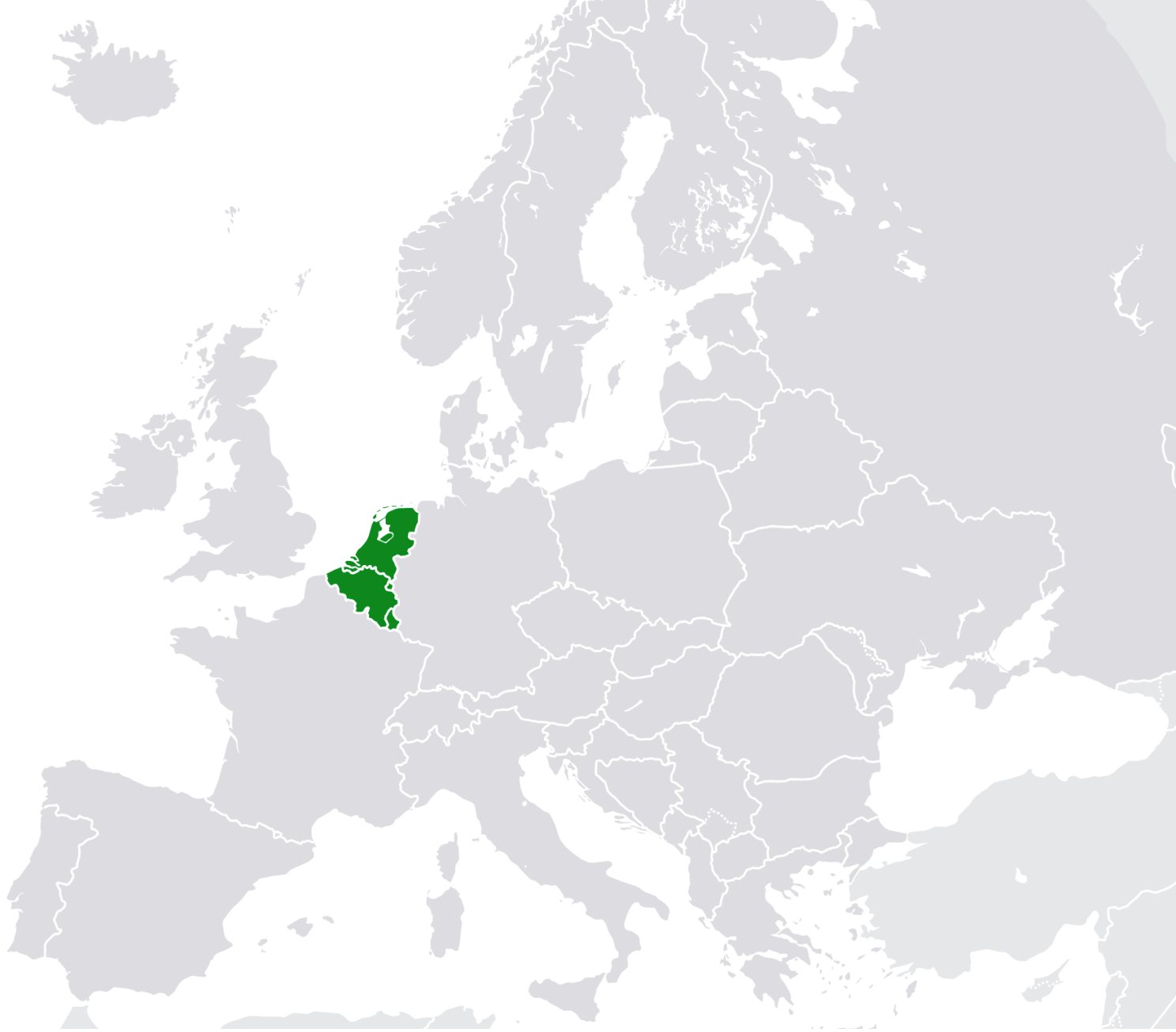
BOOST YOUR EMC PERFORMANCE: UNLEASHING THE POWER OF A LOW IMPEDANCE (RETURN) PATH

Tristen Boeckx EMC Debugging Engineer

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

WHO AM I?

- EMC debugging Engineer BeNeLux
- Hands-on experience



WHY A LOW IMPEDANCE (RETURN) PATH?

- One of the biggest fail causes
- No Black magic
- Reducing cost

WÜRTH ELEKTRONIK
MORE THAN YOU EXPECT

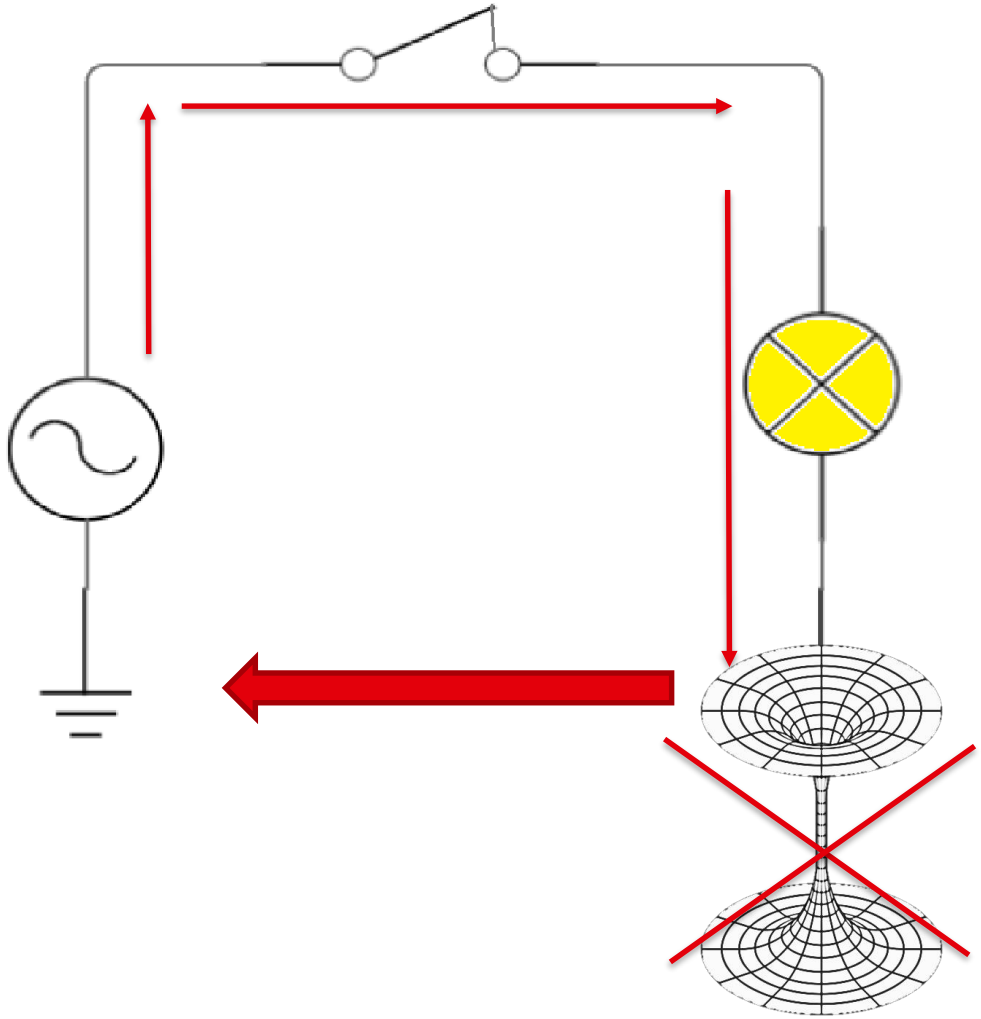
AGENDA

- Introduction in the theoretical basics
- The influence of bypassing/blocking
- Optimize your PCB design
- Practical examples
- Summary

THEORETICAL BASICS

THEORETICAL BASICS

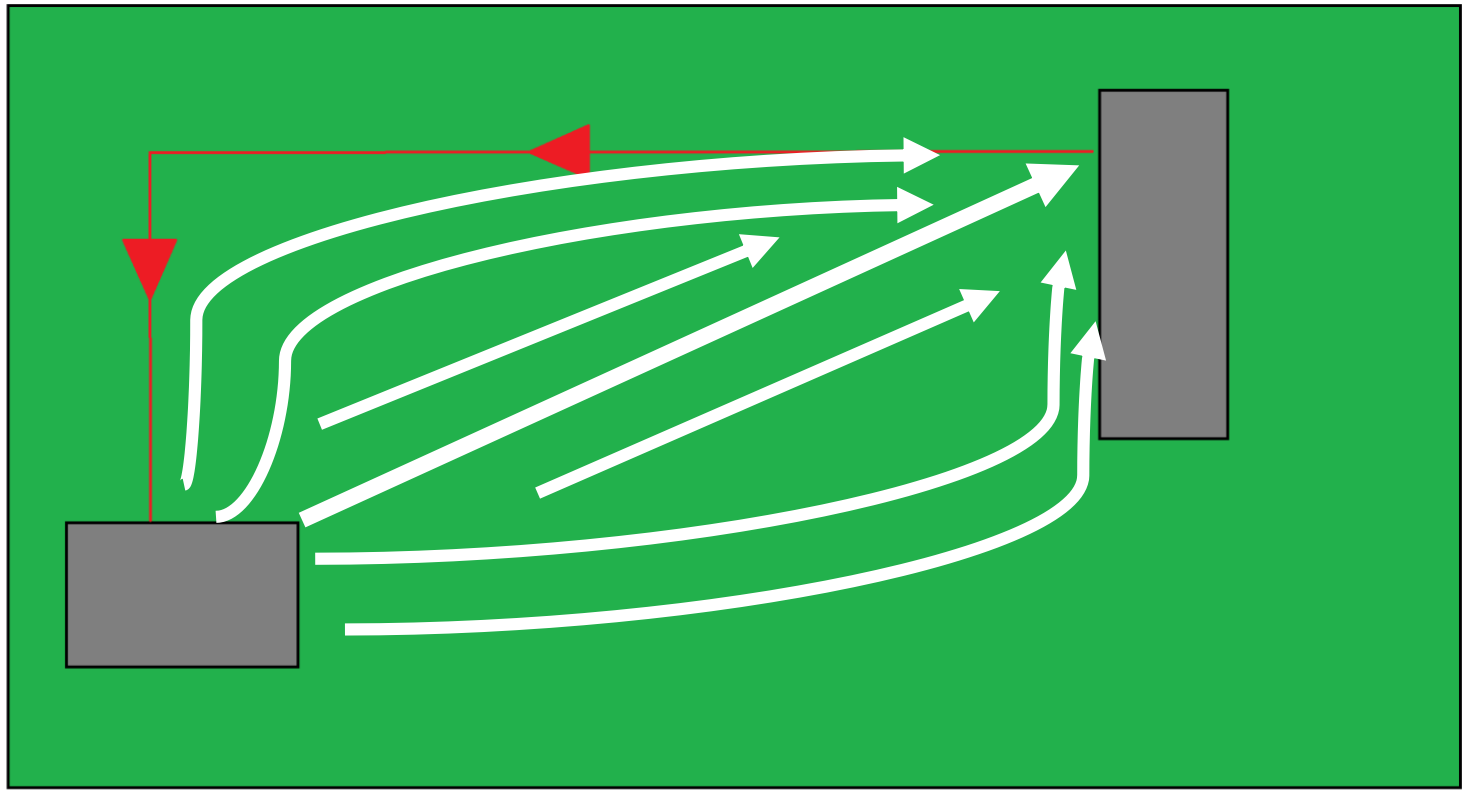
Current flows in loops



THEORETICAL BASICS

How does this current flow?

