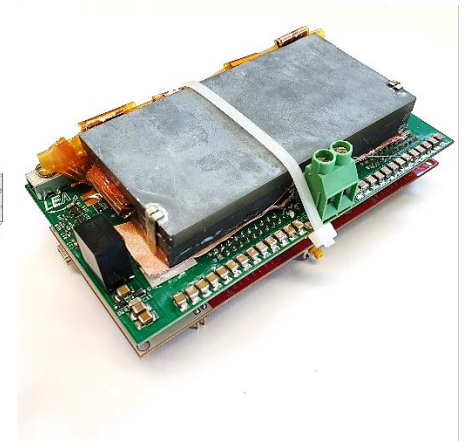
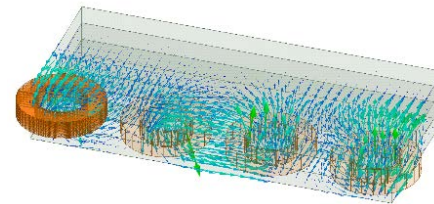
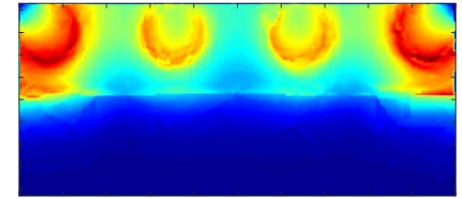




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## Abschlusspräsentation des Semesterprojekts

# Hochkompakter, hocheffizienter 48V-12V DC-DC-Wandler für Elektrofahrzeuge mit gekoppelter Magnetik

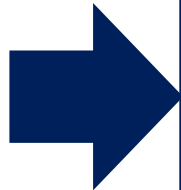
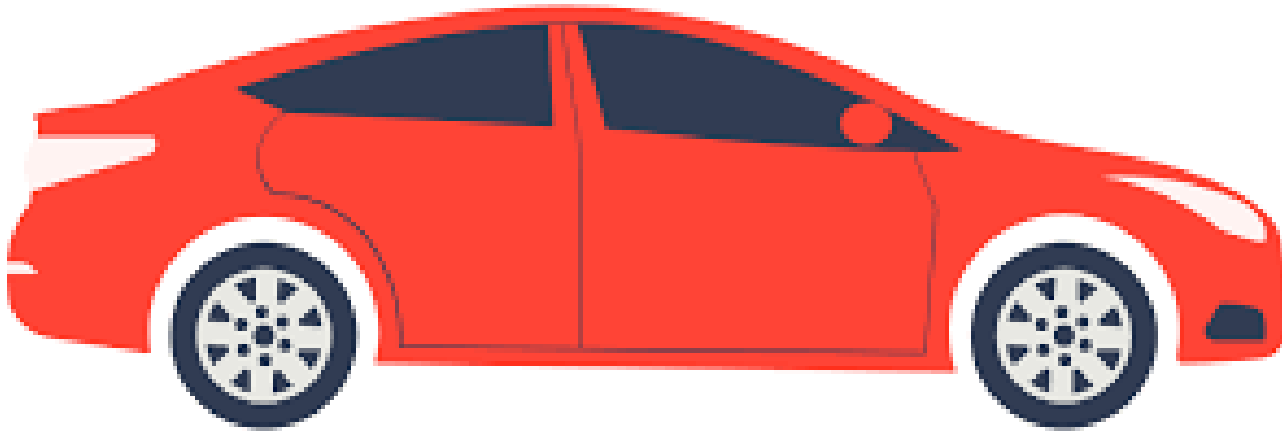
## Projektgruppe Leistungselektronik

Suraj Joshi, Matthias Orth, Robin Wolf, Marius Fischer, Niklas Gröne

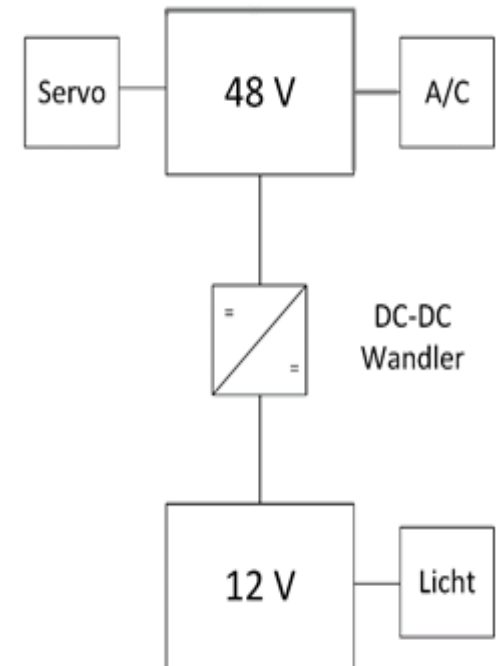
- ▶ Motivation / Einführung
- ▶ gekoppelte Magnetik
- ▶ Hardwareintegration

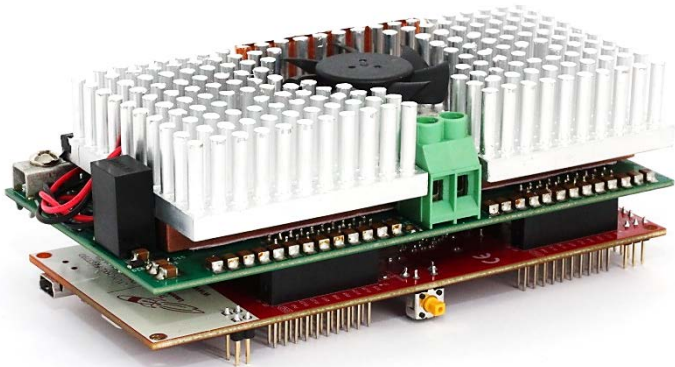
- ▶ Motivation / Einführung
- ▶ gekoppelte Magnetik
- ▶ Hardwareintegration

- Verbraucher unterschiedlicher Leistungsklassen
- Erfordert unterschiedliche Spannungsebenen
- Bedarf an DC-DC-Wandlern



**Hohe Leistungsdichte  
Hoher Wirkungsgrad**





Westfalen Weser  
Energie

solar regenerative bio  
ENERGIE effizienz  
wind einsatz marketing speicherung  
gewinnung

ENERGY  
AWARD 2018

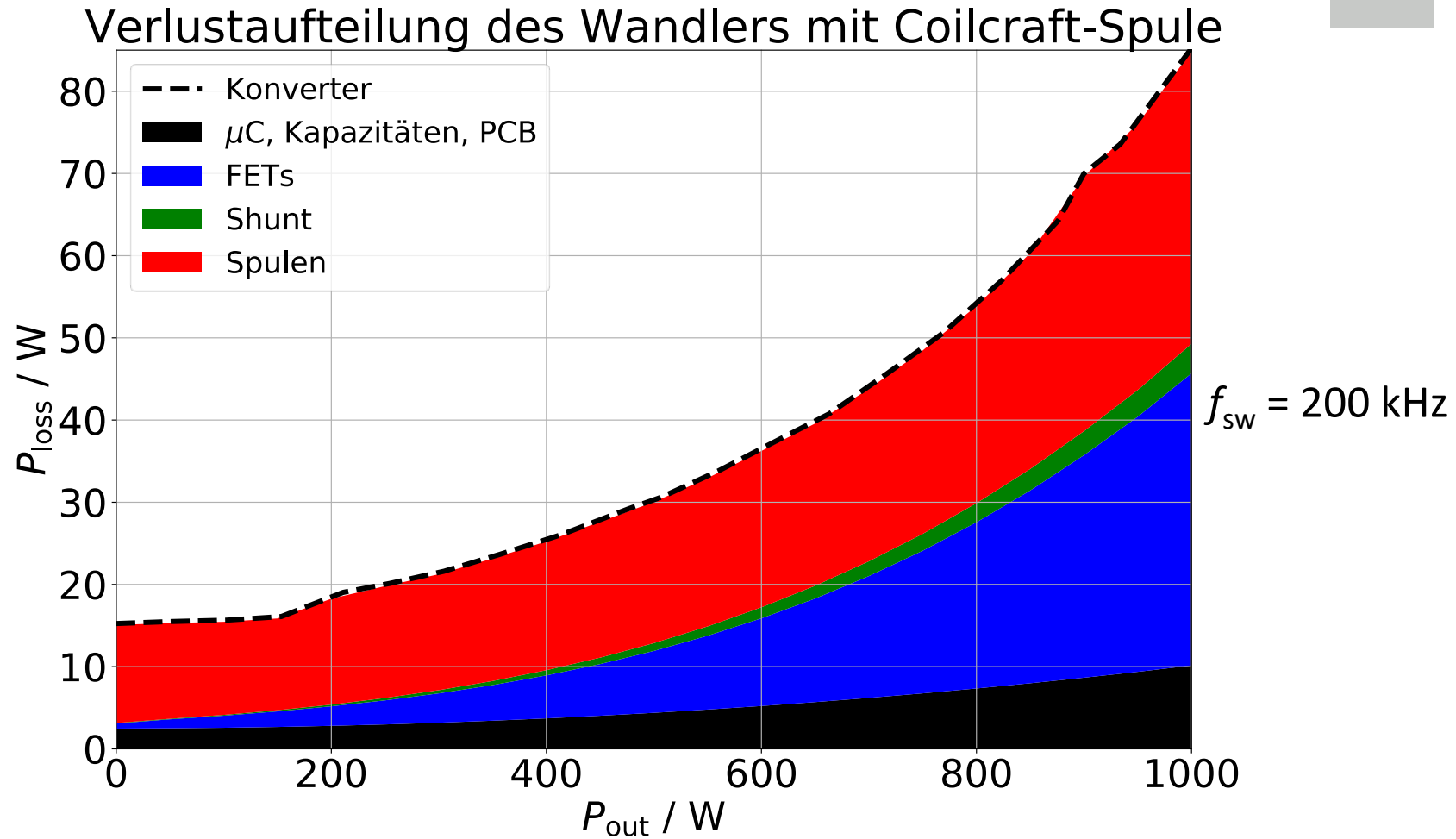
Bewerben. Gewinnen.



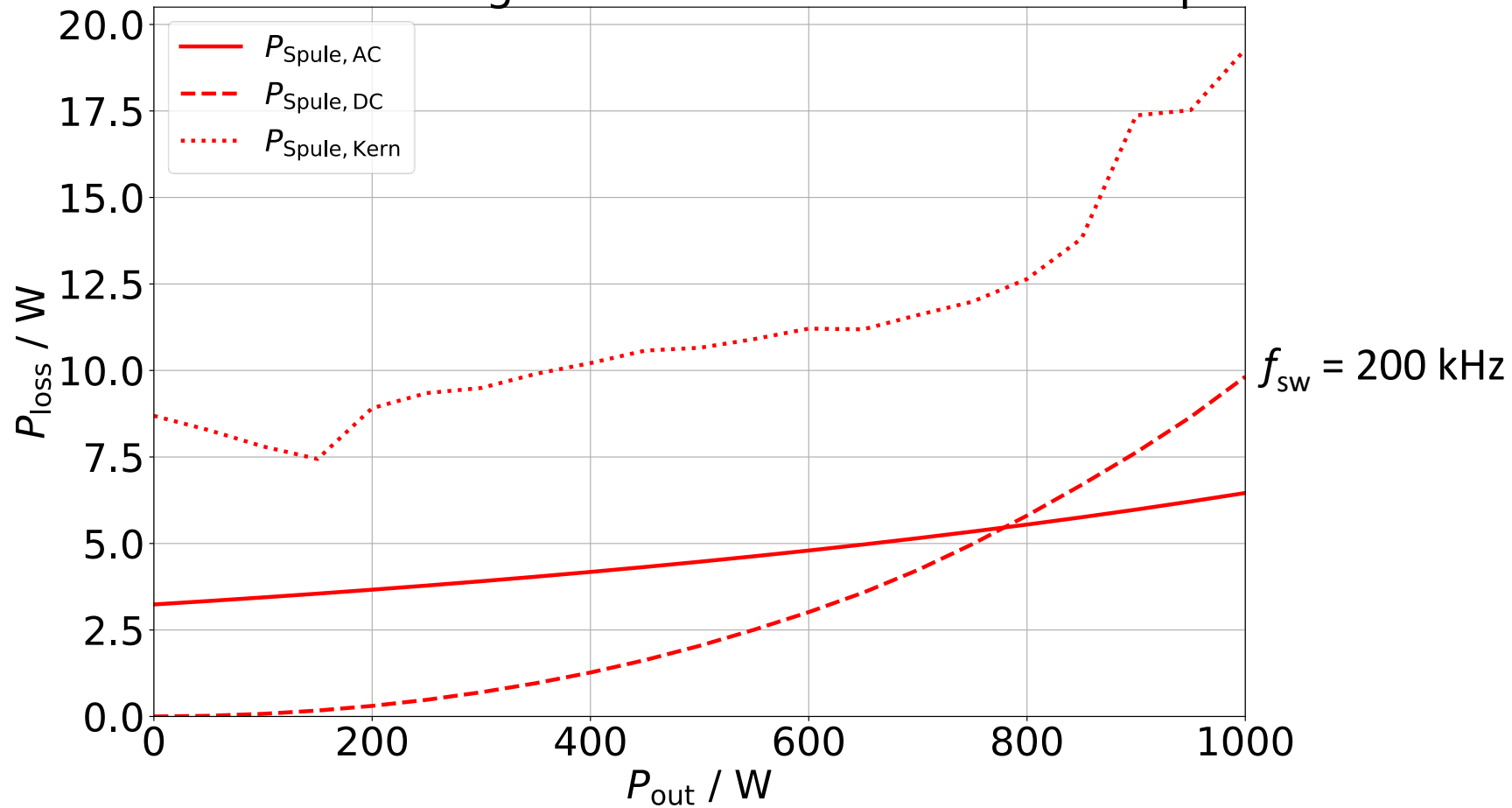
## Eigenschaften

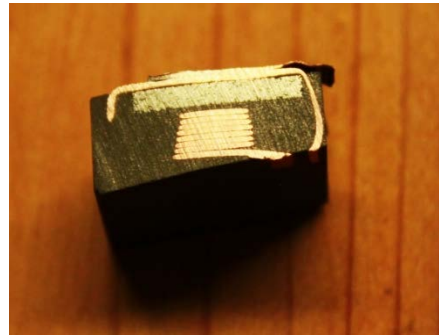
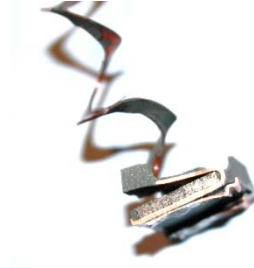
- Ausgangsleistung: 1 kW
- Leistungsdichte:  $2,1 \frac{\text{kW}}{\text{dm}^3}$
- Maximaler Wirkungsgrad: 94,3 %
- Wirkungsgrad bei Vollast: 92,2 %

