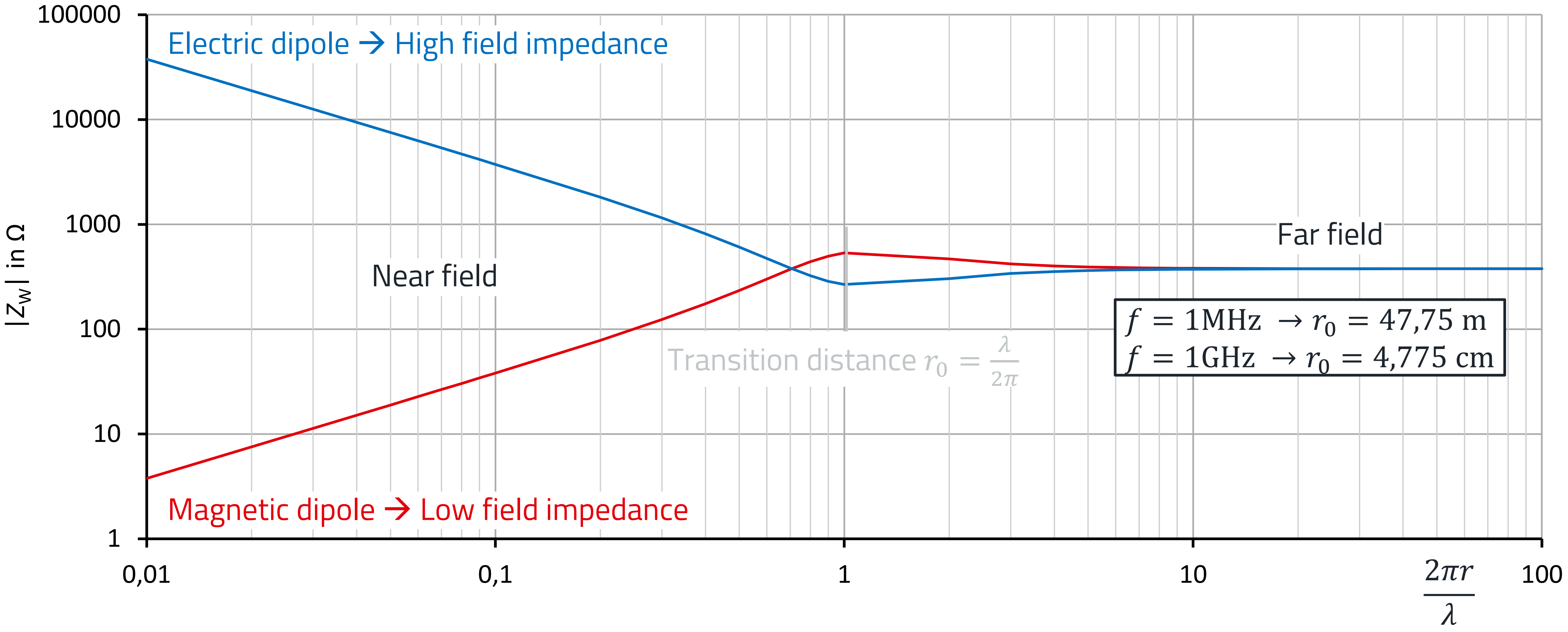
Half-wave Dipole

- A conductive structure is not a **good antenna** for each frequency.
- The **ratio** of the structure length to the wavelength is crucial.
- There is an **optimal** ratio if the structure length is equal to **half of the wavelength** (half-wave dipole).
- Signifikante Antennenwirkung tritt bei einer Länge von bis zu einem **Zwanzigstel** der Wellenlänge auf.



BASICS

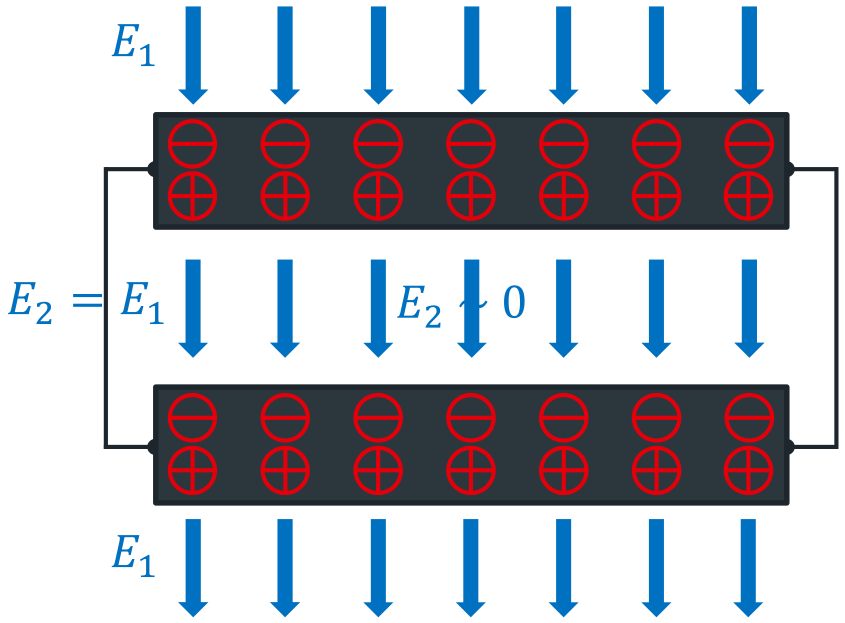
Wave Impedance



BASICS

Shielding Against Electric Fields

- Electric fields can be **shielded easily**.
- Electric field lines start and end on **charges**.
- It has to be assured that free charges can **balance** themselves.
- Shielding effect of **electrically conductive connected plates** on a static electric field:

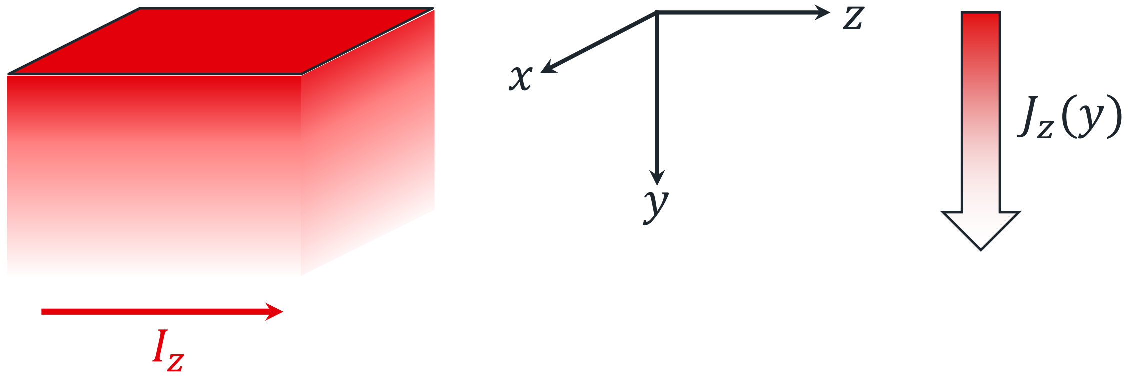


BASICS

Shielding Against Magnetic Fields

- Magnetic fields are **difficult to shield**, specifically static and low-frequency fields.

- Categorization of countermeasures:
  - Against static and low-frequency fields → **Highly permeable** materials
  - Against medium-frequency fields → Usage of the **skin effect**
  - Against high-frequency fields → **Reflection** and **absorption**



BASICS

Shielding Against Magnetic Fields

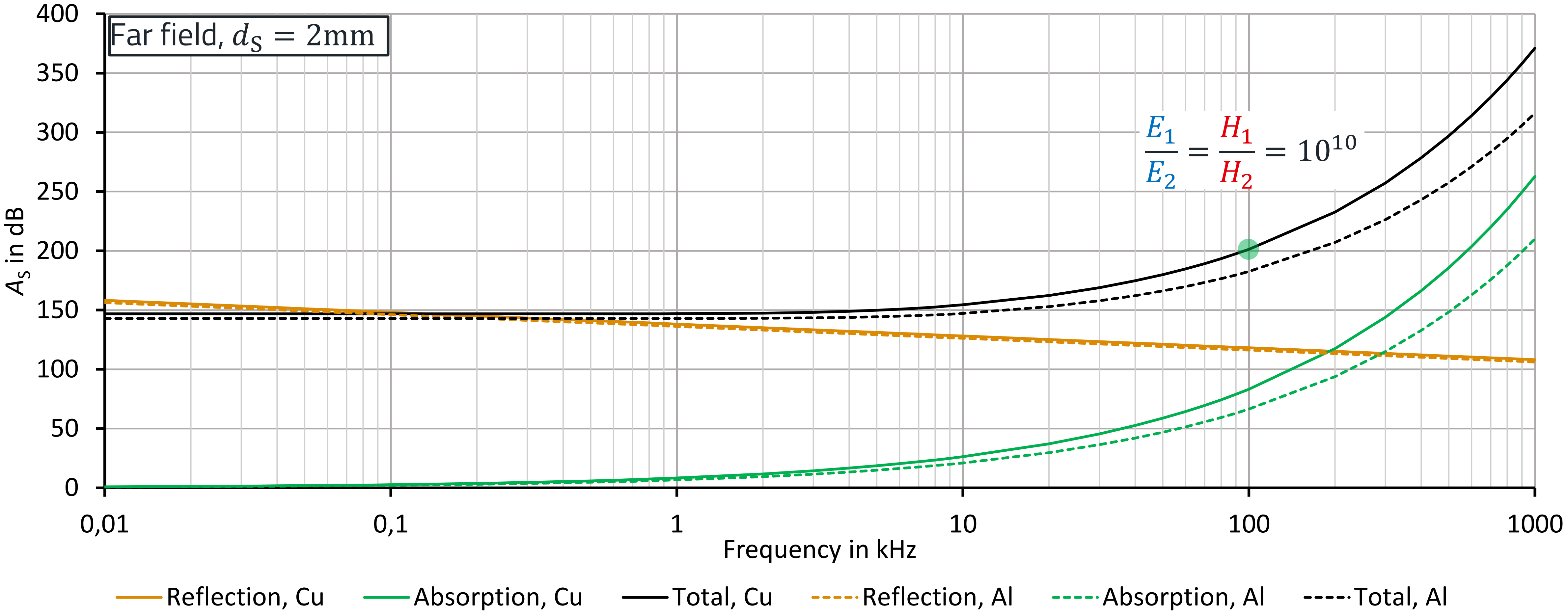
- In order to suppress static and low-frequency magnetic fields (16⅔ Hz, 50/60 Hz), **highly permeable** materials are used.
- The shielding effect increases
  - with higher permeability,
  - with higher shield thickness,
  - with smaller volume.