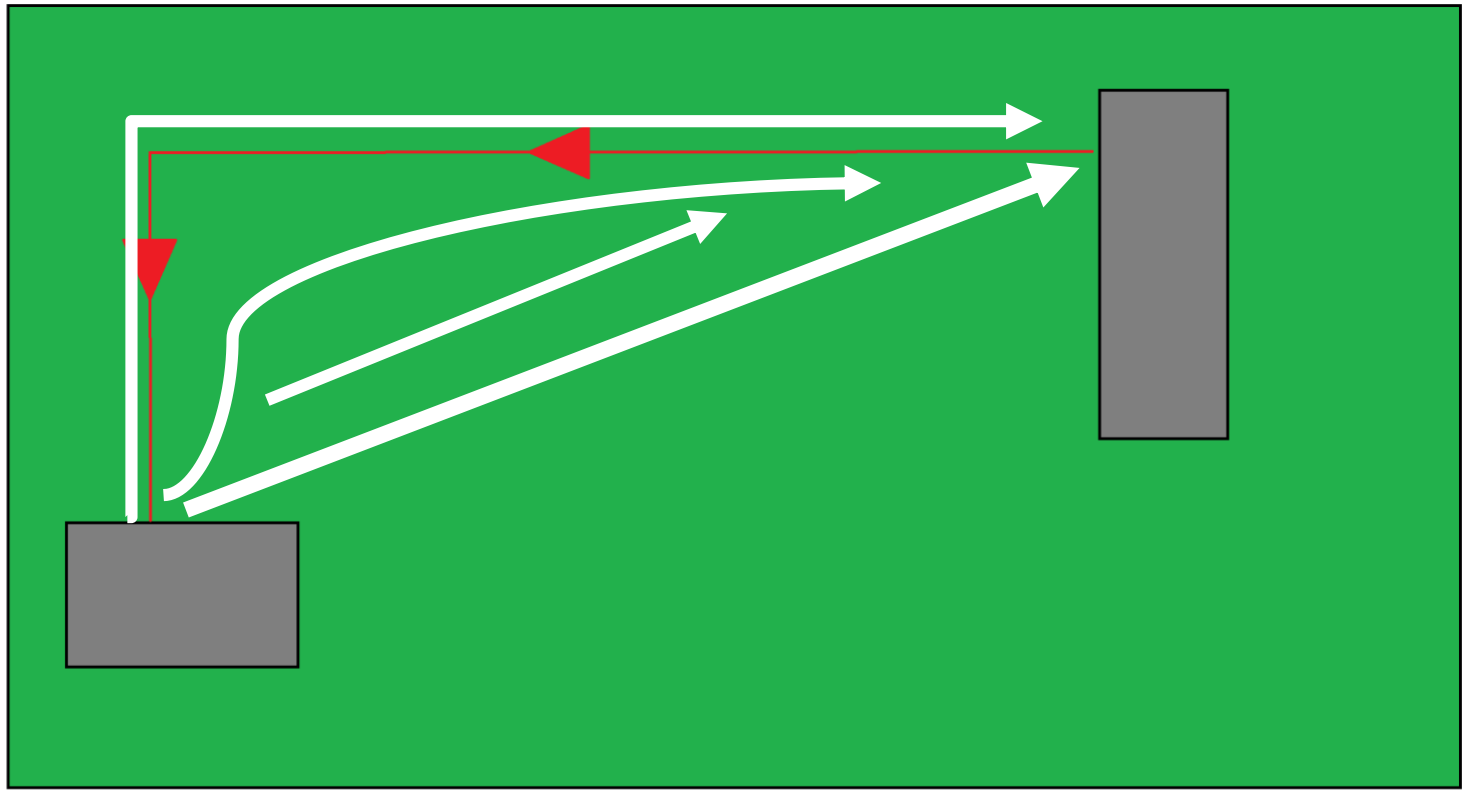
DC



THEORETICAL BASICS

How does this current flow?

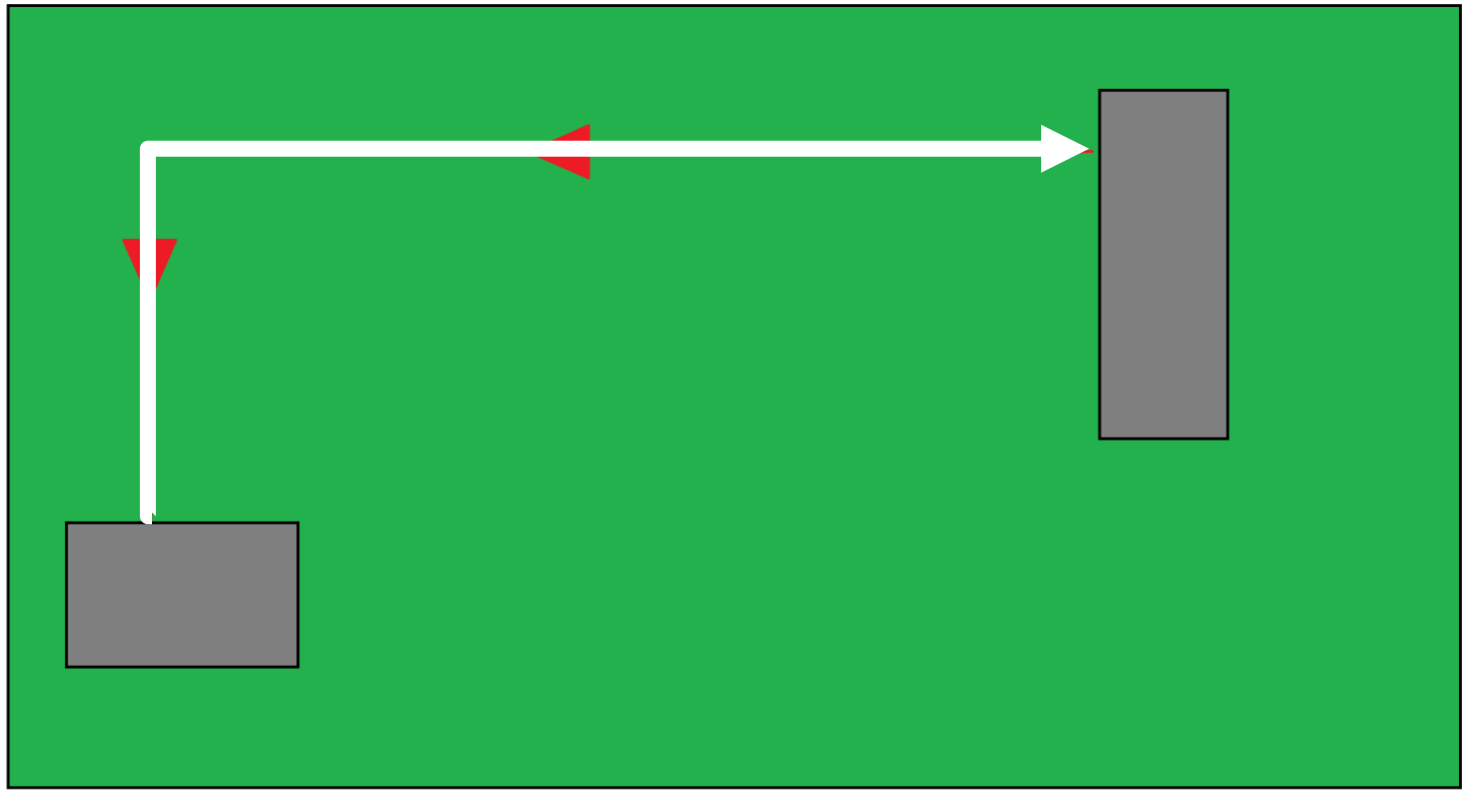
10KHz



THEORETICAL BASICS

How does this current flow?

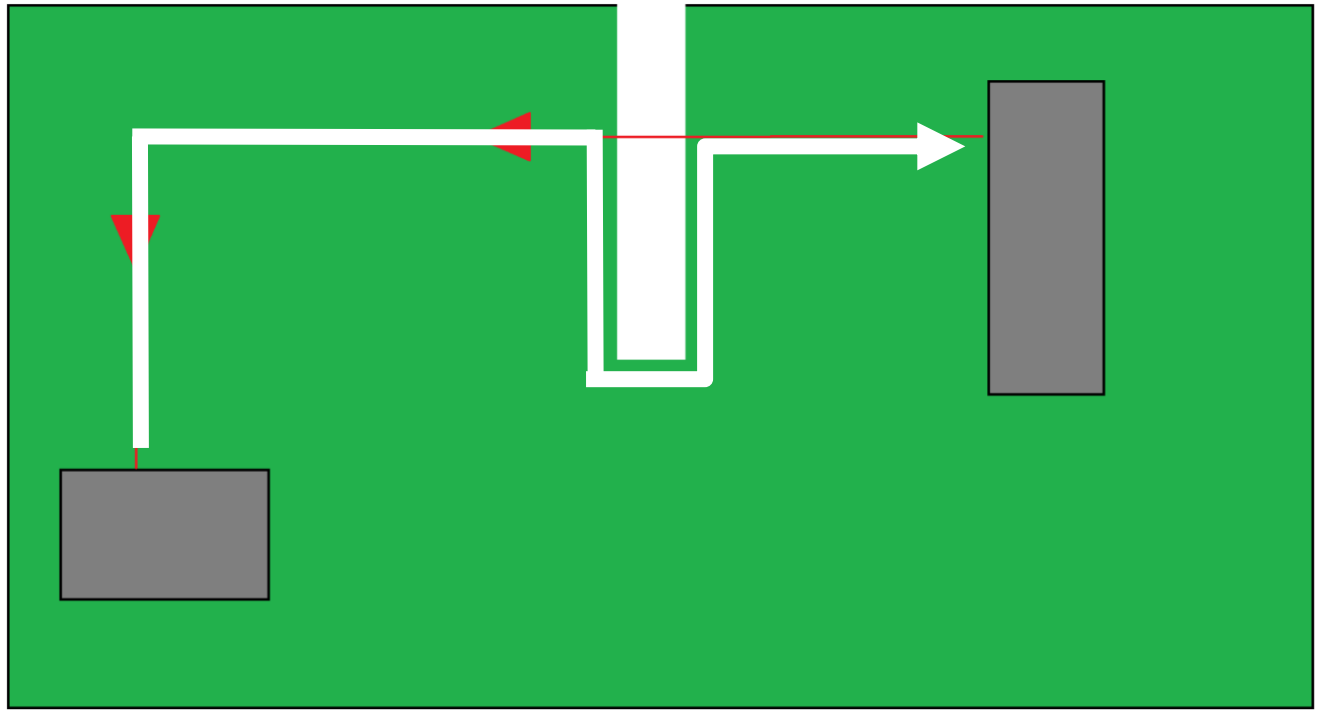
10MHz



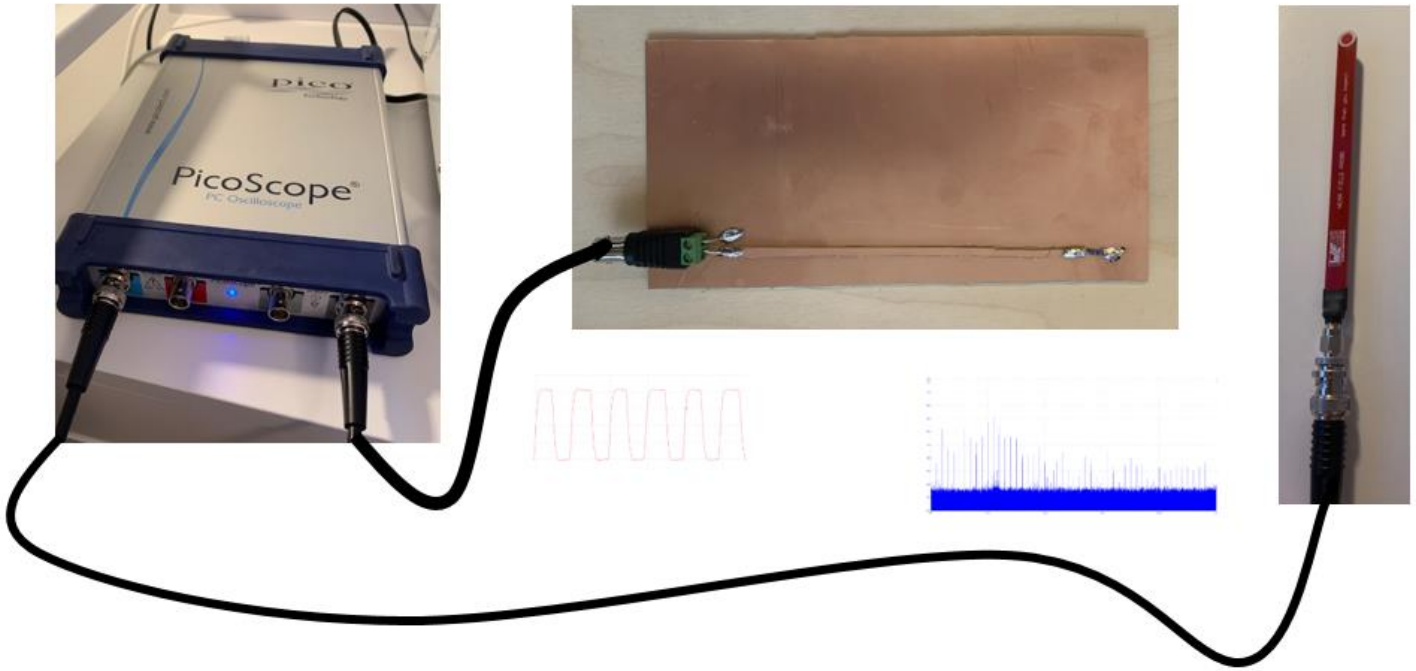
THEORETICAL BASICS

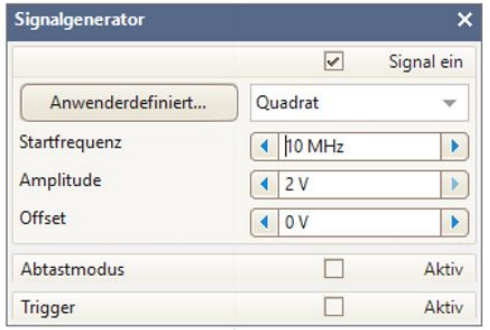
How does this current flow?