- **Effizienz erhöhen**
- **Volumen reduzieren**

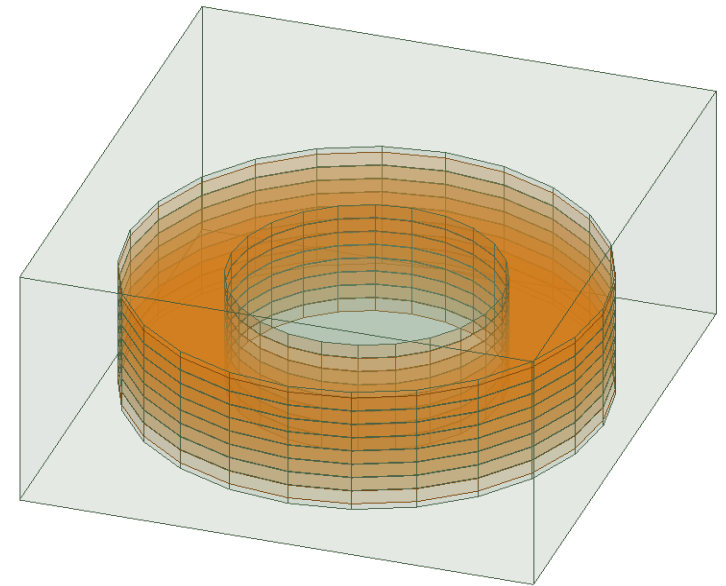


## Verlustaufteilung des Wandlers mit Coilcraft-Spule

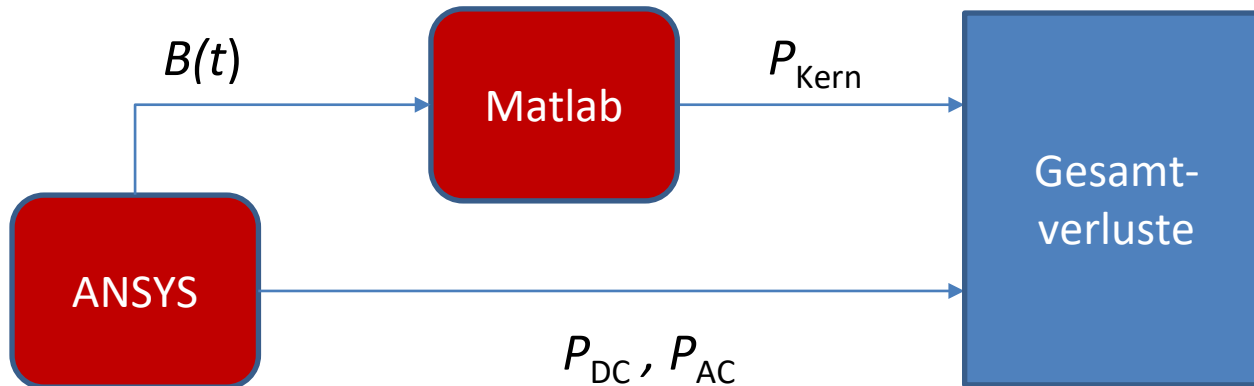




Simulationsmodell

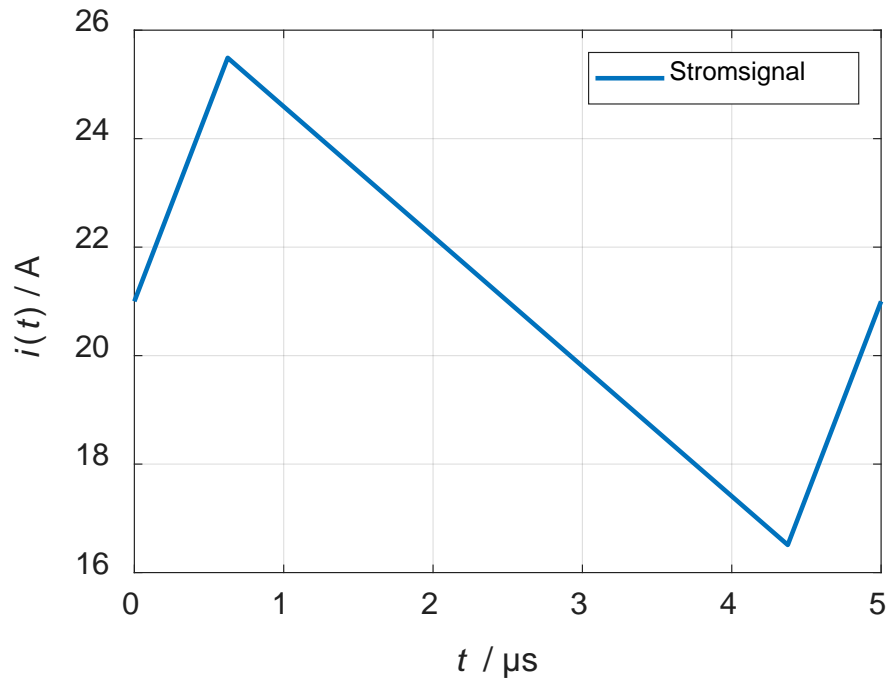




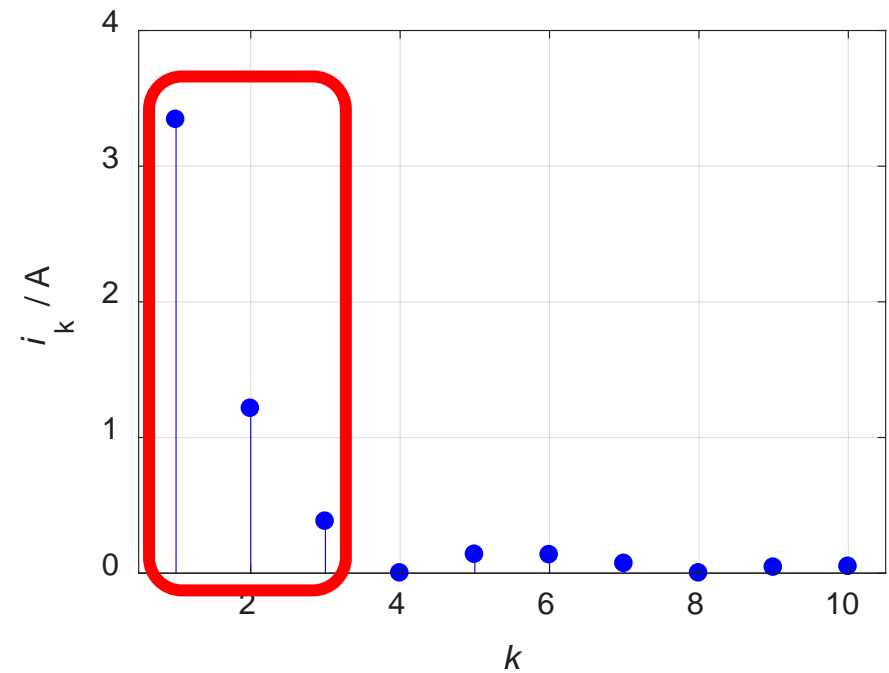


- $P_{\text{tot}} = P_{\text{Kern}} + P_{\text{DC}} + \underbrace{\sum_{i=1}^3 P_{\text{H},i}}_{P_{\text{AC}}}$
- 4 Simulationen approximieren den Stromverlauf
  - 1 DC Simulation
  - 3 AC Simulationen

