SMD Ferrite Selektion

Sprecher:

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AGENDA

- **Filter Topologien mit SMD Ferriten**
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  - **Elektrische Parameter**
- **Stromversorgung**
  - **Klassifizierung**
  - **Elektrische Parameter**
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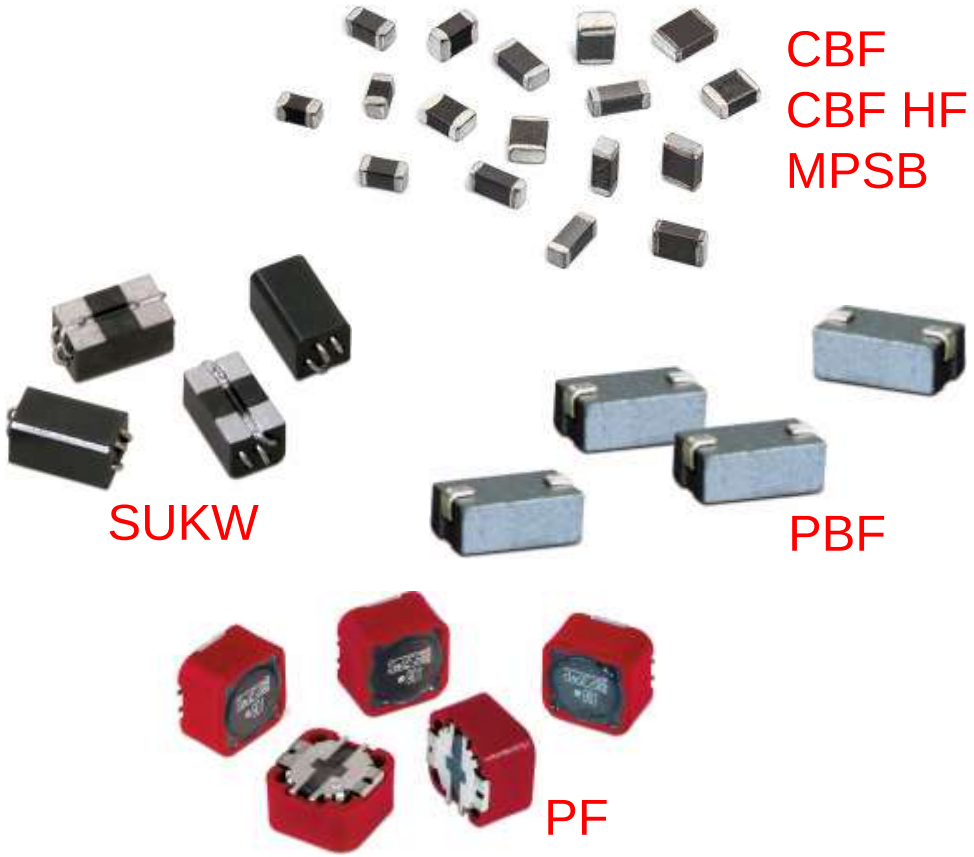
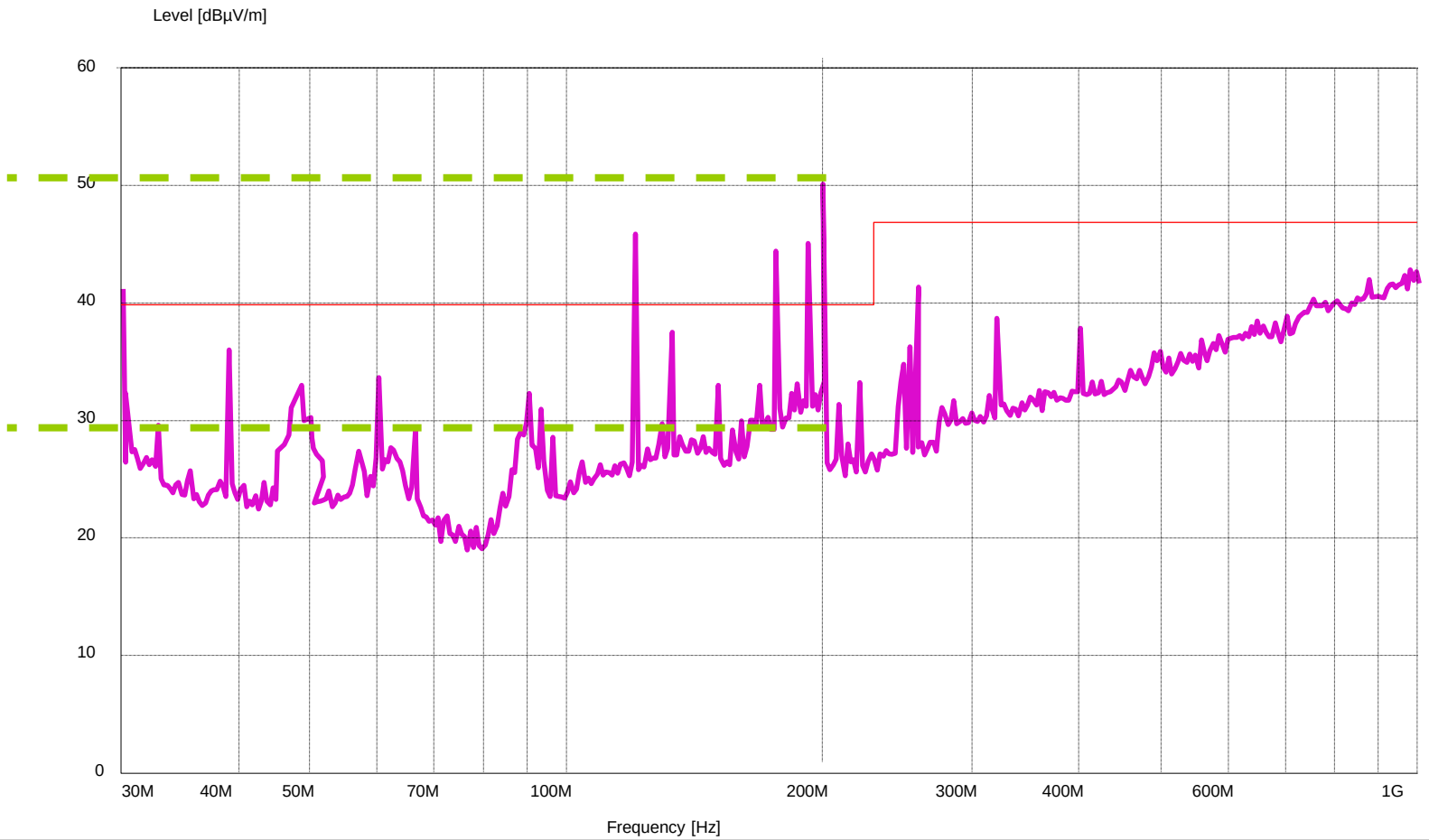
  - **Pulse Strombelastbarkeit**
- **Tools**
- **Layout Empfehlungen**



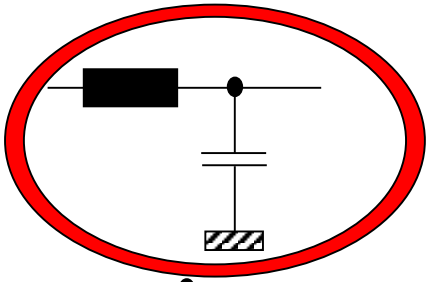
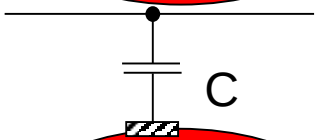
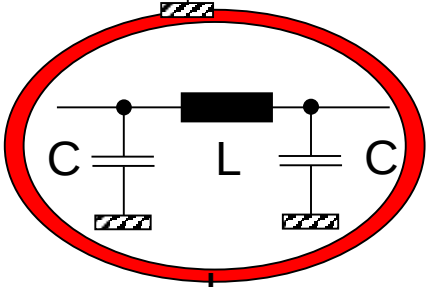
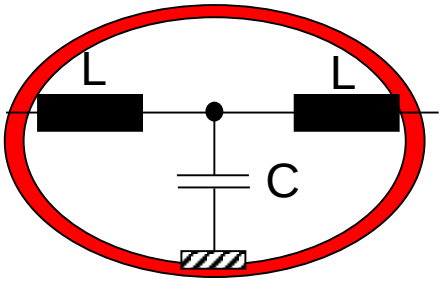
EMV Ergebnisse aus dem Labor

→ Gestrahlte Emission



FILTER TOPOLOGIE - IMPEDANZ

Filter Topologien

Quelle Impedanz		Senke Impedanz
niedrig		hoch
hoch		hoch
hoch oder unbekannt		hoch oder unbekannt
niedrig		niedrig
niedrig oder unbekannt		niedrig oder unbekannt

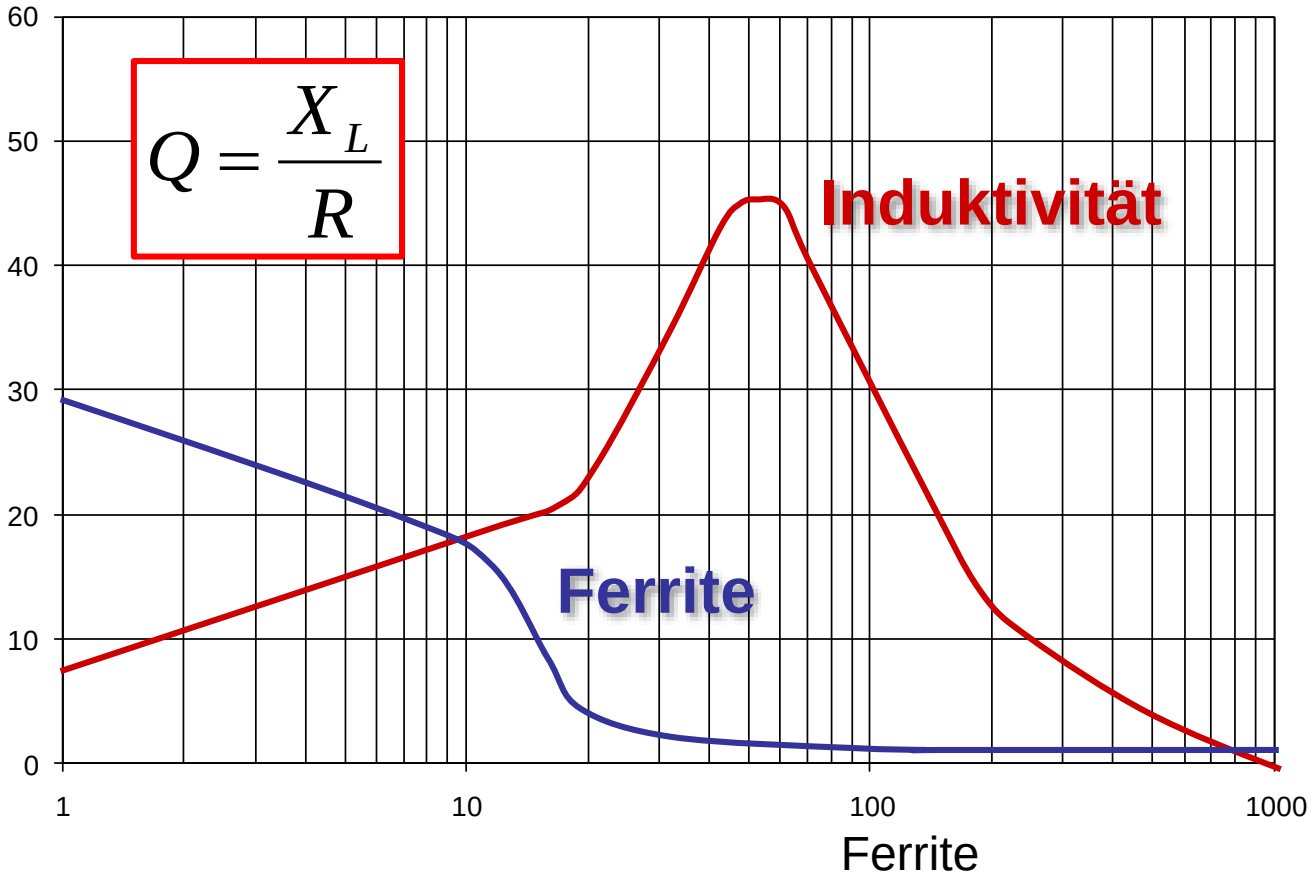
→ kleine C = höhere SRF

Wähle SMD Ferrite oder Induktivitäten L welche:
= keine Resonanz erzeugen mit dem C
= Breitbandig wirken

Beachte die:

SRF der Komponenten

Q Faktor -> Verluste



Applikation:

1. Speicher Induktivität

Anforderung: Niedrige Kern Verluste (HOHE Q)

2. Absorber / Filter

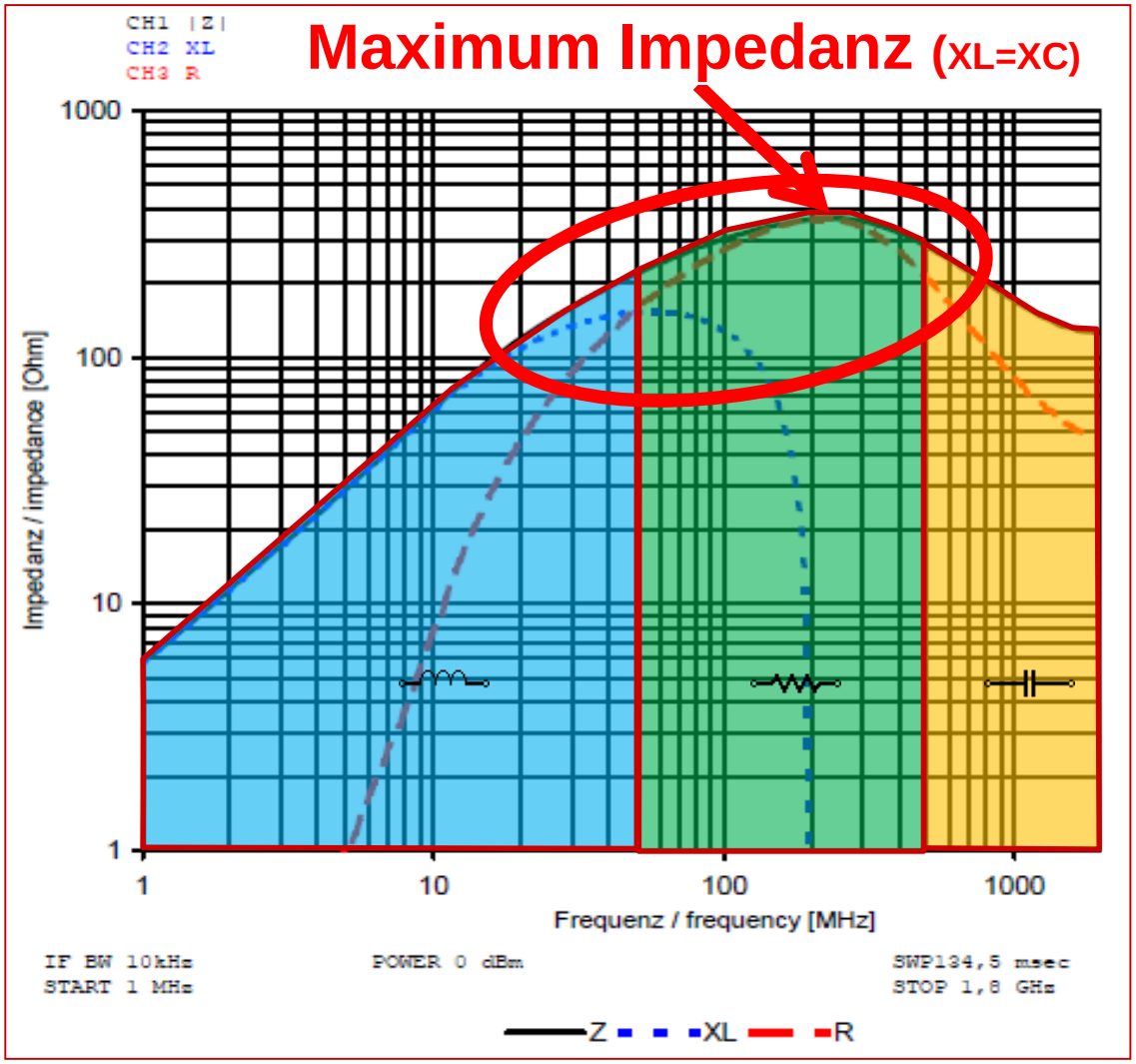
Anforderung: Hohe Kern Verluste (KLEINE Q)

