FROM HEAT TO NOISE: THE HIDDEN IMPACT OF THERMAL DESIGN

Louis Van Lommel & Raf Vleugels

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

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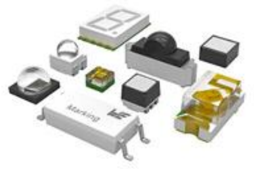
Organization Chart

WÜRTH ELEKTRONIK eiSos GROUP

PASSIVE COMPONENTS	POWER MODULES (MAGI³C-SERIES)	DIGITAL ISOLATORS	OPTOELECTRONICS	THERMAL MANAGEMENT	ELECTROMECHANICAL COMPONENTS	RADIO MODULES & SENSORS	AUTOMOTIVE
							

PE&ES event 2026

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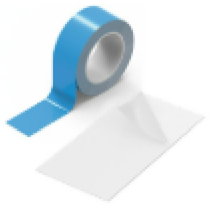
Thermal Management:

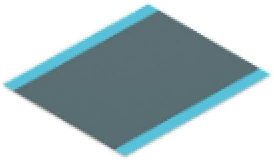


Gap Filling Solutions

WE-TGF Thermal Gap Filler Pad | WE-TINS Thermally Conductive Insulator Pad | WE-TTT Thermal Transfer Tape | WE-PCM Thermal Phase Changing Material

Hybrid Solutions

WE-TGFG Graphite Foam Gasket



Heat Spreading Solutions

WE-TGS Graphite Sheet

Heat Sinks NEW

WE-HTO Heatsink for TO220/247 | WE-HTOI Heatsink for TO220/247 with Integrated Interface Material | + 3 more

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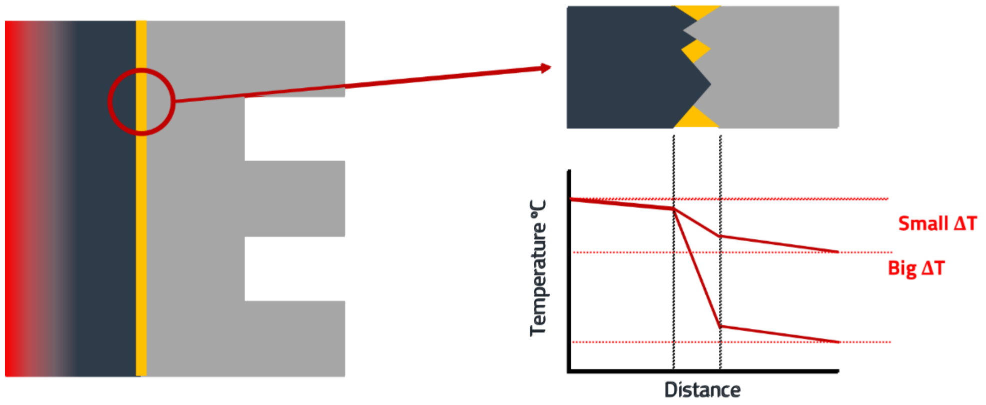
Introduction - Strategies

Thermal Management Solutions

A → B

Heating Element

- One hot component
- Multiple hot components
- Back side of a PCB
- Processing units
- Transistors, IGBTs
- Memory ICs
- Battery cells
- …