## Zeitbereich

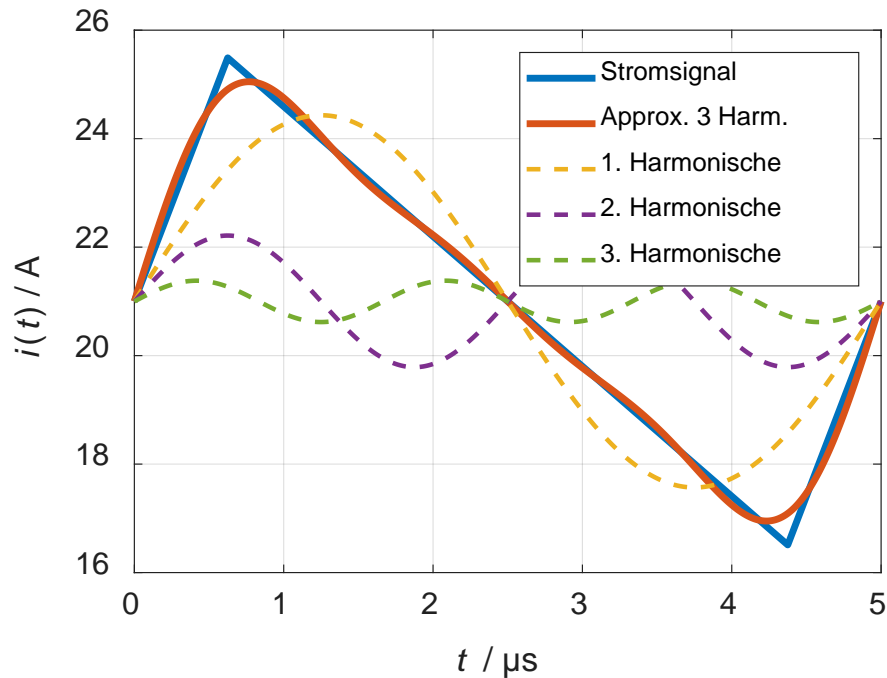


## Frequenzbereich

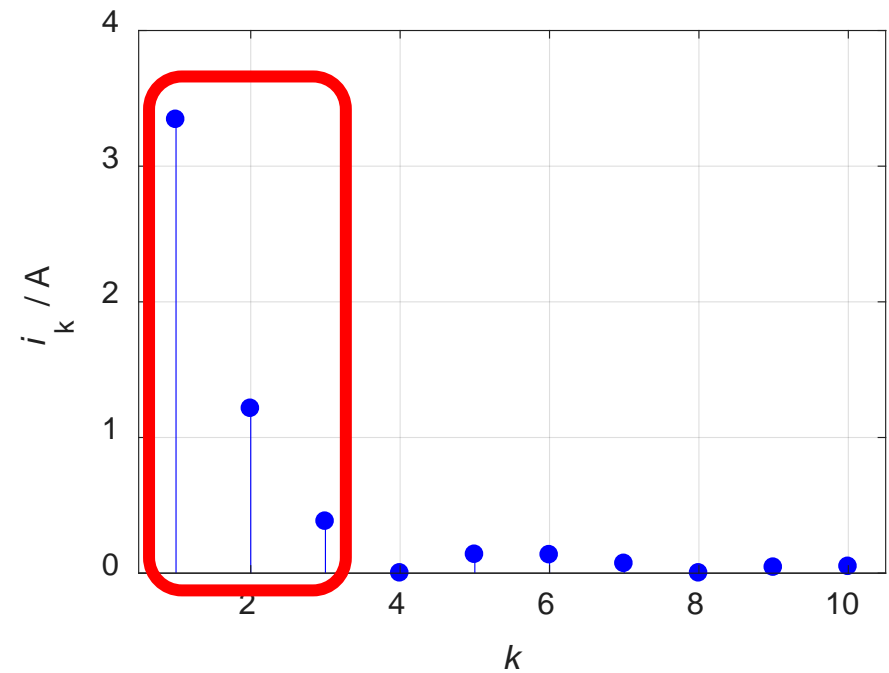


$$I_{\text{DC}} = 21 \text{ A}$$

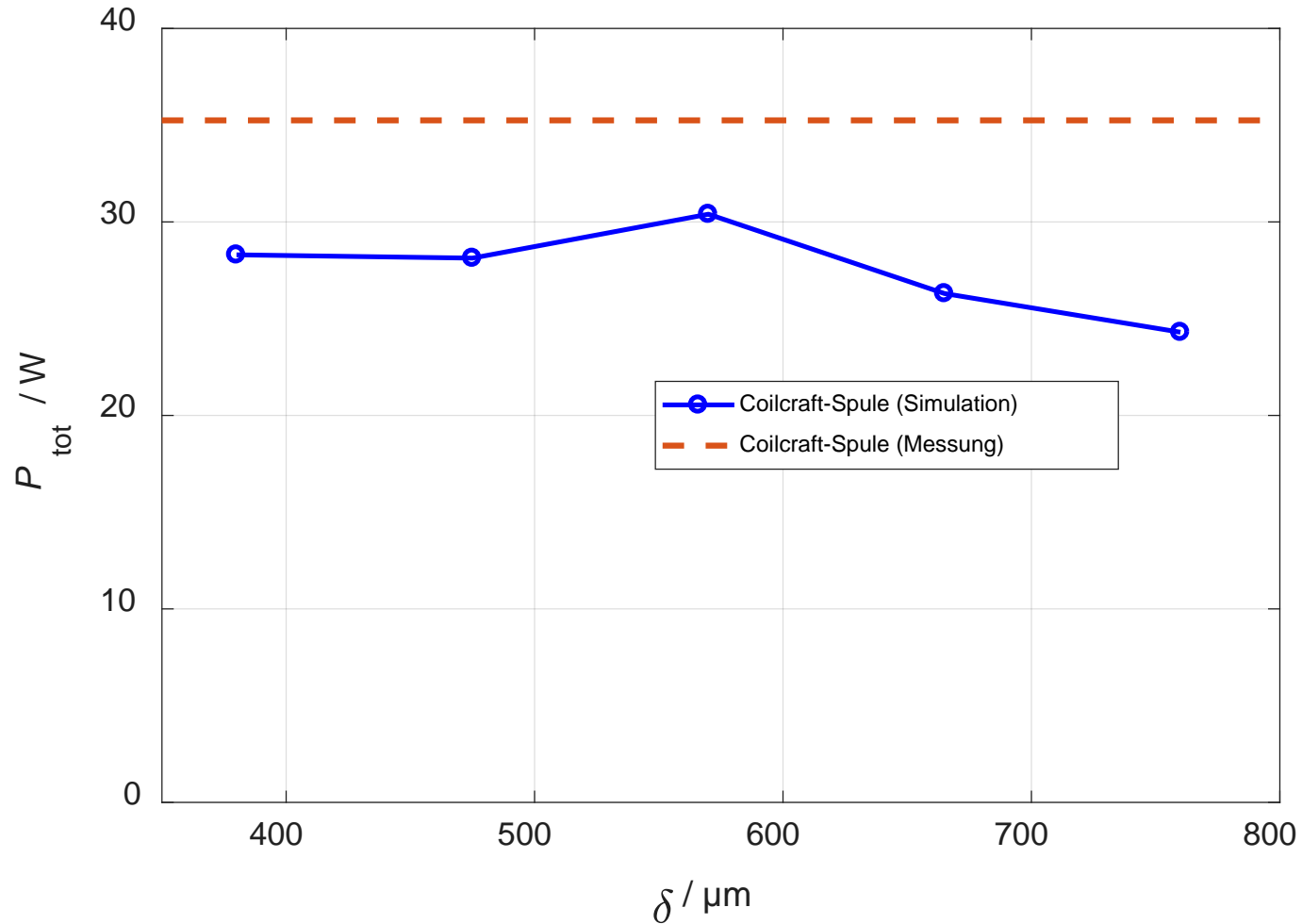
## Zeitbereich



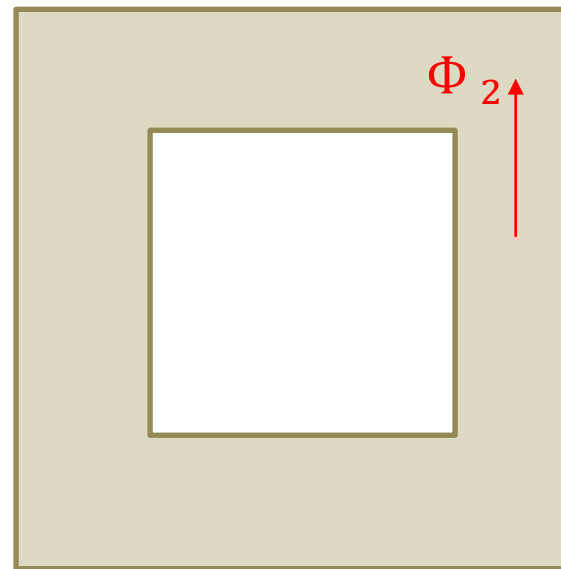
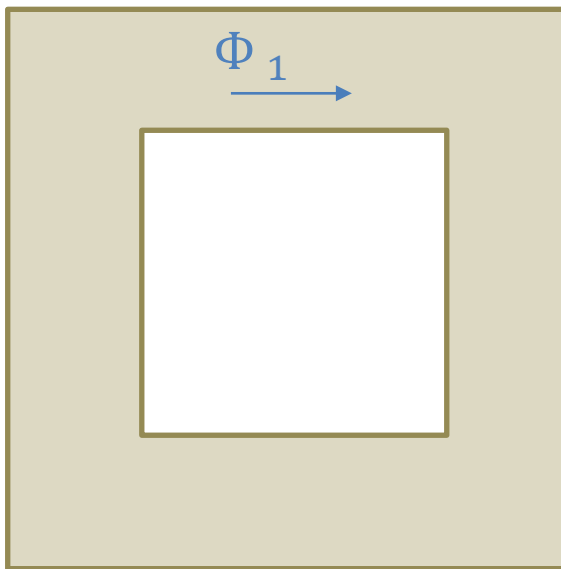
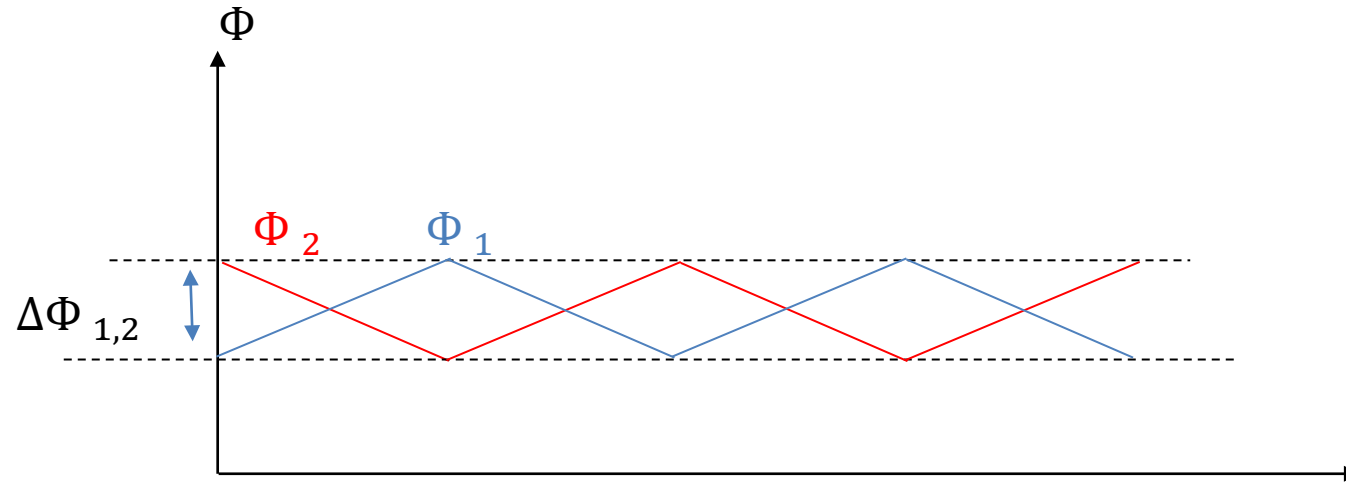
## Frequenzbereich

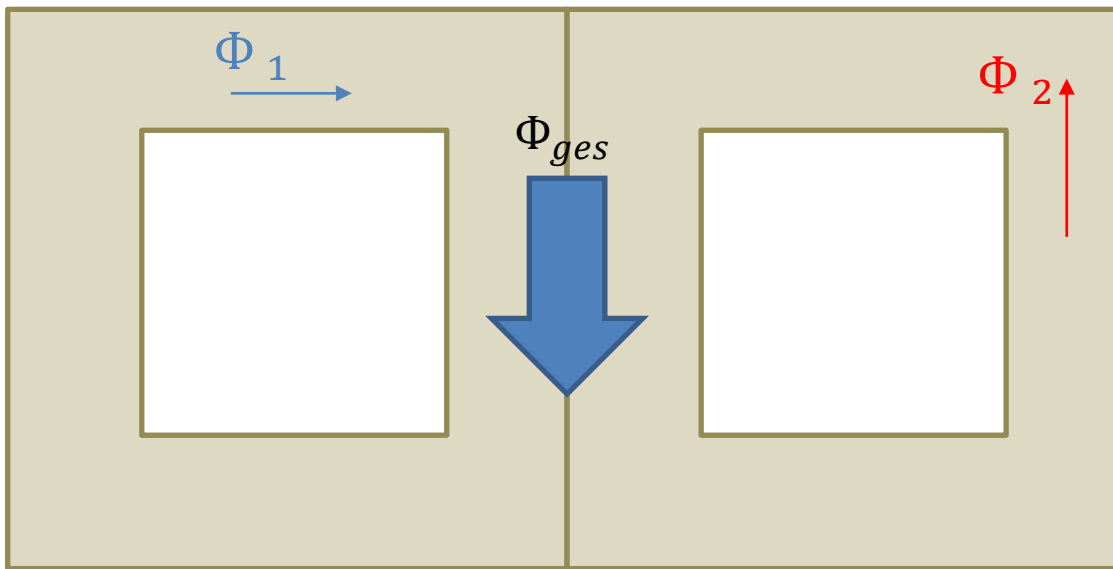
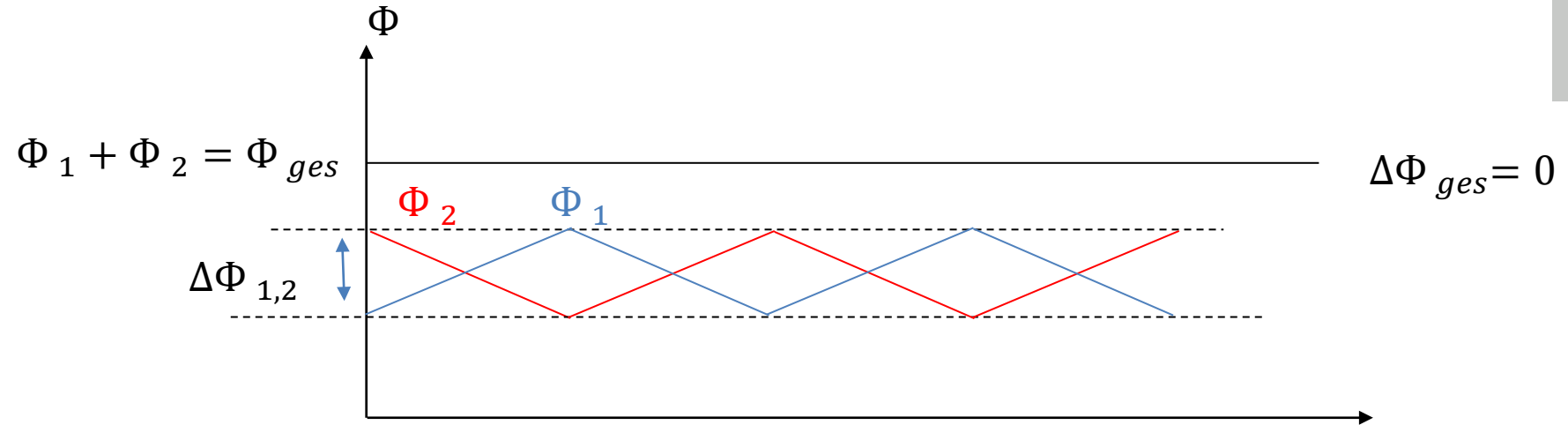


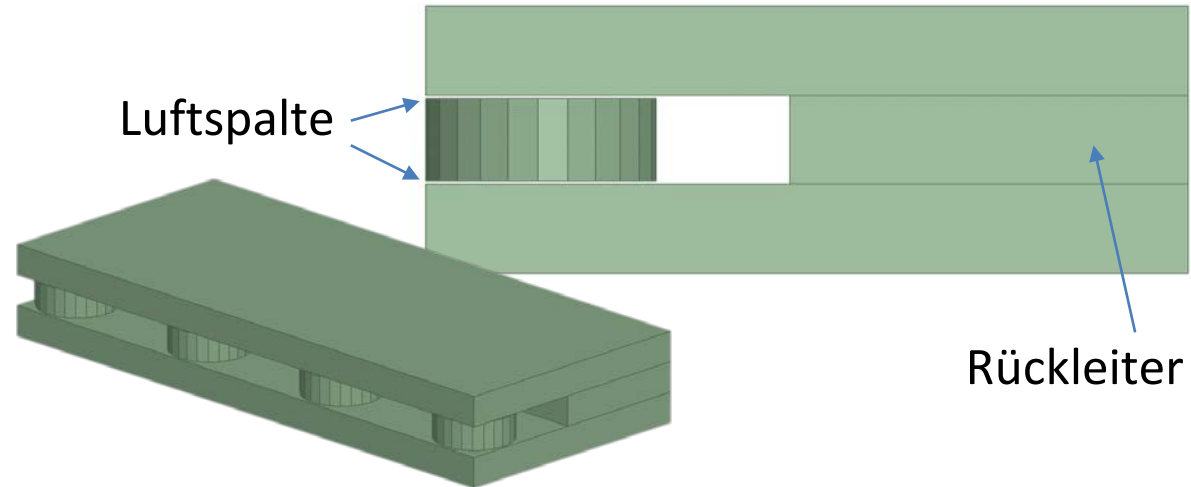
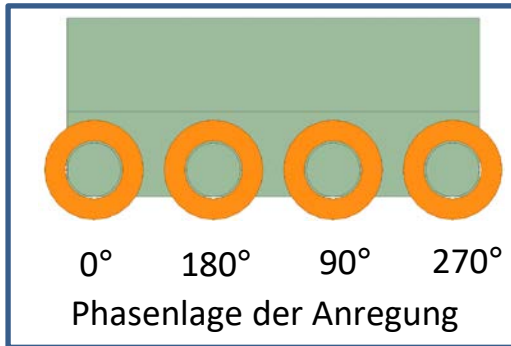
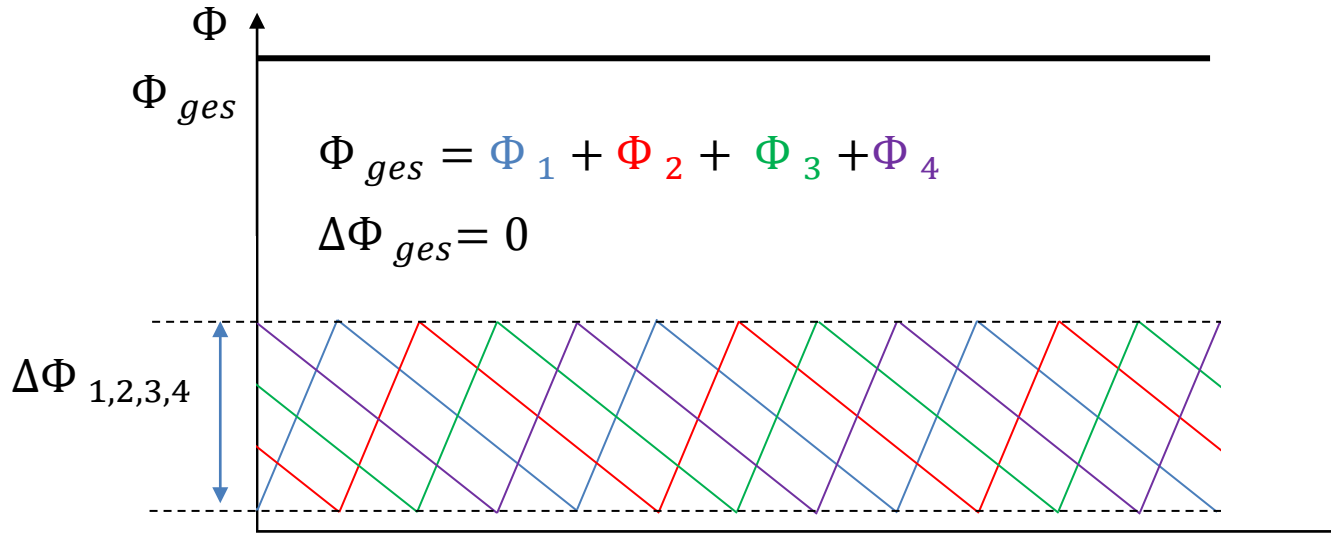
$$I_{\text{DC}} = 21 \text{ A}$$