Wandelt Störungsenergie in Wärme um:

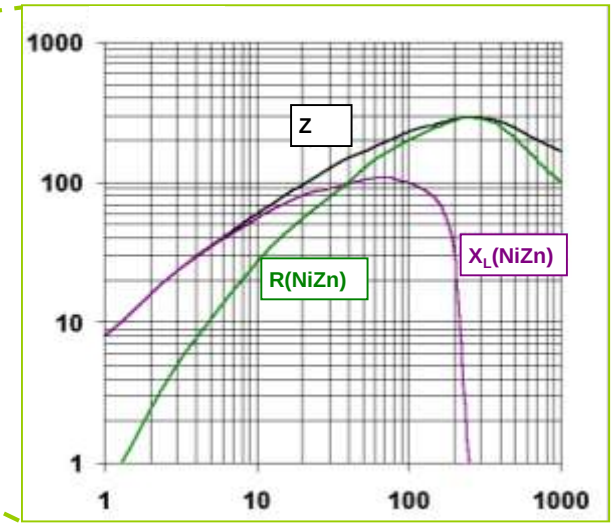
“Frequenz Abhängige Resistor”

Ferrit Impedanz

- **Resistive**
  - **Absorbiert Störenergie**
- **Induktive**
  - **Speichert Energie**
- **Kapazitive**
  - **Leitfähig für AC**



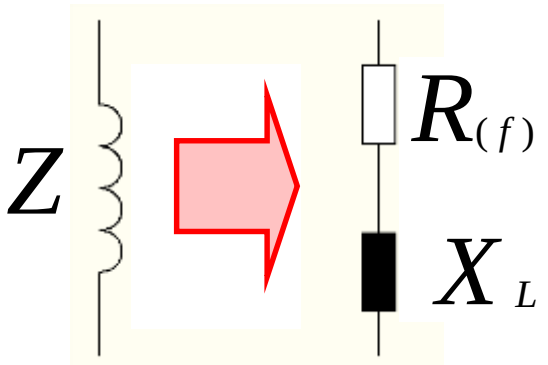
Ferrit Impedanz : Messung



Kernmaterial Parameter

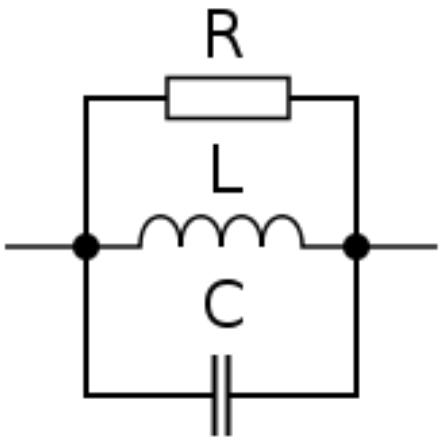
$$Z = \sqrt{R_{(f)}^2 + X_L^2}$$

Ersatzschaltbild

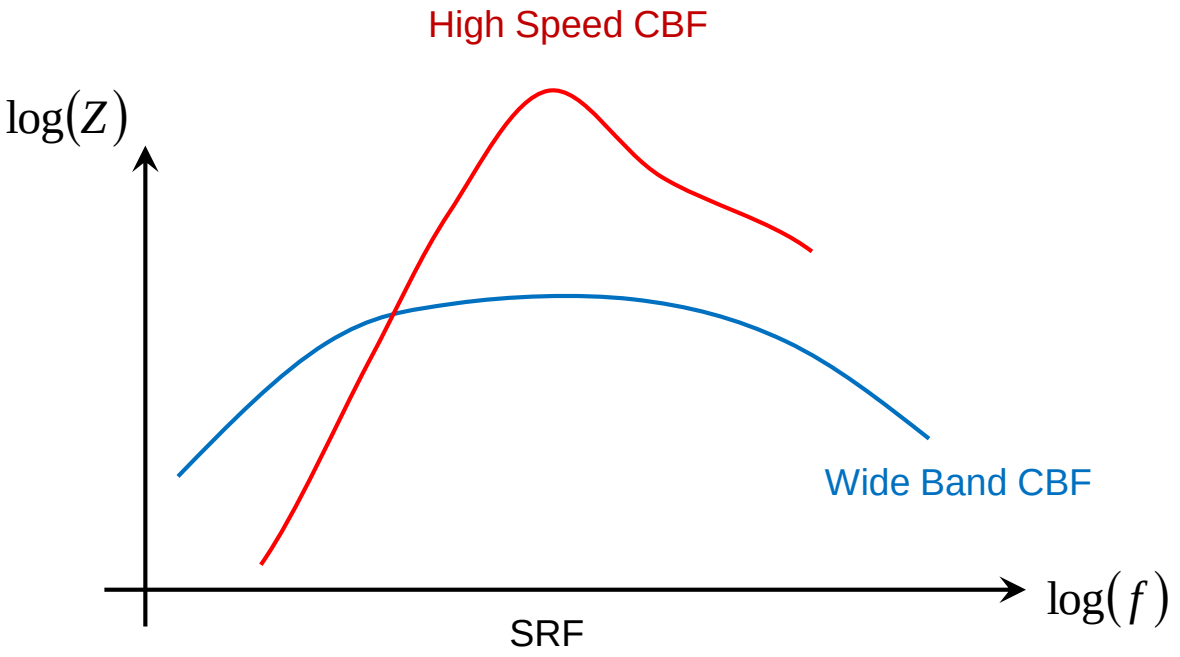


SMD Ferrite: Ersatzschaltbild

Ersatzschaltbild für CBF



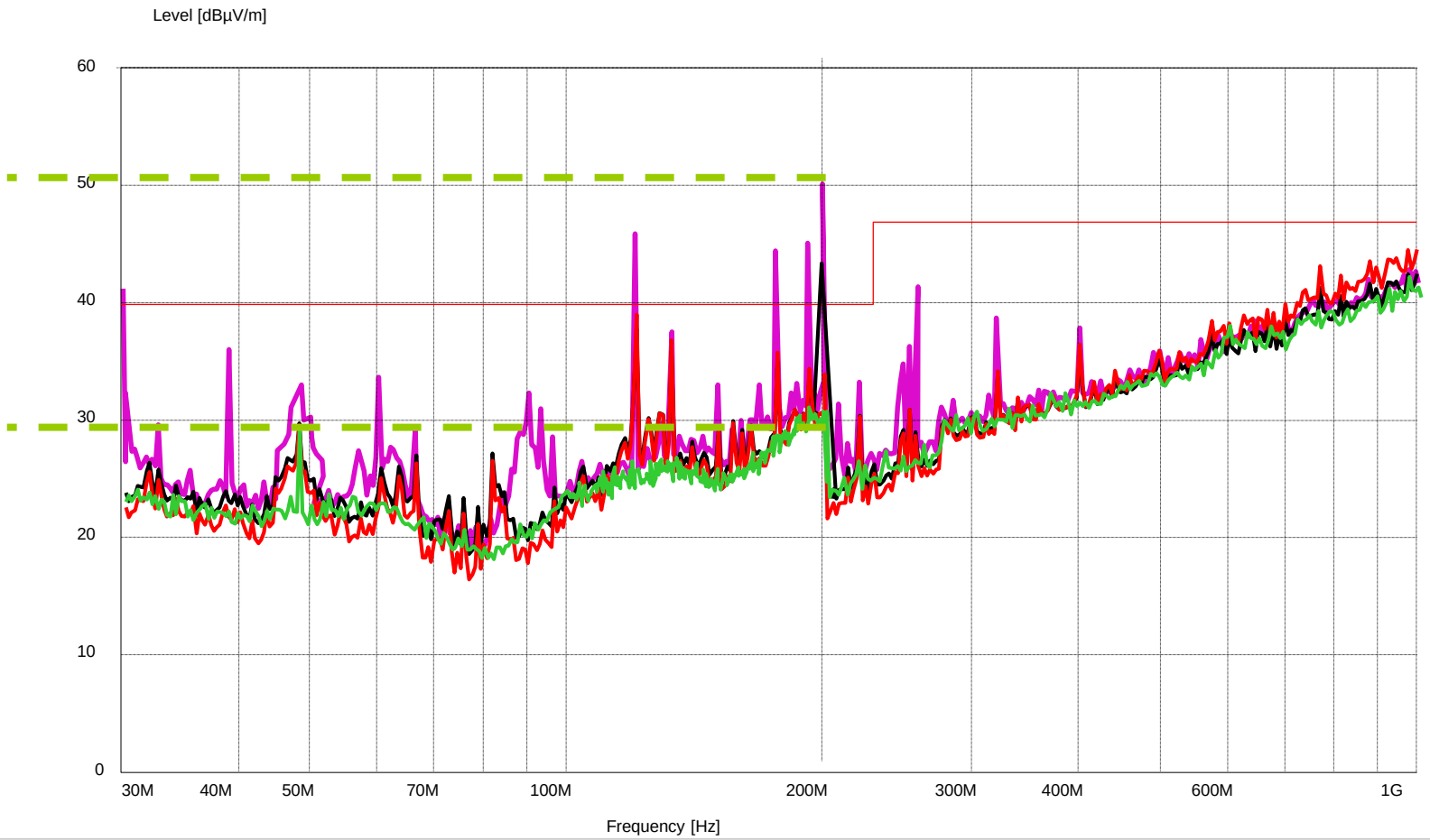
Quelle: Wikipedia.org/ Suche: “SMD Ferrit“