Material	Relative permeability μ_r
Nickel	100
Steel	1000
Stainless steel	500
Mumetal	25000

Siemens Healthineers

BASICS

Theoretical Shielding Attenuation

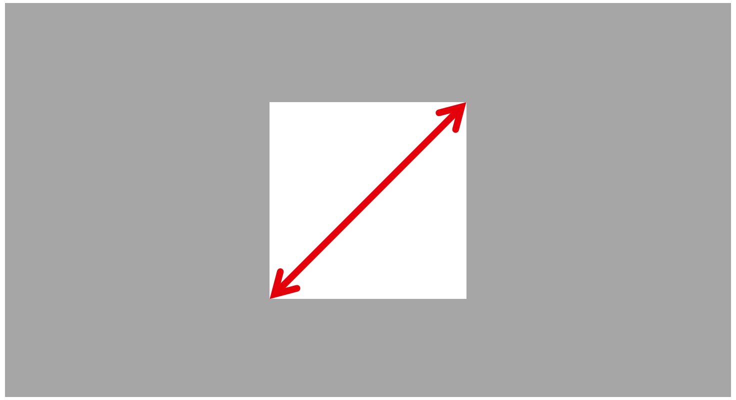


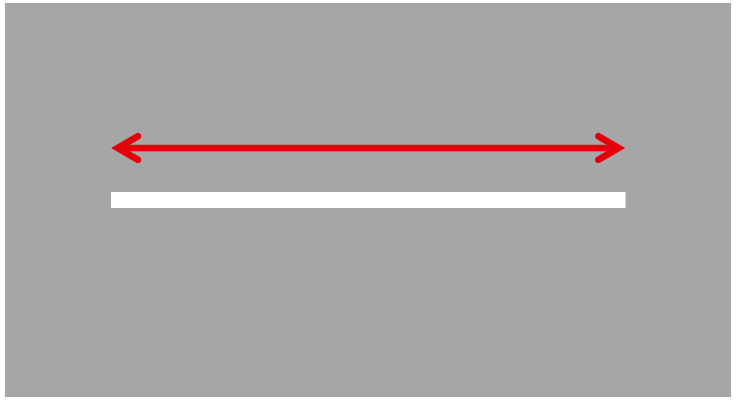
APERTURES

APERTURES

Dimensions

- The determination of the shielding attenuation by **means of measurement** is limited to 120 dB.
- There is no real shield which is perfect, i.e. completely closed.
- **Apertures** in the shield have a stronger impact on the magnetic than on the electric shielding attenuation.
- The **maximum linear dimension** of an aperture is crucial, not its surface area.



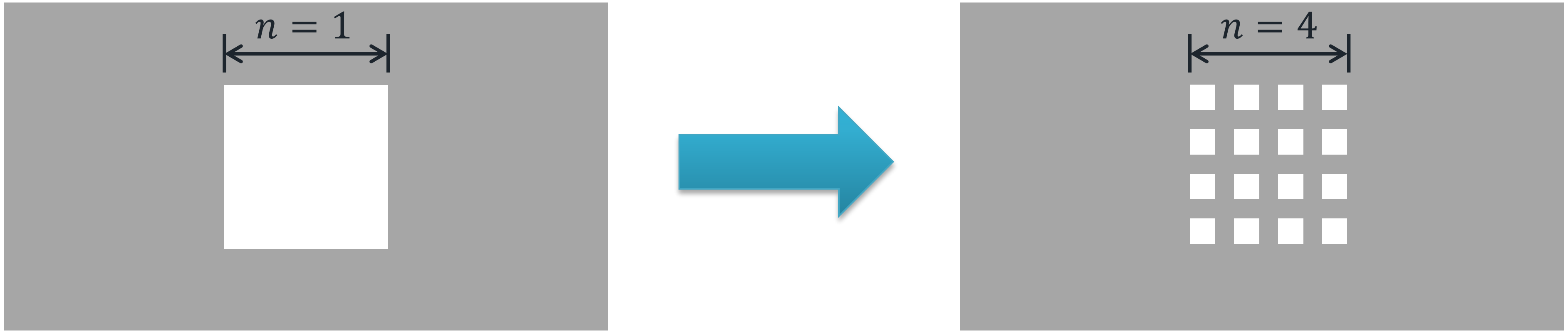


APERTURES

Dimensions

- An aperture with length $\ell = {}^{\lambda}/_{2}$ has the same effect as a **half-wave dipole**.
- If the **electric** field vector is oriented **perpendicular** or the **magnetic** field vector **parallel** to the aperture, the shielding attenuation at that frequency is 0 dB.

- If a larger window is required, e.g. for ventilation, the area should be distributed over many smaller holes.



APERTURES

Dimensions

- Maximale Schlitzlänge für 20 dB Schirmdämpfung:

Frequenz in MHz	Länge in cm
30	50
50	30
100	15
300	5
500	3
1000	1,5
3000	0,5
5000	0,3

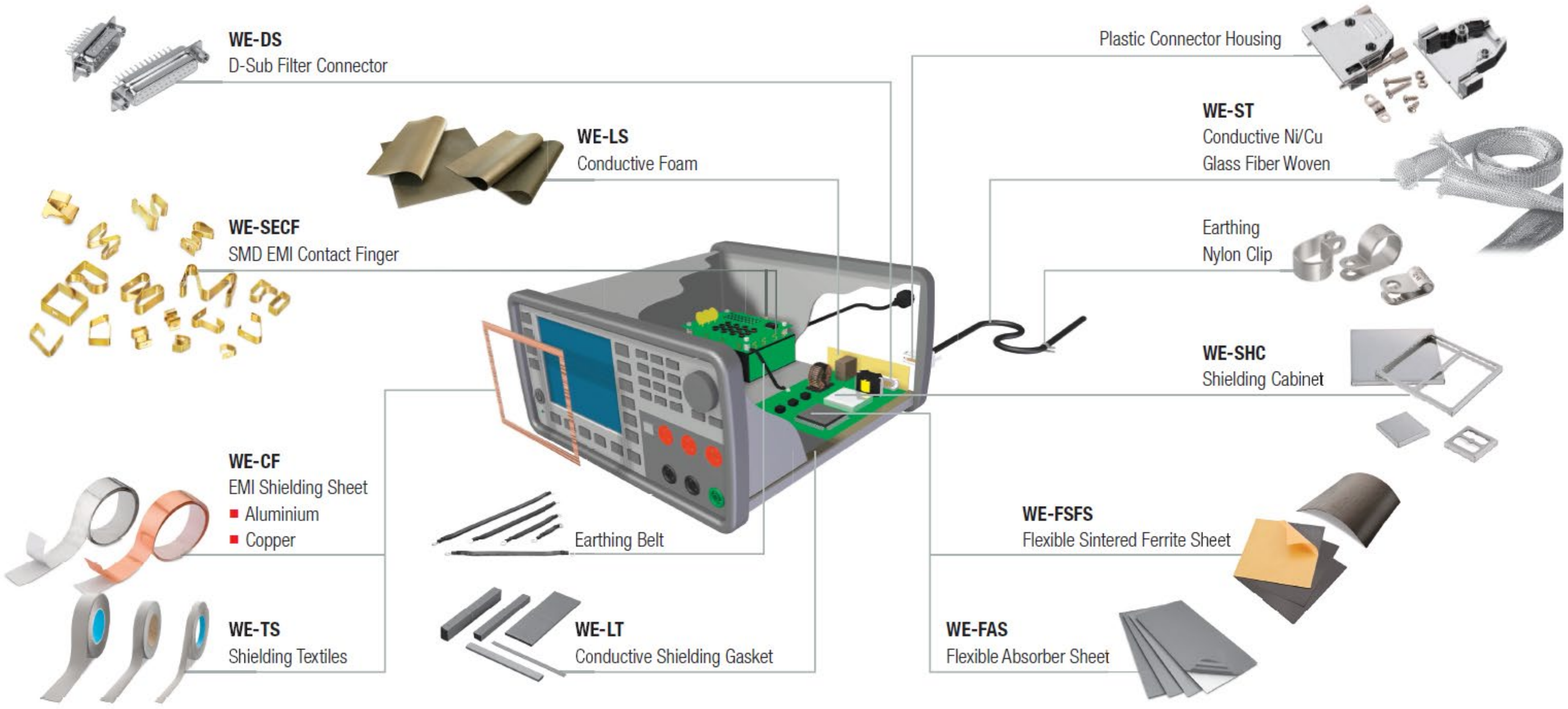
- Reduktion der Schirmdämpfung bei $n > 1$:

n	ΔA_S in dB
2	-3
4	-6
6	-8
10	-10
20	-13
40	-16
80	-19
100	-20

SHIELDING SOLUTONS

SHIELDING SOLUTIONS

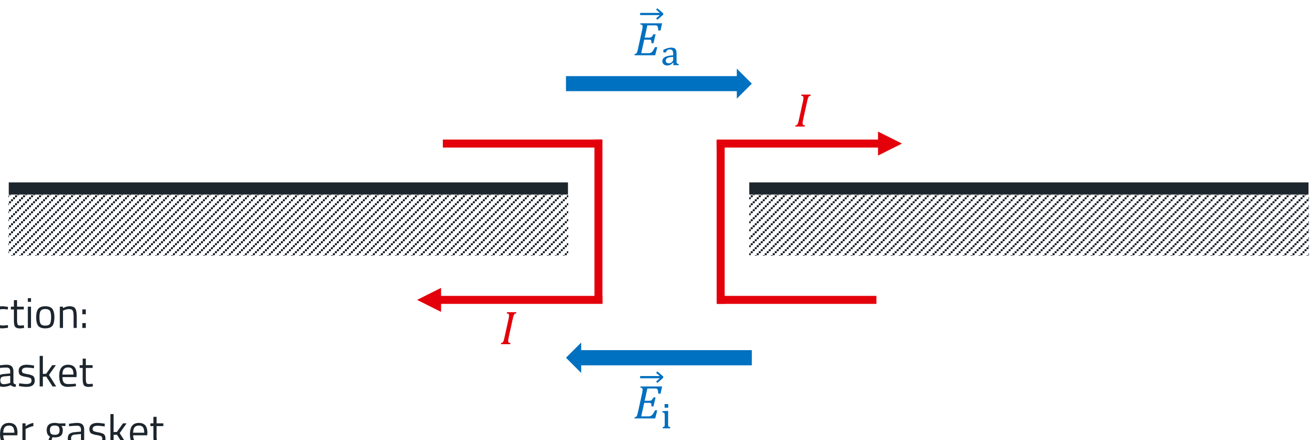
Overview



SHIELDING SOLUTIONS

Slots, Seams, Transitions

- At transistions in the housing (edges, seams) the **connection area** should be **as large as possible** and **conductive**.
- Slots without a conductive connection:

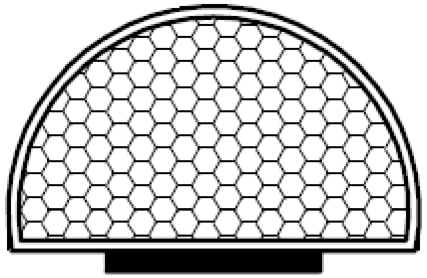


- Assuring a good connection:
  - Conductive textile gasket
  - Conductive elastomer gasket
  - Contact spring gasket

SHIELDING SOLUTIONS

Slots, Seams, Transitions

- Conductive textile gaskets consist of a **sponge core** with a **nickel-copper fabric** wrapped around. On one side a **double-sided adhesive** is attached.
- Flammability:
  - UL94 V-0
  - DIN EN 45545-2:2020 → R22/R23
- –40…85 °C



- Application examples:

SHIELDING SOLUTIONS

Slots, Seams, Transitions

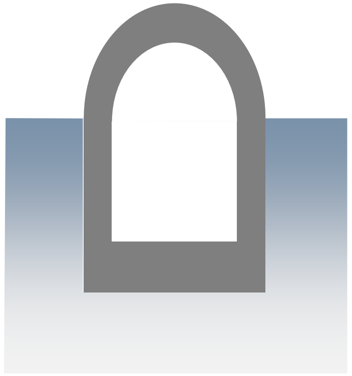
- Material combination table:

Base material	Nickel-copper	Aluminum
Zinc	−−	++
Aluminum	−−	++
Copper	+	−
Tin	+	−
Nickel-silver	+	−
Lead	+	−
Nickel	++	−−
Silver	++	−−
Nickel-copper	++	−−
Gold	++	−−

SHIELDING SOLUTIONS

Slots, Seams, Transitions

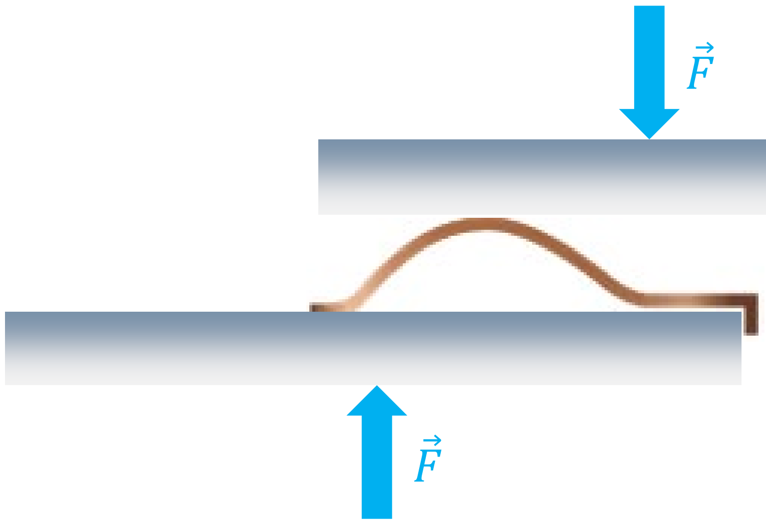
- Conductive **elastomer gaskets** are used if a higher IP rating is required.
- –50…150 °C

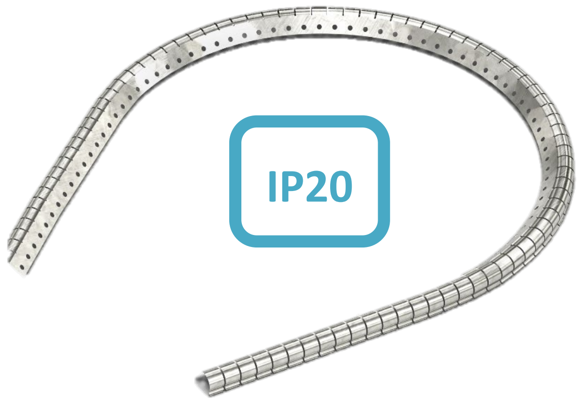


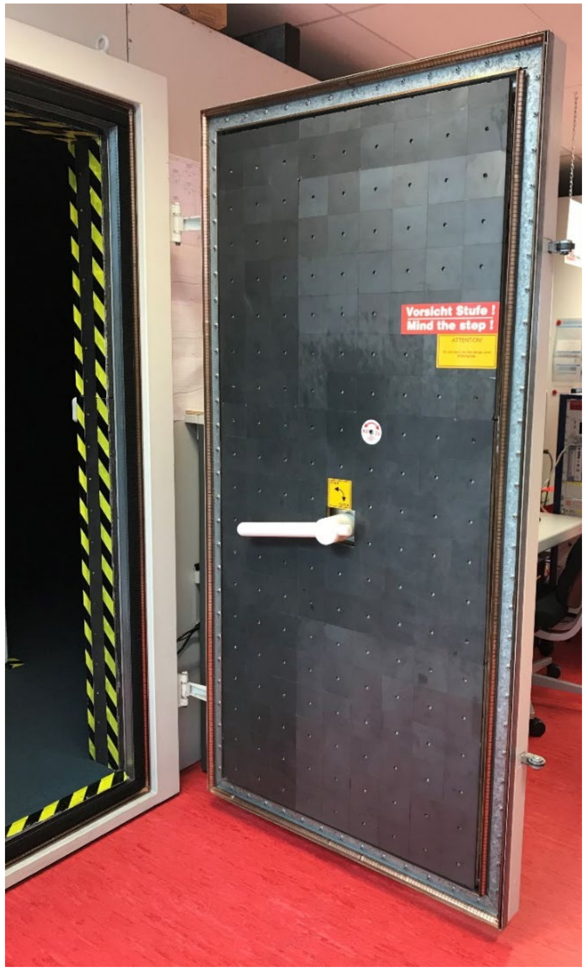
SHIELDING SOLUTIONS

Slots, Seams, Transitions

- **Contact spring gaskets** are made of copper-beryllium or stainless steel.
- –40…120 °C
- Application example:





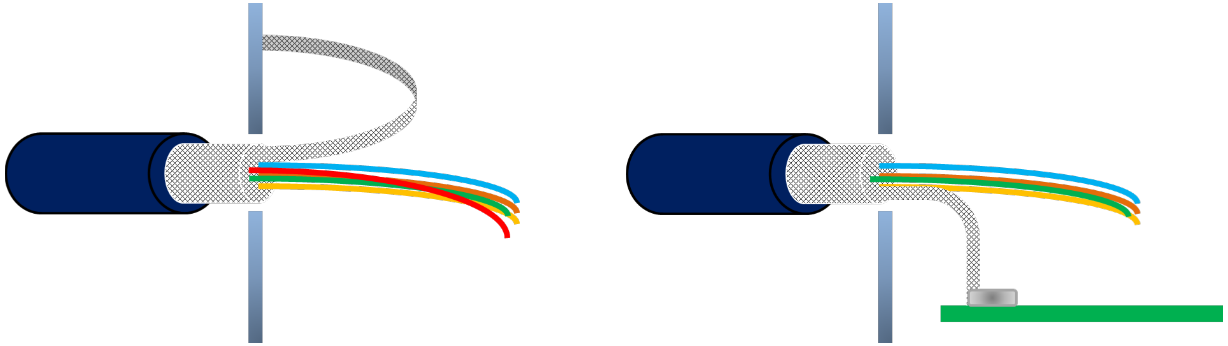


SHIELDING SOLUTIONS

Cables

- Shielding of cables and cable bundles:

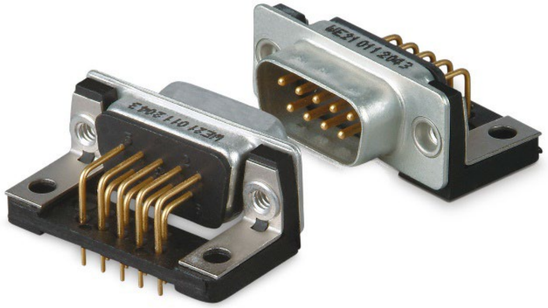
- Avoidance of pigtails is crucial:



SHIELDING SOLUTIONS

Interfaces

- Filtered **D-Sub interface** for RS-232, RS-485 or power supply (max. 5 A @ 100 V_{DC}):



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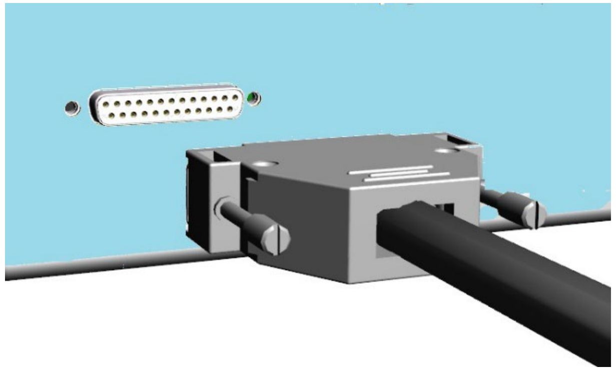
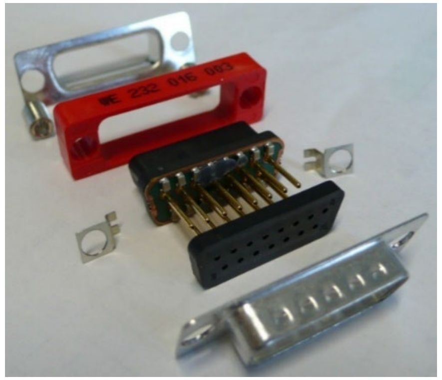


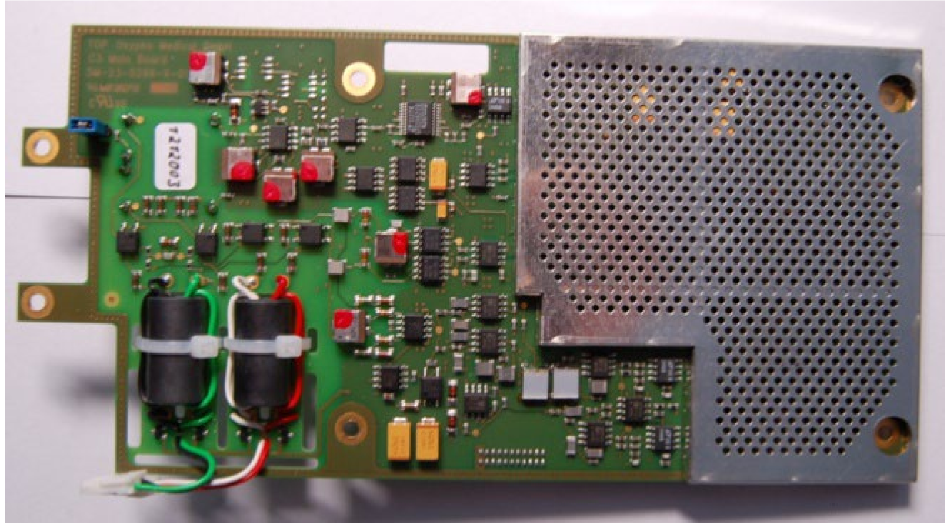
- D-Sub filter adapter:

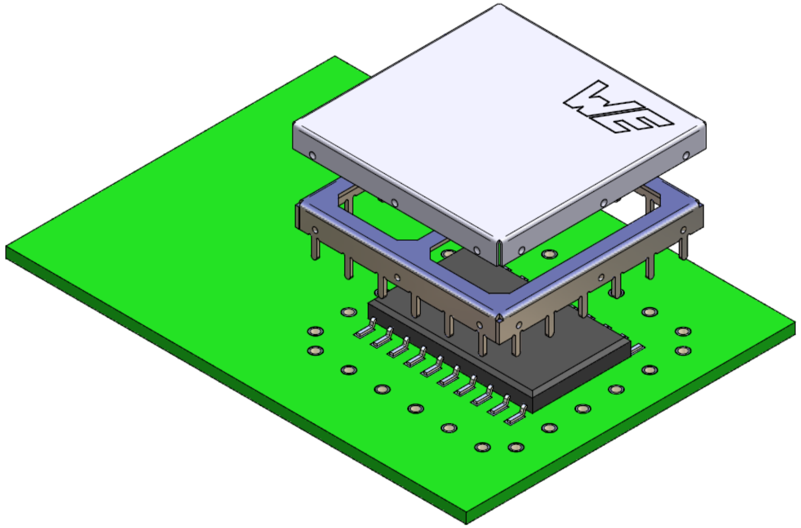


SHIELDING SOLUTIONS

Board Level

- Copper **groundplanes** are a useful shield against electric fields.
- Local shielding by means of **metal cabinets** for sensitive or noisy circuits



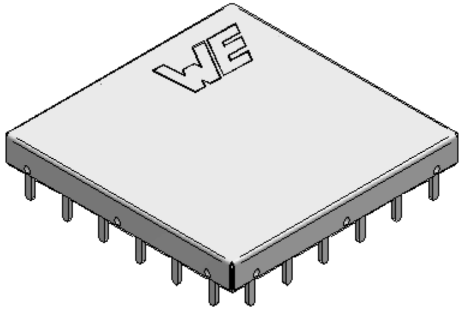


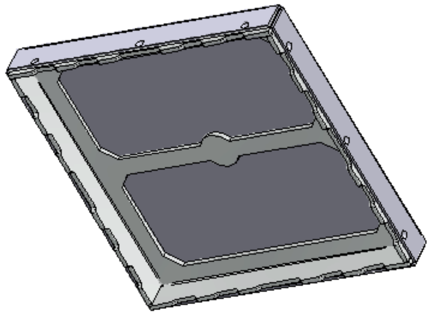
- Important: The cabinet must be connected with a **low impedance** to the local circuit ground.

SHIELDING SOLUTIONS

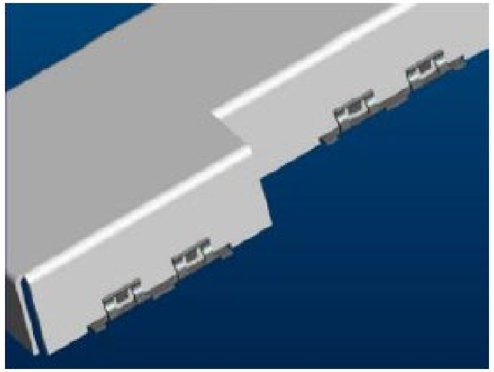
Board Level

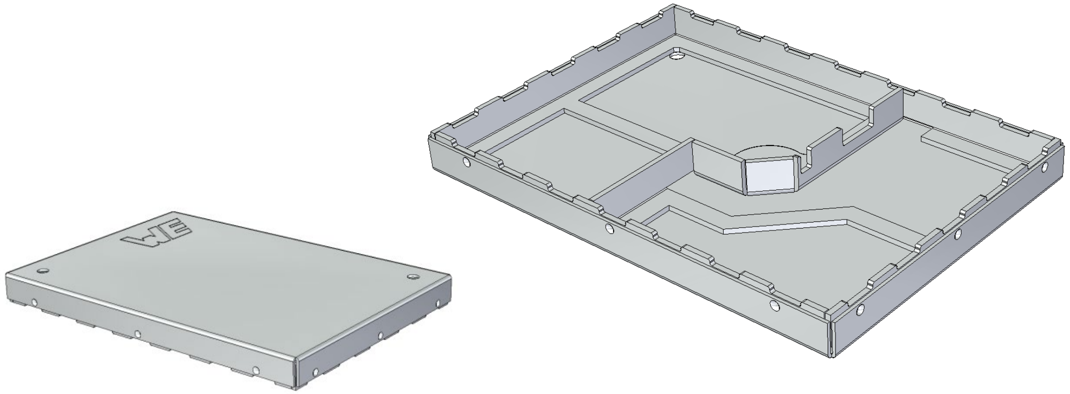
- One-pice or two-piece (frame + cover) cabinet:





- SMT clips:

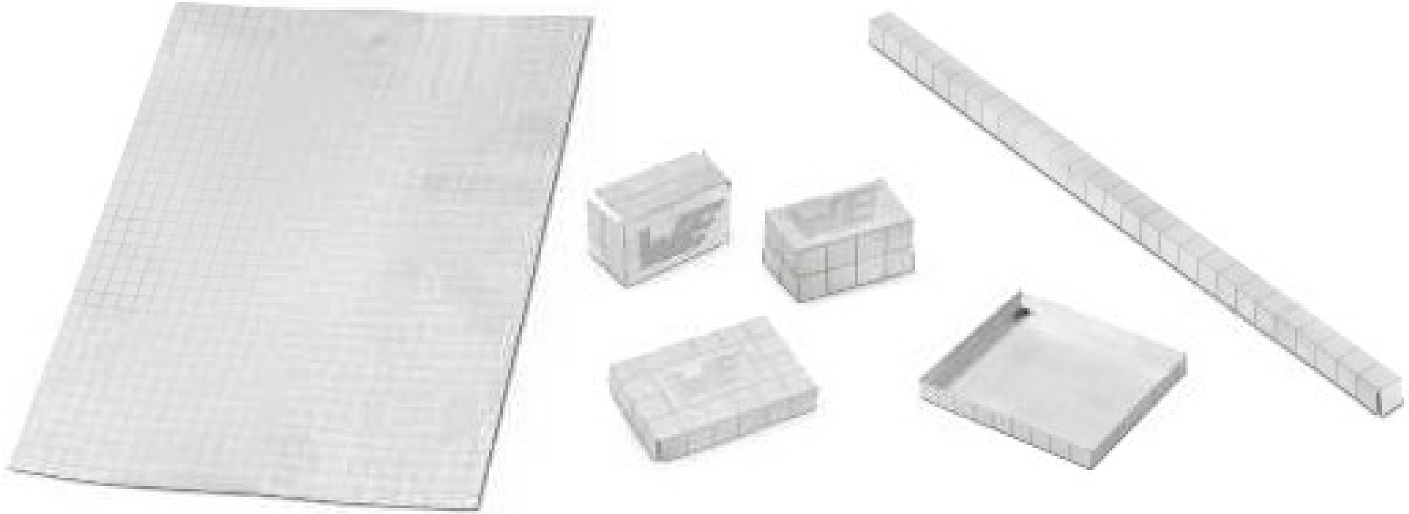




SHIELDING SOLUTIONS

Board Level

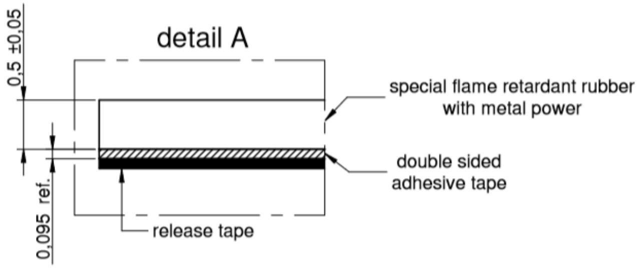
- Do-it-yourself metal sheet:
  - Tinned steel (0,2 mm)
  - Square-shaped grid (5 mm)

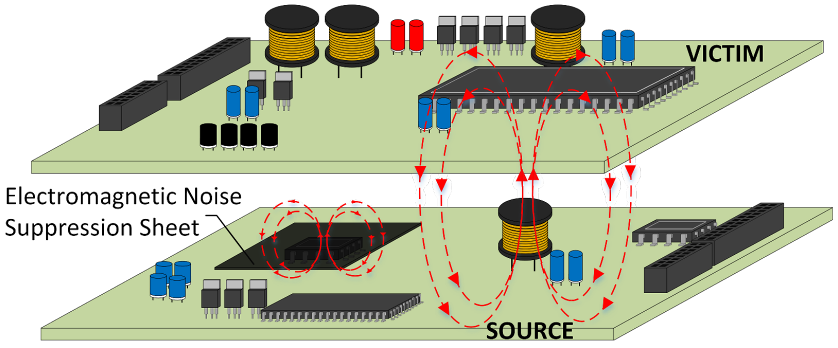


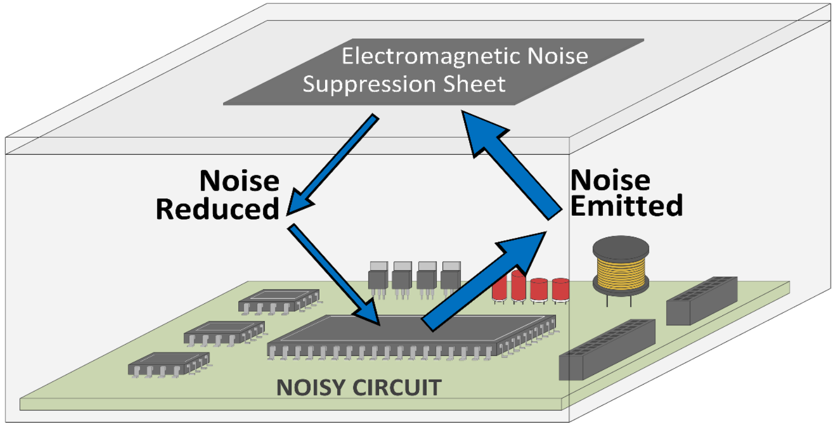
SHIELDING SOLUTIONS

Board Level, Housing

- **Flexible absorber sheet** with adhesive layer for attaching to the PCB or housing
- Effect → **Reflection** and **absorption** in the near electric and magnetic field and in the far field