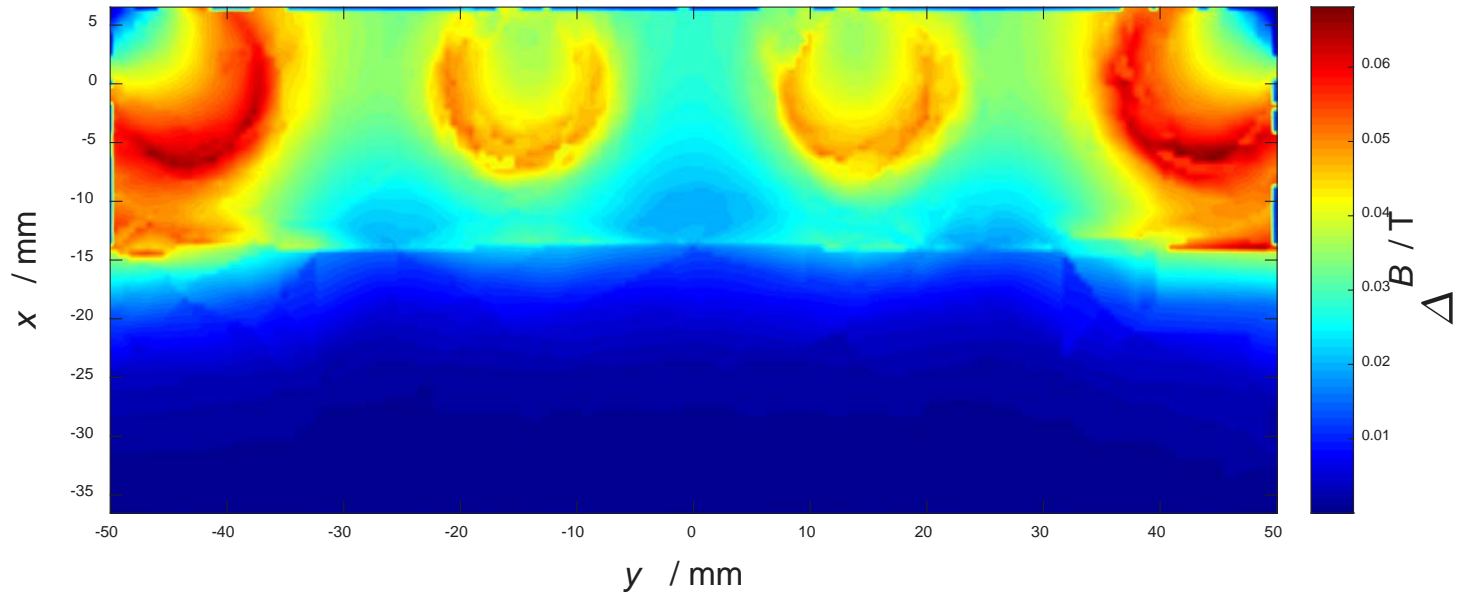
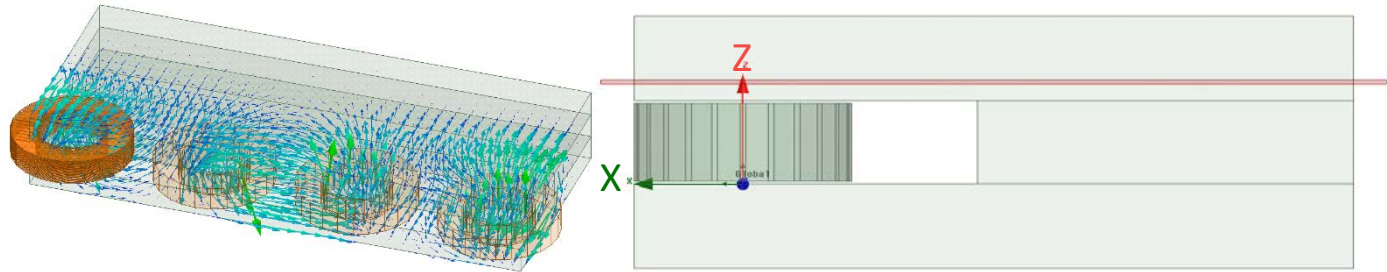
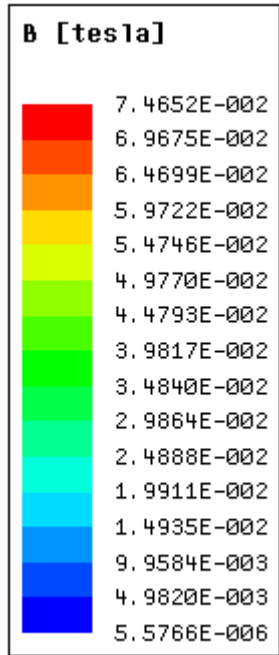
- ▶ Motivation / Einführung
- ▶ gekoppelte Magnetik
- ▶ Hardwareintegration

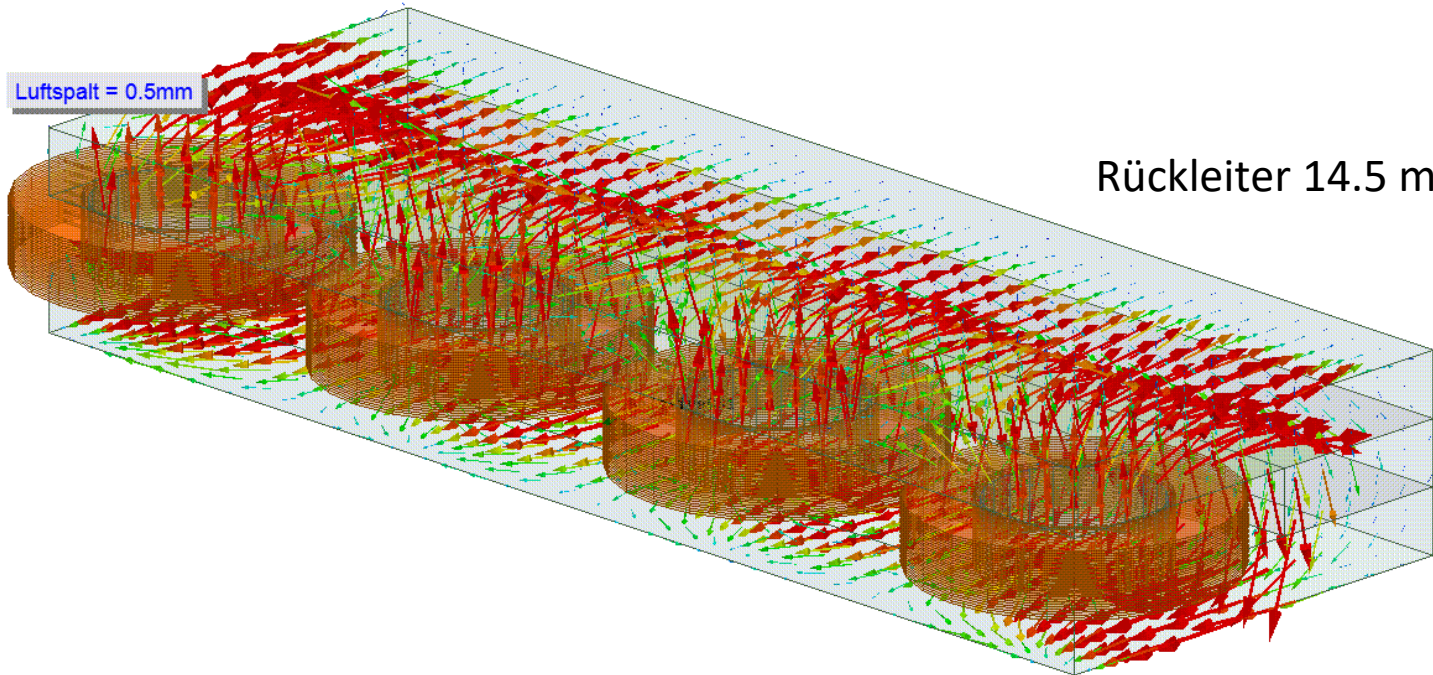
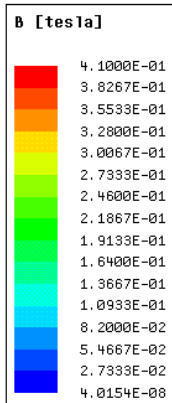




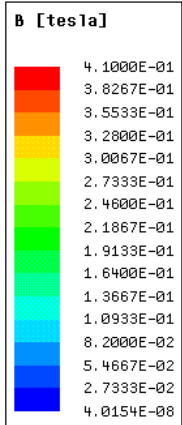




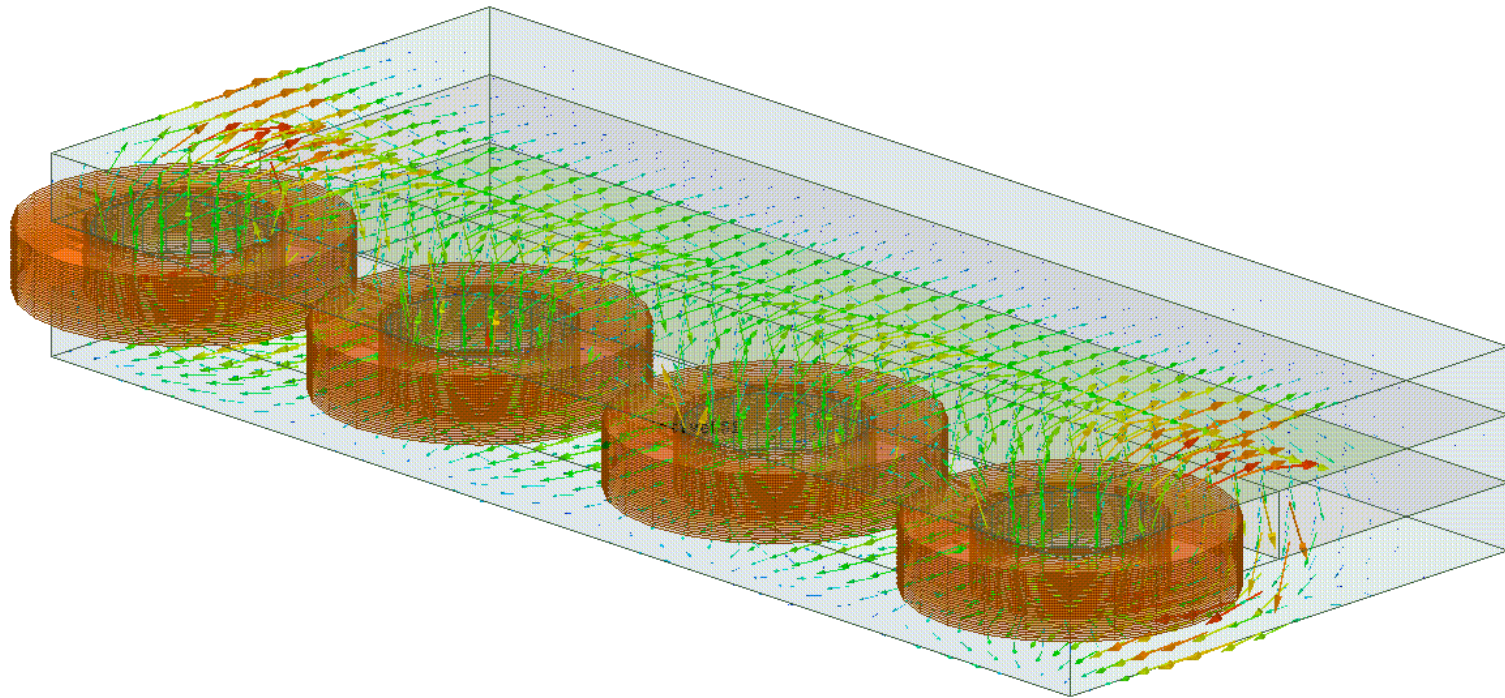




Rückleiter 14.5 mm



Luftspalt 900  $\mu\text{m}$

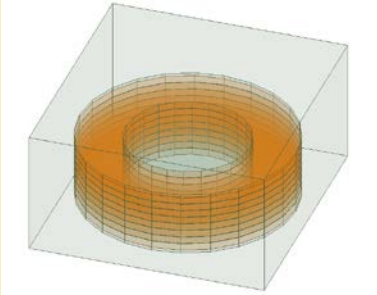


Parameter	Werte
Gleichstrom	21 A
Kupferdicke	0,4 mm 0,3 mm (Litz)
Luftspalt	380 $\mu$ m bis 760 $\mu$ m
Luftspaltposition	Gleichmäßig verteilt / nur oberhalb / nur unterhalb des Kerns
Ferrite Material	N95
Kerndurchmesser	12 mm
Windungszahl	4 bis 8

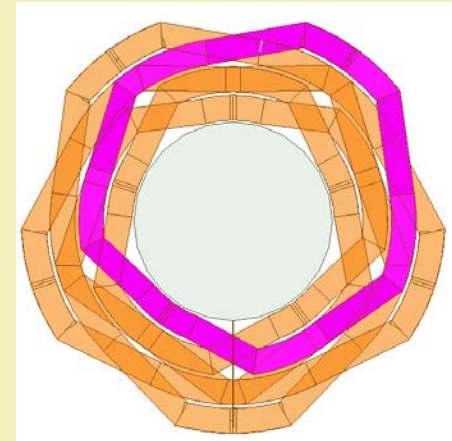
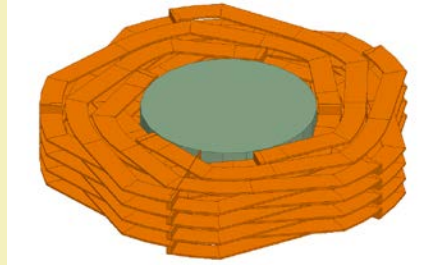
**Vorgabeparameter**