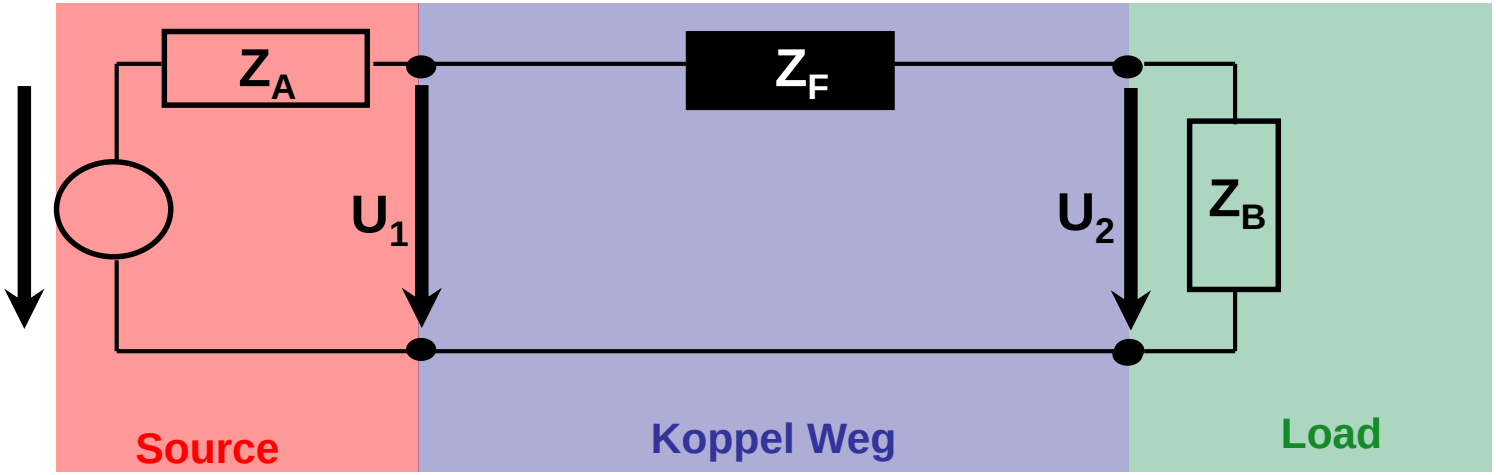
APPLIKATIONEN

EMV Ergebnisse aus dem Labor

→ Ergebnisse vergleichen



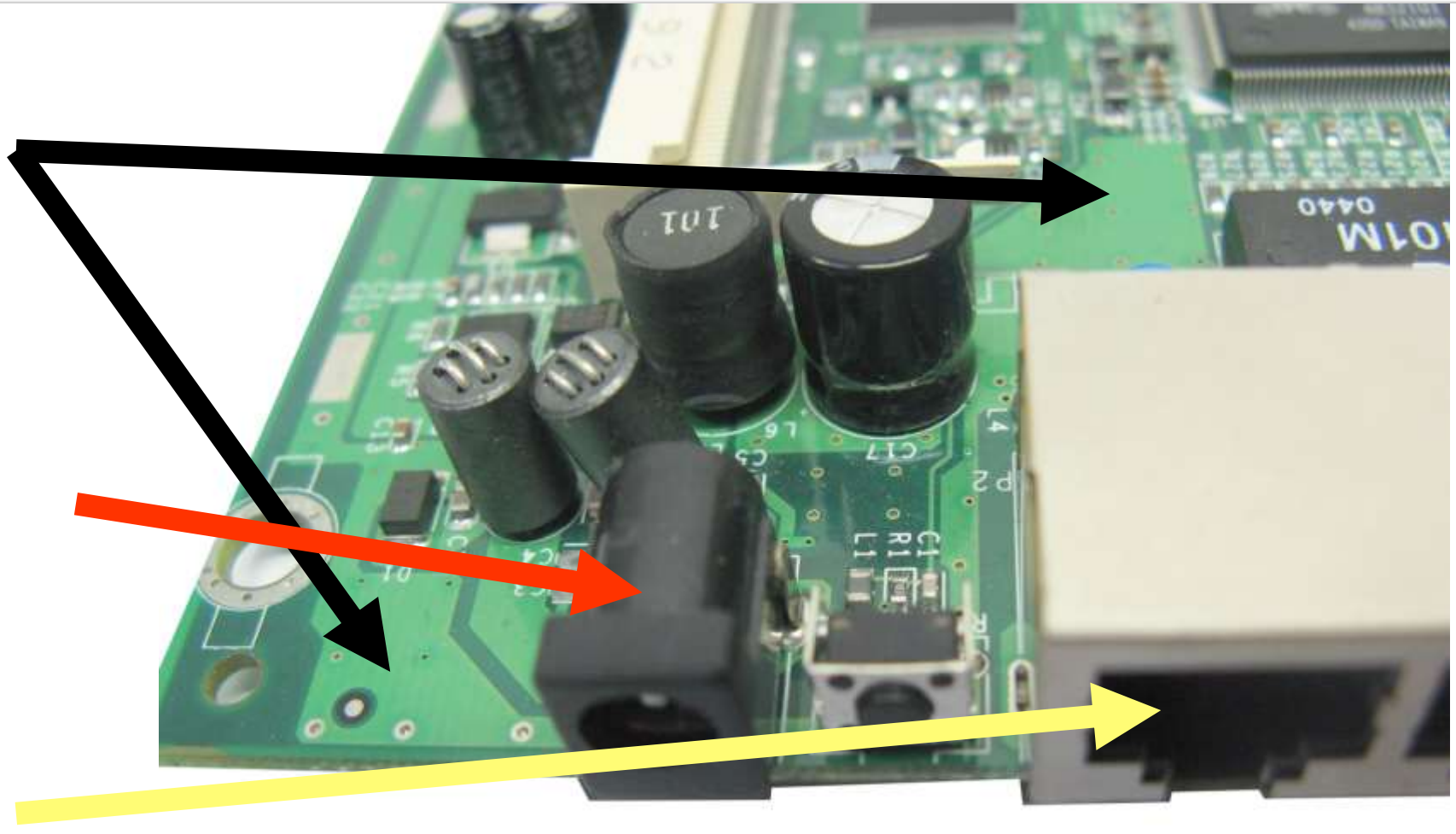
Einfügedämpfung vs. Impedanz



- Einfügedämpfung

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

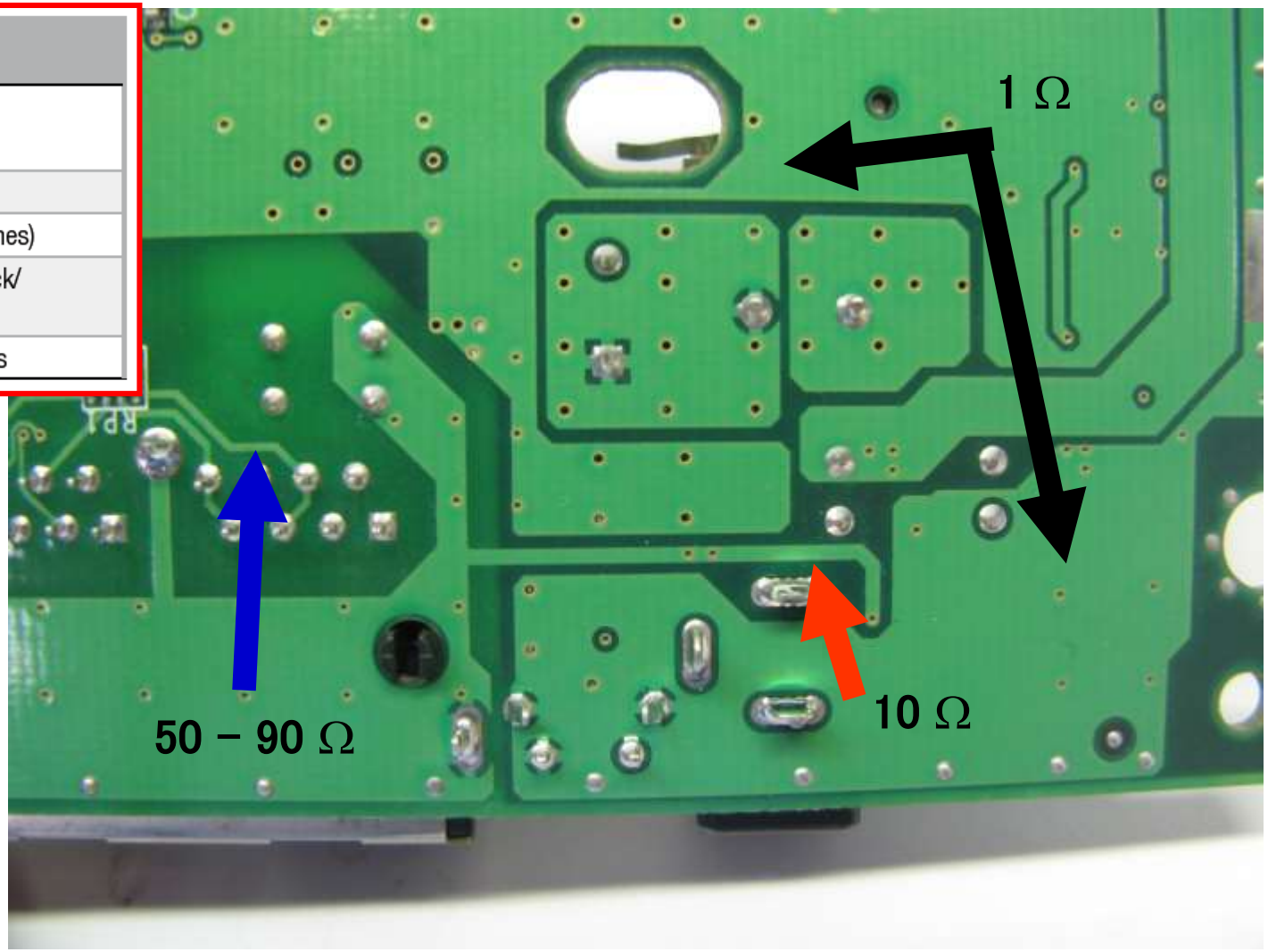
Praktische Werte



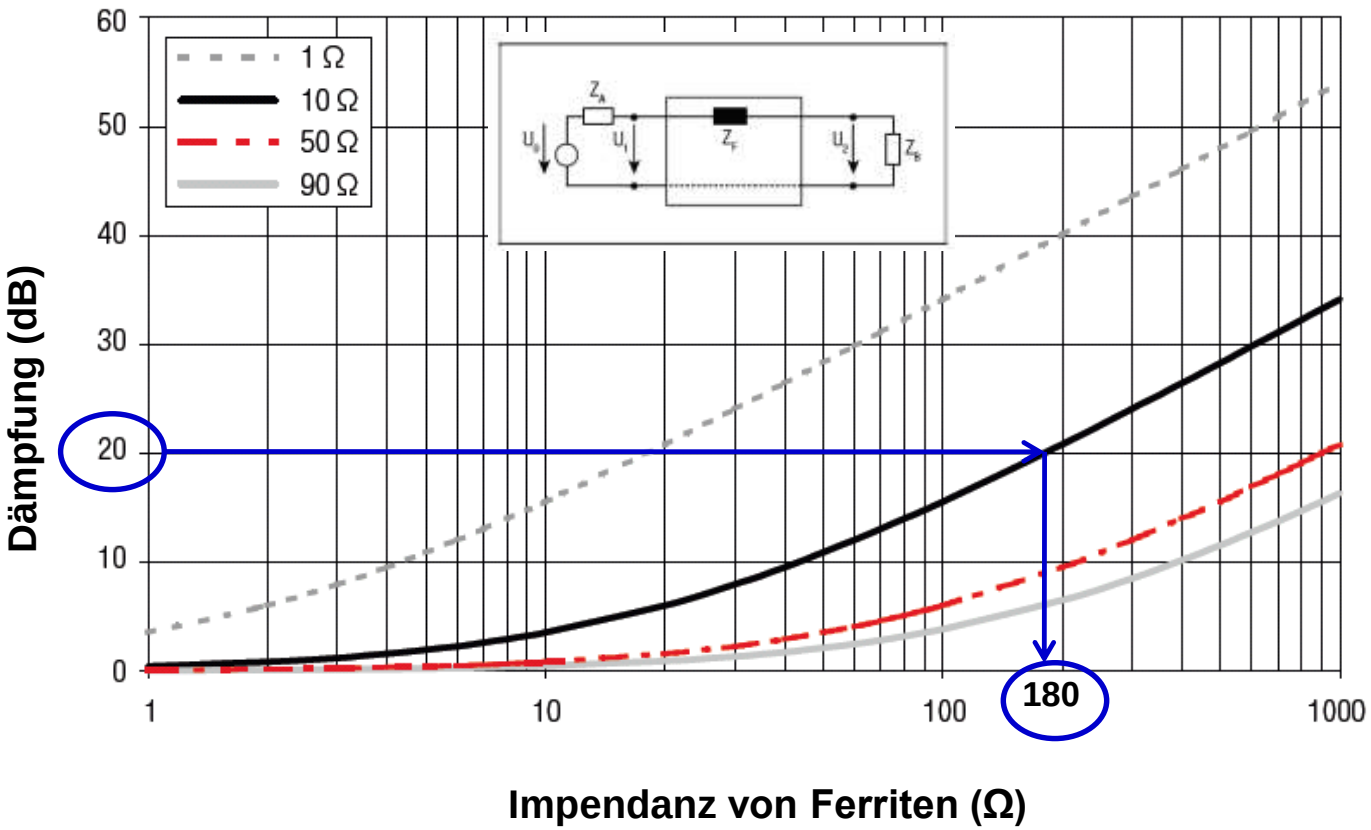
Praktische Werte

Application overview

Assumend practical system impedance	Application
1 Ω	GND (Ground Planes)
10 Ω	V_{cc} (Supply Voltage lines)
50 Ω – 90 Ω	Datasignal Lines/Clock/ Video Signal/USB
90 Ω – 150 Ω	Long Datasignal Lines



Einfügedämpfung vs. Impedanz



1. **Benötigt werden mind. 20dB Dämpfung bei 125 MHz**
2. **Es ist bekannt, dass die Störung auf dem Spannungsversorgung-kabel kommt**
3. **Spanungsversorgung hat ca. 10 Ω Impedanz**

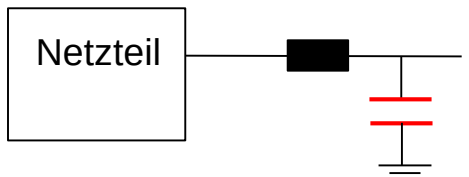
- **Resultat: Minimum Impedanz liegt bei 180 Ω**

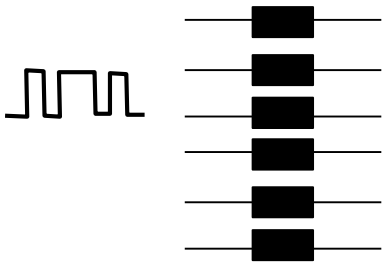
Applikationen

Application overview	
Assumend practical system impedance	**Application**
1 Ω	GND (Ground Planes)
10 Ω	V_{cc} (Supply Voltage lines)
50 Ω – 90 Ω	Datasignal Lines/Clock/ Video Signal/USB
90 Ω – 150 Ω	Long Datasignal Lines

Datenleitungen

Spannungsversorgung

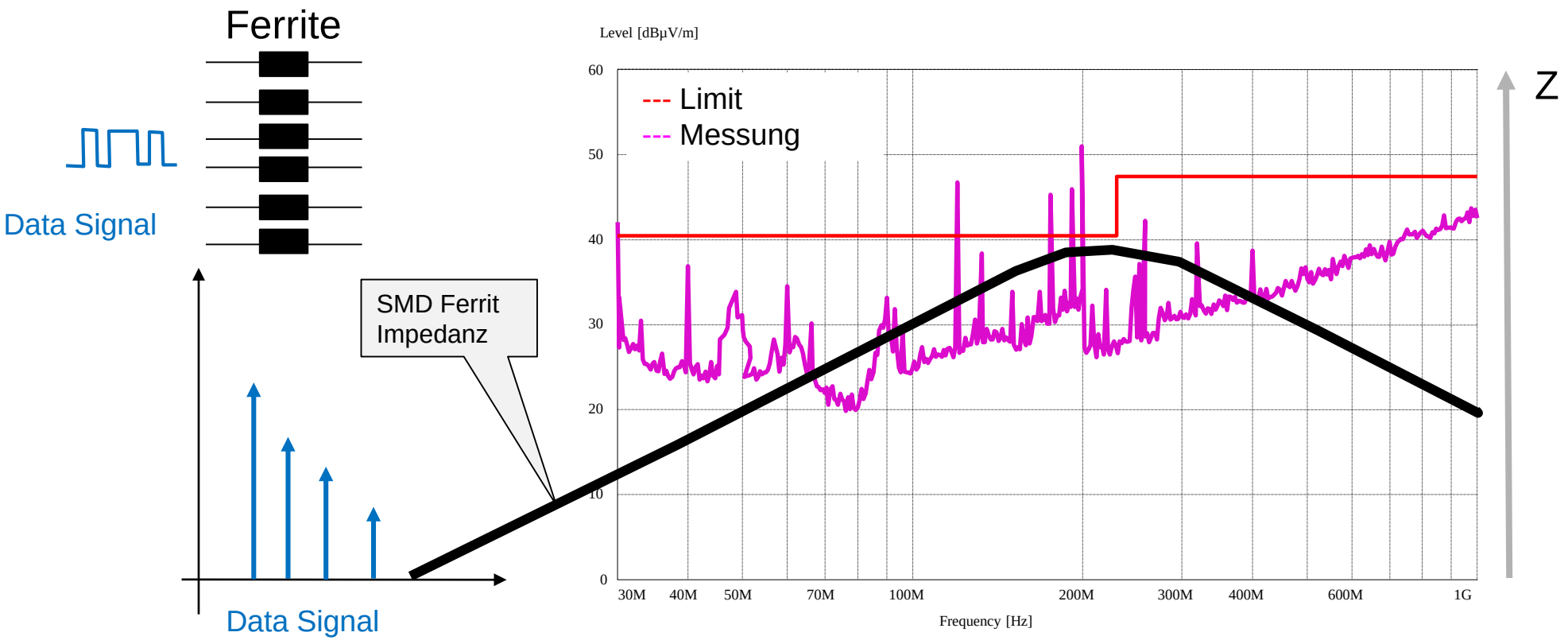




FERRITSELEKTION FÜR DATENLEITUNGEN

CBF
CBF HF
MPSB

Datenleitungen: Kompromisse



Die Impedanz des Ferrits, soll groß genug sein um die Störungen zu dämpfen, aber auch gleichzeitig klein genug an der Signalträgerfrequenz.