Cooling Assembly

- Heatsink
- Metal housing
- Cooling plate
- Radiator
- …

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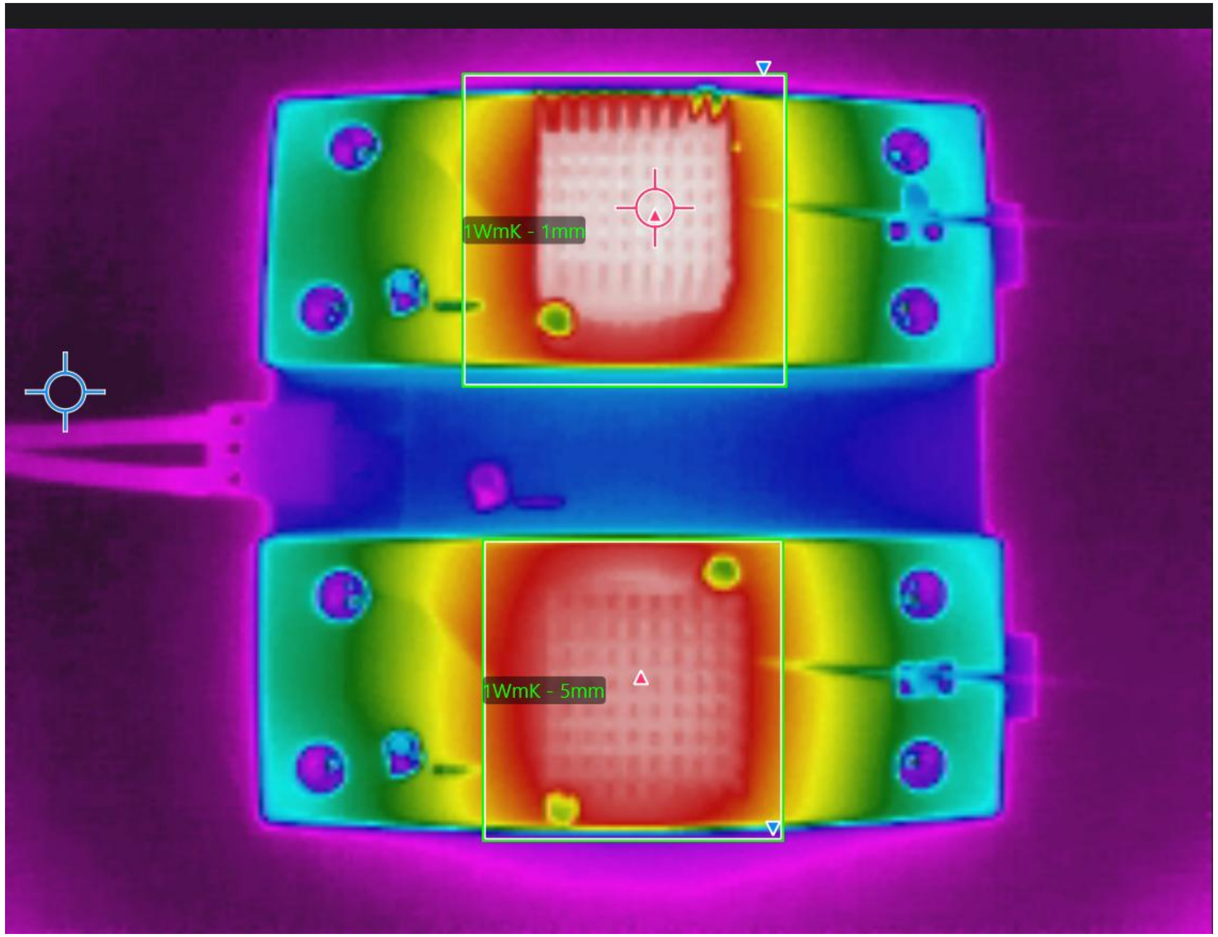
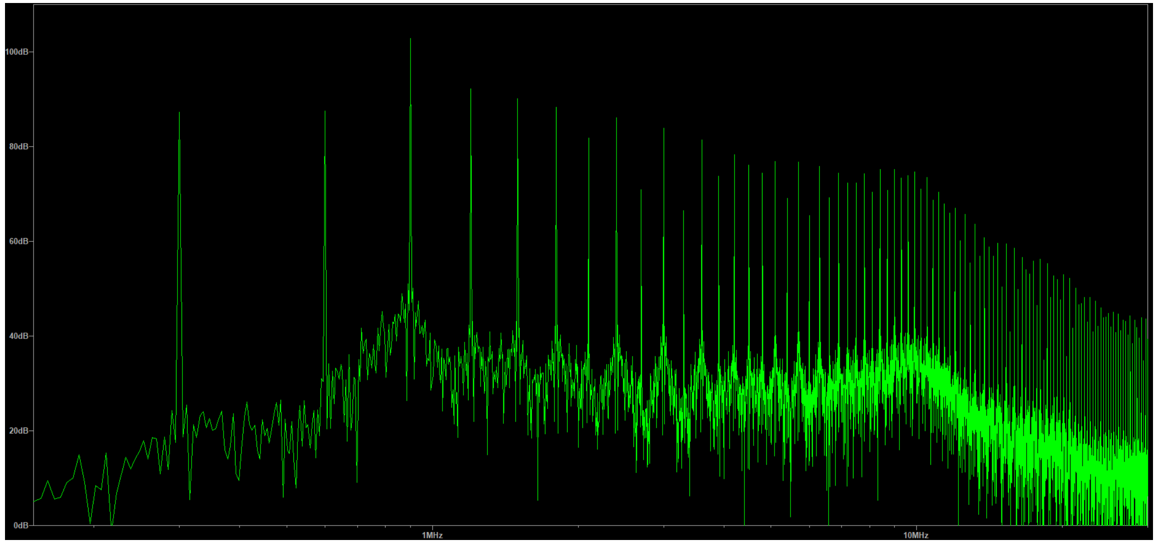
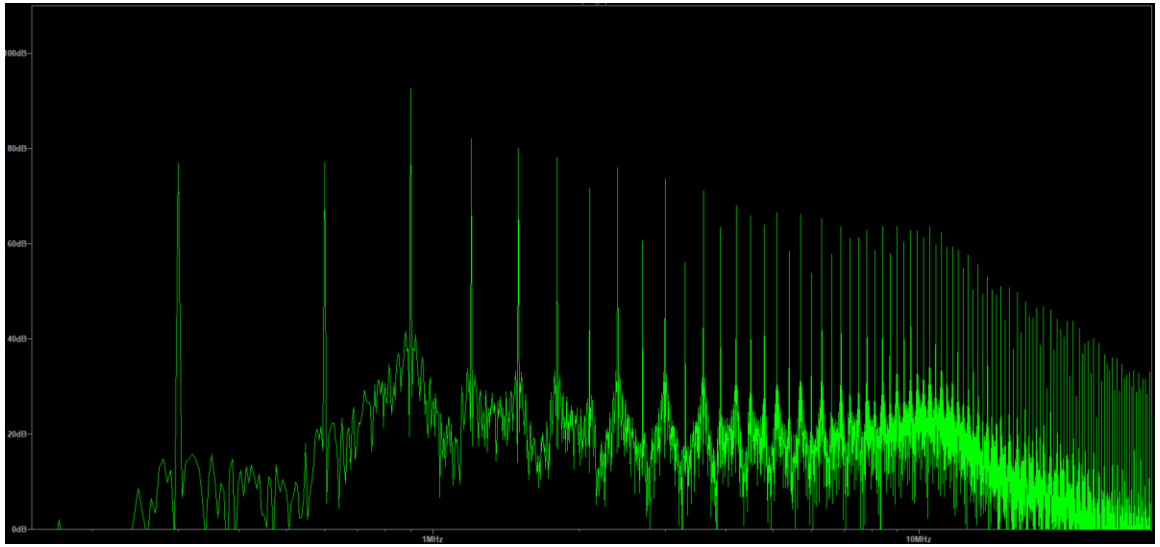
Today's Demo:







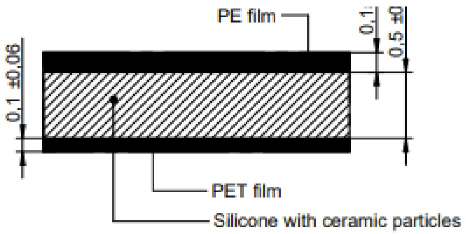
Thermal Resistance of TGF

Thermal Resistance of TGF

$$R_{th-TIM} = \frac{l}{\lambda \cdot A} = \frac{0{,}002\text{m}}{1\frac{\text{W}}{\text{m}\cdot\text{K}} \cdot (0.031 * 0{,}031)} = \mathbf{2{,}08\frac{K}{W}}$$

$$R_{th-TIM} = \frac{l}{\lambda \cdot A} = \frac{0{,}005\text{m}}{1\frac{\text{W}}{\text{m}\cdot\text{K}} \cdot (0.031 * 0{,}031)} = \mathbf{5{,}20\frac{K}{W}}$$

- $l = Material\ thickness\ of\ TIM[m]$
- $A = Contact\ surface\ area\ of\ TIM[m^2]$
- $\lambda = Thermal\ conductivity\ coefficient\ of\ TIM[\frac{W}{m \cdot K}]$