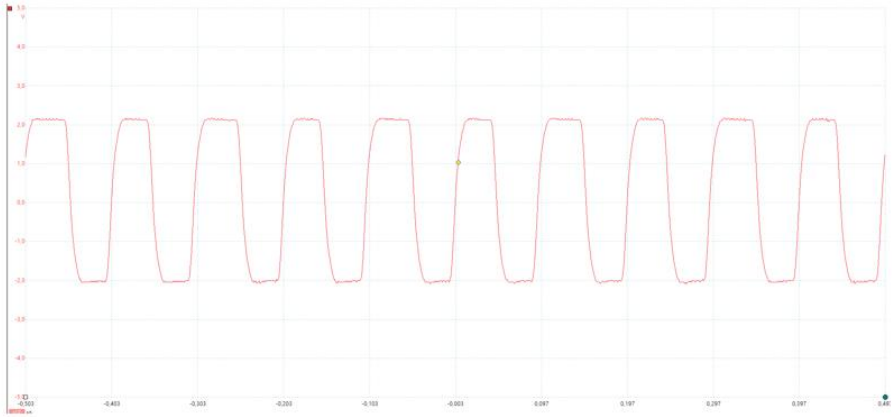
Slotted



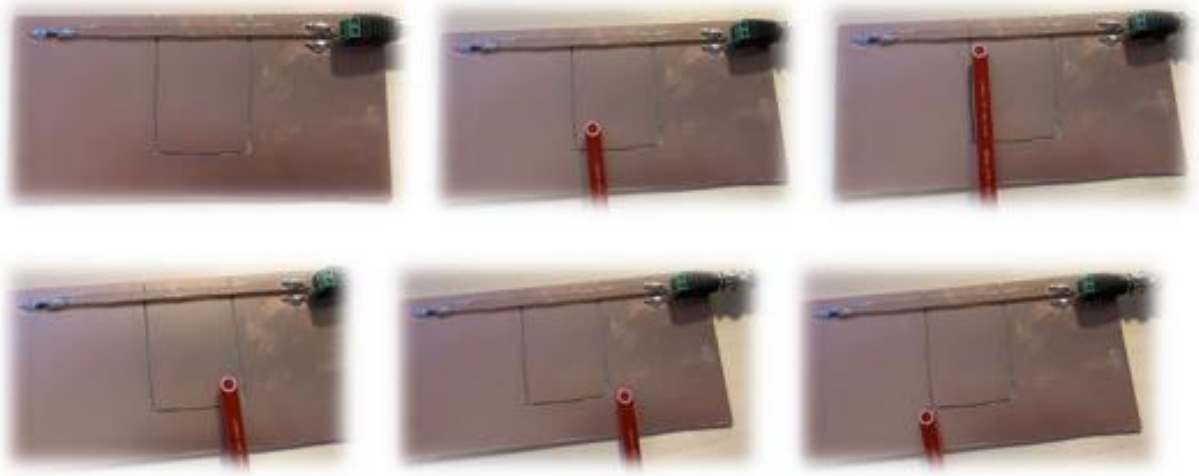
THEORETICAL BASICS

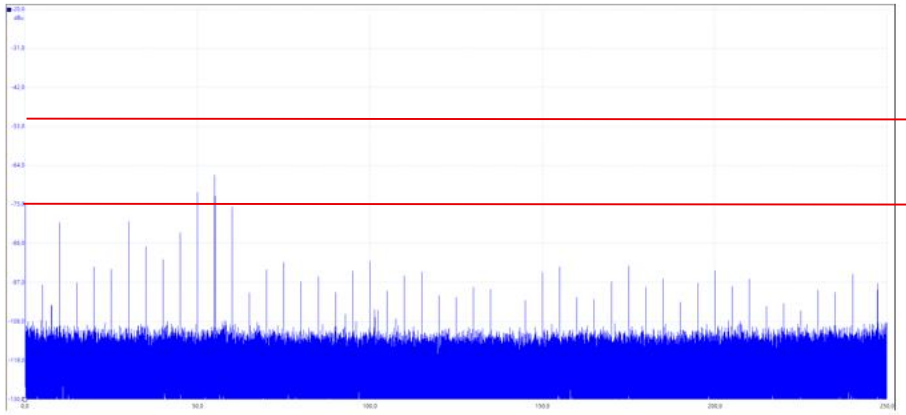






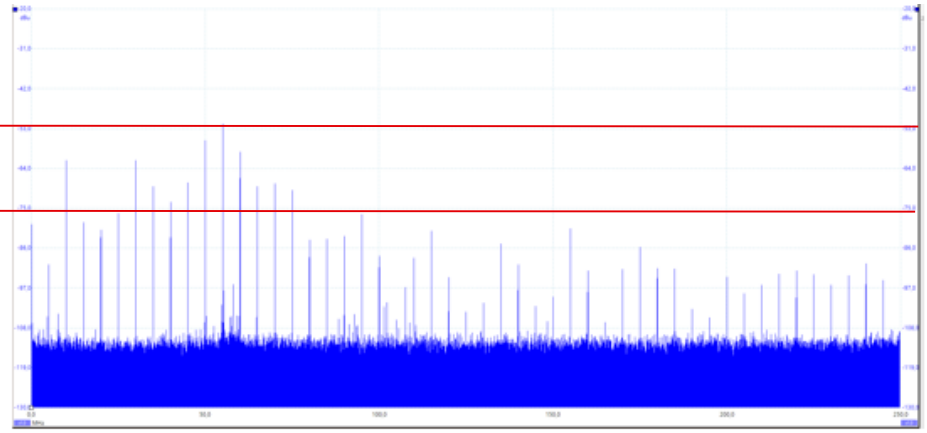
THEORETICAL BASICS





... ca. -67dB

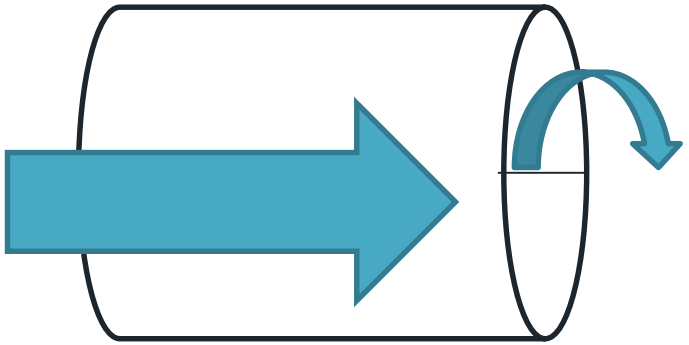
+/-15dB difference



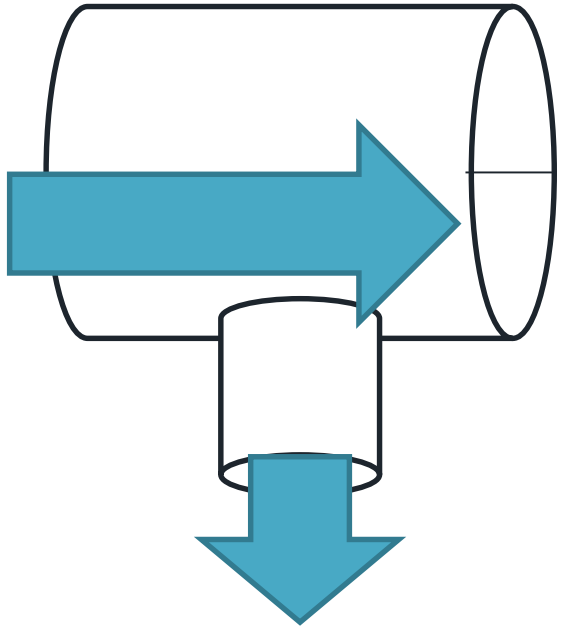
BYPASSING/BLOCKING

THEORETICAL BASICS

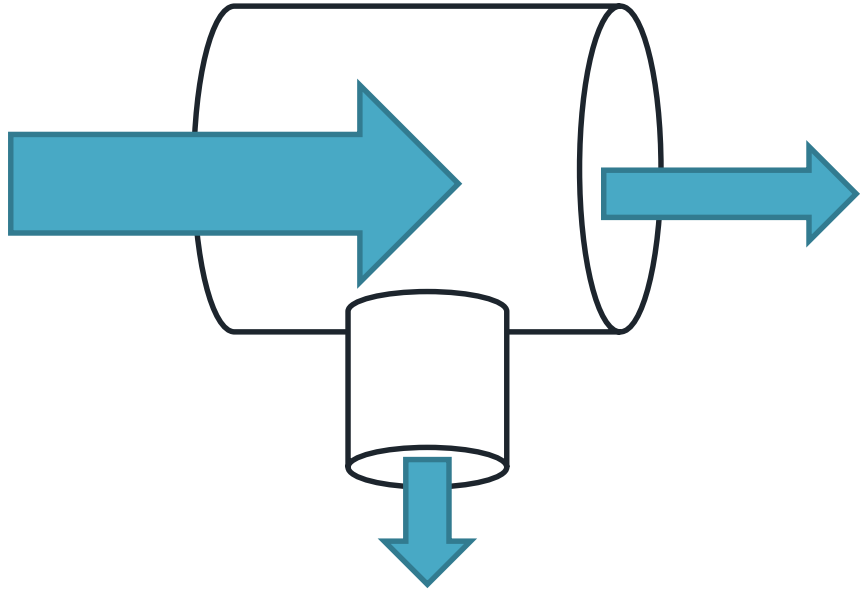
Blocking



Bypassing+Blocking



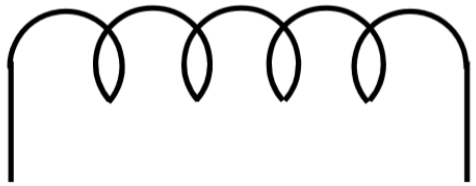
Bypassing



THEORETICAL BASICS

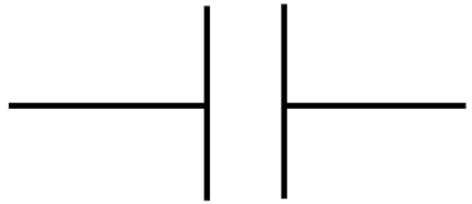
Blocking ELEMENTS

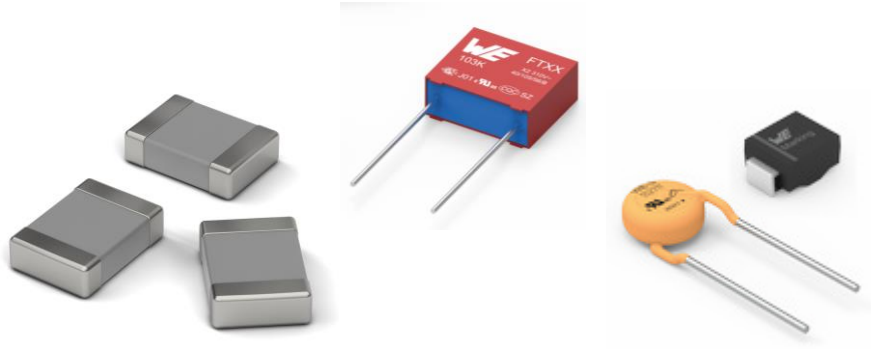
- Introducing HIGH impedance
- Inductors
- Traces/wires



Bypassing ELEMENTS

- Introducing LOW impedance
- Capacitor
- Surge/ESD protection



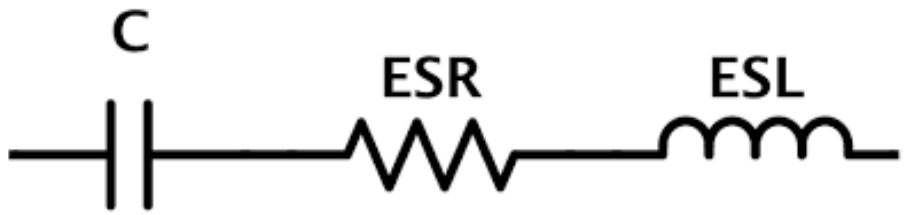


PCB DESIGN TIPS

PCB DESIGN TIPS

- Creating a bypass at 20MHz
- What are the component parasitics?