WE: Klassifikation des SMD Ferrits

		High Speed	Wide Band	High Current		
CBF	Haupteinsatz	Datenleitungen	Datenleitung / Spannungsversorgung	Spannungsversorgung	Haupteinsatz	CBF
	µr	50 - 80	200 - 250	200 - 250	µr	
	Nennstrom Ir [mA]	100 - 700	50 - 500	1000 - 6000	Nennstrom Ir [mA]	
	Ir Testcondition [ΔK]	20	20	40	Ir Testcondition [ΔK]	
	Impedanz @ 1MHz [Ohm]	0,09 - 39	0,29 - 51	0,08 - 57,3	Impedanz @ 1MHz [Ohm]	
	Impedanz @ 100MHz [Ohm]	5 - 1200	10 - 2700	7 - 1500	Impedanz @ 100MHz [Ohm]	
	RDC [mOhm]	50 - 800	50 - 1500	30 - 300	RDC [mOhm]	
	Größe [EIA]	0402,0603,0805, 1206, 1806, 1812	0402,0603,0805, 1206, 1806, 1812	0402,0603,0805, 1206, 1806, 1812	Größe [EIA]	
	Pulsfestigkeit Spezifiziert	nein	nein	nein, auf Anfrage könnte eine Aussage getroffen werden, keine Garantien	Pulsfestigkeit Spezifiziert	
	Anwendungen	Filterschaltungen, USB 2.0, USB 3.0, HDMI, IEEE (Fire Wire) Rundfunk, CB Funk, TV, DAB	Filterschaltungen, RS232, RS422, Navigation, Industieller Funk DC/DC Konverter für geringe Ströme	Filterschaltungen, DC/DC Konverter für Ströme bis 6A, USB Spannungsversorgung	Anwendungen	
	Anzahl an Katalogartikeln	54	53	52	Anzahl an Katalogartikeln	

		High Speed	Wide Band	High Current		
CBF HF	Haupteinsatz	Datenleitungen	Datenleitung / Spannungsversorgung	Spannungsversorgung	Haupteinsatz	CBF HF
	µr	50 - 80	200 - 250	200 - 250	µr	
	Nennstrom Ir [mA]	100	50 - 500	500 - 600	Nennstrom Ir [mA]	
	Ir Testcondition [ΔK]	20	20	40	Ir Testcondition [ΔK]	
	Impedanz @ 1MHz [Ohm]	8,1	3,7 - 27,7	3,6 - 8,9	Impedanz @ 1MHz [Ohm]	
	Impedanz @ 100MHz [Ohm]	100	180 - 1000	220 - 600	Impedanz @ 100MHz [Ohm]	
	RDC [mOhm]	1500	380 - 1800	250 - 350	RDC [mOhm]	
	Größe [EIA]	0603	0402, 0603	0603	Größe [EIA]	
	Pulsfestigkeit Spezifiziert	nein	nein	nein	Pulsfestigkeit Spezifiziert	
	Anwendungen	Funkmodule, Bluetooth, WLAN, GSM, UMTS, DECT, LTE, Radar			Anwendungen	
	Anzahl an Katalogartikeln	1	6	3	Anzahl an Katalogartikeln	

CBF: Spezifikationen

CBF – High Speed

D Electrical Properties: 74279202

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	120	Ω	±25%
Maximum impedance	400 MHz	Z	200	Ω	typ.
Rated current	ΔT = 20K	I_R	500	mA	max.
DC Resistance		R_{DC}	0.10	Ω	max.
Type			High Speed		

Für Datenleitungen und für alle unter 1A Nennstrom gilt:
ΔT= 20K Eigenerwärmung

CBF HF – High Speed

D Electrical Properties: 742862160

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	600	Ω	±25%
Impedance @ 1 GHz	1 GHz	Z	850	Ω	min.
Maximum impedance	700 MHz	Z	1700	Ω	typ.
Rated current	ΔT = 20K	I_R	100	mA	max.
DC Resistance		R_{DC}	1.50	Ω	max.
Type			High Speed		

CBF HF – Wide Band

D Electrical Properties: 742861210

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	1000	Ω	±25%
Impedance @ 1 GHz	1 GHz	Z	1100	Ω	min.
Maximum impedance	550 MHz	Z	2200	Ω	typ.
Rated current	ΔT = 20K	I_R	50	mA	max.
DC Resistance		R_{DC}	1.80	Ω	max.
Type			Wide Band		

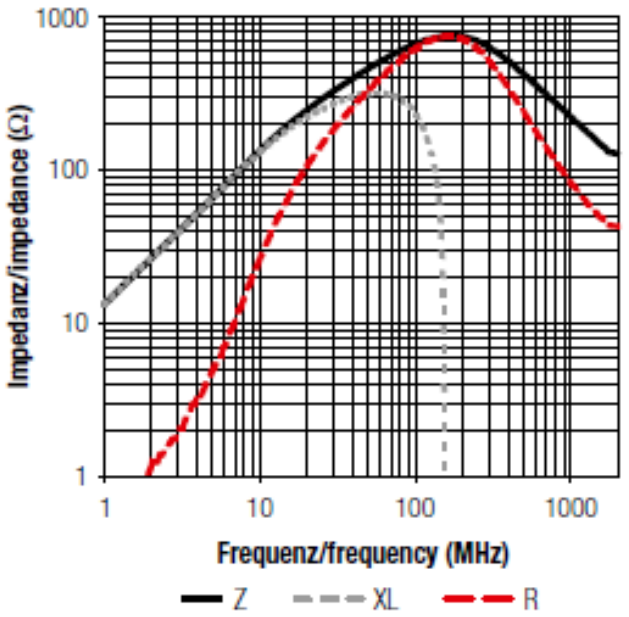
1GHz Impedanz

Beispiel: Langsame Datensignale

- **RS232/RS485: 75 bits/sec – 115200 bits/sec (slow speed)**
  - **z.B. Einwahlmodem (14.4k / 56k)**

- **USB 1.0: 1.5 Mbit/sec (low speed)**

Wide Band CBF



Beispiel : High Speed Signale

- **USB 1.1: 12 Mbit/sec (full speed)**

- **Firewire: 400 Mbit/sec or 50 MB/sec (high speed)**

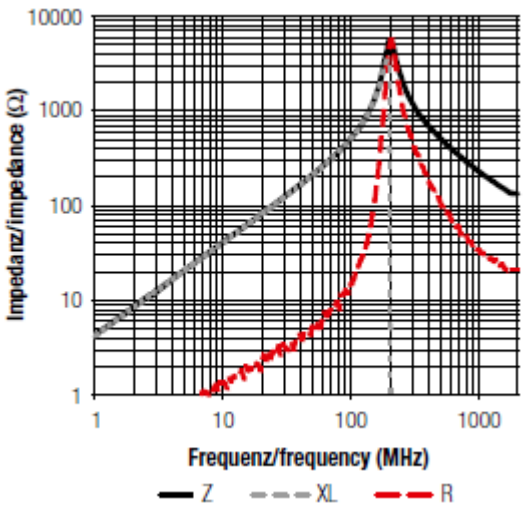
- **USB 2.0: 480 Mbit/sec or 60 MB/sec (high speed)**

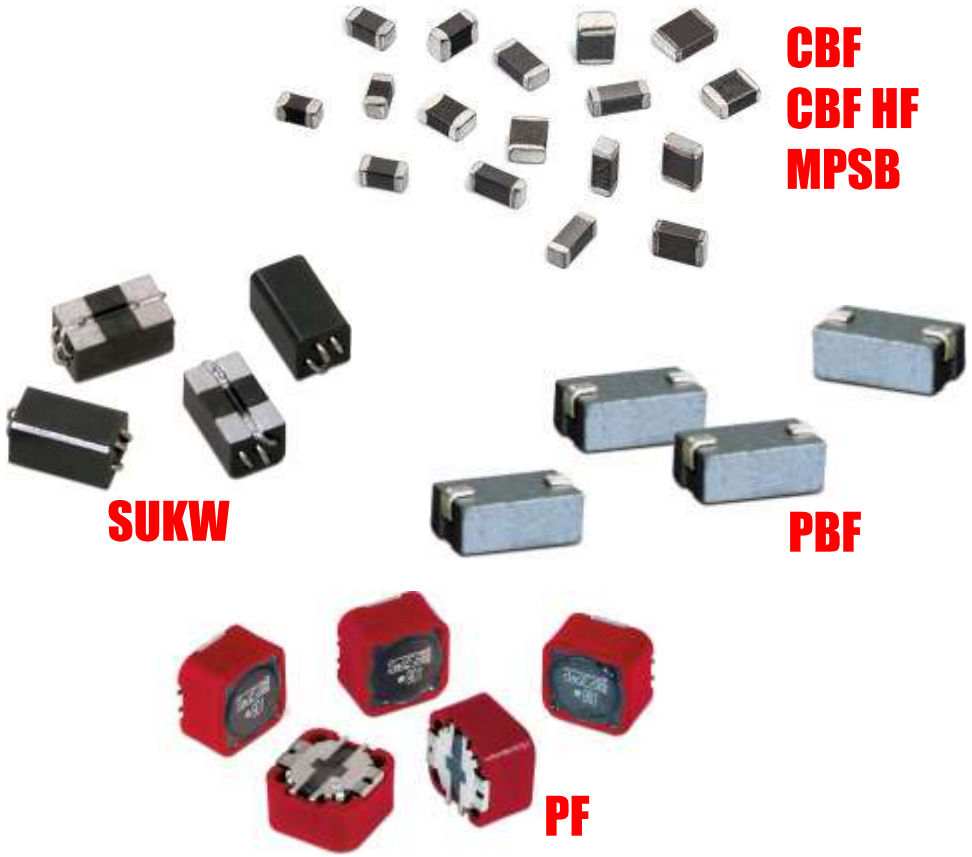
- **HDMI Standard: 2.2 Gbit/sec or 275 MB/sec (high speed)**
  - ***720P/1080i***

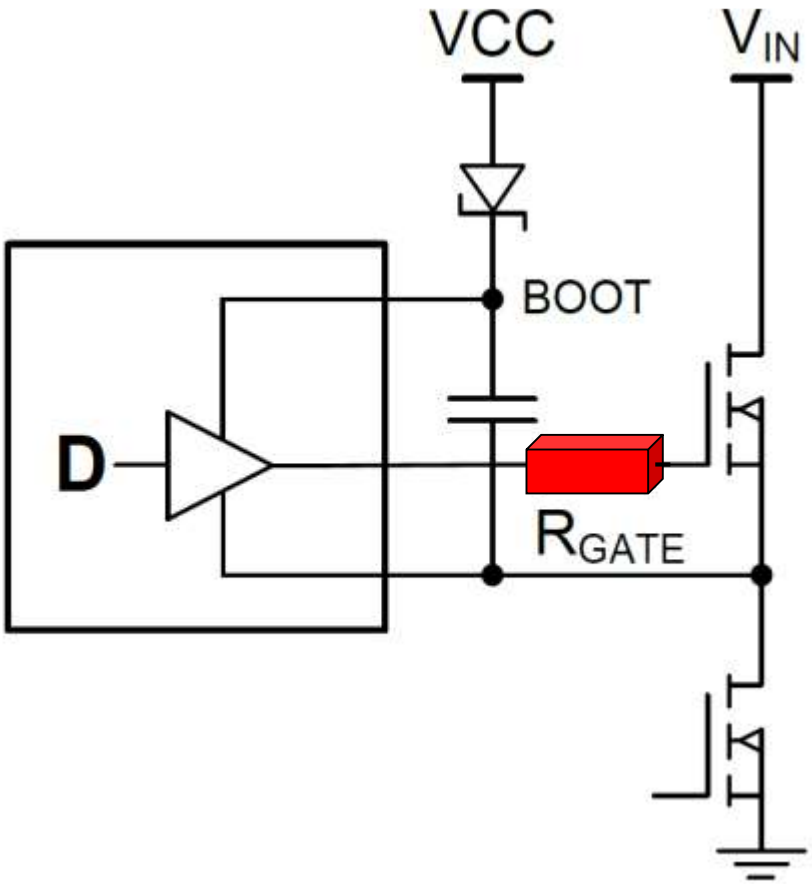
- **USB 3.0: 5 Gbit/sec or 625 MB/sec (super speed)**