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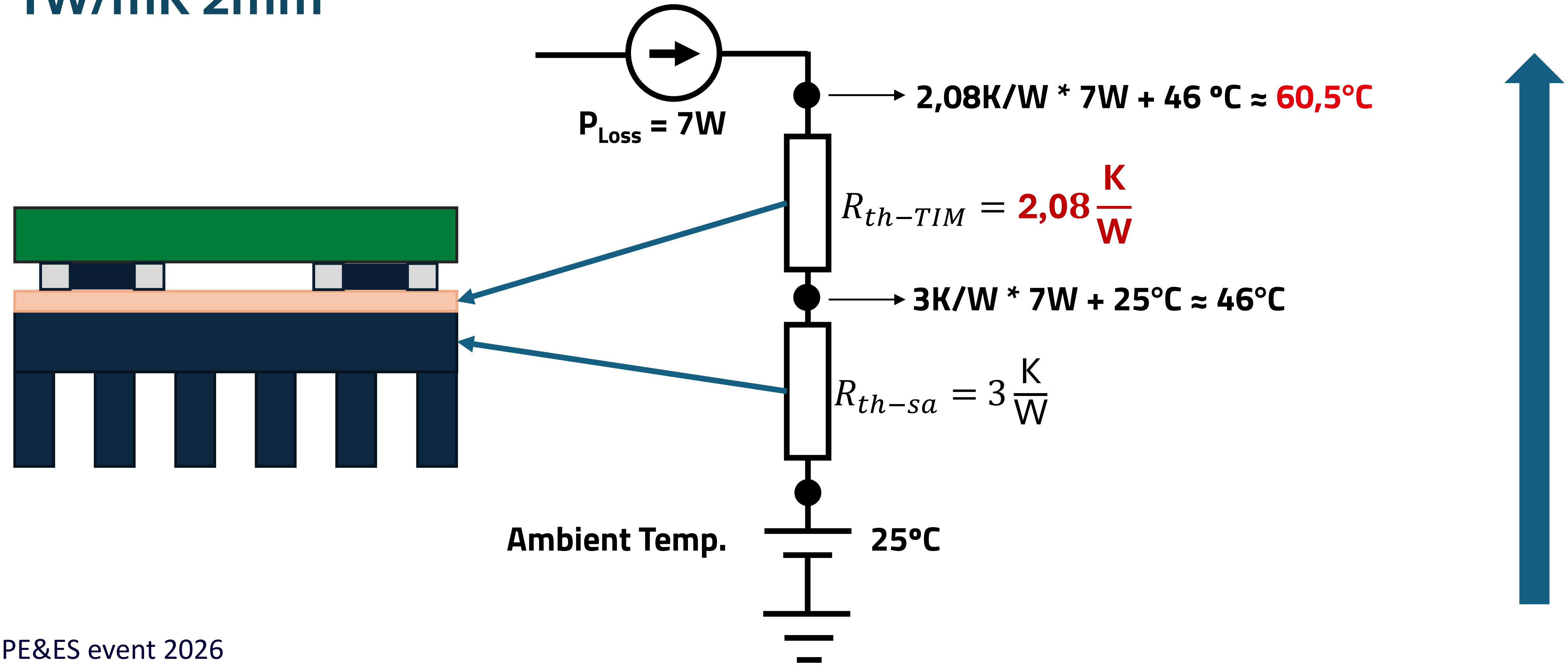
Thermal Demo PCB - Maximum component temperature