REDEXPERT
- https://we-online.com/re/5pagHL95



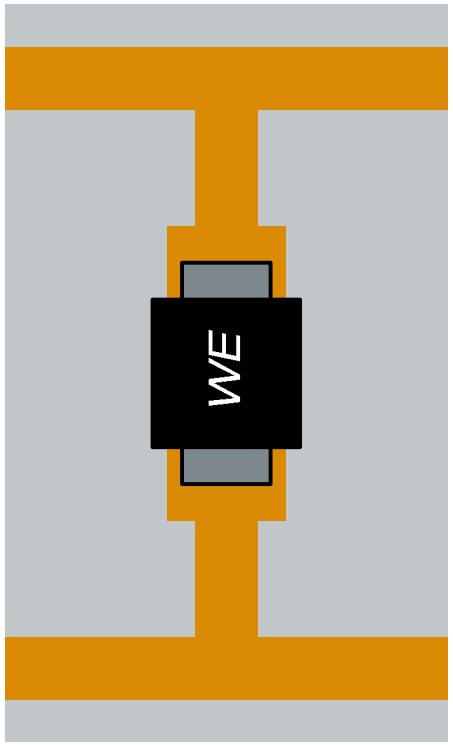
REDEXPERT

Size	C...	R_S	L_S
1206	150 nF	17.9 mΩ	589 pH
0805	150 nF	14.6 mΩ	350 pH
0603	150 nF	14.9 mΩ	331 pH

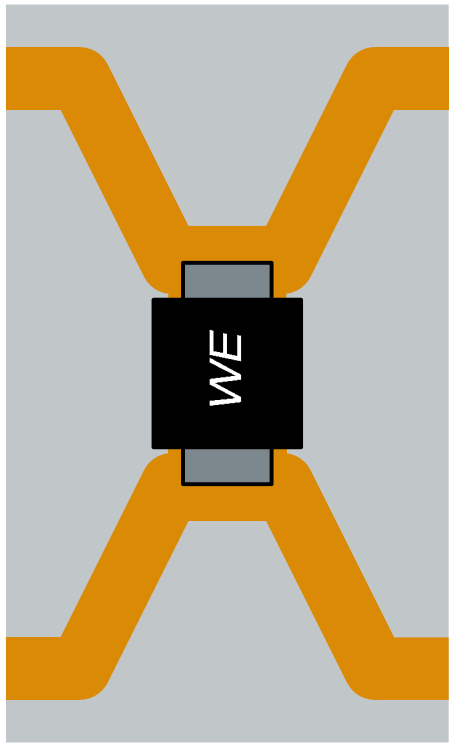
REDEXPERT

ROUTING COMPONENTS

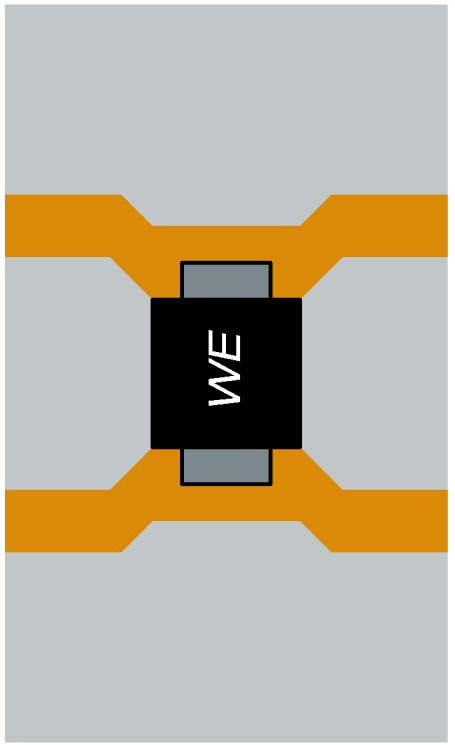
Keep Traces short and low impedance



Bad
Stub Traces



Good
Routing across SMD Pads



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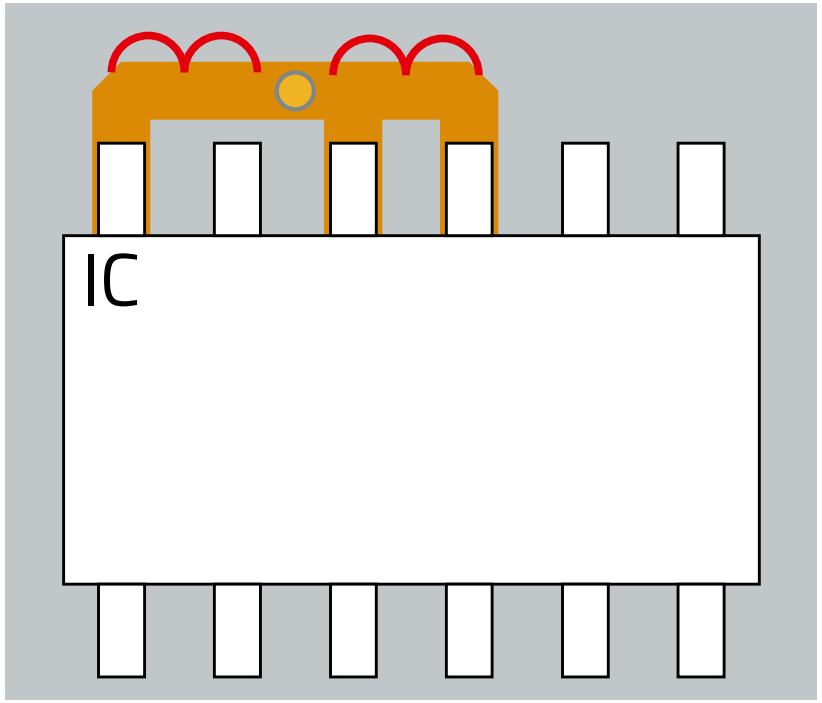
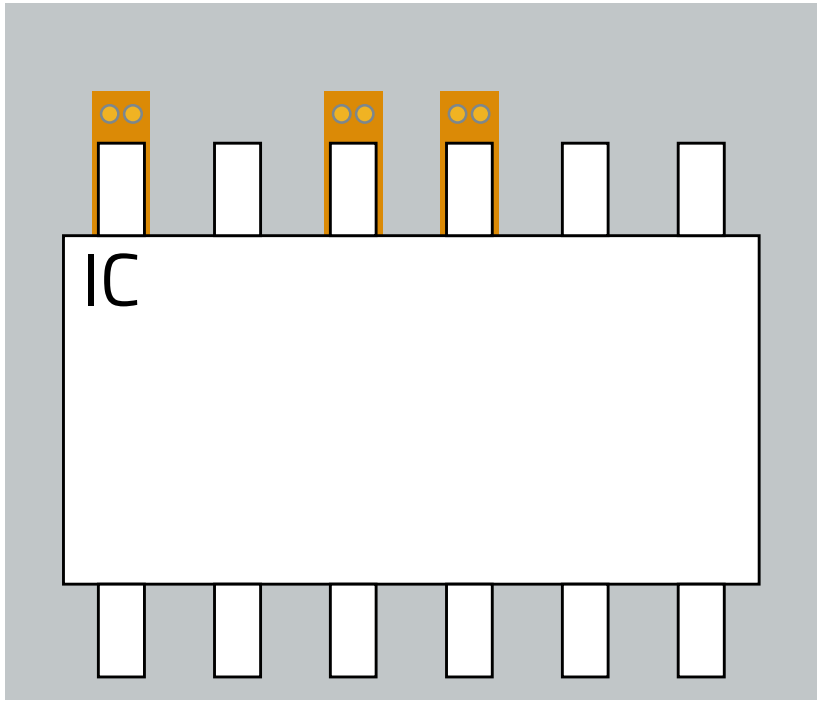
Best
Using Constictions at SMD Pads

VIA PLACEMENT

Ground Connection @ IC Pins



Bad



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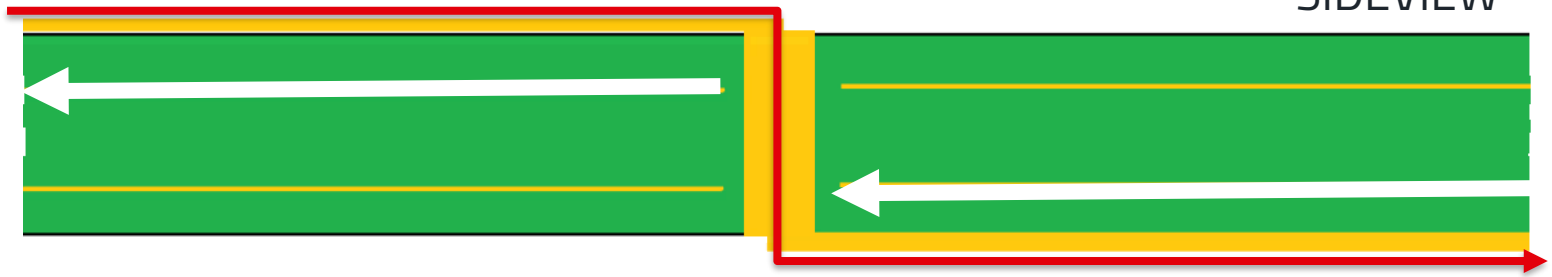
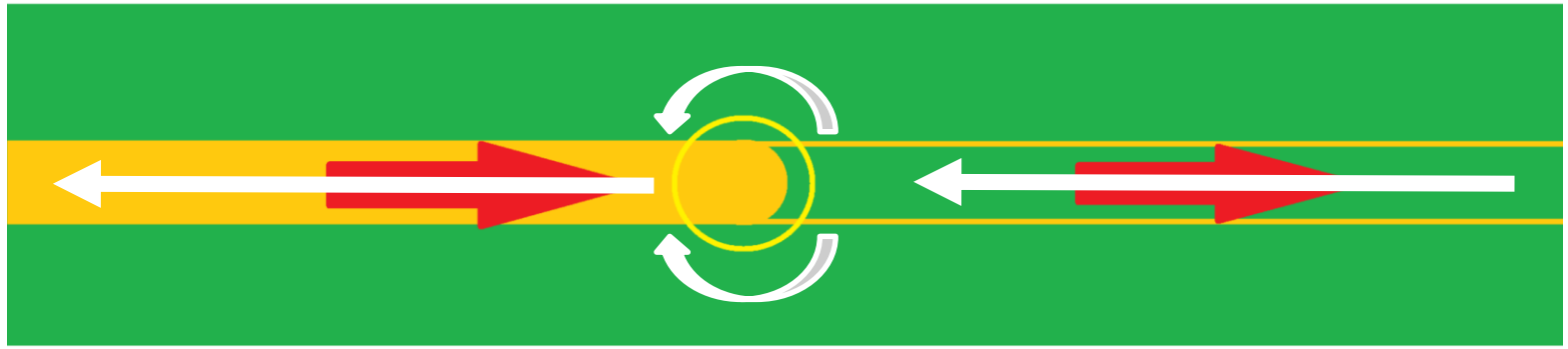
Better