- **HDMI High-Speed: 10.2 Gbit/sec or 1.275 GB/sec**
  - ***1080p***

High Speed CBF

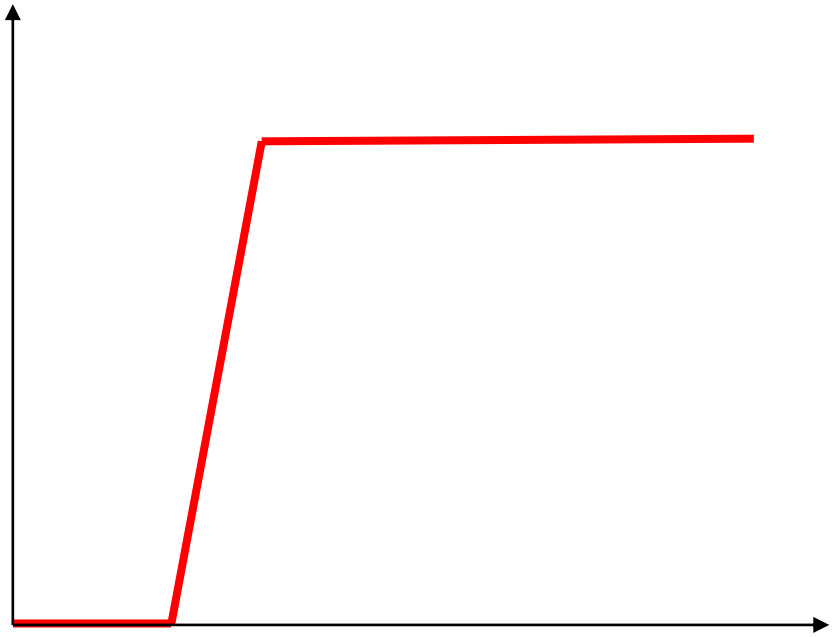




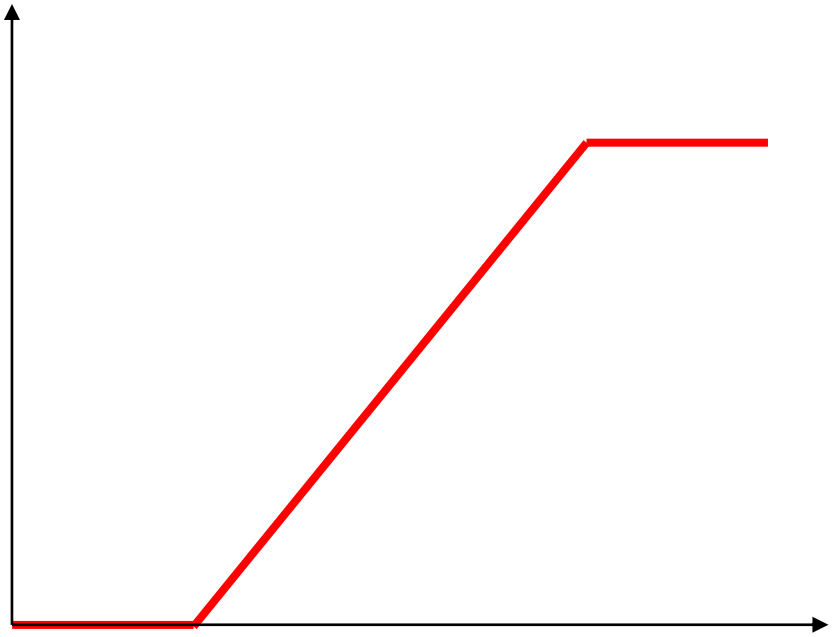


FERRITE FÜR ANSTIEGSGESCHWINDIGKEIT LIMITIEREN & RINGING CONTROL

Anstiegsgeschwindigkeit

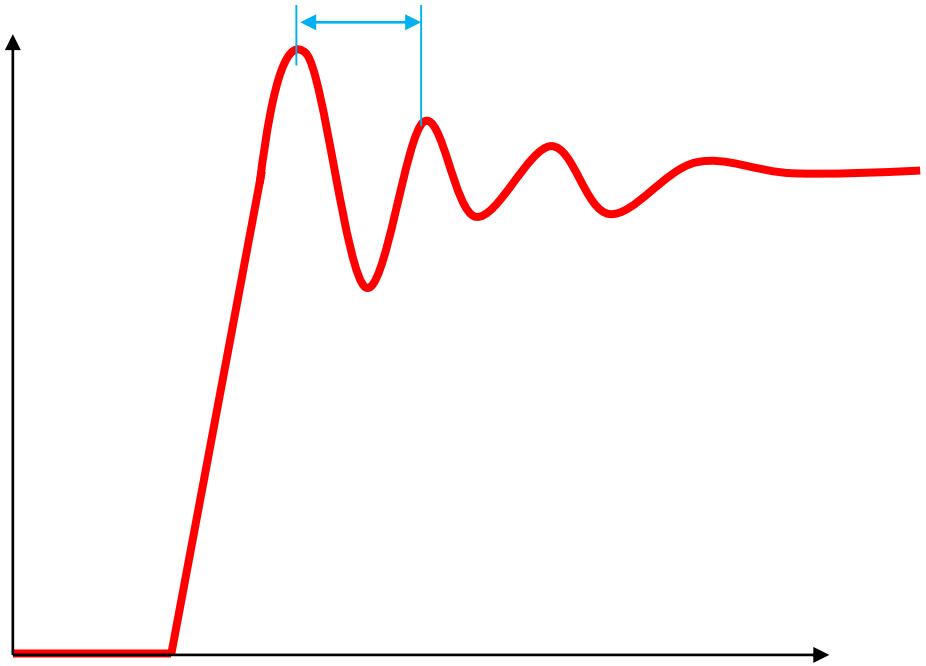


Hohe Anstiegsgeschwindigkeit

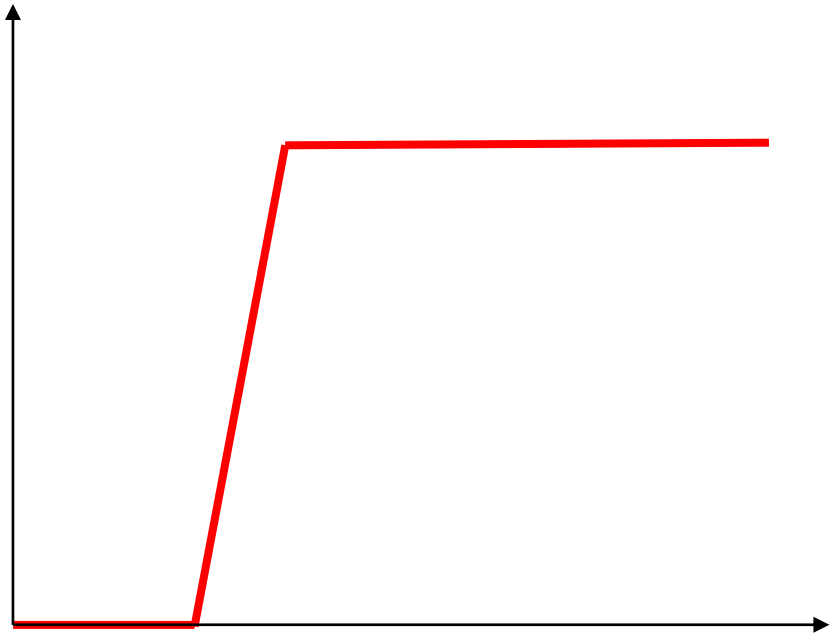


Langsame Anstiegsgeschwindigkeit

Ringing / Nachschwingen

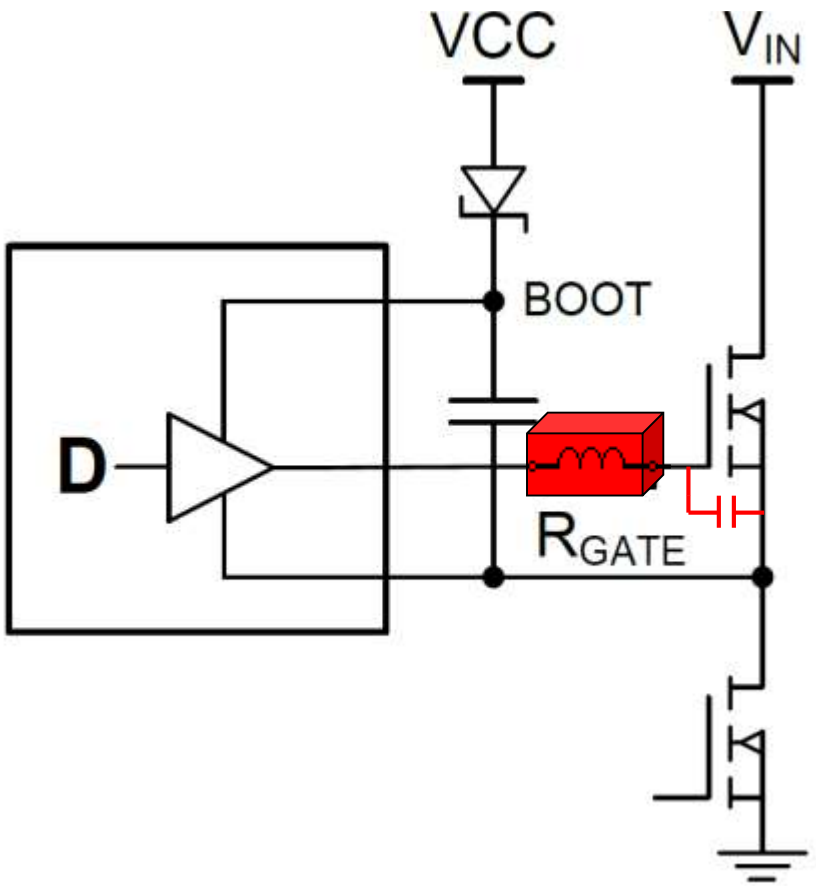


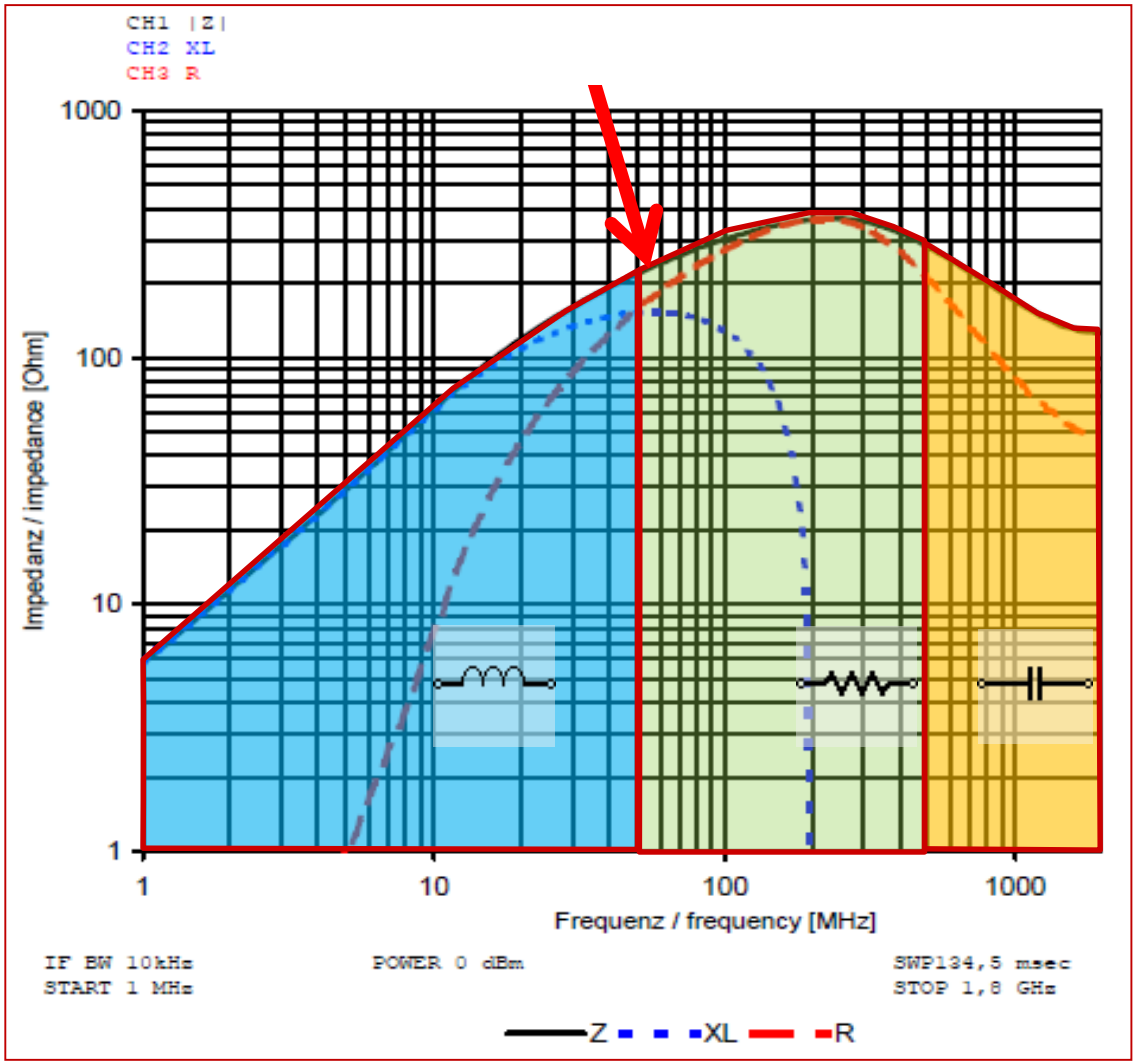
Ringing / Nachschwingen



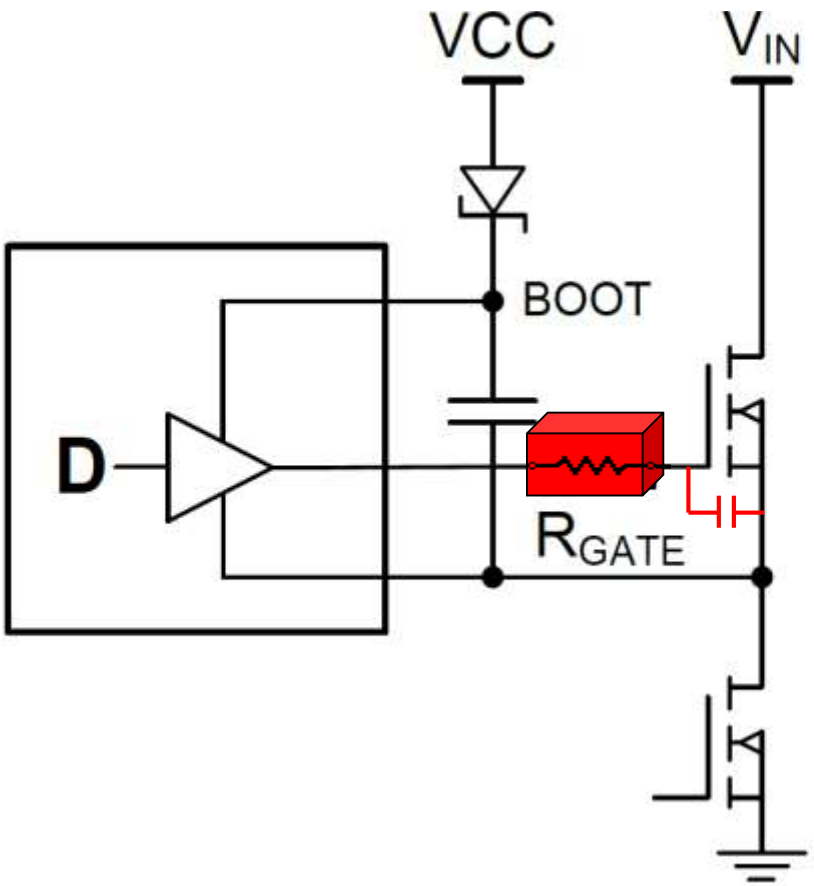
Keine Ringing / Nachschwingen

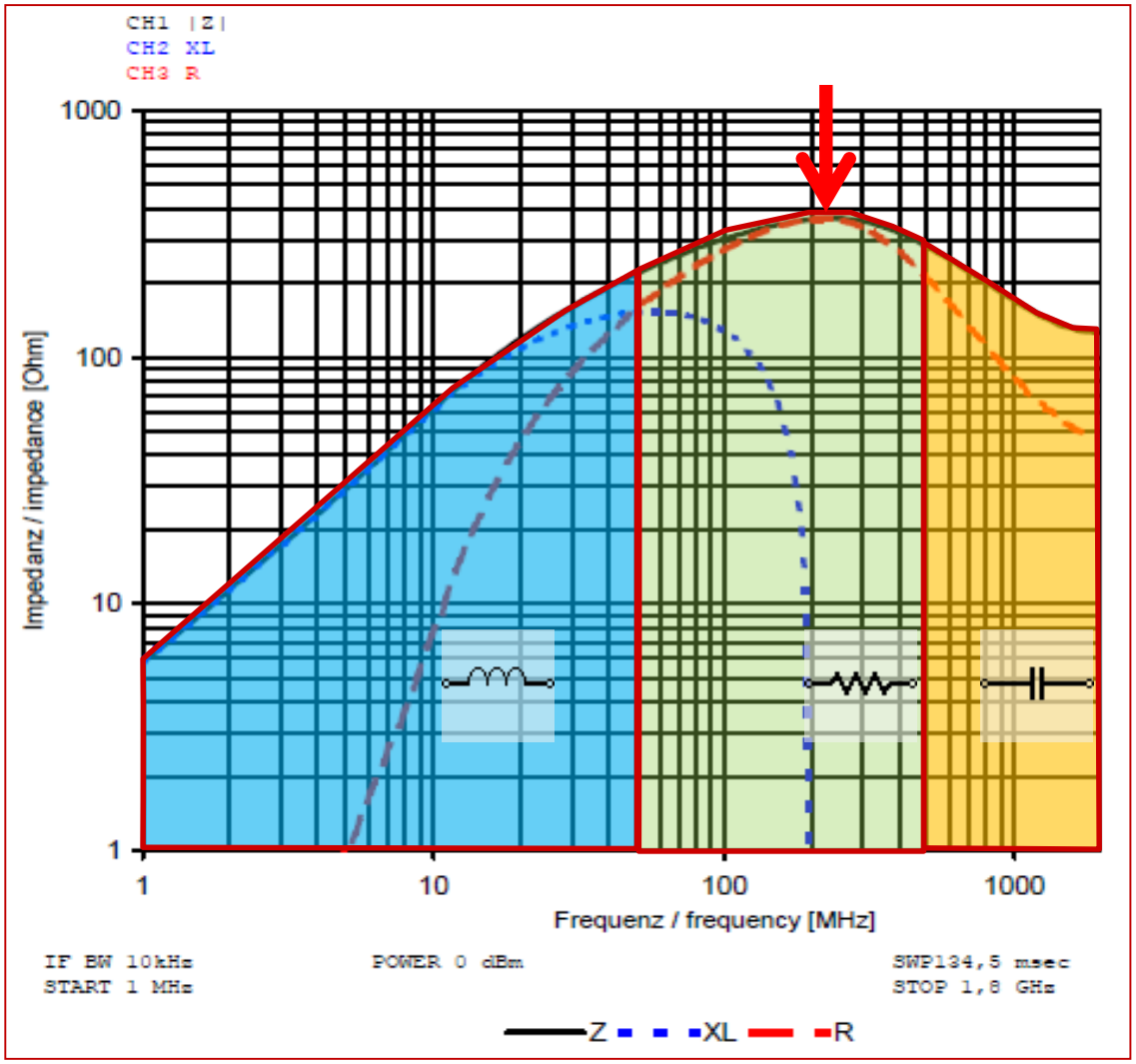