**Variabler Parameter**

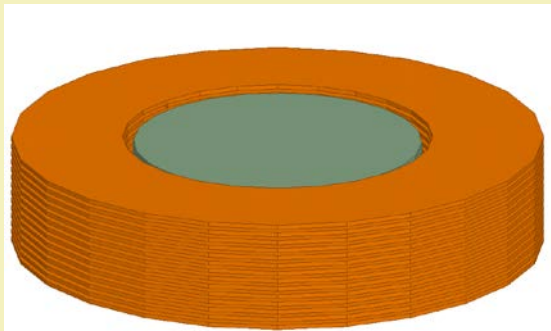
## Coilcraft-Spule



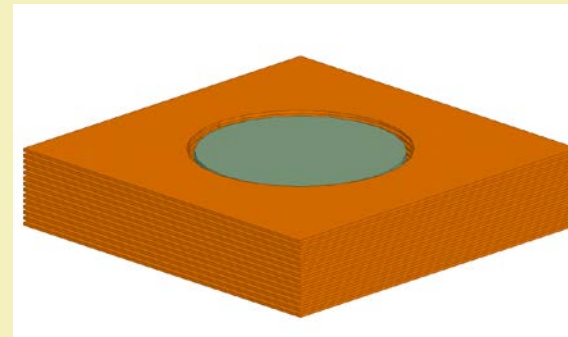
## Litz-Wicklung

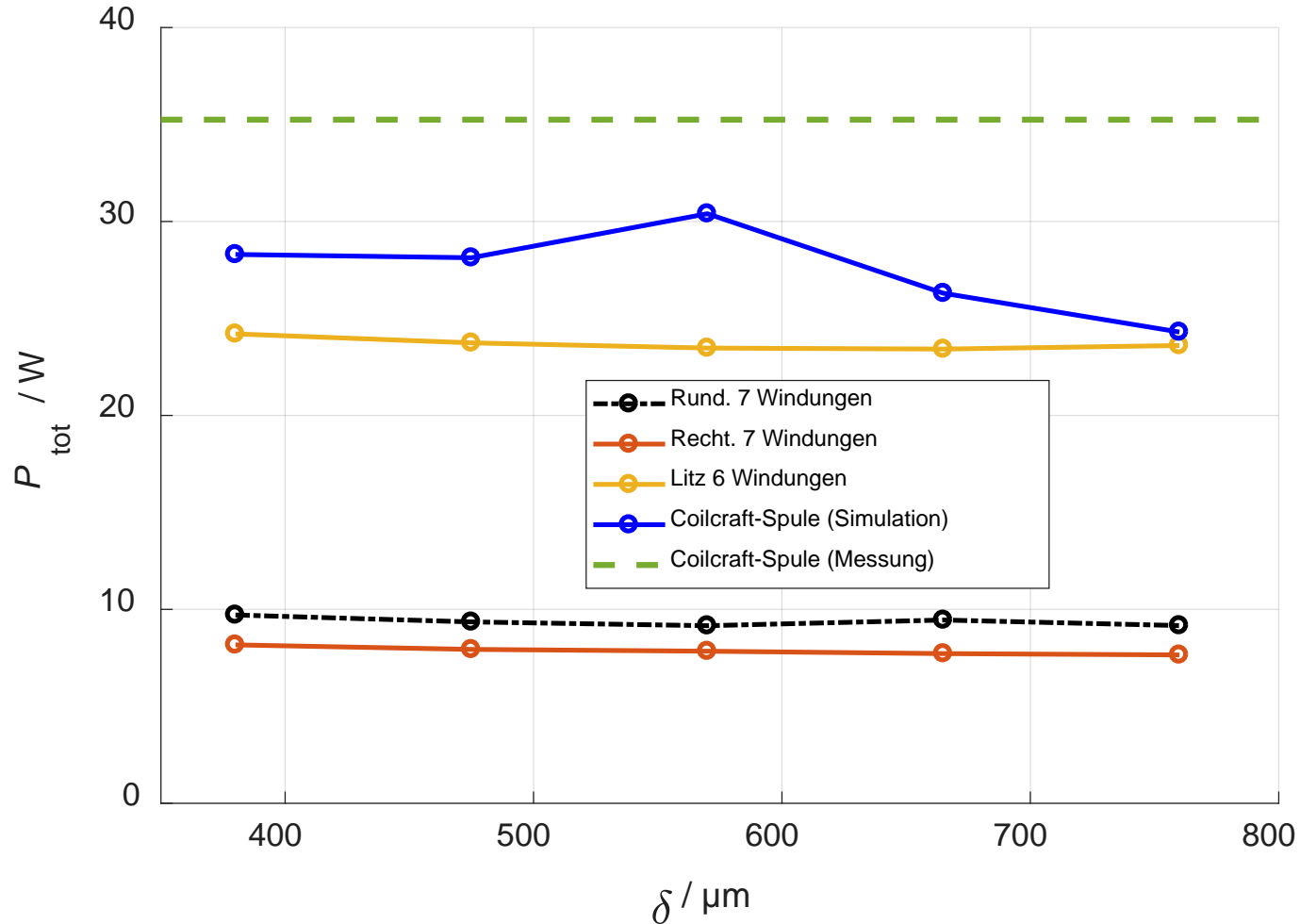


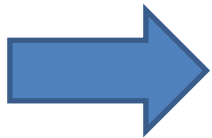
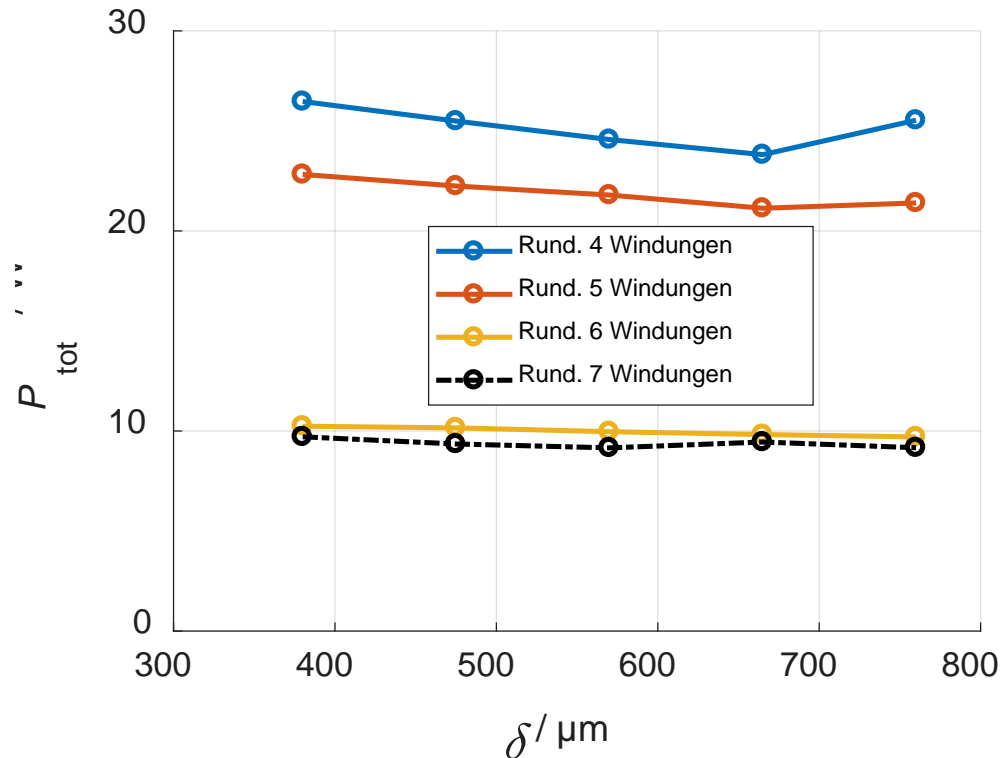
## Runde Wicklungsform



## Rechteckige Wicklungsform







Ergebnis: Runder Windungstyp mit 7 Windungen

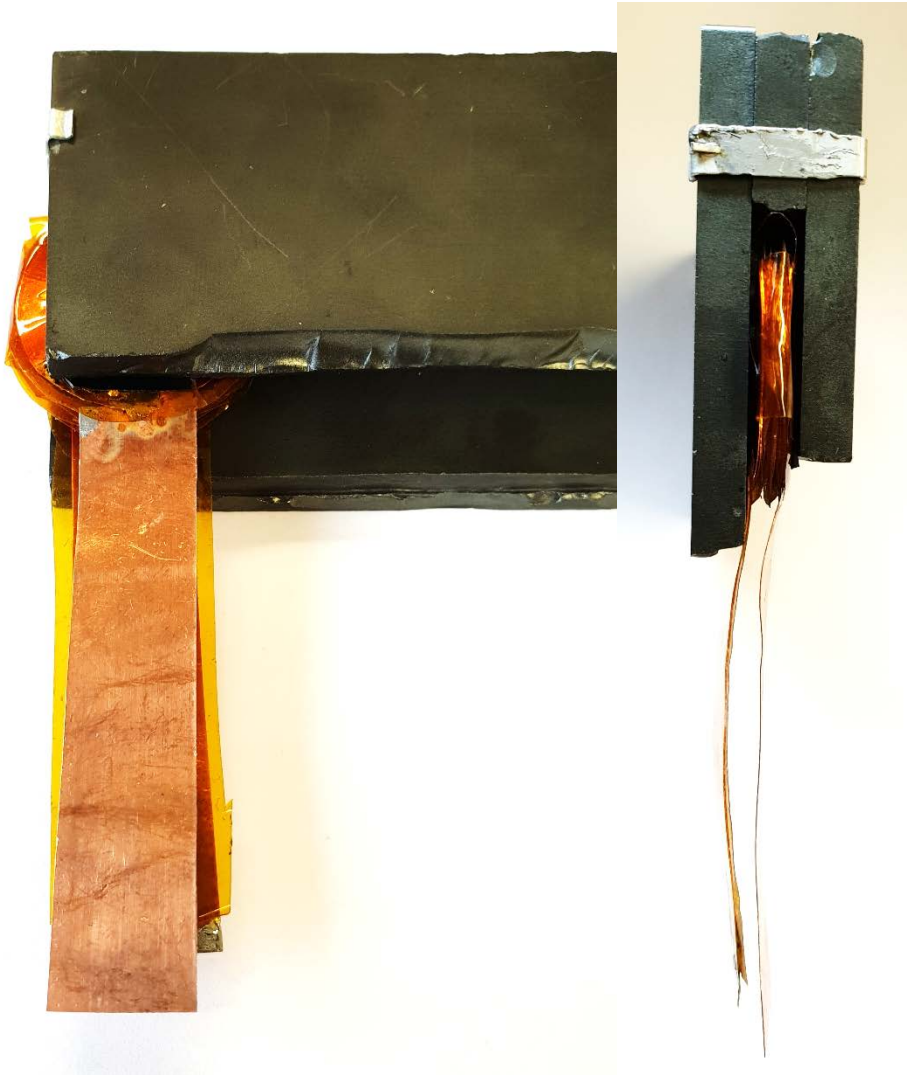
- ▶ Motivation / Einführung
- ▶ gekoppelte Magnetik
- ▶ **Hardwareintegration**



Ferrite Material	N95
Kerndurchmesser	12 mm
Windungsdurchmesser (Innen/Außen)	14 mm / 28mm
Kupferstärke der Windungen	400 $\mu\text{m}$ (2*200 $\mu\text{m}$ )
Windungen	7
Luftspalt	500 $\mu\text{m}$



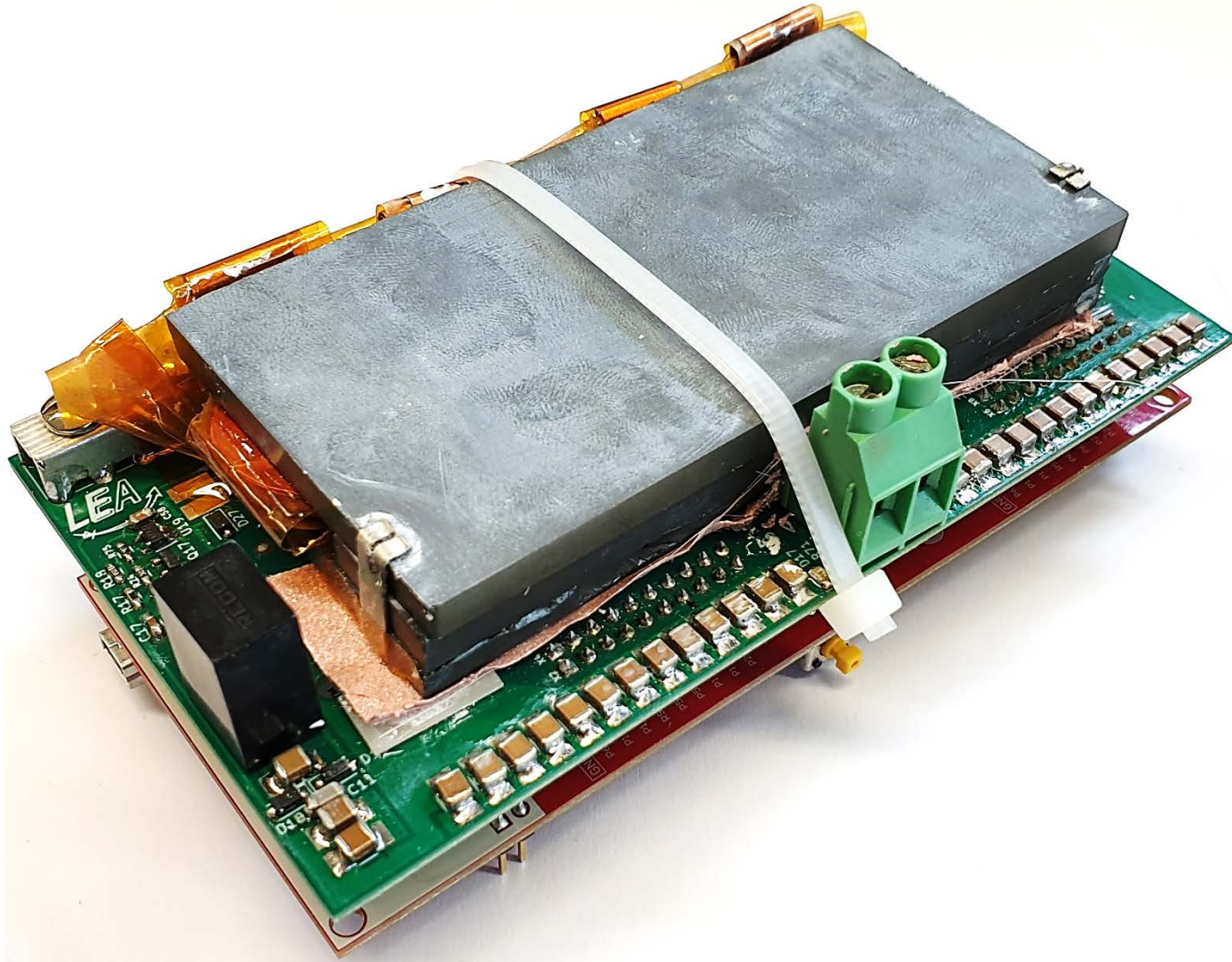
► Isolation zwischen Windungen mit Kaptonfolie