A PCB IS 3D

SIDEVIEW

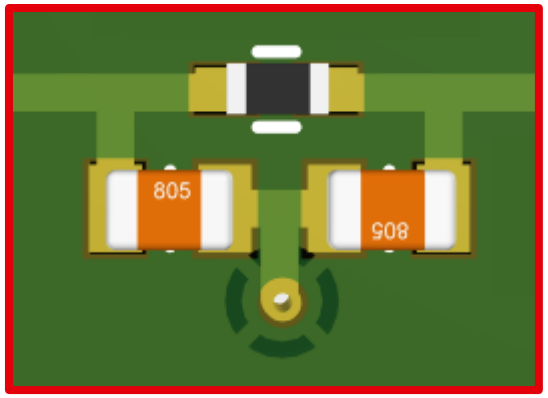


TOPVIEW

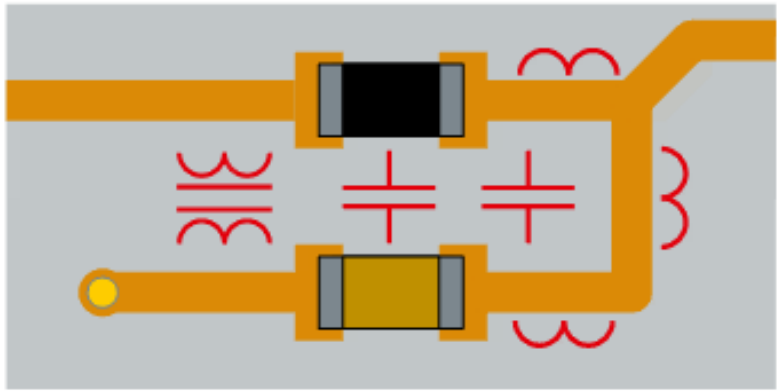


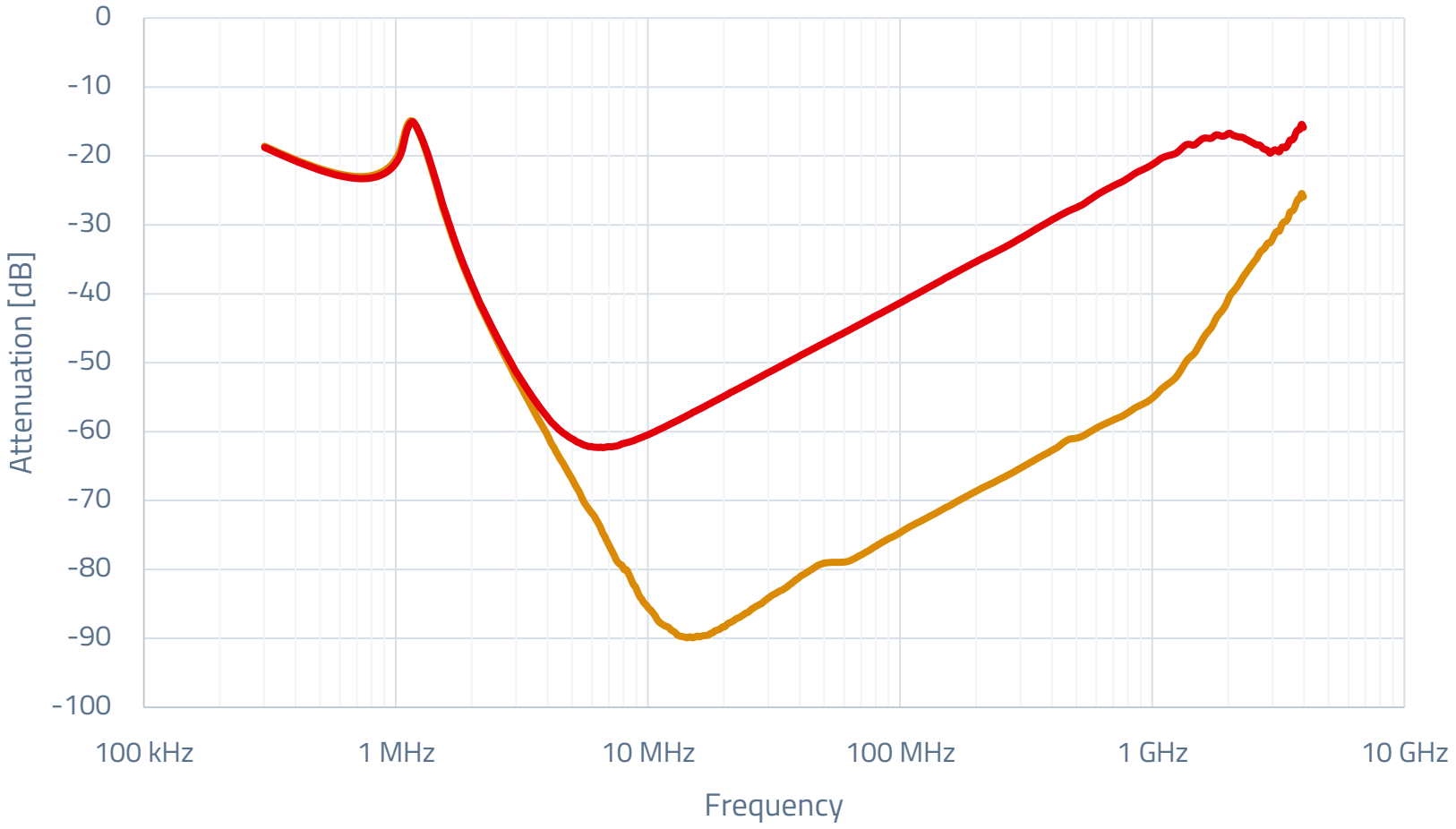
FILTER ARRANGEMENT

Layout: Influence on Insertion Loss



0805, Bad Layout





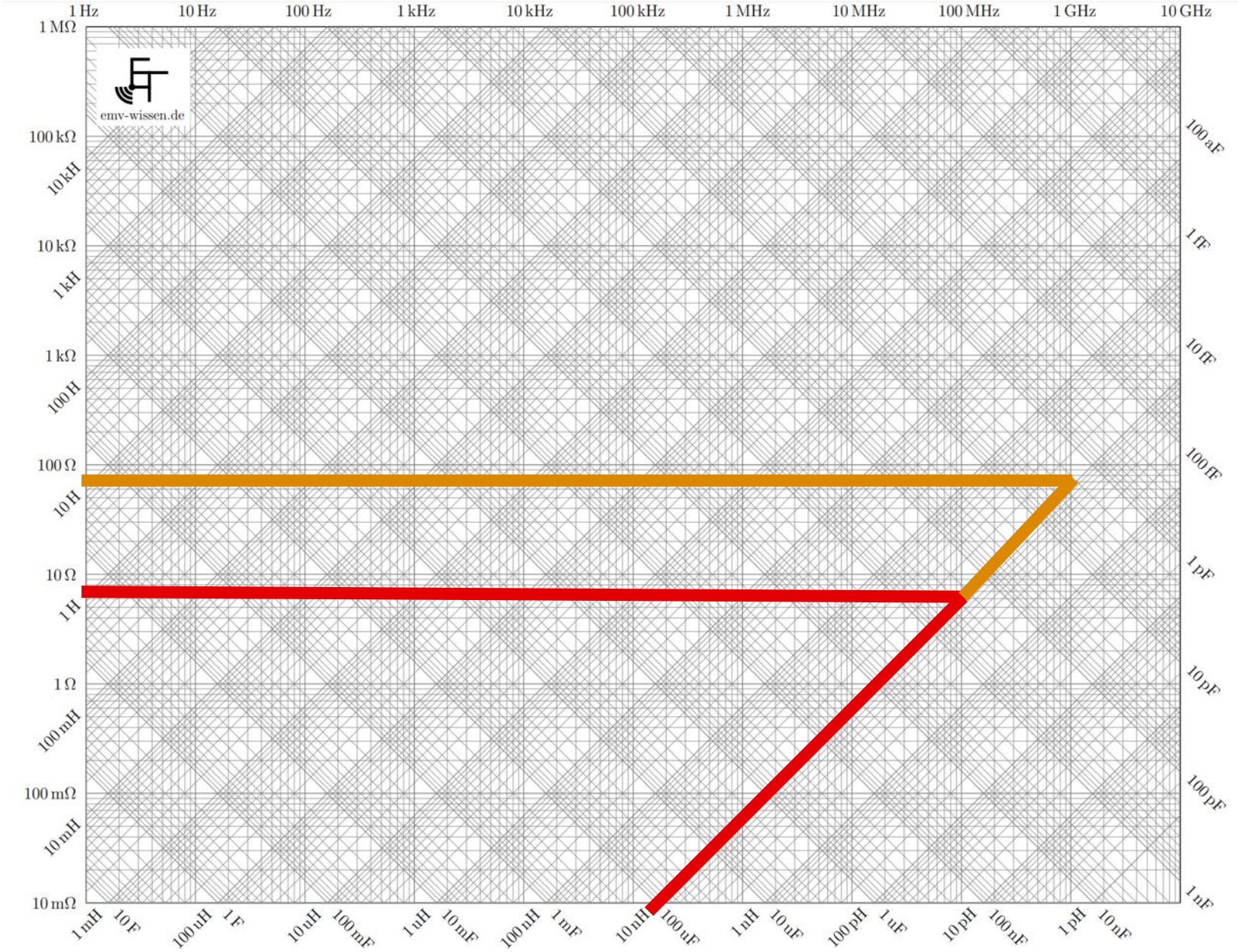
THEORETICAL BASICS

Important parasitics

- 1CM trace/cable ➔10nH
- Frequency Nomograph

@100MHz +/-7 Ohm

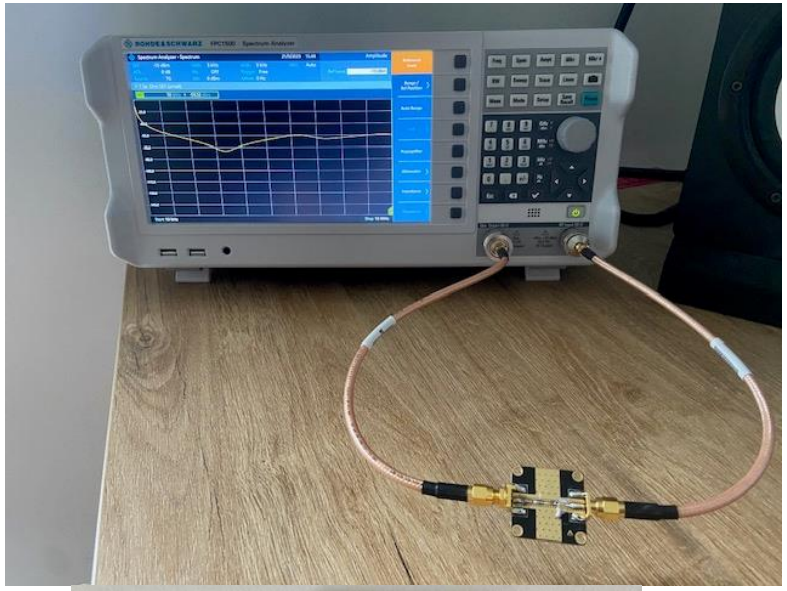
@1GHz +/- 70 Ohm

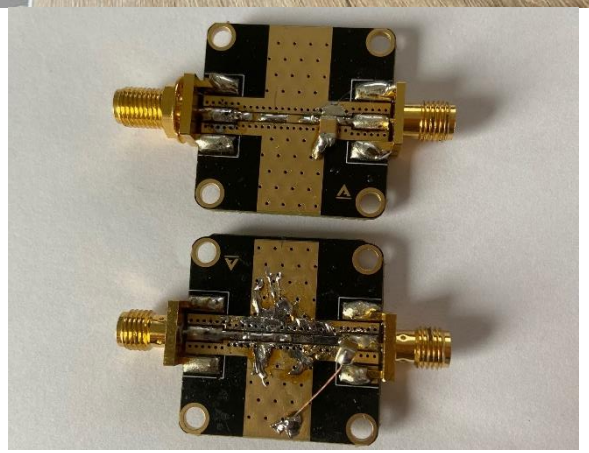


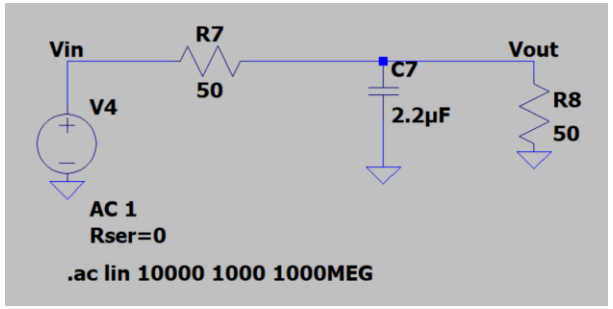
https://emv-kurs.de/wp-content/uploads/2022/10/39_HF_tapete_leicht.pdf