Falsche Auswahl: (L+R)-C Ringing



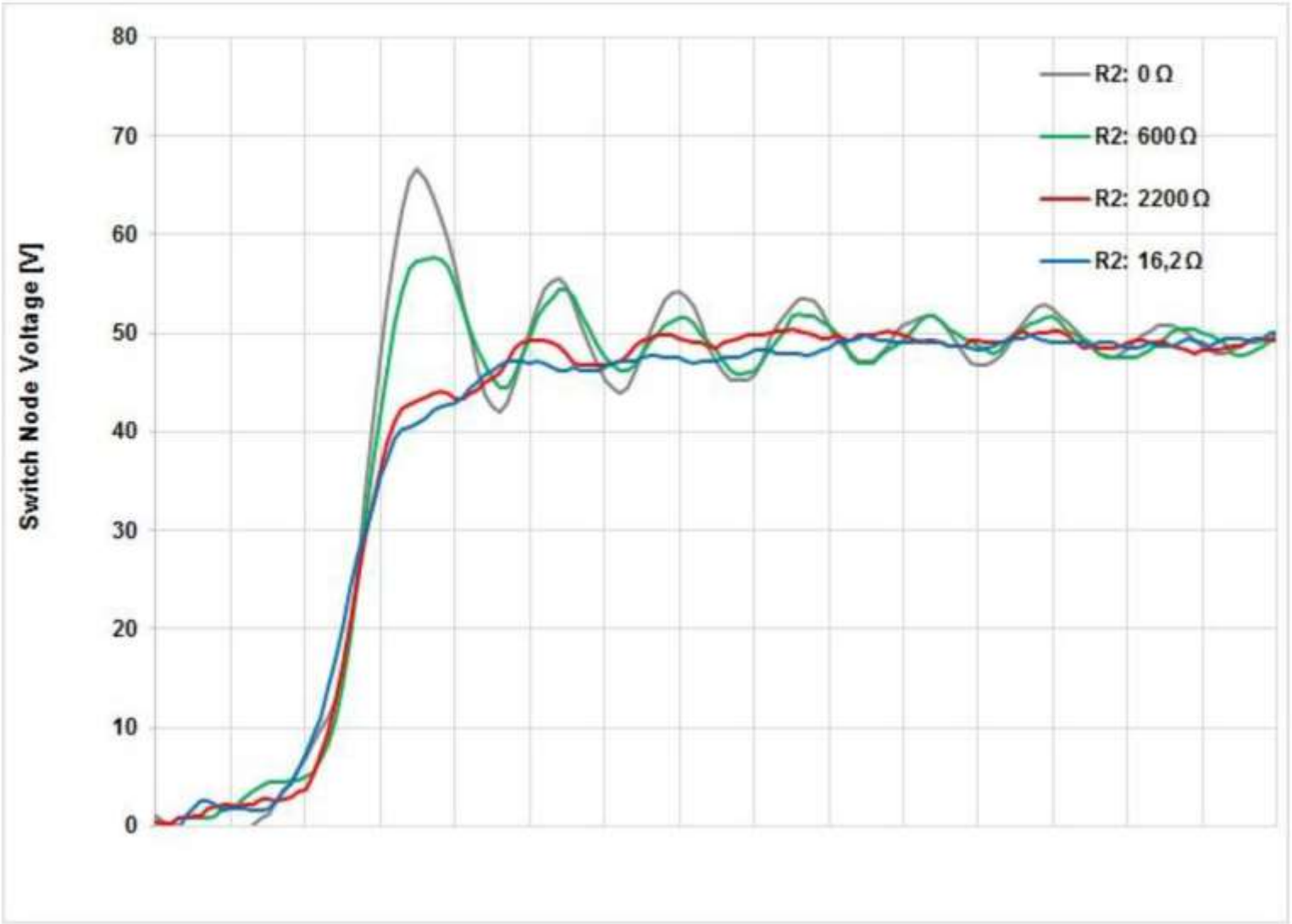


Richtige Auswahl: R-C

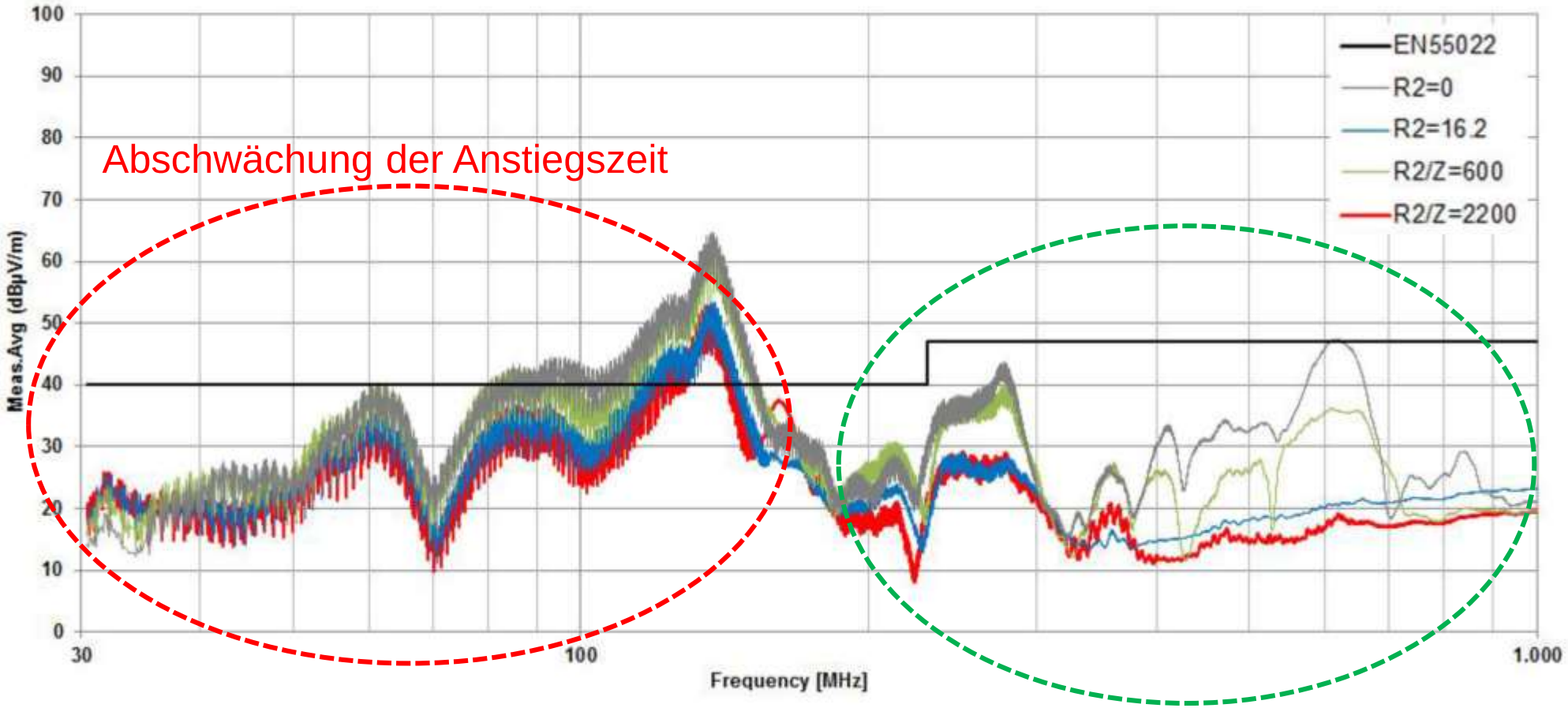


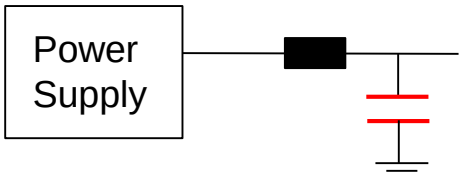


Vergleich unterschiedliche Ferrite und Wiederstand



Ausgestrahlte Emissionsscans





SPANNUNGSVERSORGUNG: POWER FERRIT SELEKTION

Power Line Ferrite

CBF – Hoch Strom

D Electrical Properties:

742792040

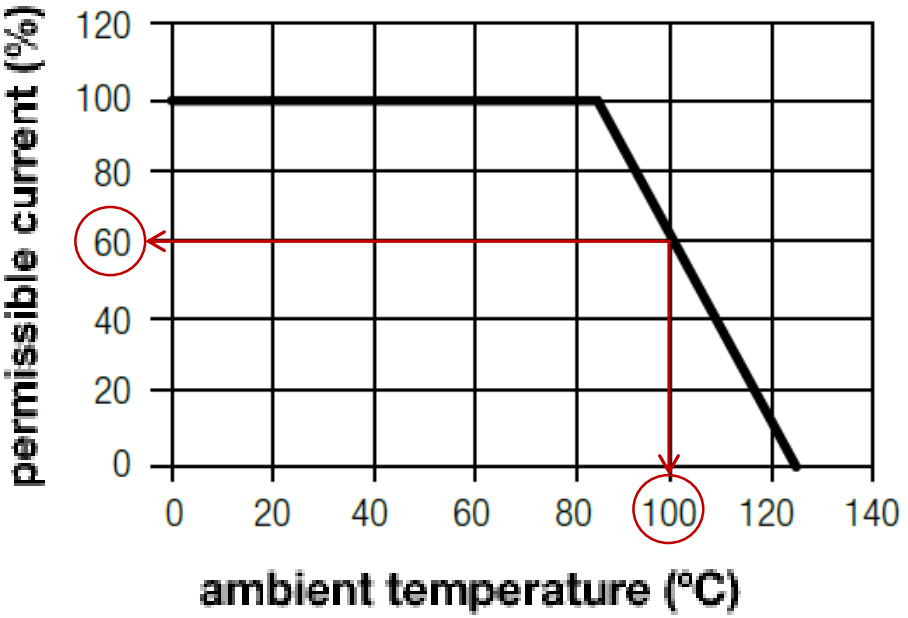
Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	600	Ω	±25%
Maximum impedance	150 MHz	Z	700	Ω	typ.
Rated current	ΔT = 40K	I_R	2000	mA	max.
DC Resistance		R_{DC}	0.15	Ω	max.
Type			High Current		