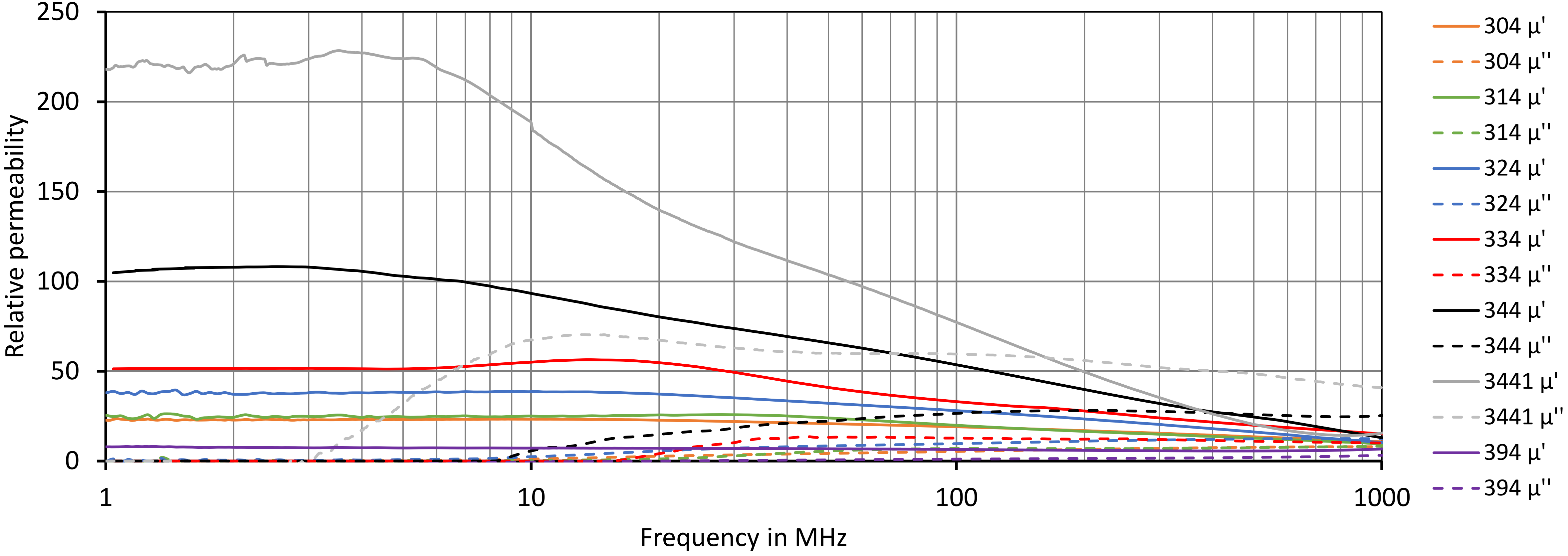




SHIELDING SOLUTIONS

Board Level, Housing

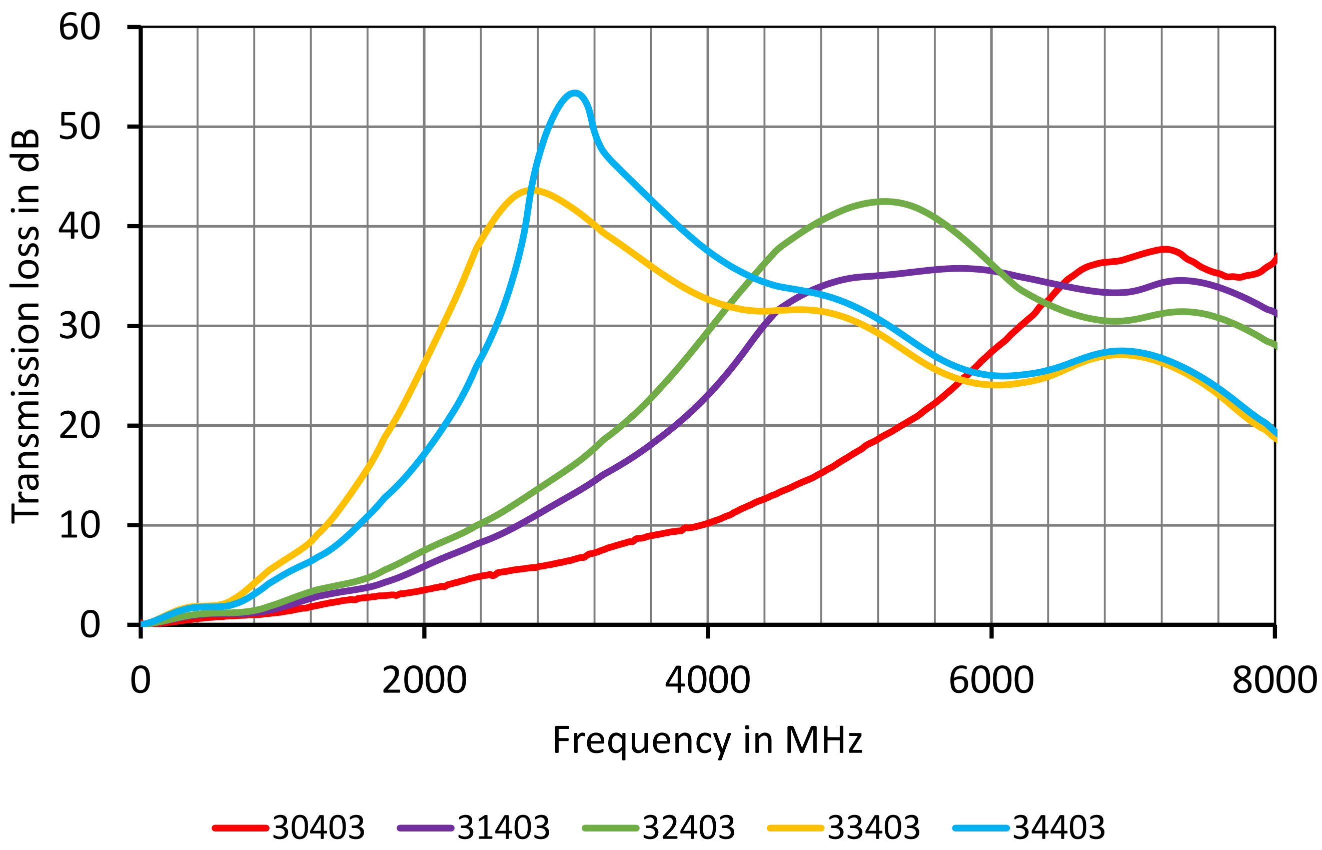
- Complex permeability of all **WE-FAS** materials:

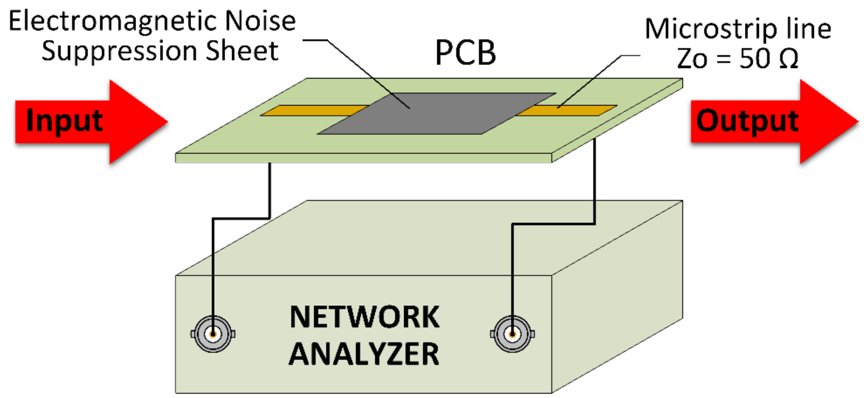


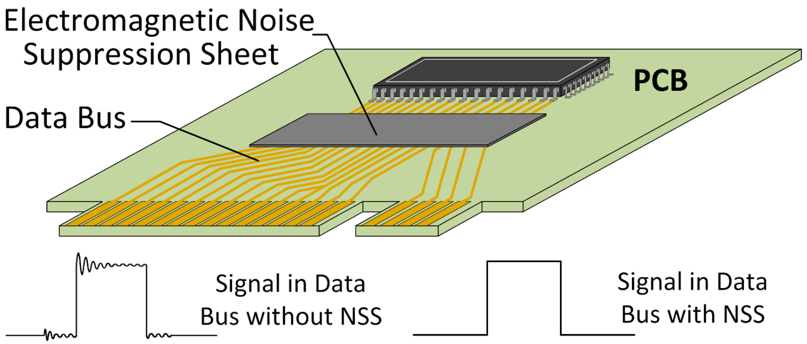
SHIELDING SOLUTIONS

Board Level, Housing

- Transmission loss depending on the **material** (thickness: 0,3 mm):



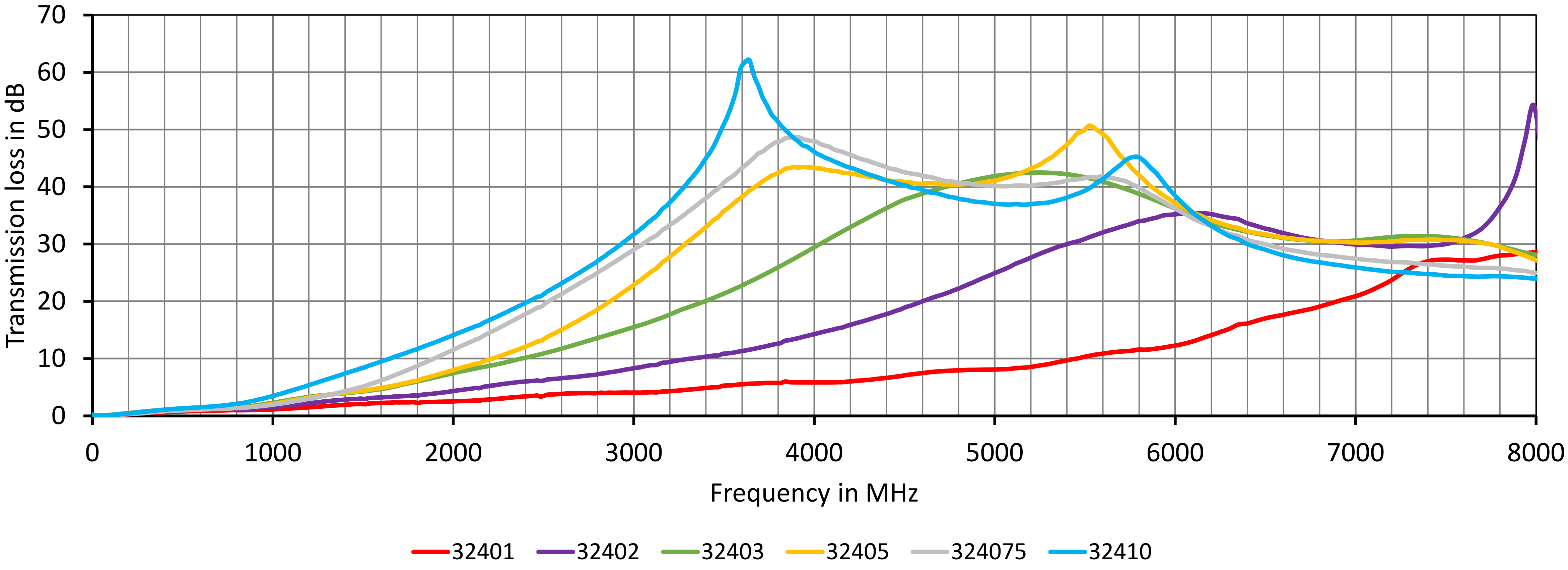




SHIELDING SOLUTIONS

Board Level, Housing

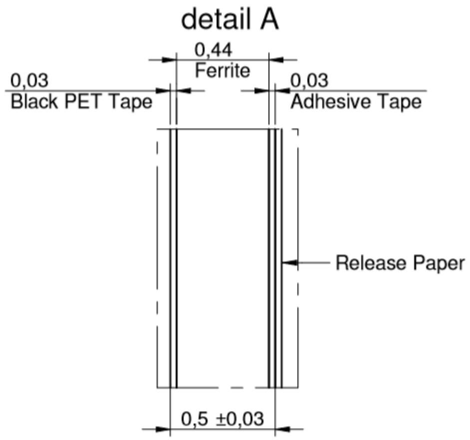
- Transmission loss depending on the **material thickness** (material 324; 0,1…1 mm):