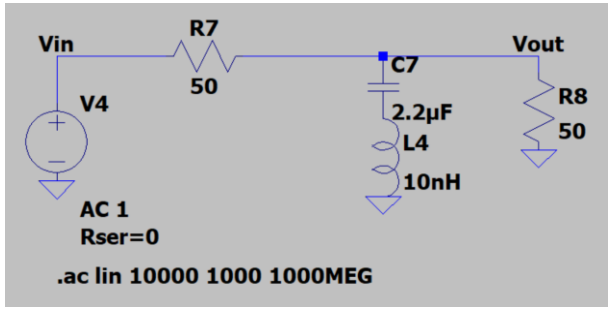
THEORETICAL BASICS

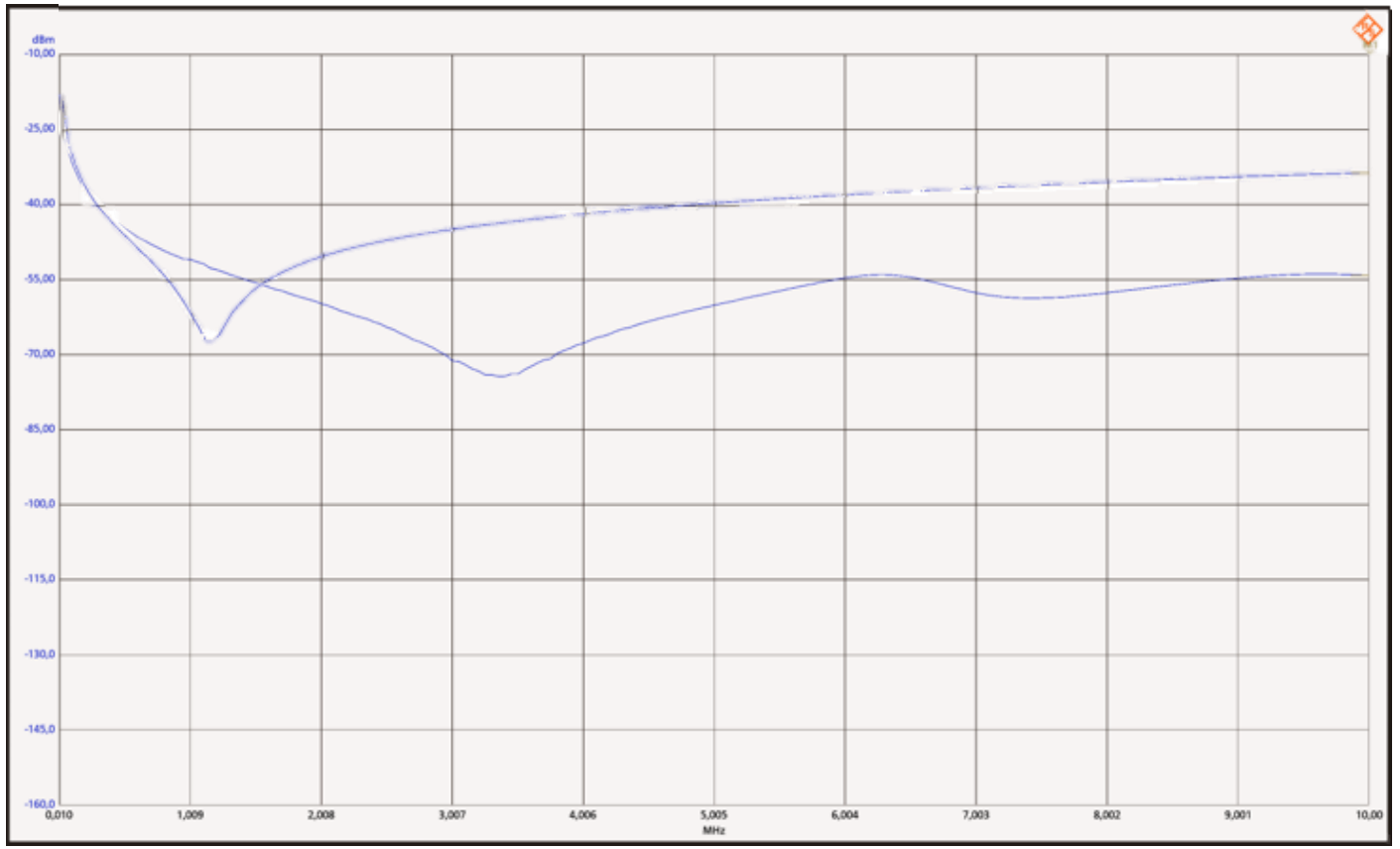
Important parasitics





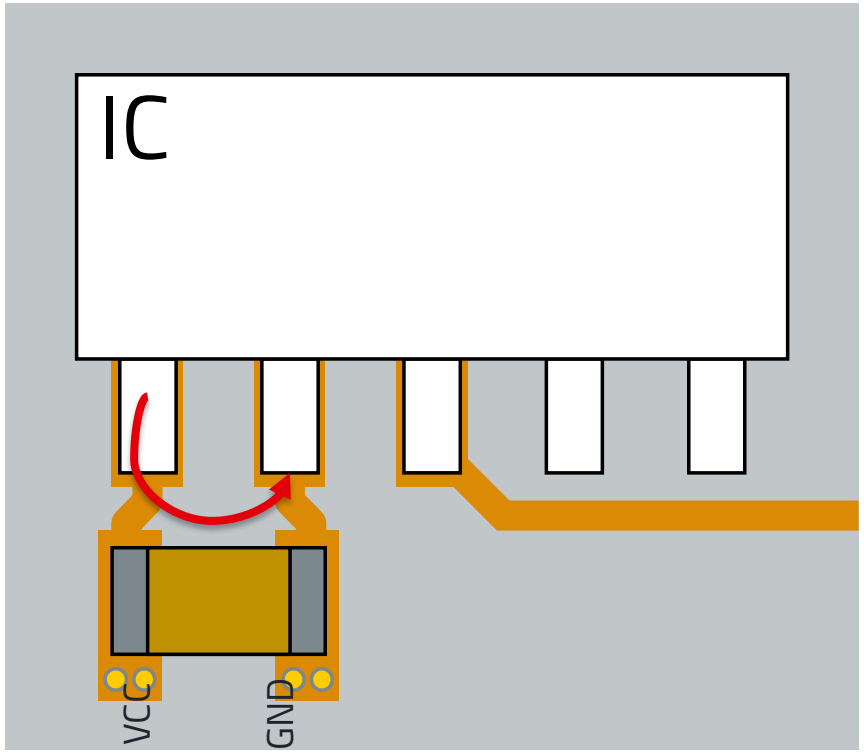






BYPASSING CAPACITORS

- HF Currents are fed from the Capacitor
  - Vcc/GND Plane only see low frequency currents
  - Keeps magnetic loop for RF as small as possible
  - Distance of Cap to PIN ≤ 0,3mm
- Low impedance connection to the capacitor
  - Keep lines symmetrical (if possible)
- Parallel Vias reduce impedance to GND/Vcc planes



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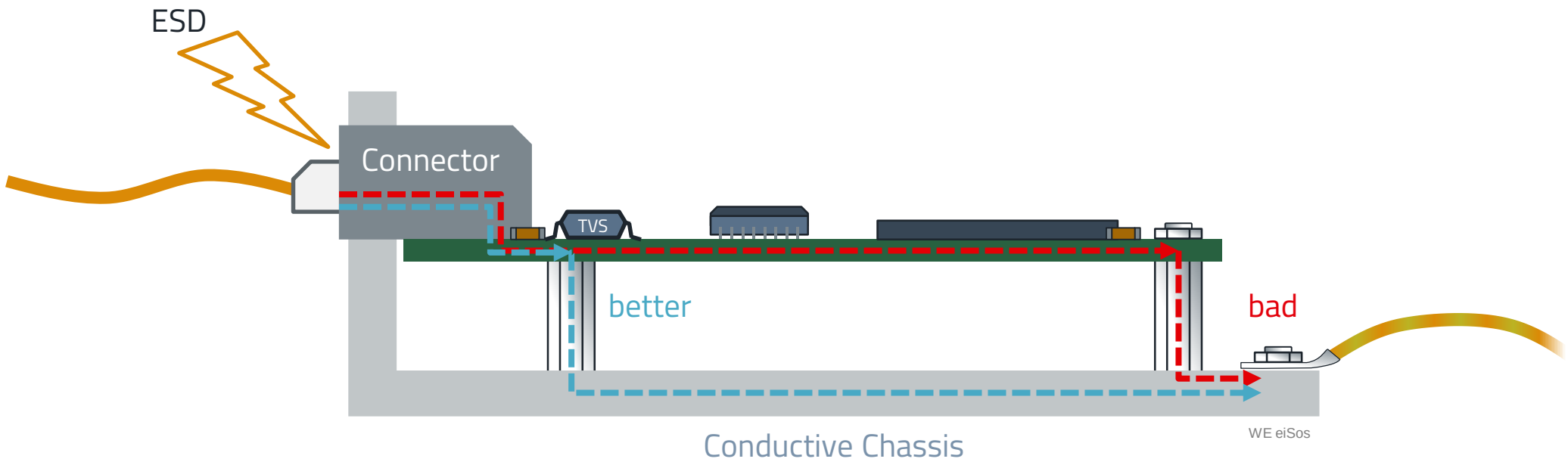
IMMUNITY DESIGN TIPS

FILTER PLACEMENT

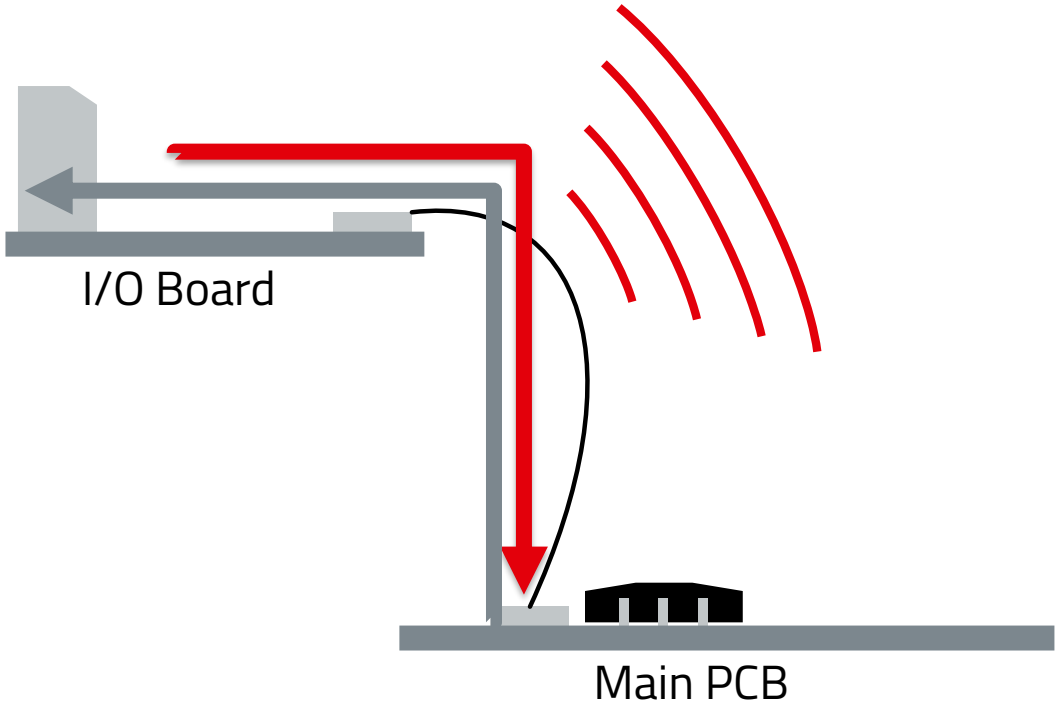
Diverting Noise to Earth



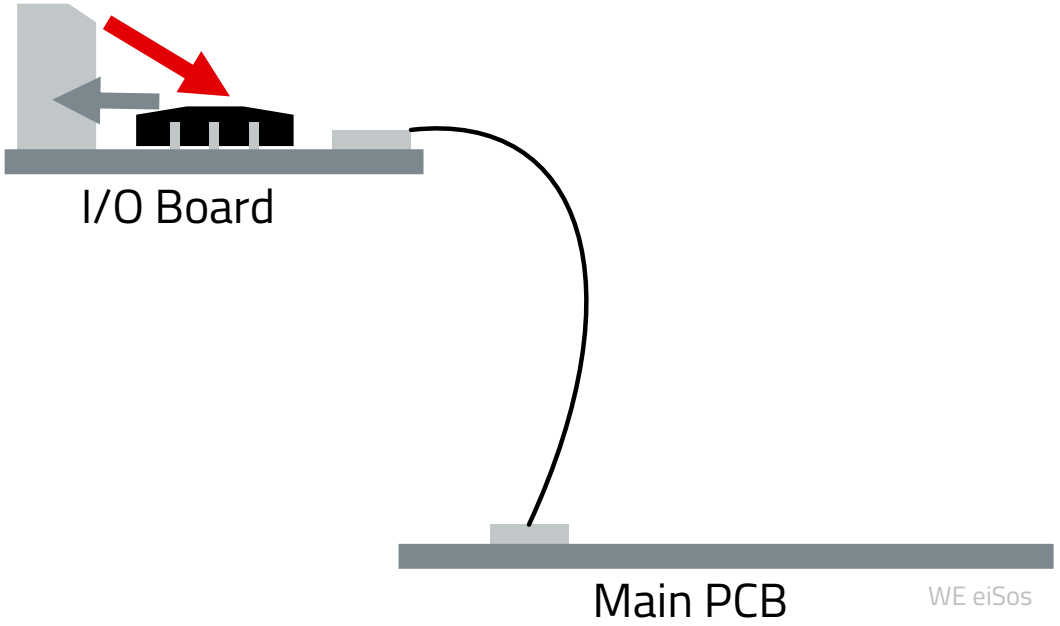
- Grounding studs have to placed so that disturbances don’t affect the electronic parts