- **Case 2: passive heatsink with TGF**

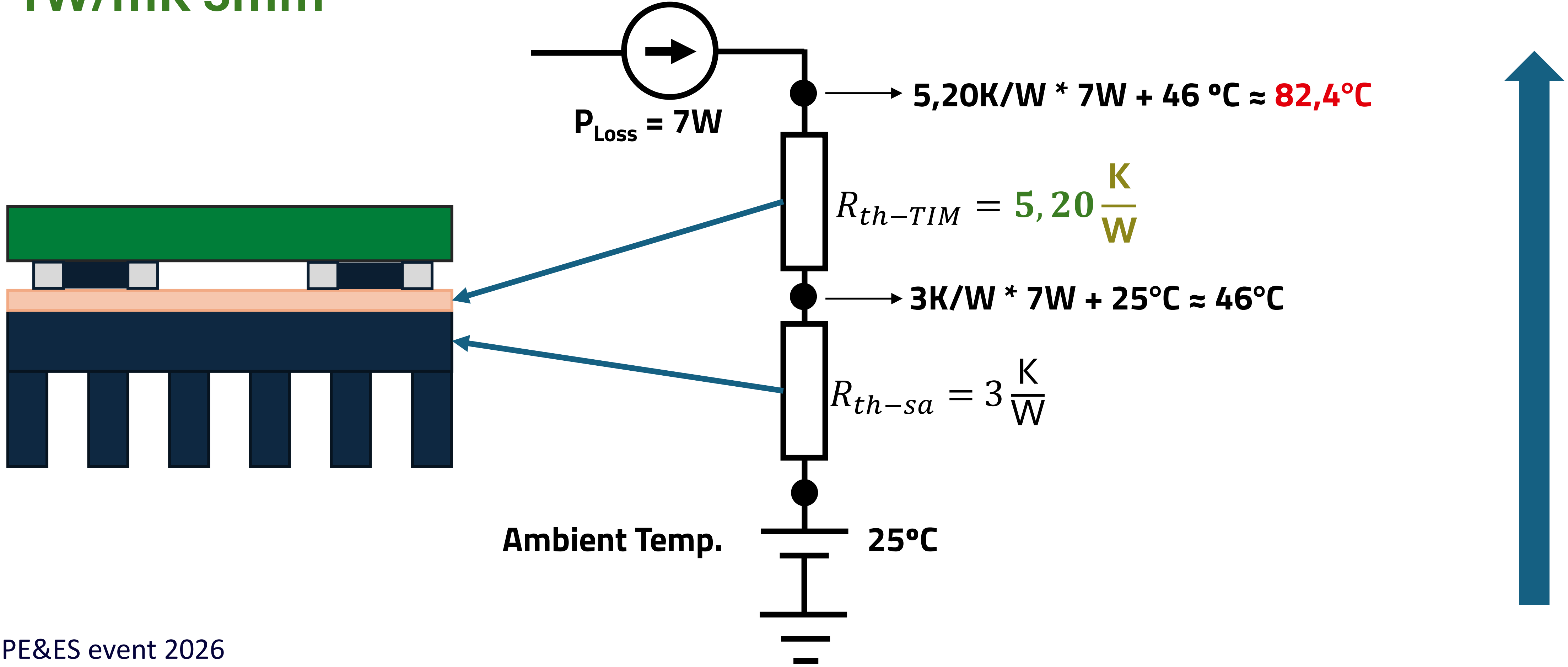
1W/mK 2mm



Thermal Demo PCB - Maximum component temperature

- **Case 2: passive heatsink with TGF**

1W/mK 5mm



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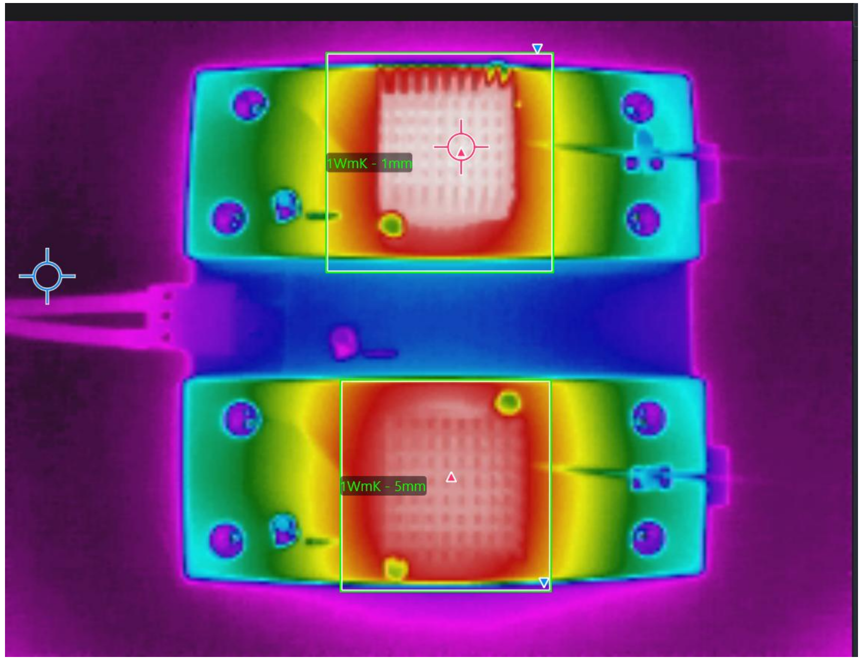
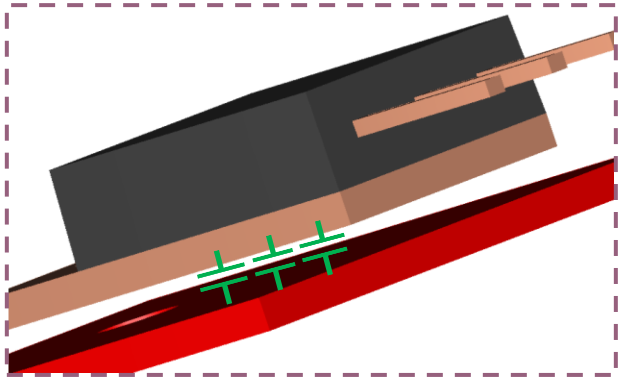
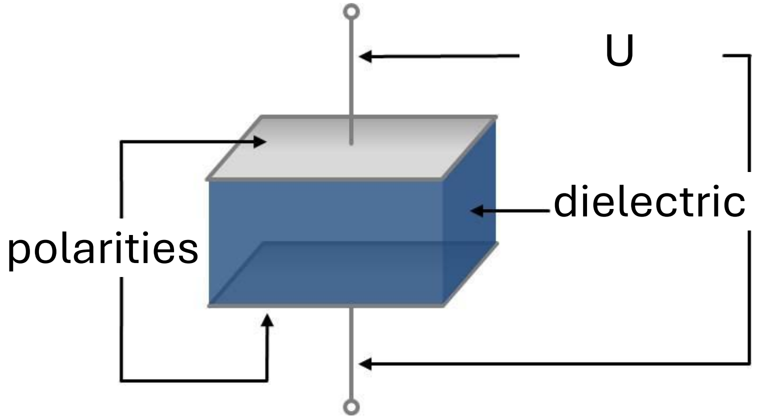
Thermal Demo PCB - Measurement



TMI	T°C Component		T°C Heatsink	
	Calculation	Measurement	Calculation	Measurement
1W/mK 2mm	60,5	66	46	62
1W/mK 5mm	82,4	84	46	60

EMC Aspects - Thermal interface is not only a thermal path, but also electrical coupling path.

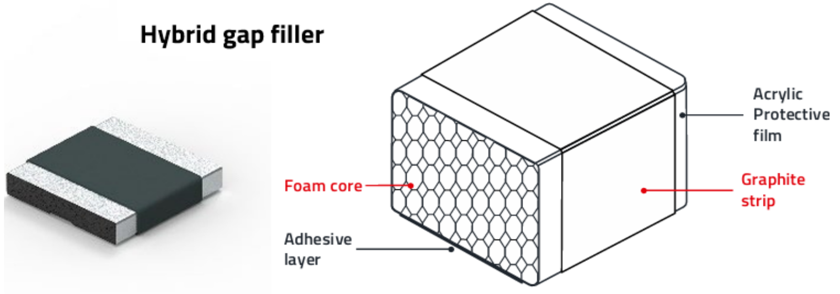




$$C = \varepsilon * \frac{A}{d} = \varepsilon_0 * \varepsilon_r * \frac{A}{d}$$

C – Capacitance [F]
A – plate area [m]
d – plate distance [m]
εr – relative permittivity TIM
ε0 –absolute permittivity : $8{,}85 \times 10^{-12} [\frac{As}{Vm}]$

Silicone WE-TGF 5mm k = 3			Silicone WE-TGF 5mm k = 1			Silicone WE-TGF 2mm k = 1			Hybrid WE-TGFG 5mm		
Permittivity	13		Permittivity	7,8		Permittivity	7,8		Permittivity		
	8,85E-12			8,85E-12			8,85E-12			8,85E-12	
A	0,0004	m²	A	0,0004	m²	A	0,0004	m²	A	0,0004	m²
d	0,004	m	d	0,004	m	d	0,0016	m	d	0,004	m
Calculated C	1,15E-11	11,51 pF	Calculated C	6,90E-12	6,90 pF	Calculated C	1,73E-11	17,26 pF	Calculated C		pF
Measured C		11,4 pf	Measured C		7,5 pF	Measured C		13,5 pF	Measured C		81 pF