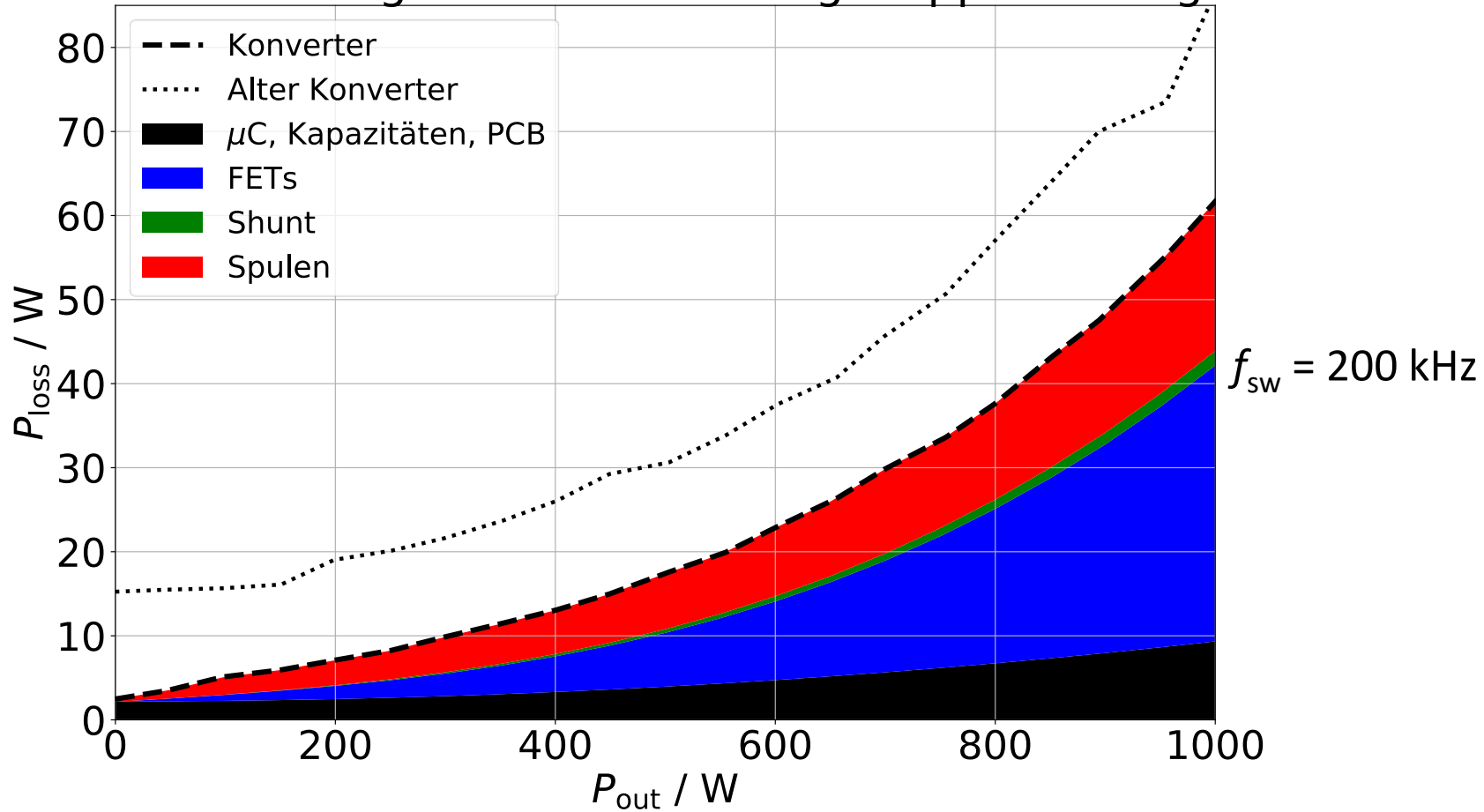
	Coilcraft-Spule	Gekoppelte Magnetik
$P_{DC}$	10,5 W	2,5 W
$P_{AC}$	6,5 W	1,5 W
$P_{Kern}$	19 W	15 W
$P_{tot}$	<b>36 W</b>	<b>19 W</b>

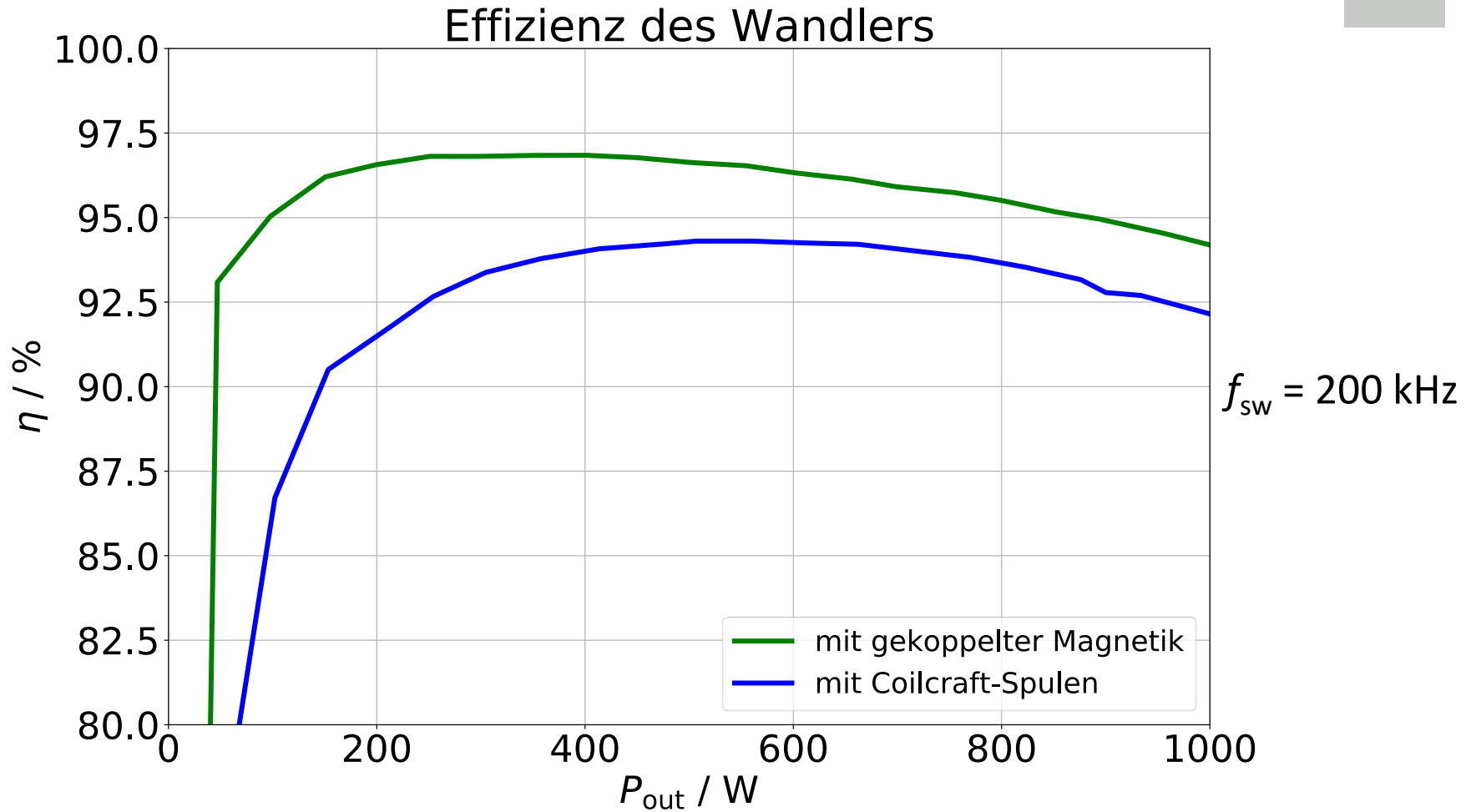
Werte für vier Spulen @  $P_{out} = 1 \text{ kW}$

► Reduktion um 17 W (ca. 47 %)

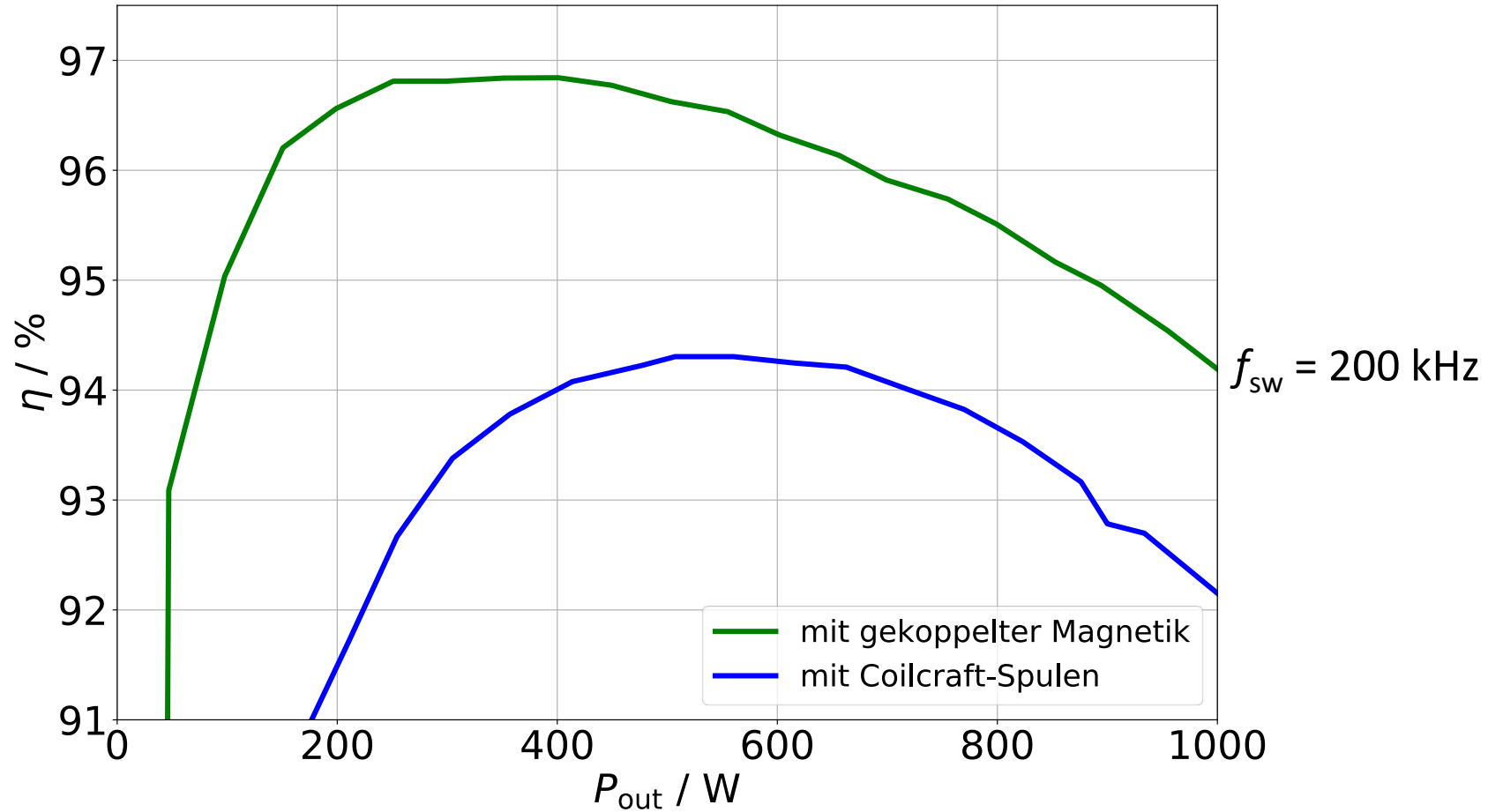


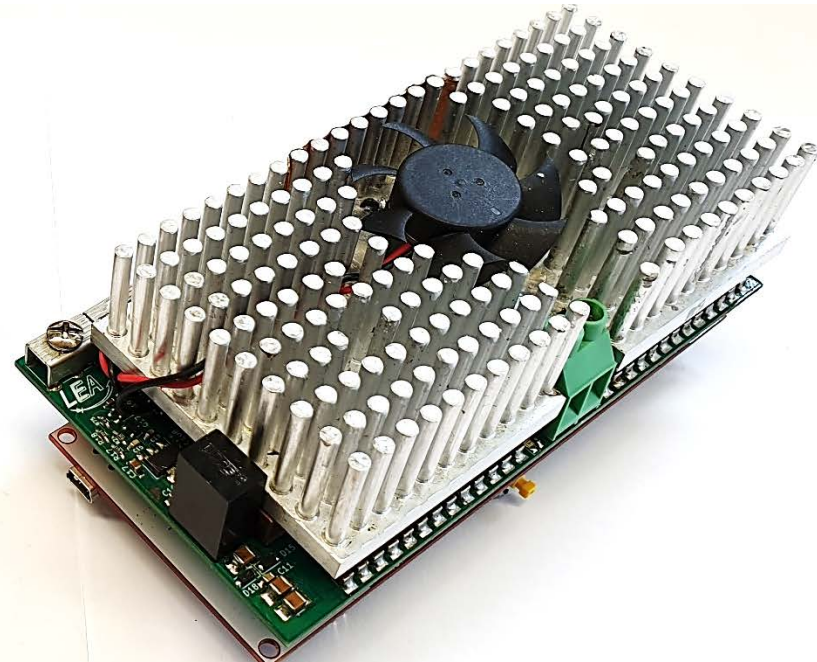
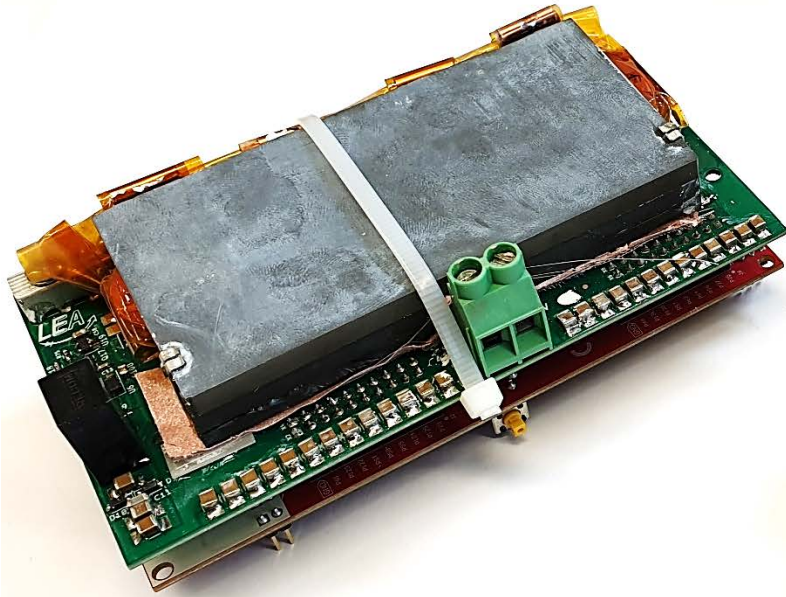
## Verlustaufteilung des Wandler mit gekoppelter Magnetik