SHIELDING SOLUTIONS

Near Field Communication Standards

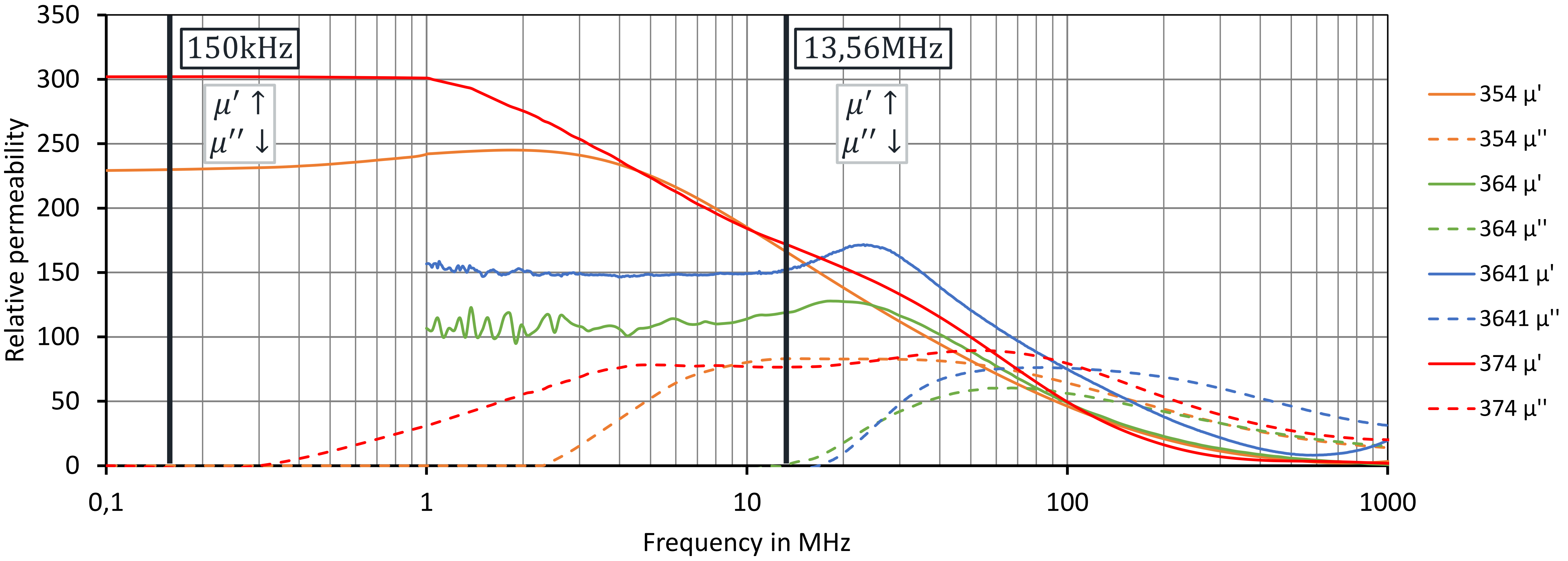
- **Flexible ferrite sheet** with adhesive layer for attaching to the PCB or housing
- Effect → **Reflection** in the near magnetic field, **deflection** of the field lines
- Applications → Near-field magnetic shielding, NFC, RFID, wireless power transfer (WPT)



SHIELDING SOLUTIONS

Near Field Communication Standards

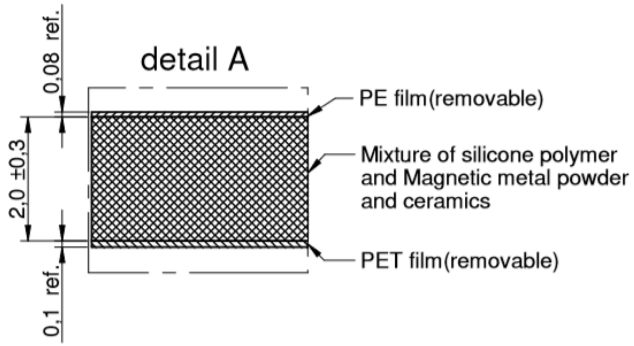
- Complex permeability of all **WE-FSFS** materials:

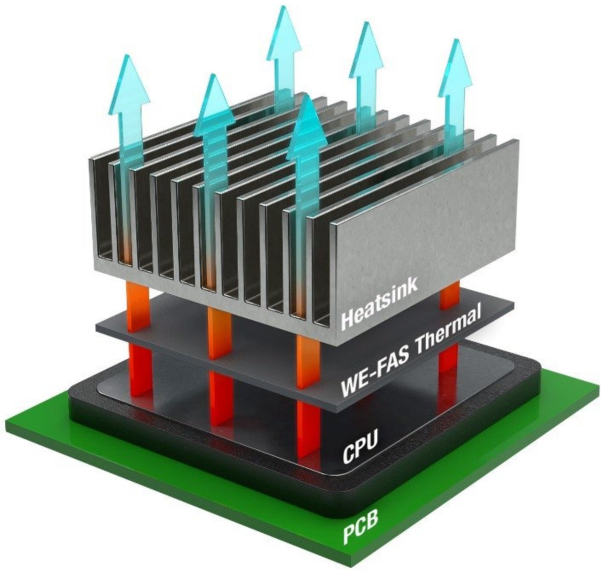


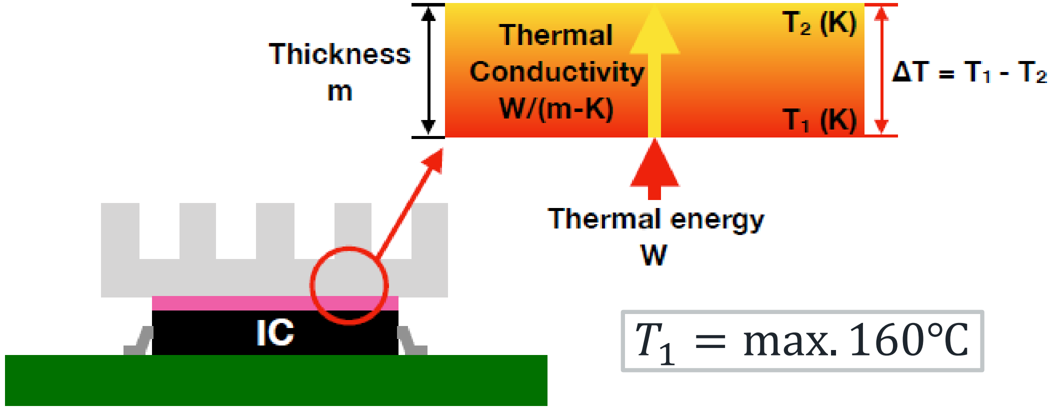
SHIELDING SOLUTIONS

Heatsinks

- **Flexible ferrite foil** with ceramic particles for additional **heat transfer** ($\kappa = 1{,}4\ \mathrm{W \cdot m^{-1} \cdot K^{-1}}$)







$T_1 = \text{max. } 160°\text{C}$

SHIELDING SOLUTIONS

Ground Connection

- Conductive housing parts and PCB groundplanes are to be connected by means of a **low impedance path**.
- **Mechanical** variants:

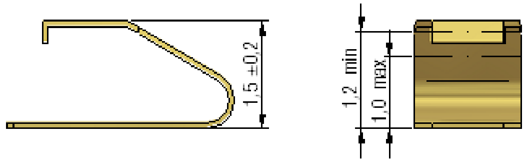
Spacer

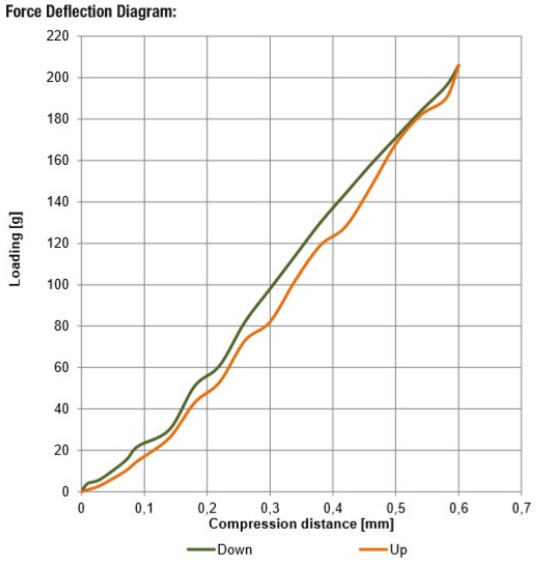
Earthing belt

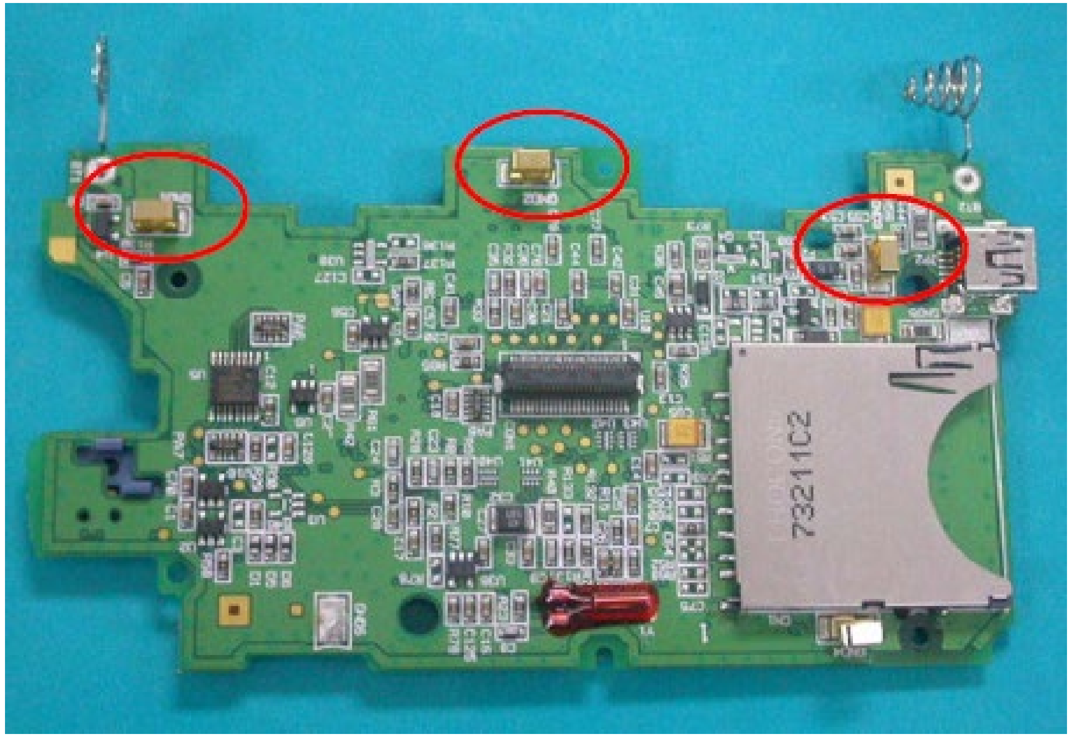
SHIELDING SOLUTIONS

Ground Connection

- Surface mountable **contact springs** made of copper-beryllium (gold-plated) or phosphor-bronze (nickel-plated)
- Plating options:
  - Au: 38...406 nm
  - Ni: 0,1...0,5 µm
  - Sn: 0,8...2 µm



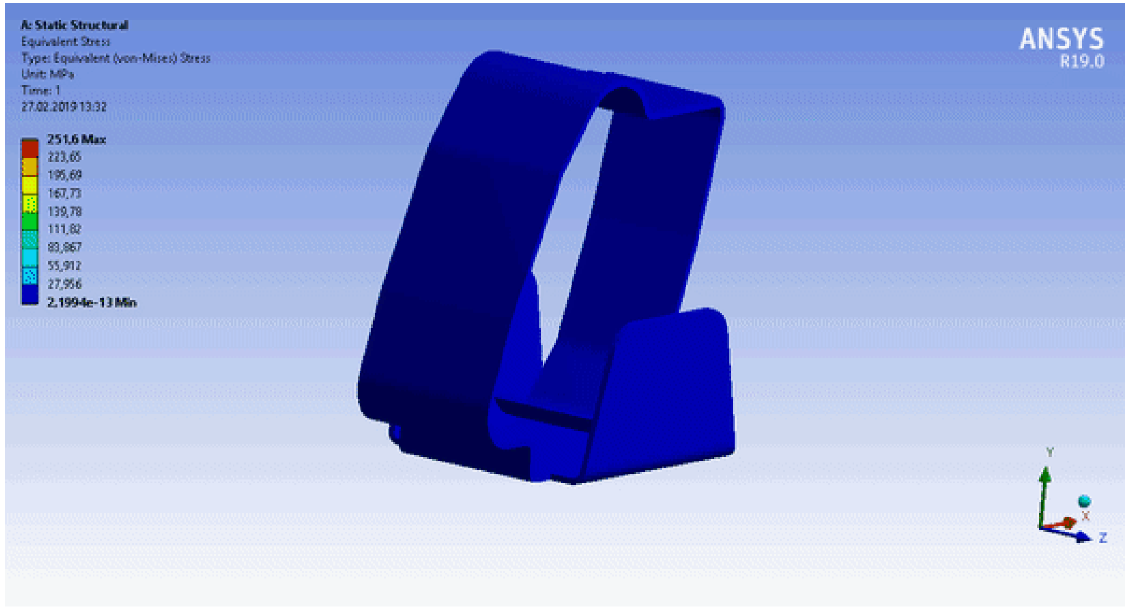




SHIELDING SOLUTIONS

Ground Connection

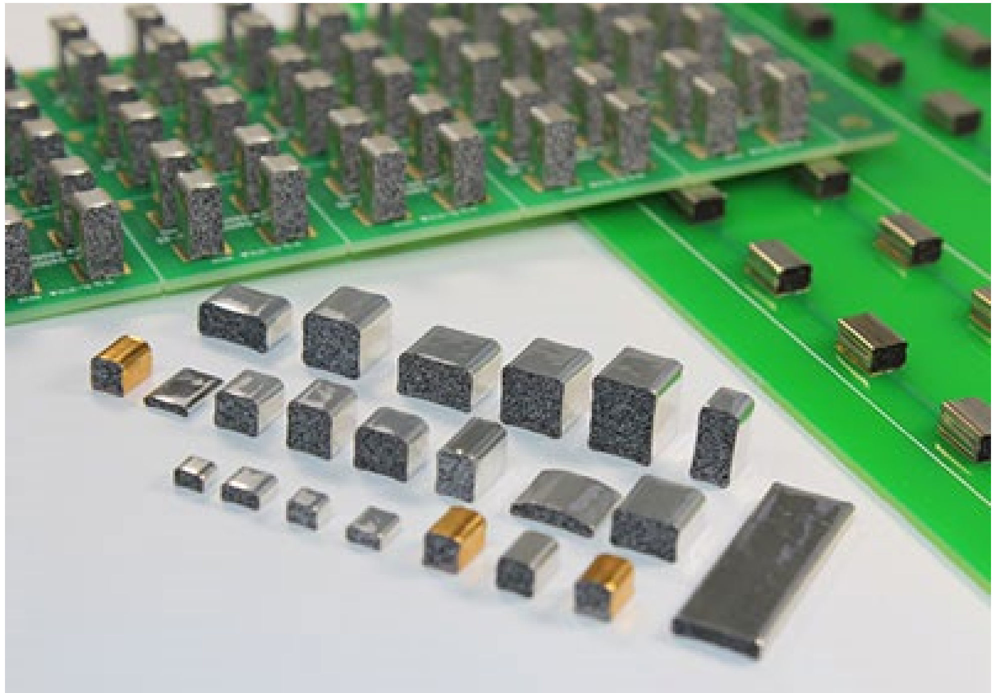
- Contact springs lose their elasticity when **over-compressed**.
- Special designs prevent over-compression.
- Maximum permissible current: 20 A

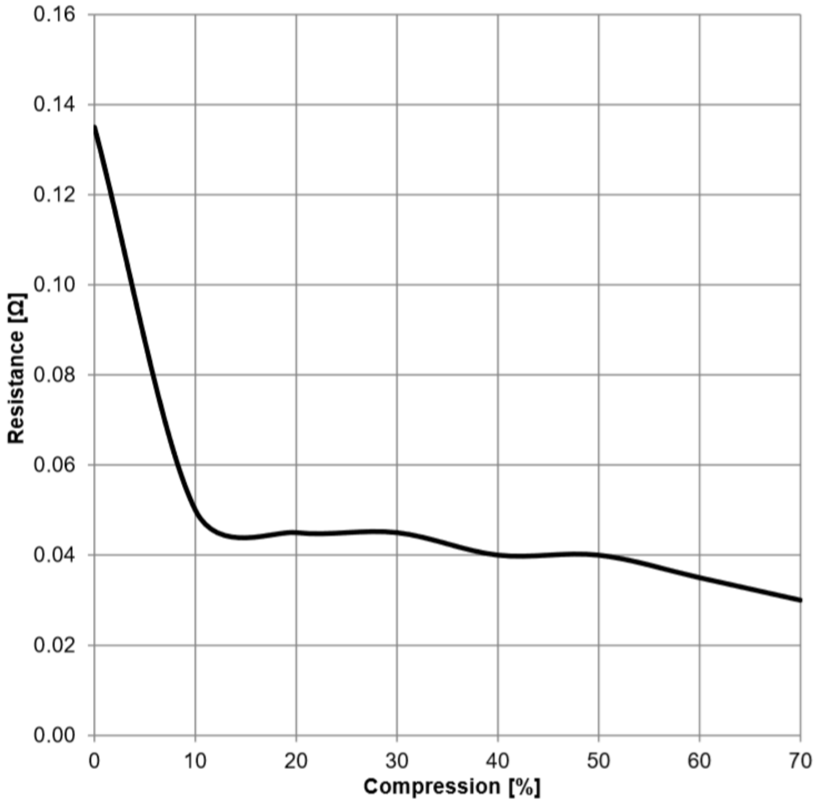


SHIELDING SOLUTIONS

Ground Connection

- Surface mountable **foam gasket block** with plating (tin, gold)
- Can be used like a contact spring
- Optimal compression: 20...70%





Questions
& Answers

We are here for you now!
Ask us directly via our chat or via E-Mail.

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