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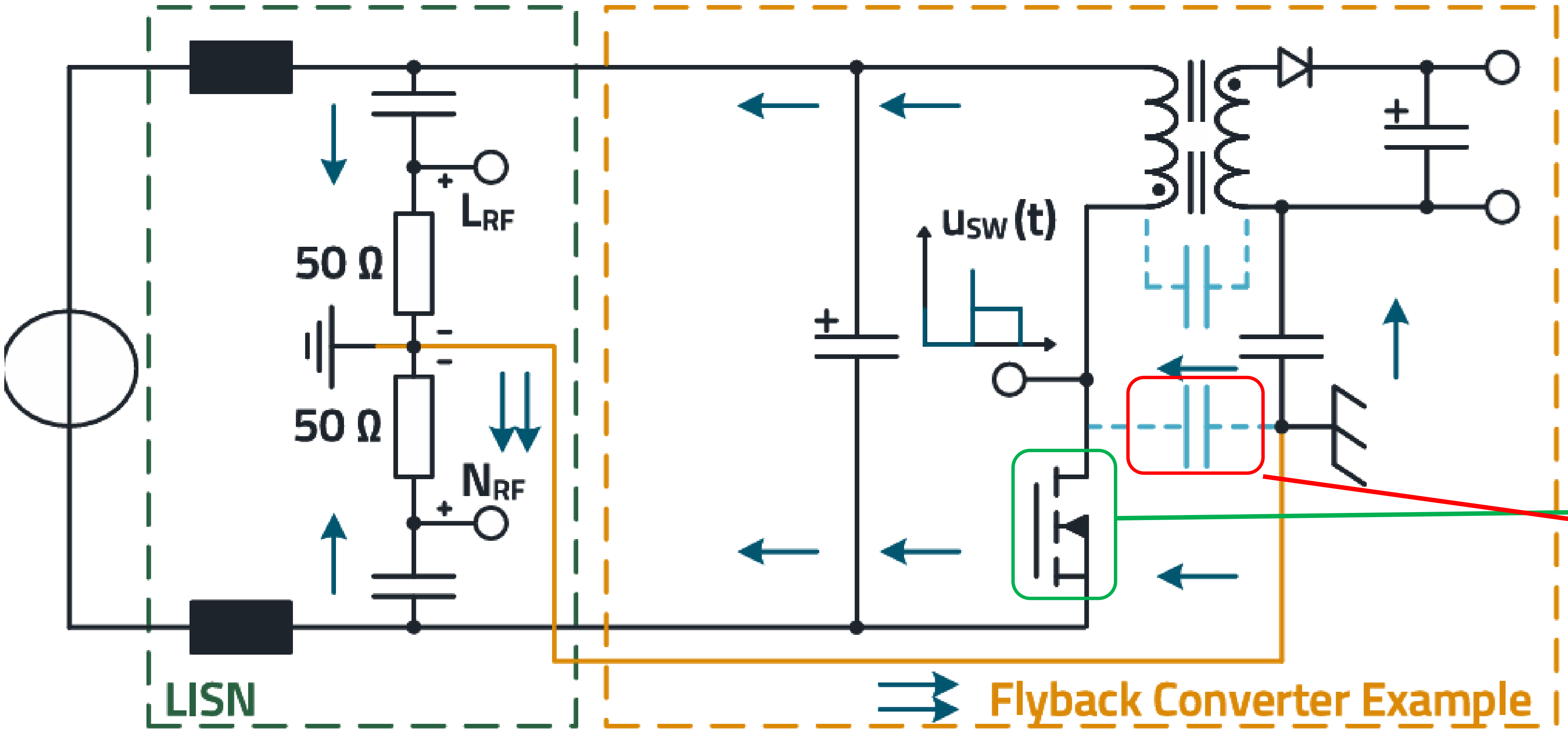
EMC Aspects - Parasitic capacitance creates common-Mode Current in a Flyback converter



$$I_{cm} = \boxed{C_{TIM}} \cdot \boxed{\frac{\Delta V}{\Delta t}}$$

THE BIGGER THE PARASITIC CAPACITOR, THE BIGGER THE COMMON MODE CURRENTS!

THERMAL COUPLING CAN UNINTENTIONALLY BECOME AN EMI COUPLING PATH

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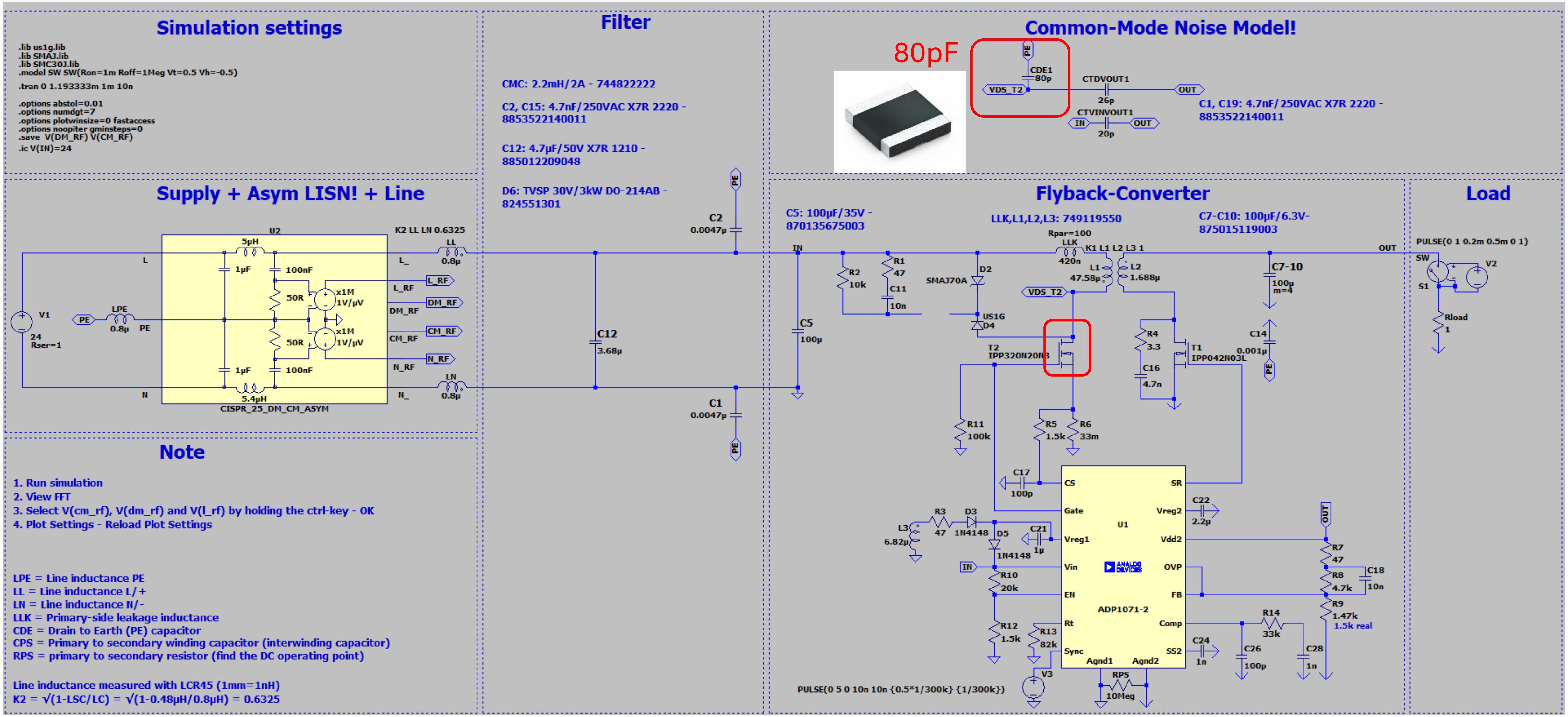
LTSPICE Simulation