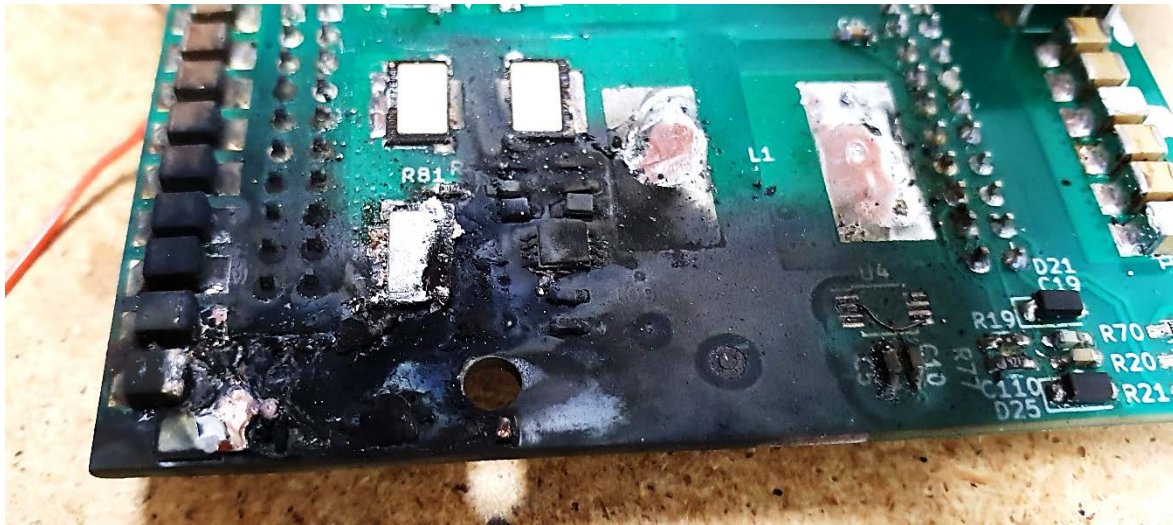
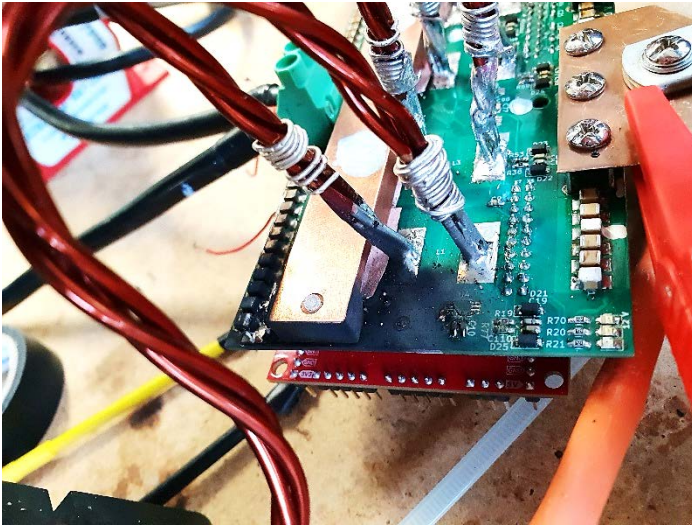


## Effizienz des Wandlers





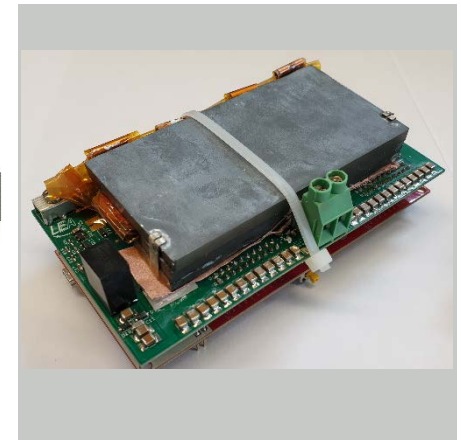
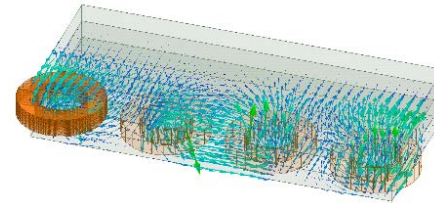
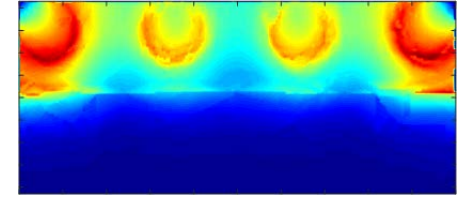
	Coilcraft-Spule	Gekoppelte Magnetik	Veränderung
$\eta_{\max}$	94,3 %	96,8 %	+2,5 %
$\eta_{1 \text{ kW}}$	92,2 %	94,2 %	+2 %
$P_{\text{loss, 1 kW}}$	85 W	62 W	-23 W







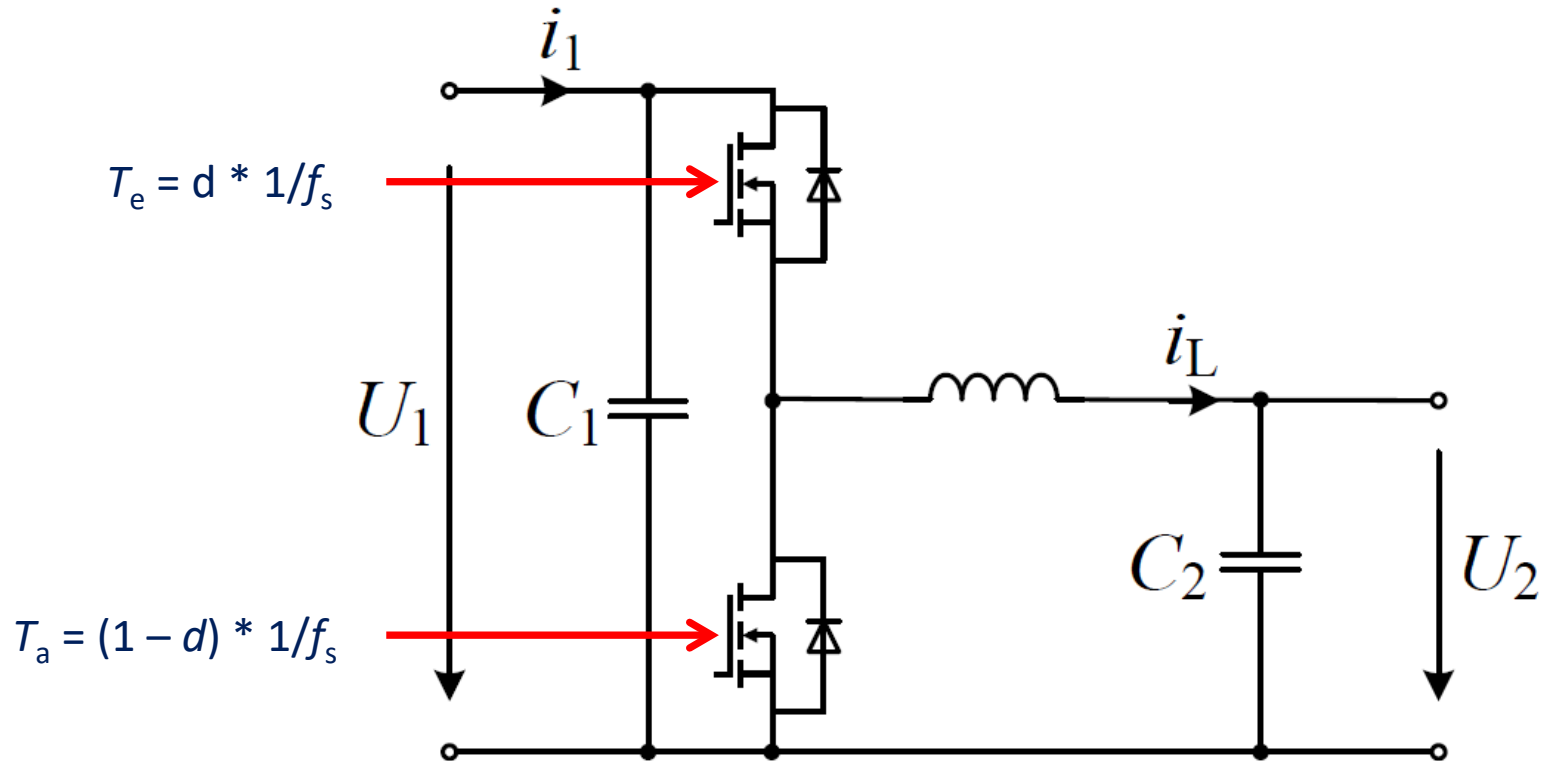
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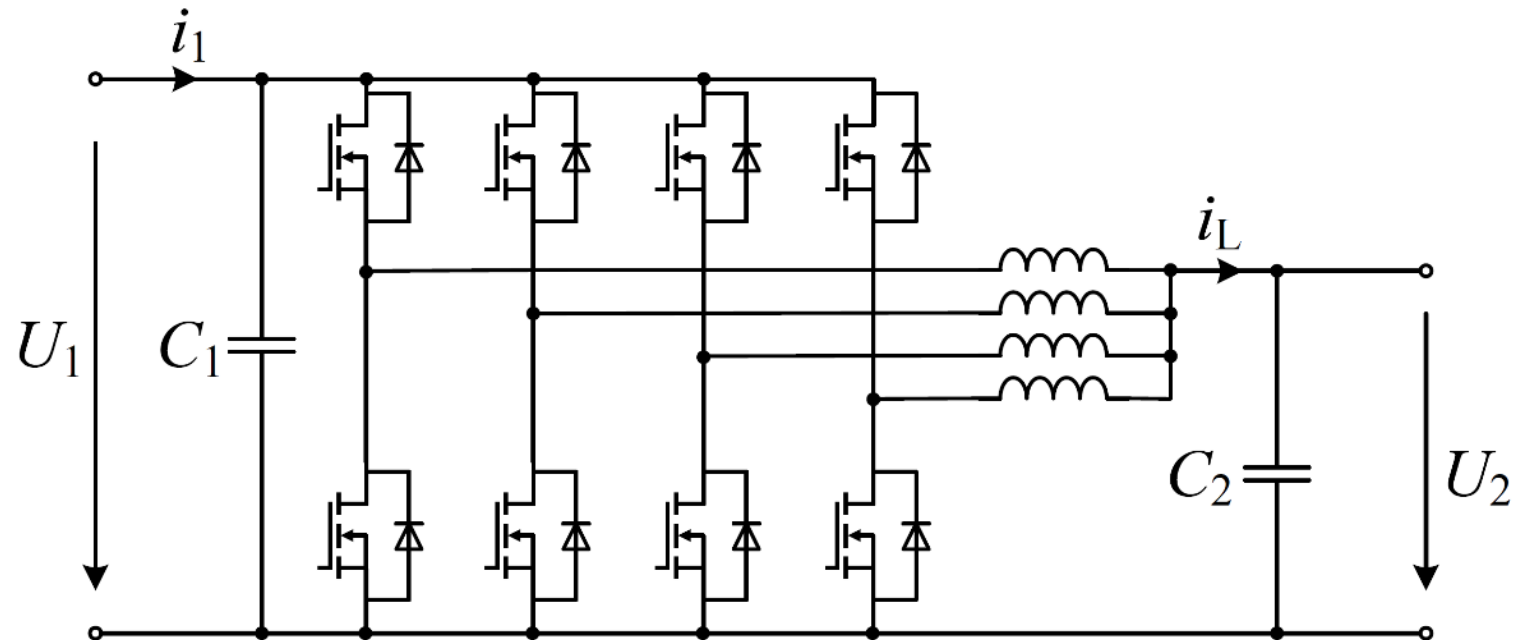
**Danke für Ihre Aufmerksamkeit!**