I/O BOARDS

Where to Place Overvoltage Protection



Placement on Main PCB



Placement on I/O Board

EFT

Electrical fast transient

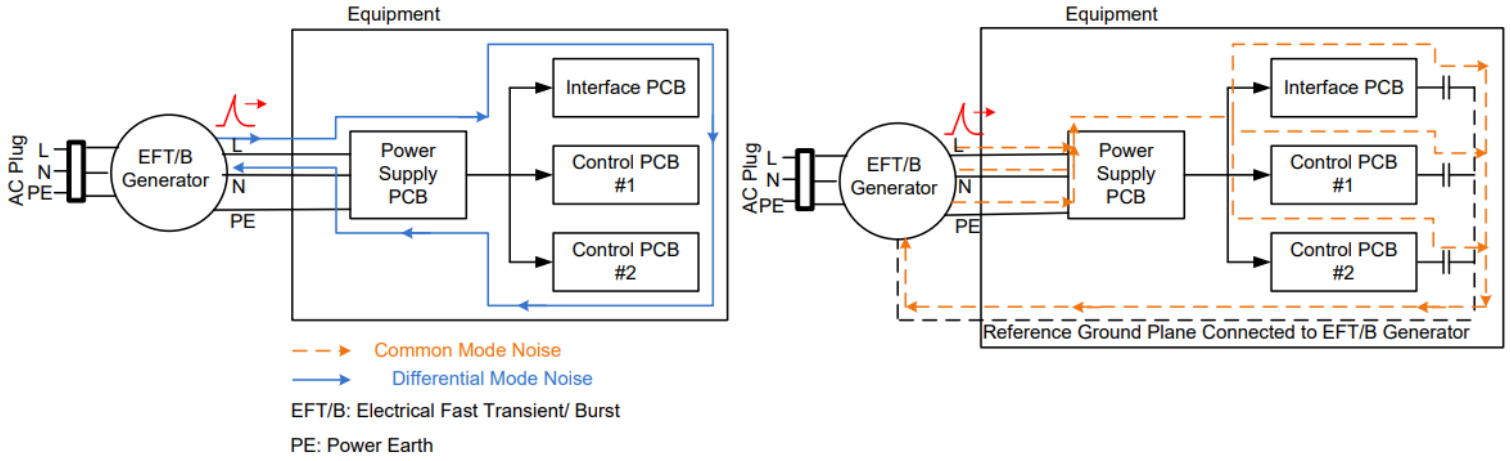
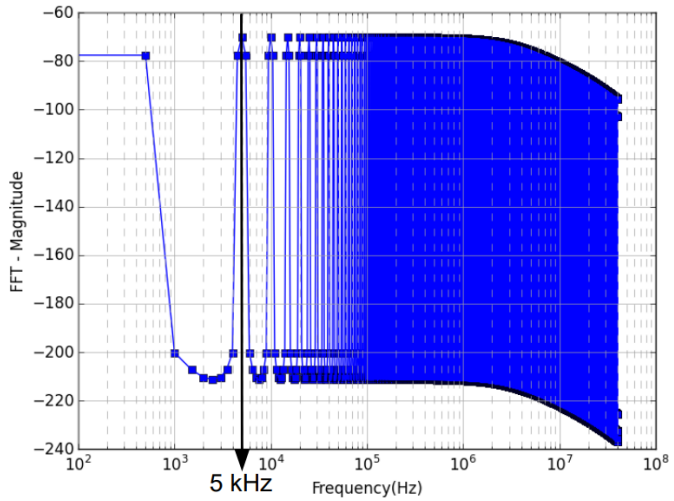
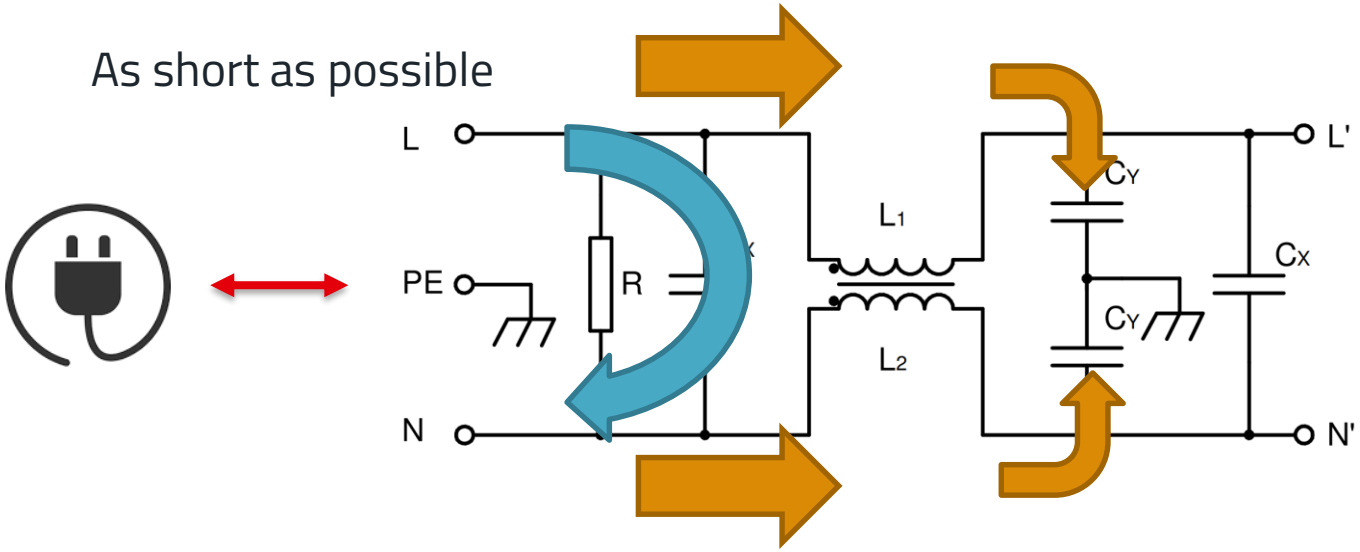
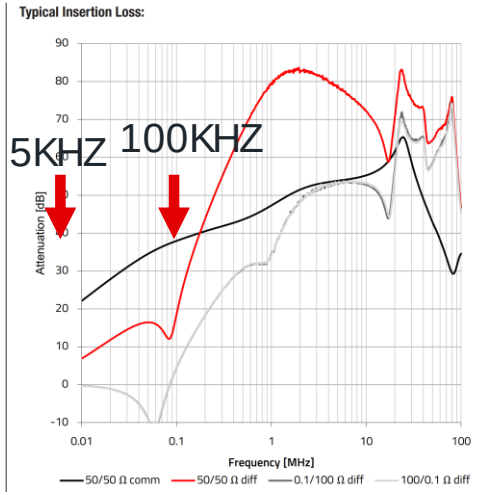


Figure 3. EFT – 5 kHz Burst: Frequency Spectrum



As short as possible

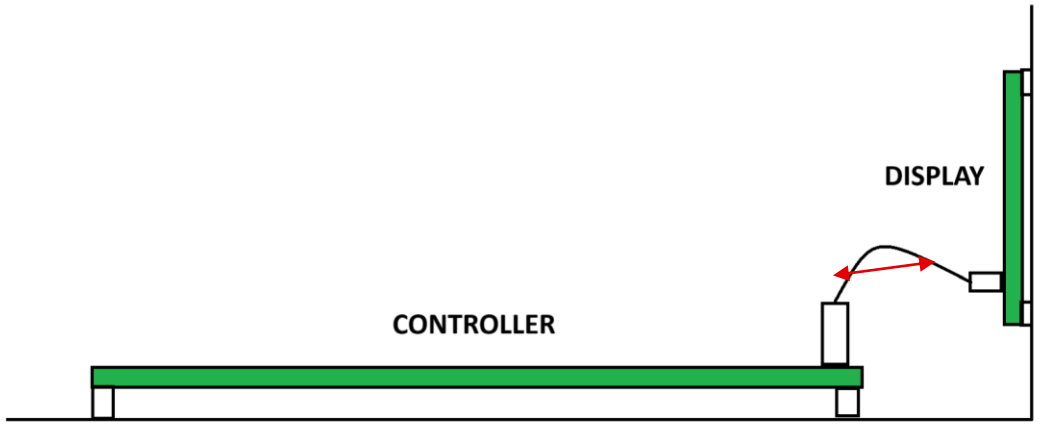


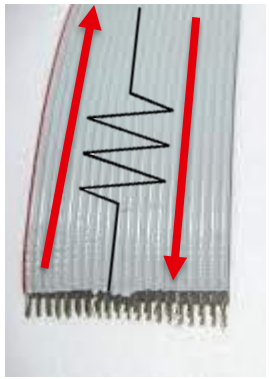


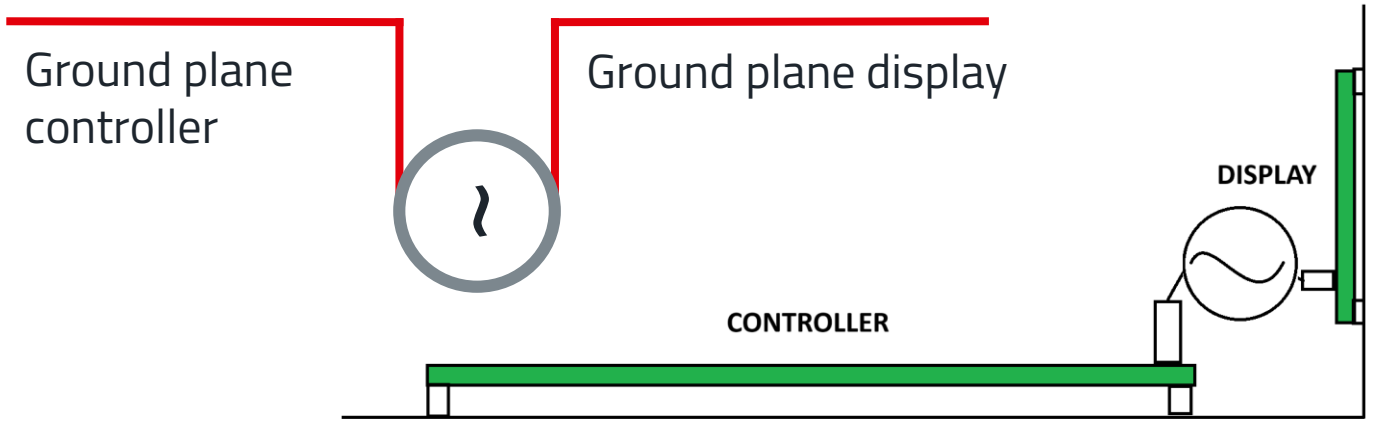
PRACTICAL EXAMPLES

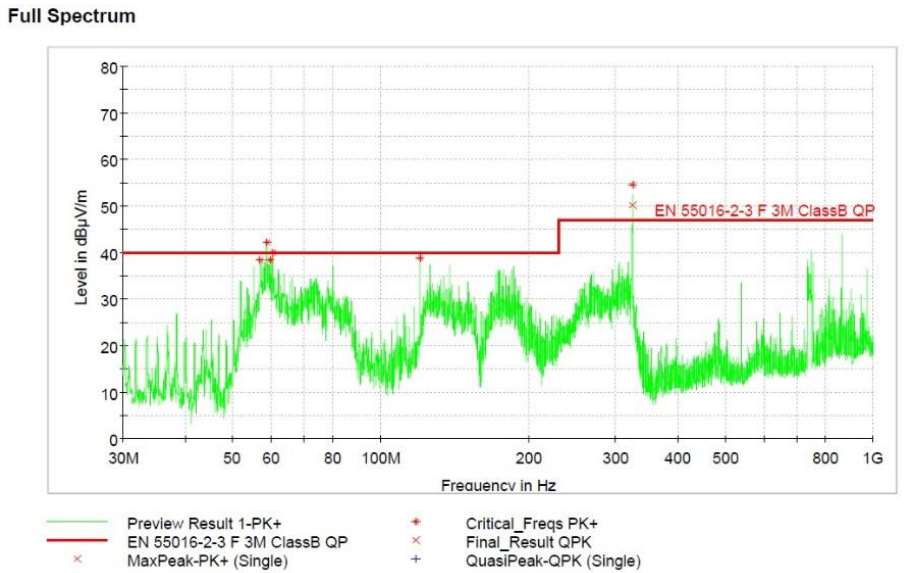
LOW IMPEDANCE RETURN PAD ON DEVICE LEVEL