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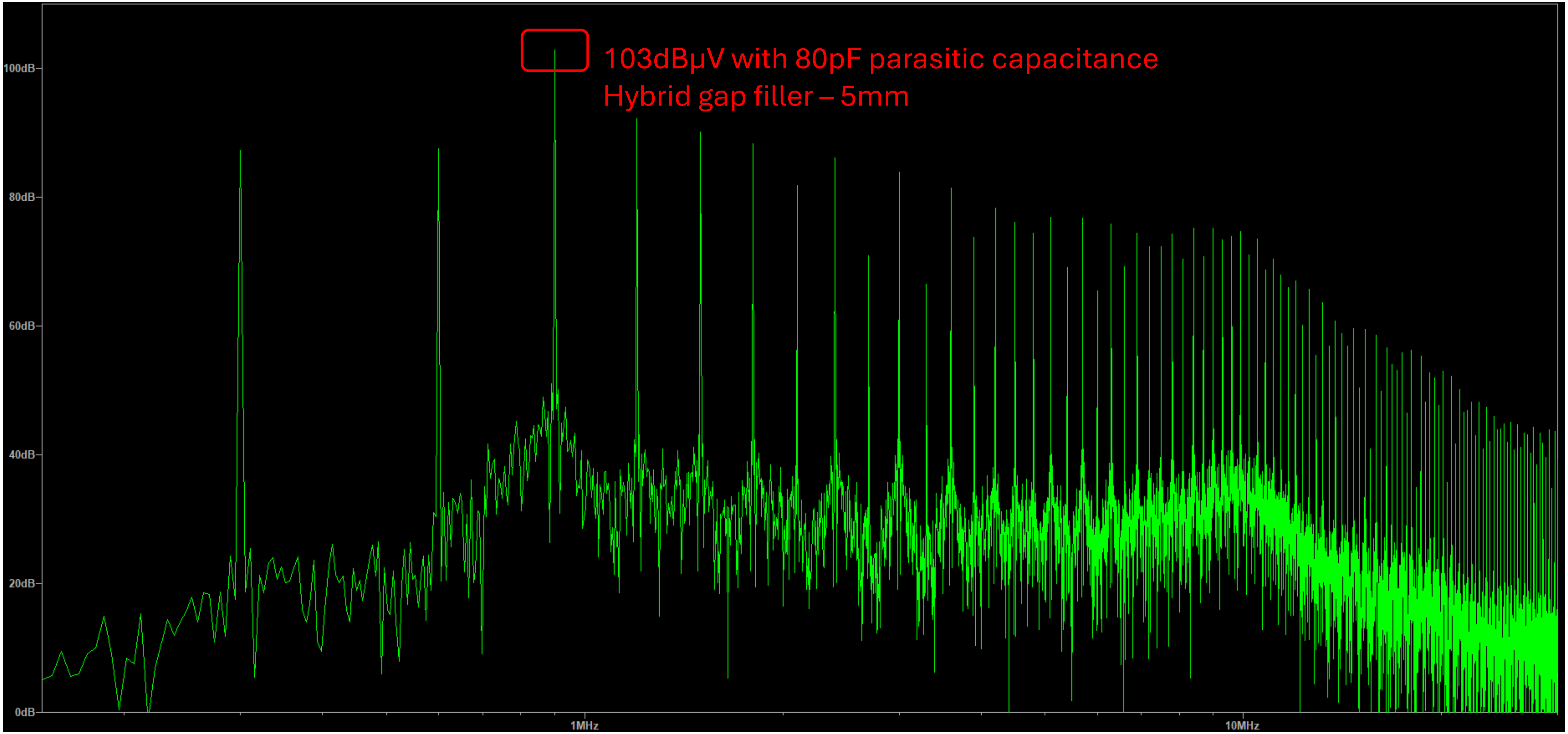

LTSPICE SIMULATION - SUMMARY

	Thermal Resistance	Capacitance	dbµV @ 900kHz
5mm Graphite over Foam	Low	80pF	103
5mm TIM – k = 3	Medium	11,5pF	94
5mm TIM – k = 1	High	7,5pF	93
2mm TIM – k = 1	Medium	13,5pF	94,5