## Tiefsetzsteller

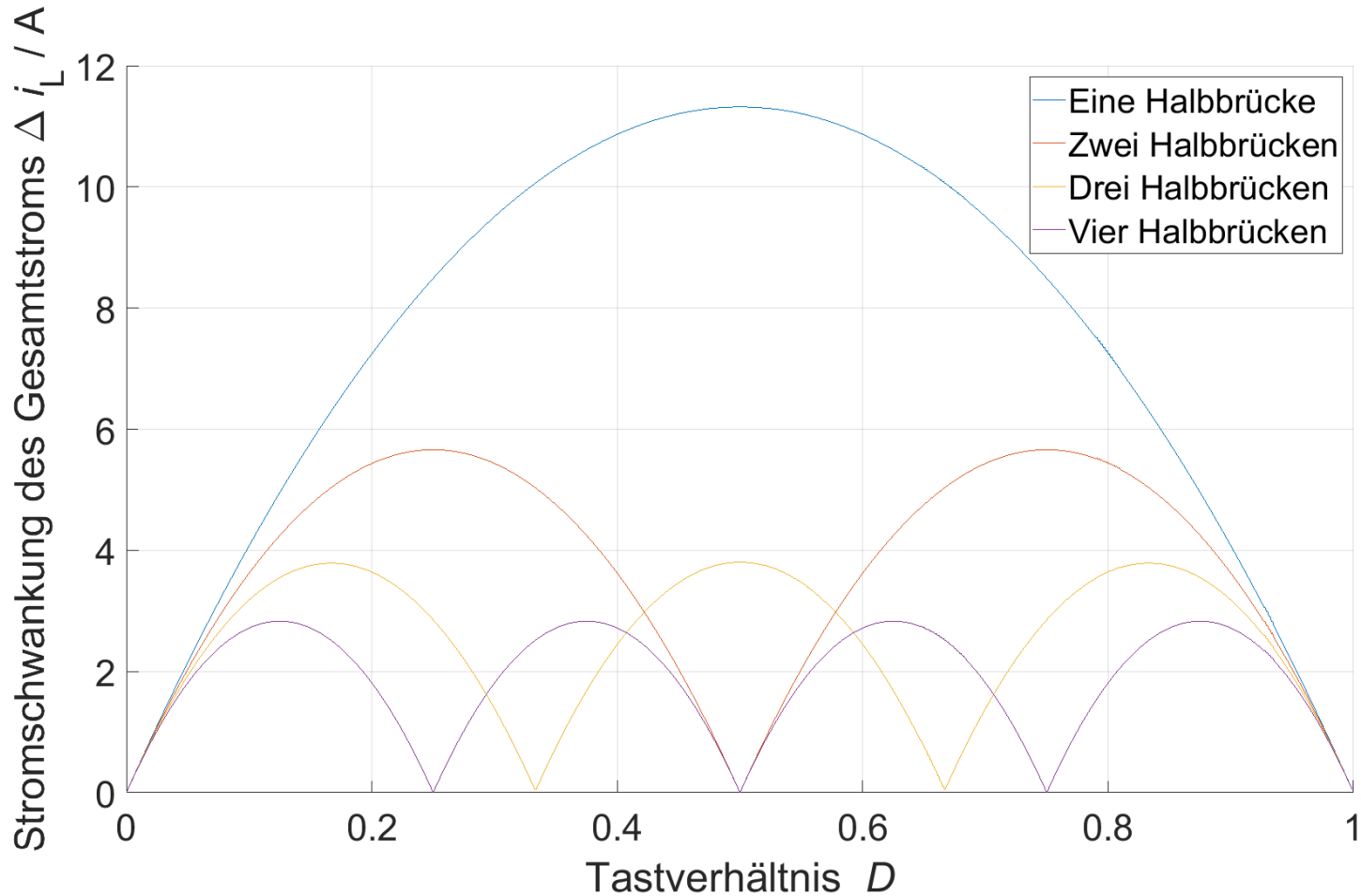


$$d = \frac{U_2}{U_1} = \frac{48 \text{ V}}{12 \text{ V}} = 0,25$$

## Schaltungstopologie

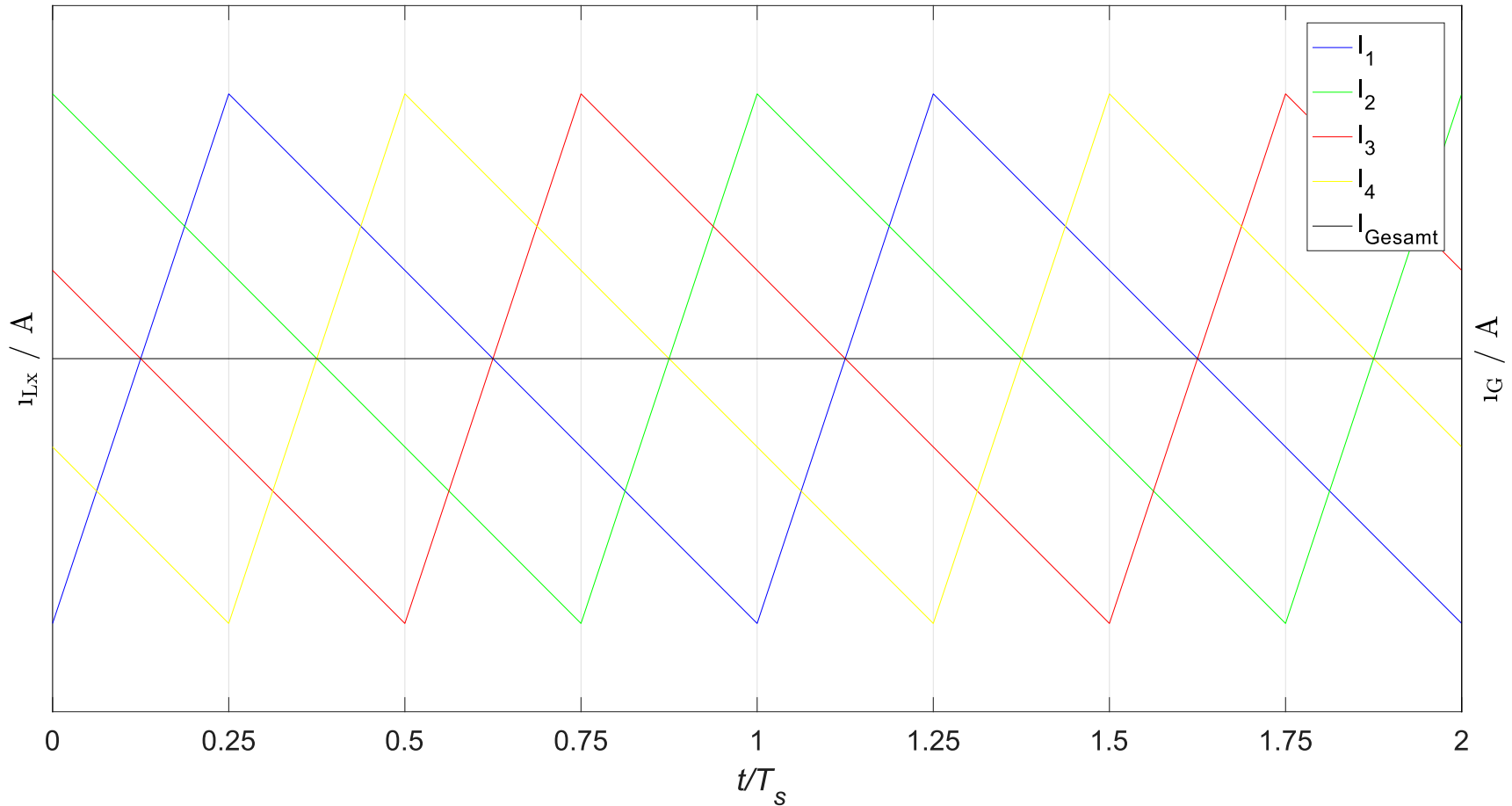


## Stromrippel

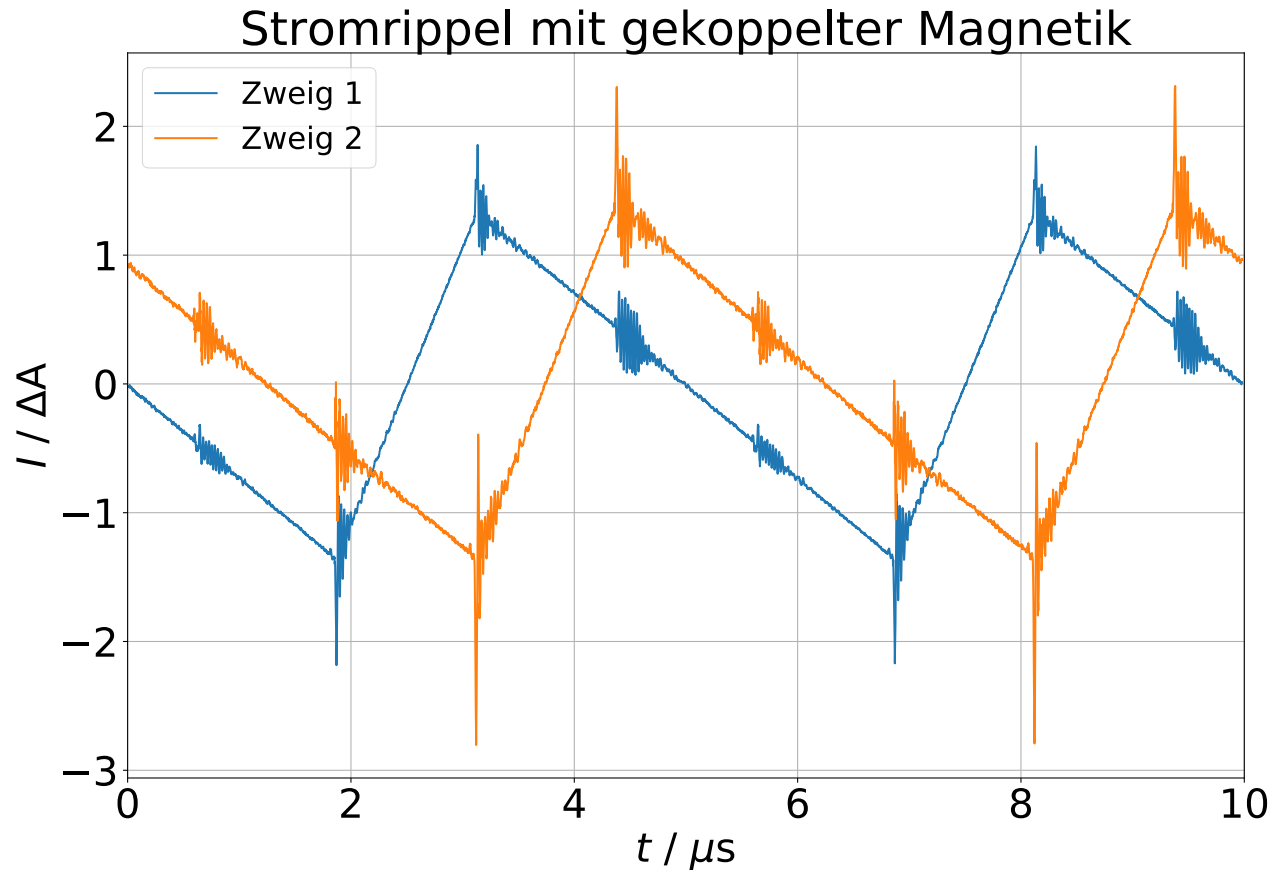


## Stromrippel

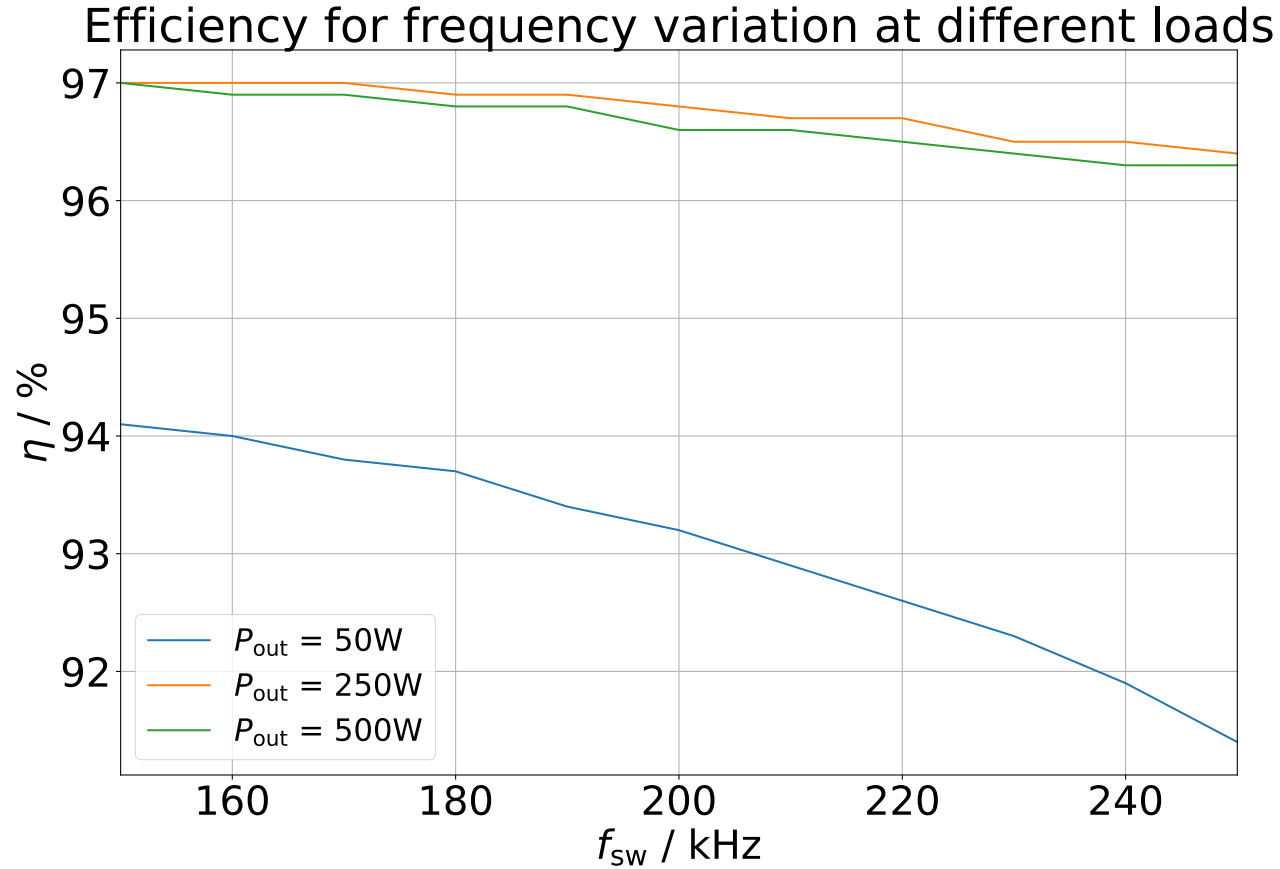
Ströme bei vier Zweigen (90° Phasenversetzt)



## Stromrippel



## Effizienz bei verschiedenen Frequenzen



## Effizienz bei verschiedenen Frequenzen