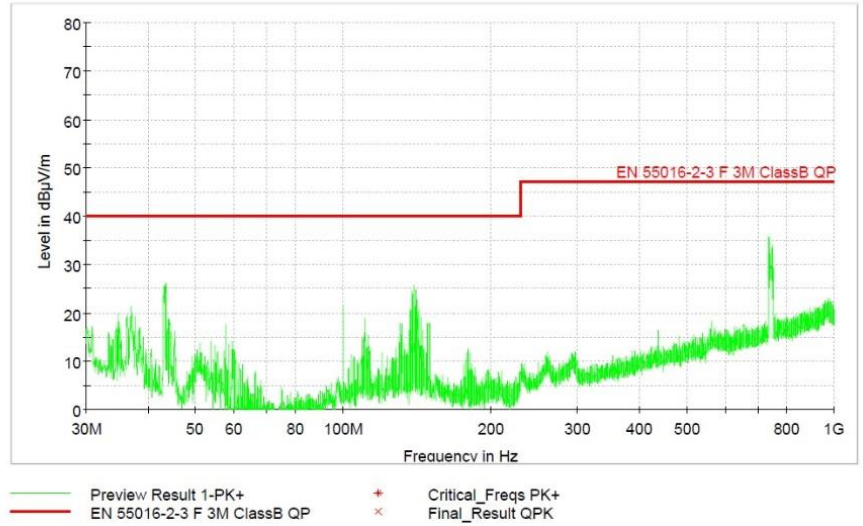
PRACTICAL EXAMPLE 1:





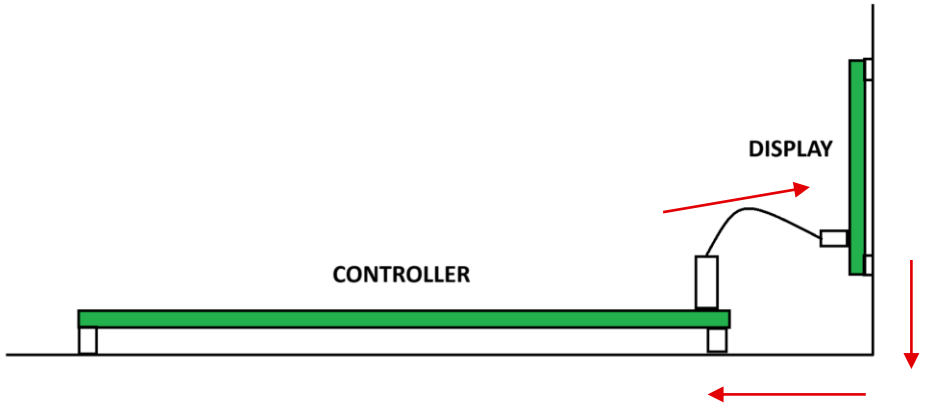






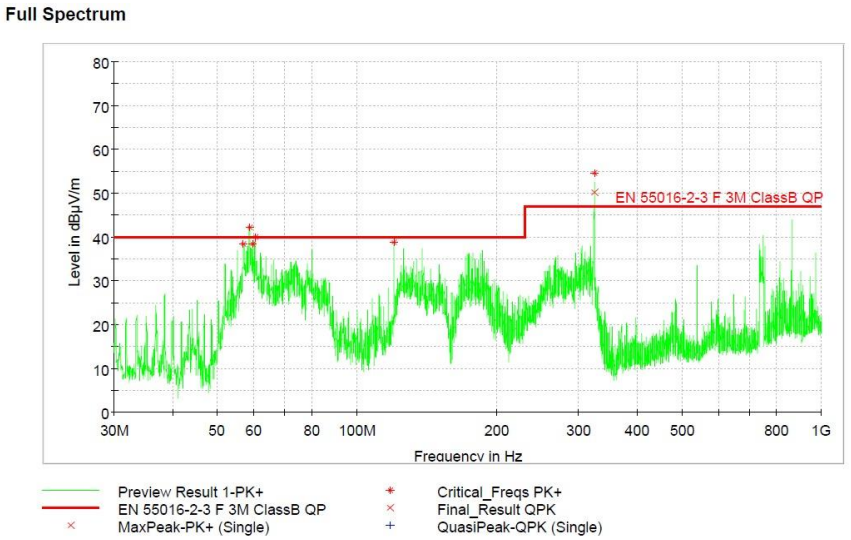
LOW IMPEDANCE RETURN PAD ON DEVICE LEVEL

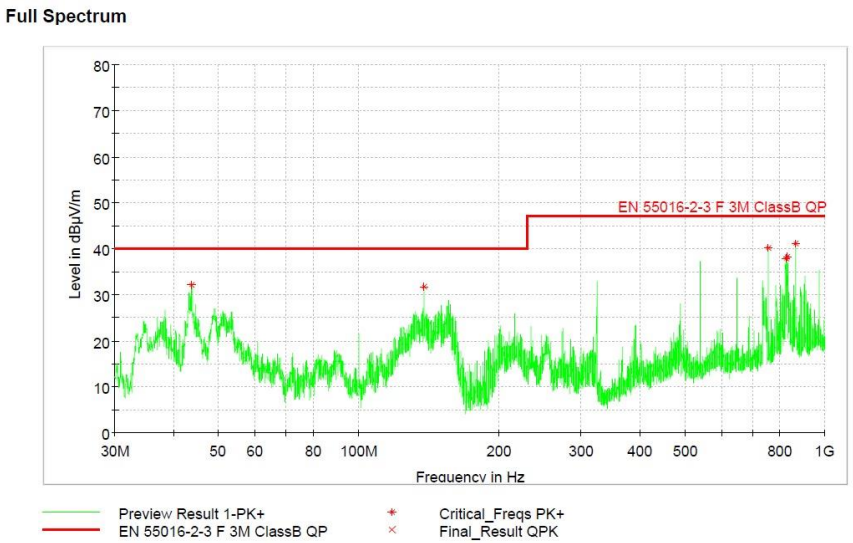
PRACTICAL EXAMPLE 1 solution:



SMT Spacers

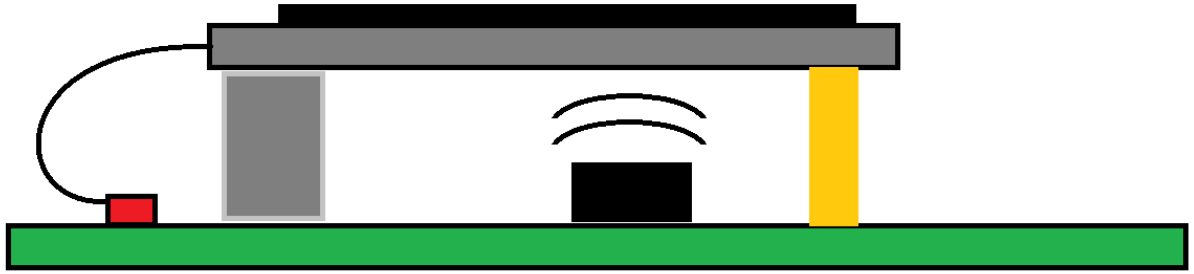
Earthing Belt





LOW IMPEDANCE RETURN PAD ON DEVICE LEVEL

PRACTICAL EXAMPLE 2:



CUSTOMIZABLE PRODUCT SERIES

WE-SECF
SMD EMI Contact Finger

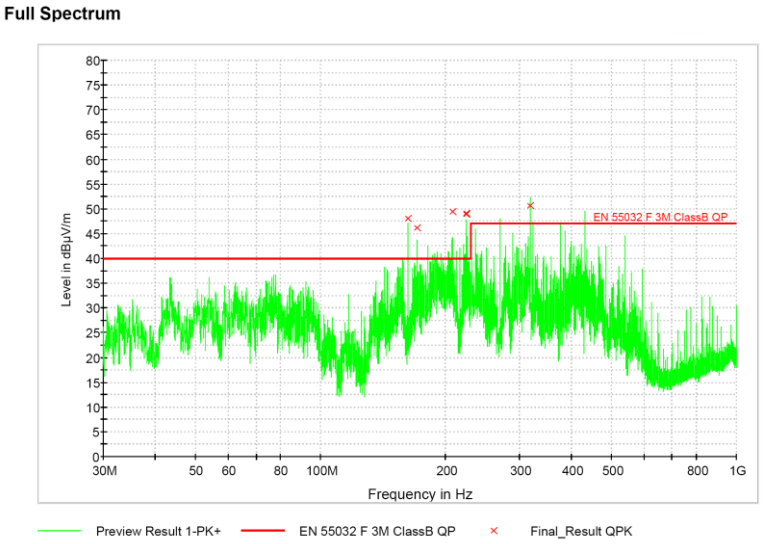
WE-SMGS
SMD Solderable Gasket

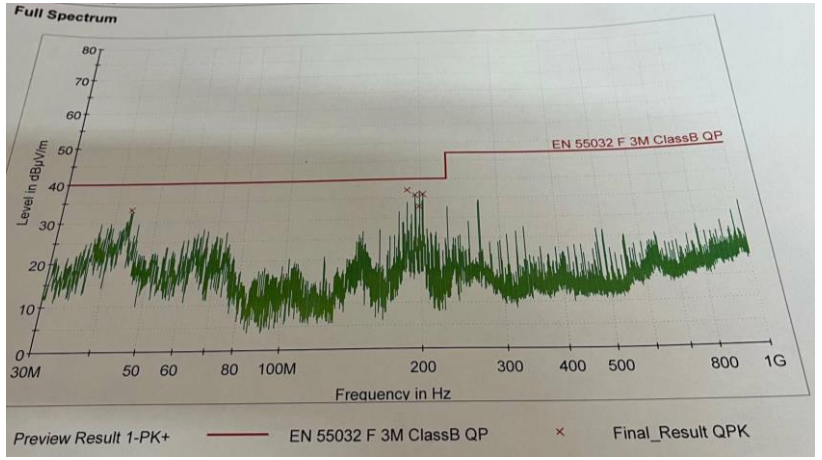
CUSTOMIZABLE PRODUCT SERIES

WE-LT
Conductive Shielding Gaskets

WE-CF
EMI Shielding Sheet
- Aluminium
- Copper

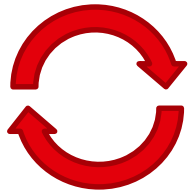
WE-TS
Shielding Textiles



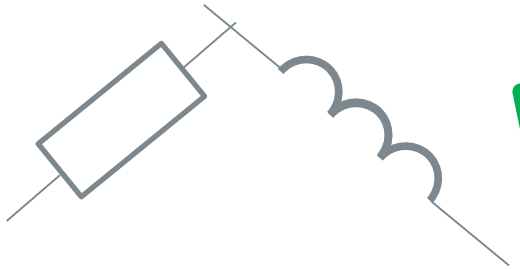


SUMMARY

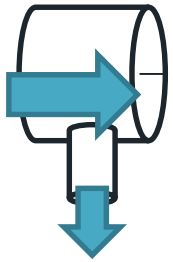
- Current flows in loops



- DC R dominant / HF Z dominant



- Control the return path by bypassing/blocking



- Identify the parasitics