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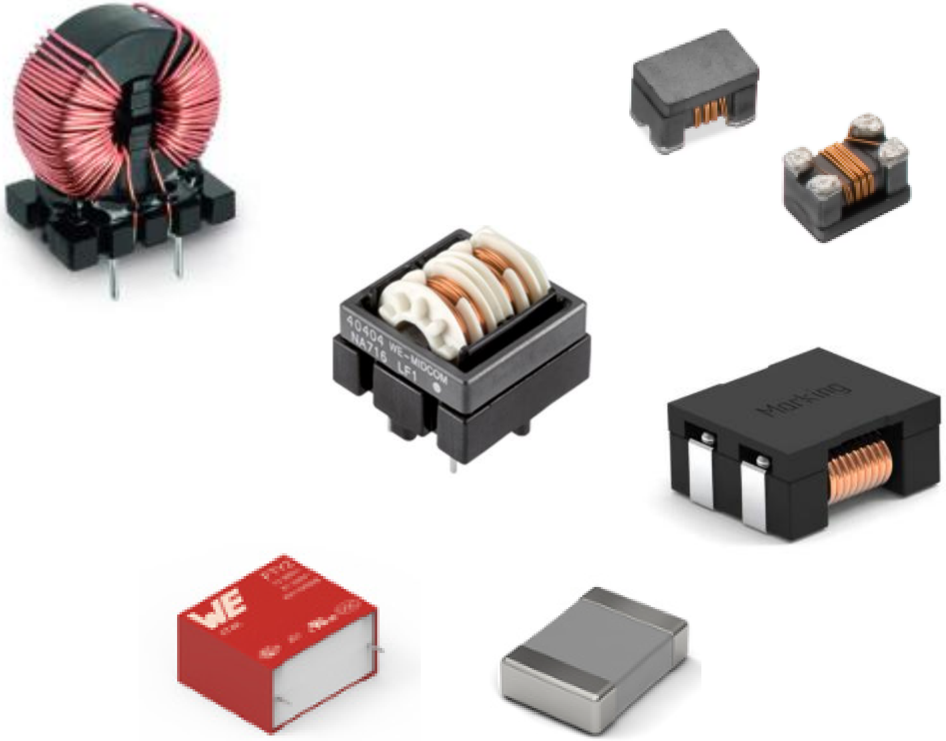
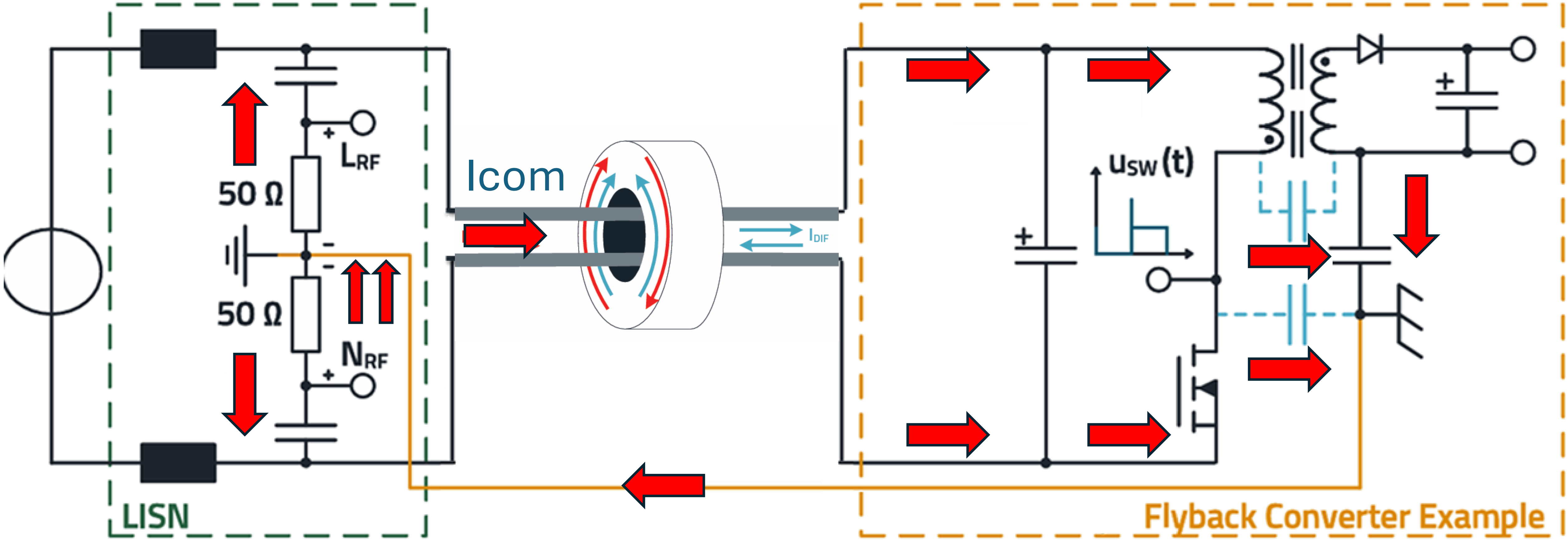
Common mode solutions

System-Level / Mechanical Measures

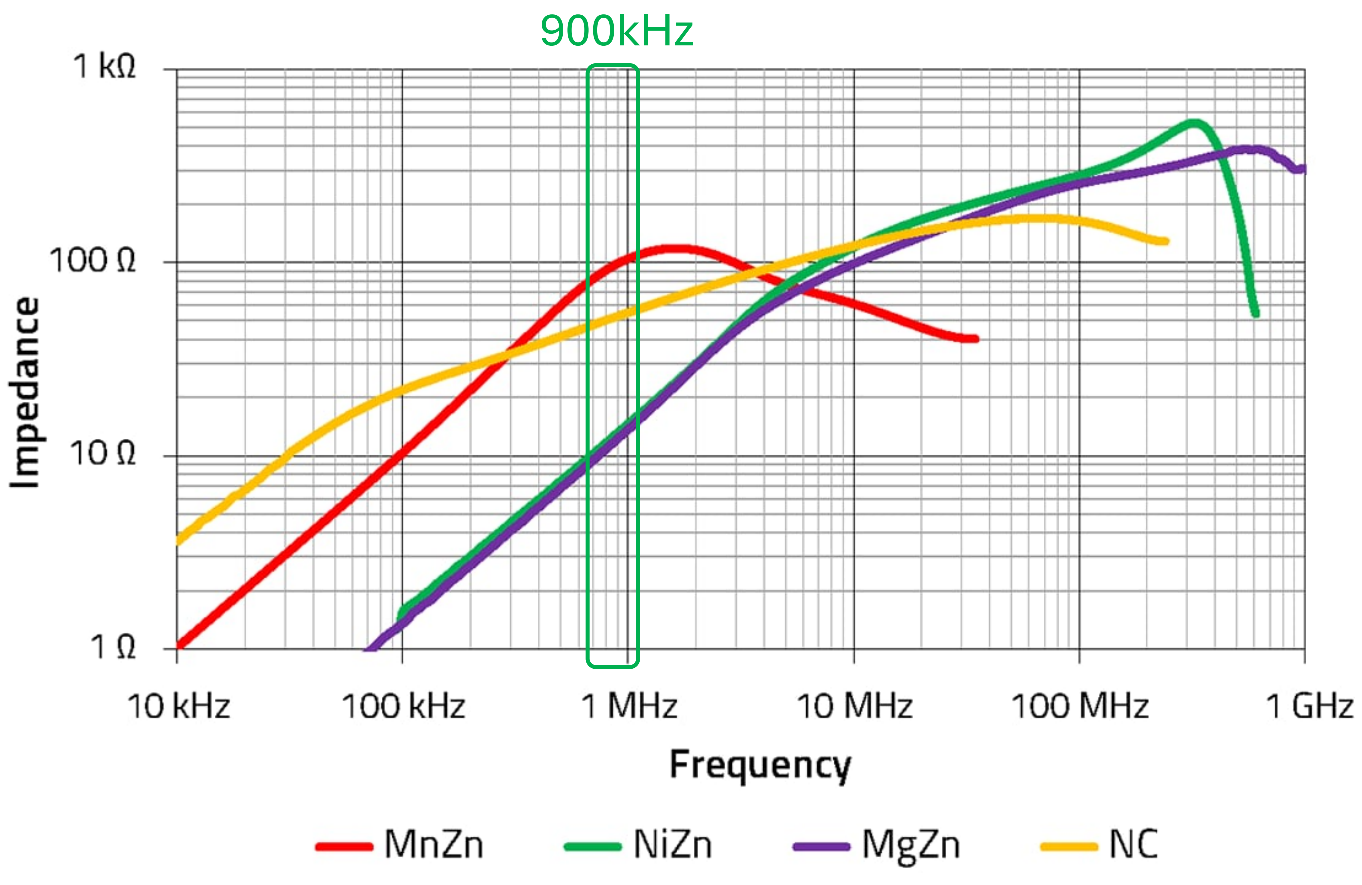
PCB-Level / Circuit Measures

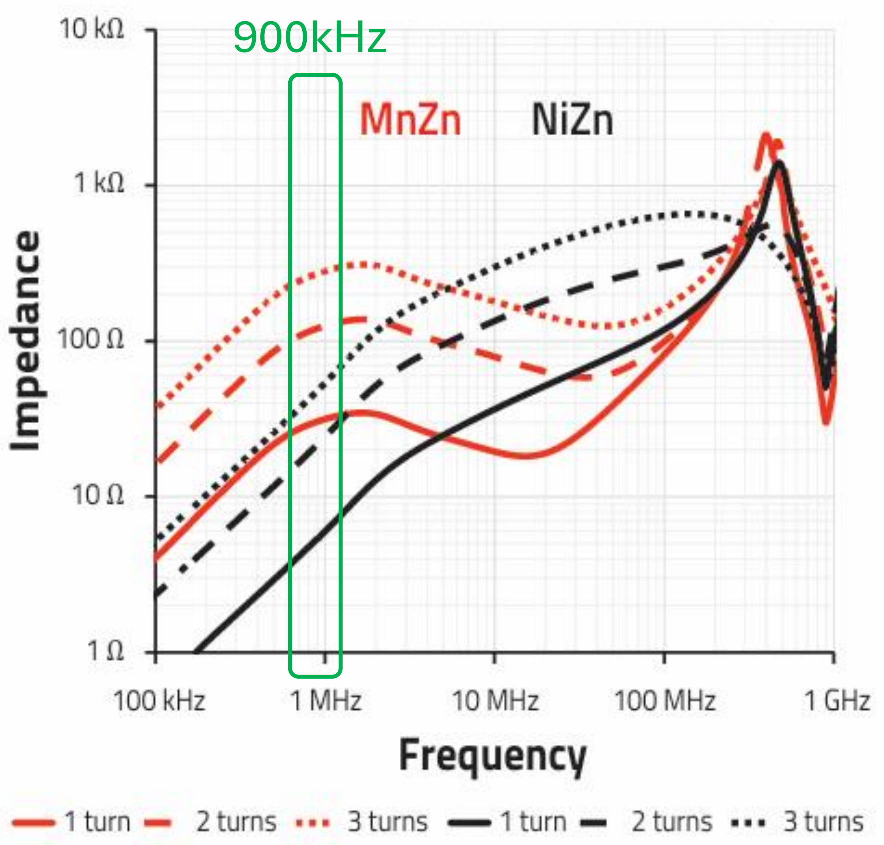


Common mode solutions - Cable Ferrites



Common mode solutions - Cable ferrites





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Design considerations - Thermal Performance versus EMI considerations

Thermal

- Thinner TIM = Better thermal performance
- High conductivity = Better thermal performance

$$R_{th} = \frac{l}{\lambda \cdot A} = \left[\frac{K}{W}\right]$$

$$\lambda = Thermal\ conductivity \left[\frac{W}{m.K}\right]$$

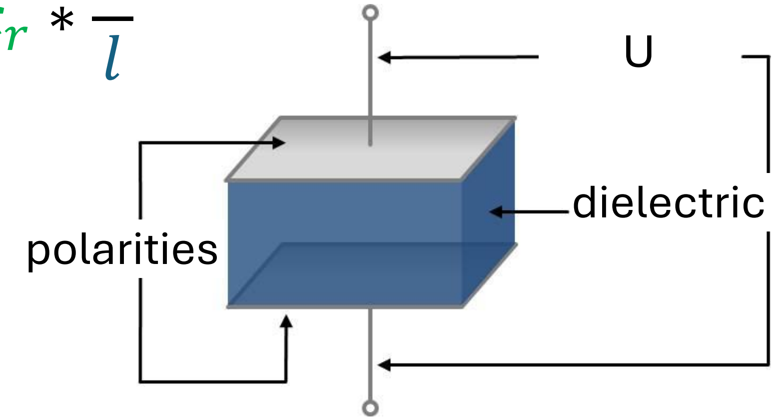
$$l = Material\ thickness [m]$$

$$A = Cooling\ overall\ surface [m^2]$$

EMI

- Thicker TIM = Better EMI performance
- Lower permittivity = Better EMI performance

$$C = \varepsilon_0 * \varepsilon_r * \frac{A}{l}$$



$$\varepsilon_r = Permittivity$$

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Summary

- Do not select a TIM on thermal conductivity alone.
- Check thickness, area and permittivity as EMC-relevant parameters.
- If redesign is difficult, use system-level mitigation such as cable ferrites.
- Come check out our demo!

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