CBF Hochstrom: Ferrite mit über 1A oder höherem Nennstrom

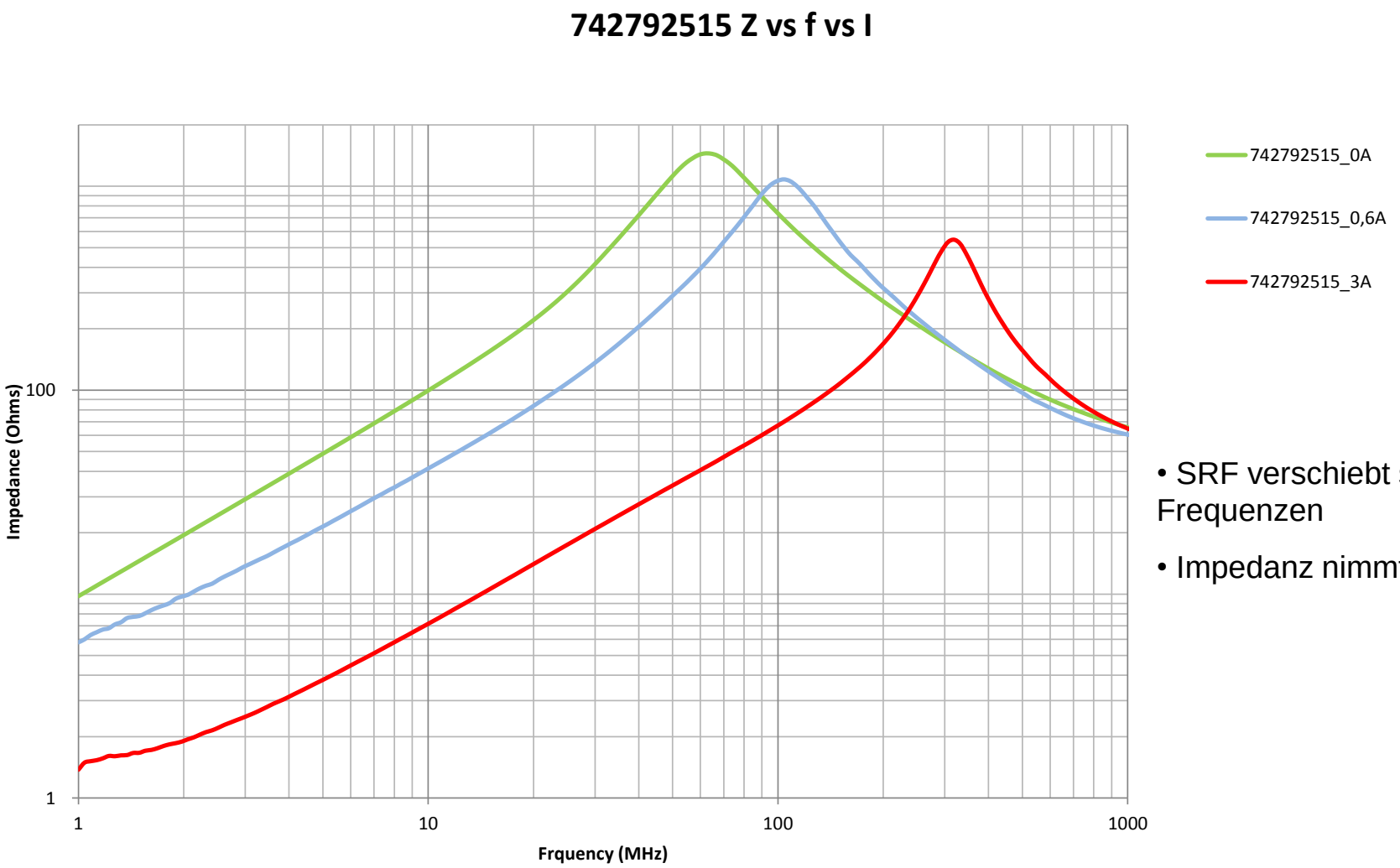
Für Power Hochstrom-Ferrite (CBF, MPSB) ist der Nennstrom bei 40K Eigenerwärmung definiert.

Strom Derating

Achten Sie bei einer Verwendung vom SMD-Ferriten für hohe Nennströme >1A und Umgebungstemperaturen von über +85°C darauf, dass der Nennstrom oberhalb +85°C reduziert werden muss (Derating).

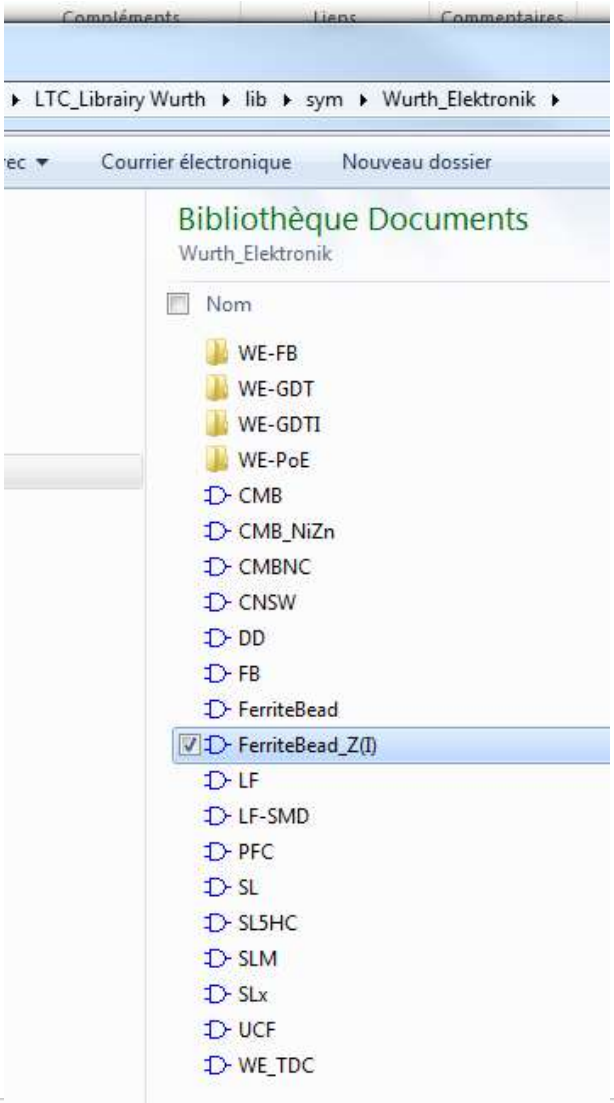


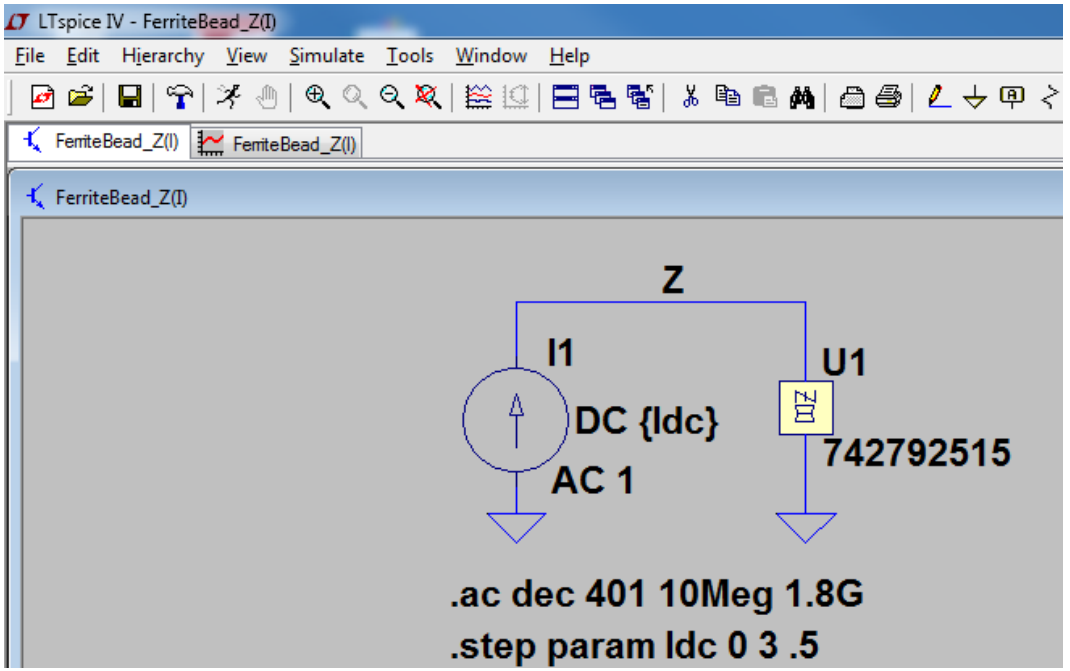
DC Bias Load: Messung



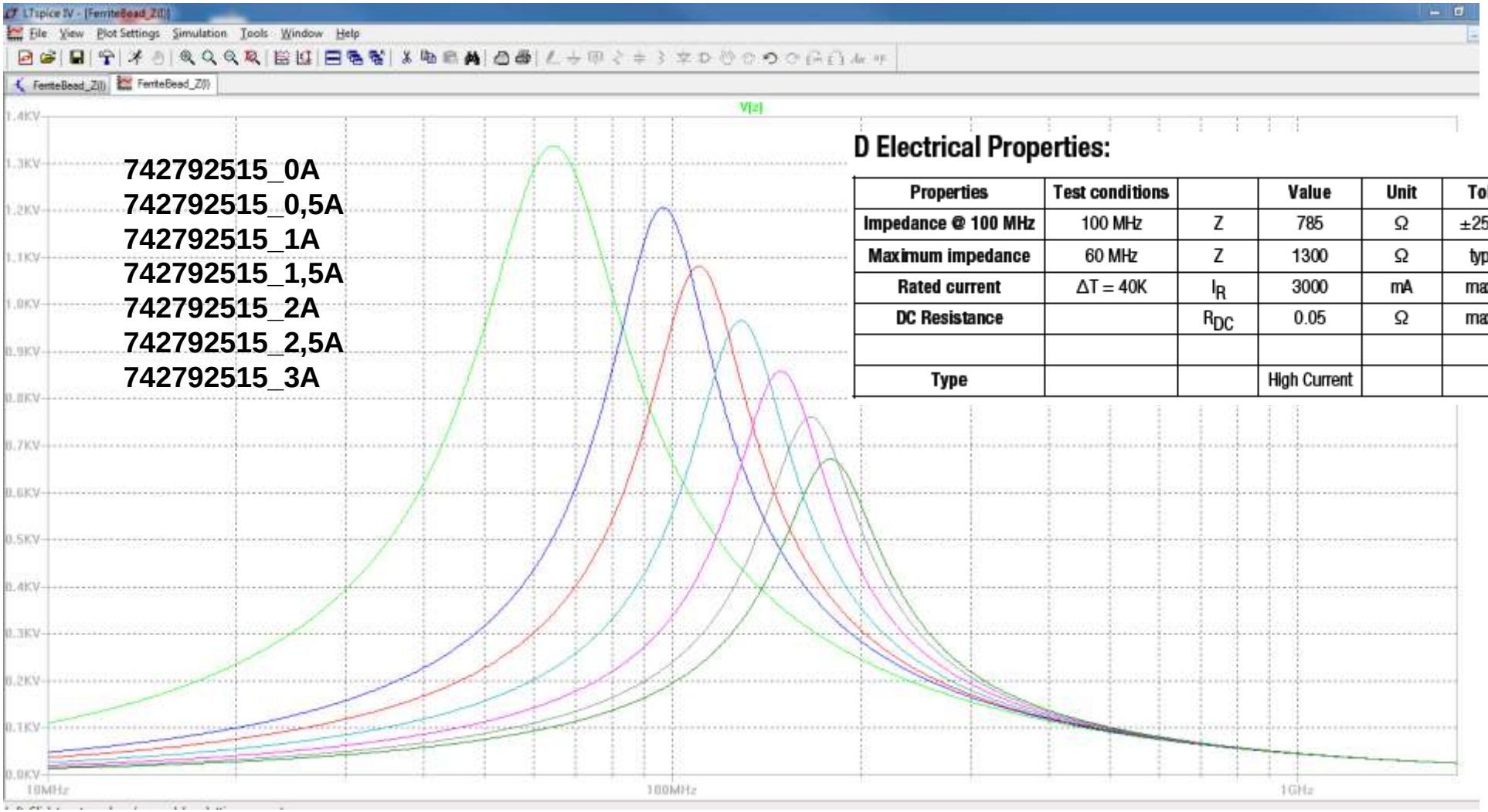
- SRF verschiebt sich in höhere Frequenzen
- Impedanz nimmt ab

DC Bias: Simulation LTspice®





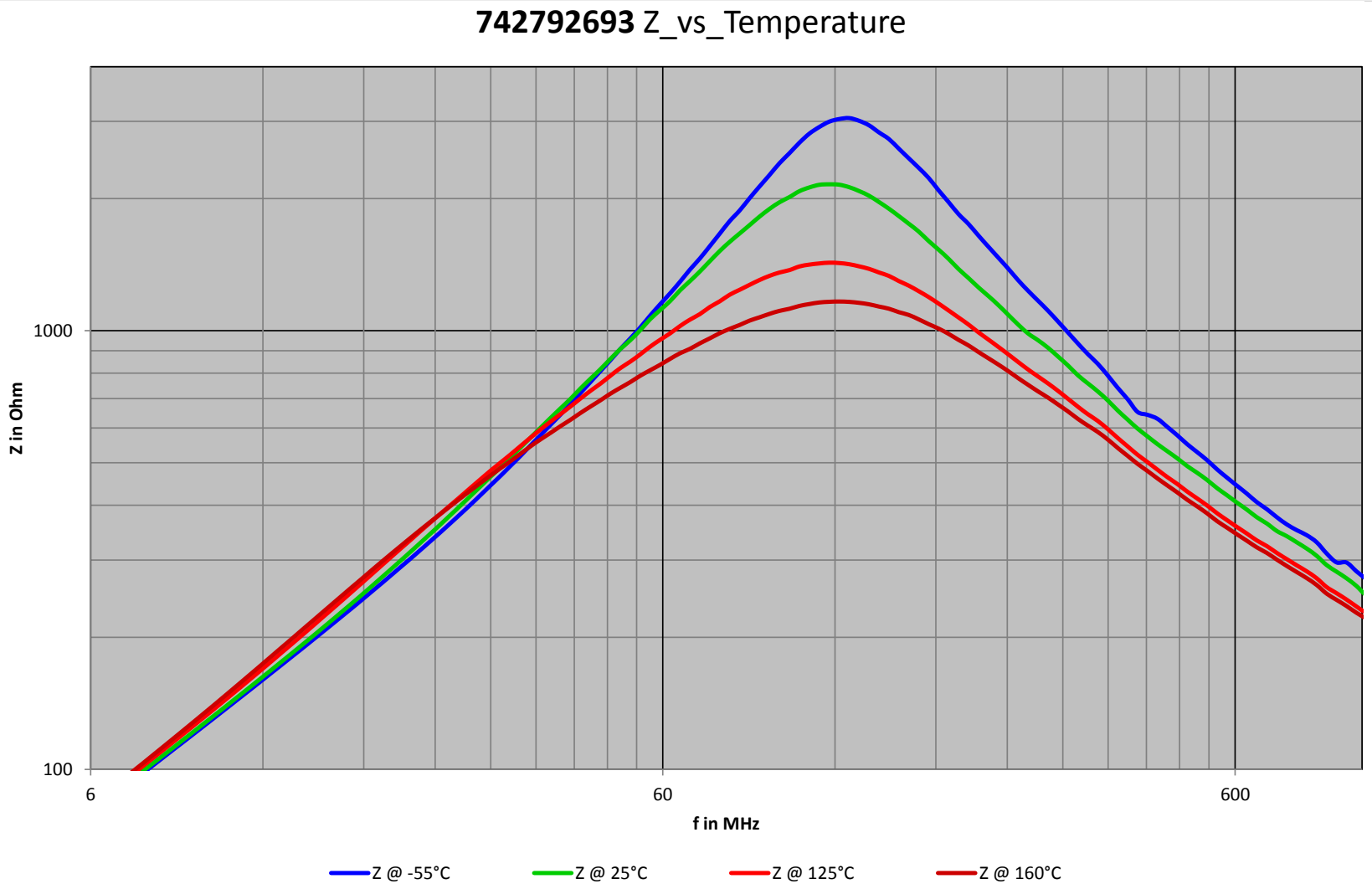
DC Bias: Simulation LTspice®



D Electrical Properties:

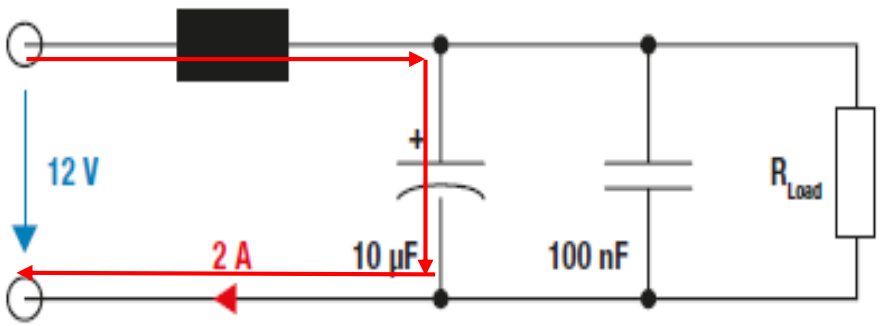
Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	785	Ω	±25%
Maximum impedance	60 MHz	Z	1300	Ω	typ.
Rated current	ΔT = 40K	I_R	3000	mA	max.
DC Resistance		R_{DC}	0.05	Ω	max.
Type			High Current		

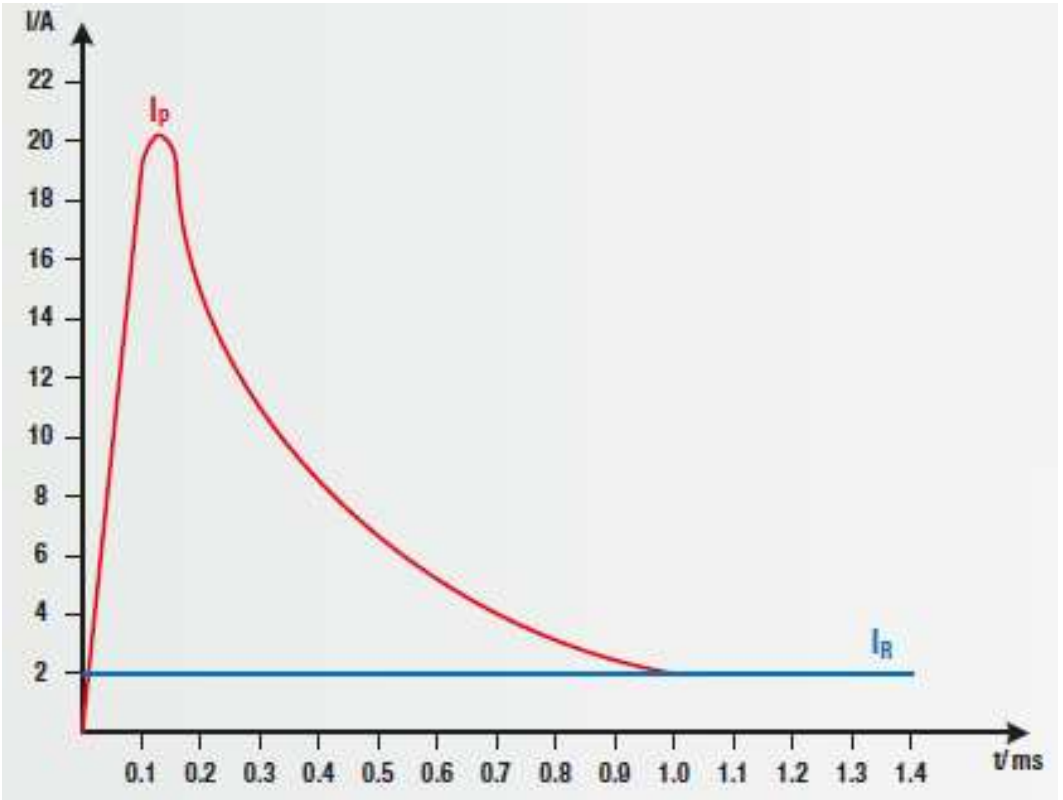
Beeinflussung der Temperatur auf die Impedanz



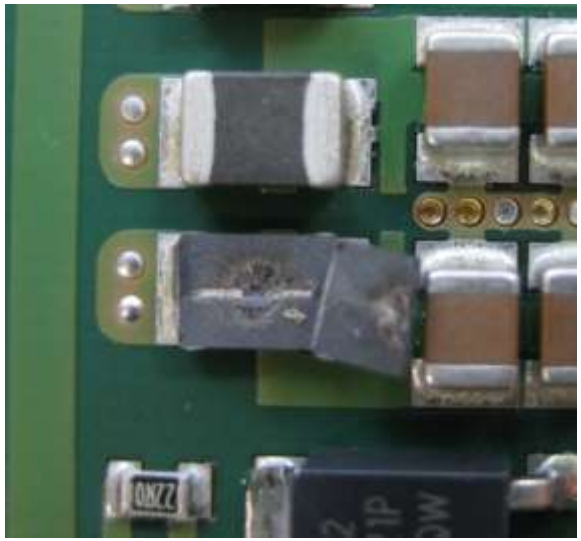
Mit steigender Temperatur nimmt die Impedanz ab.

Einschaltstrom



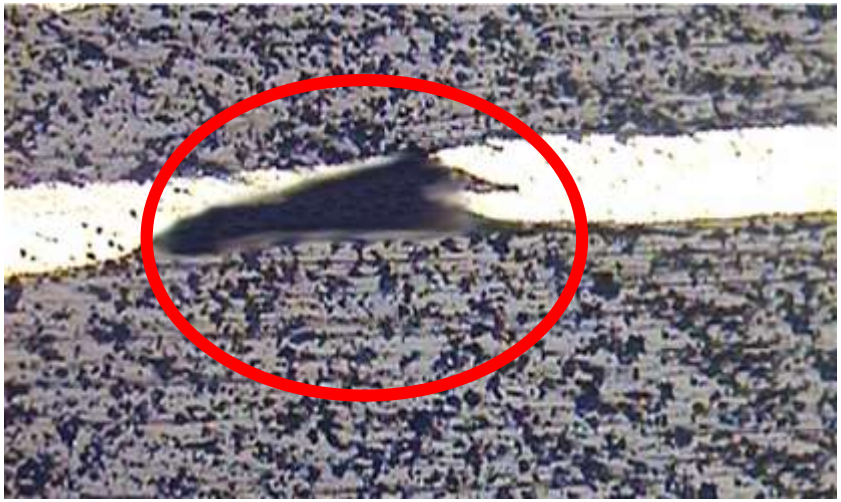


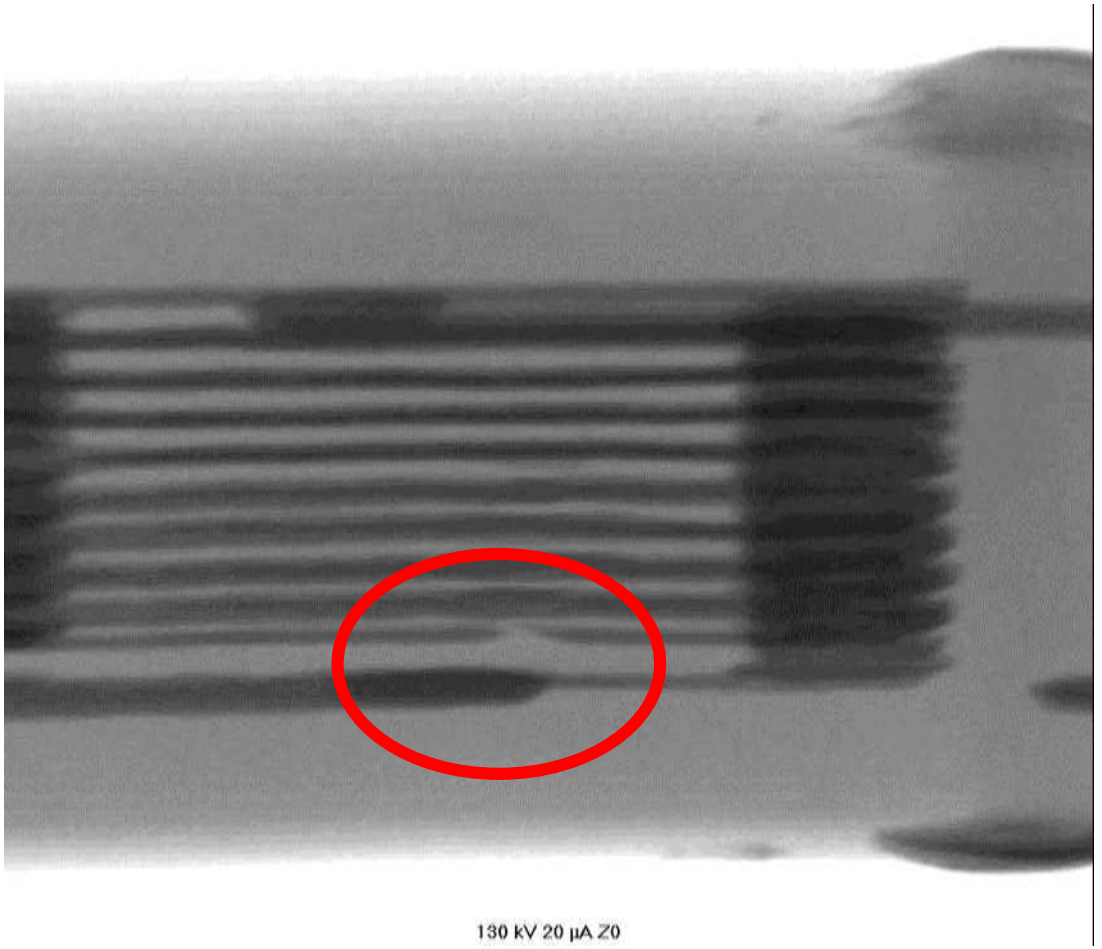
Einfluss von Überstrom



Einschaltstrom

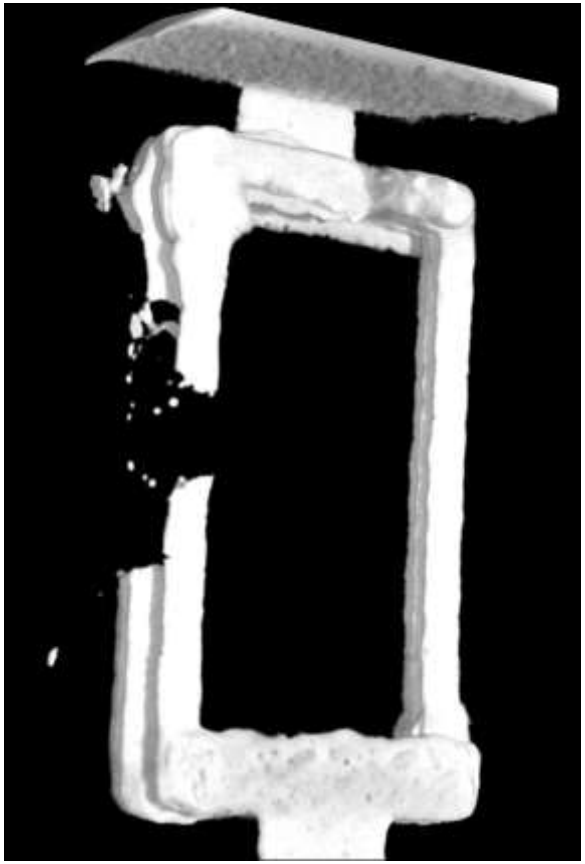
- **Unterbrechung wegen zu hohem Strom**

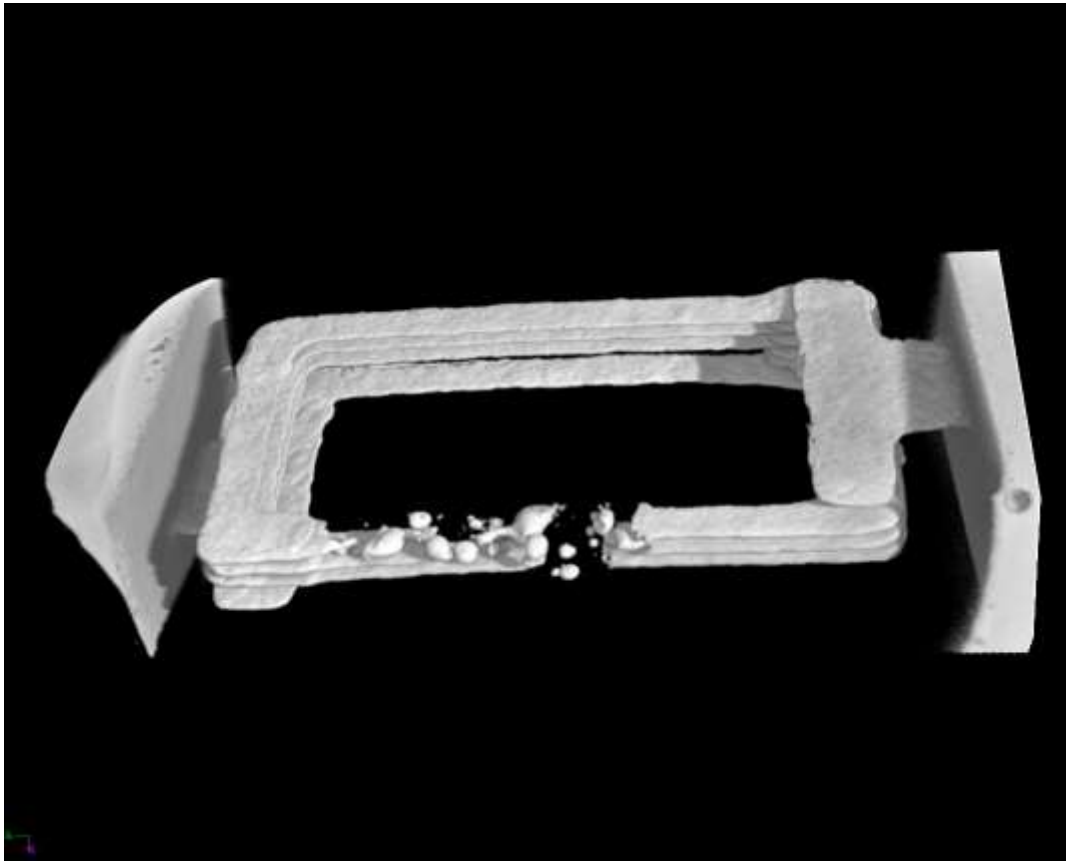




Einschaltstrom

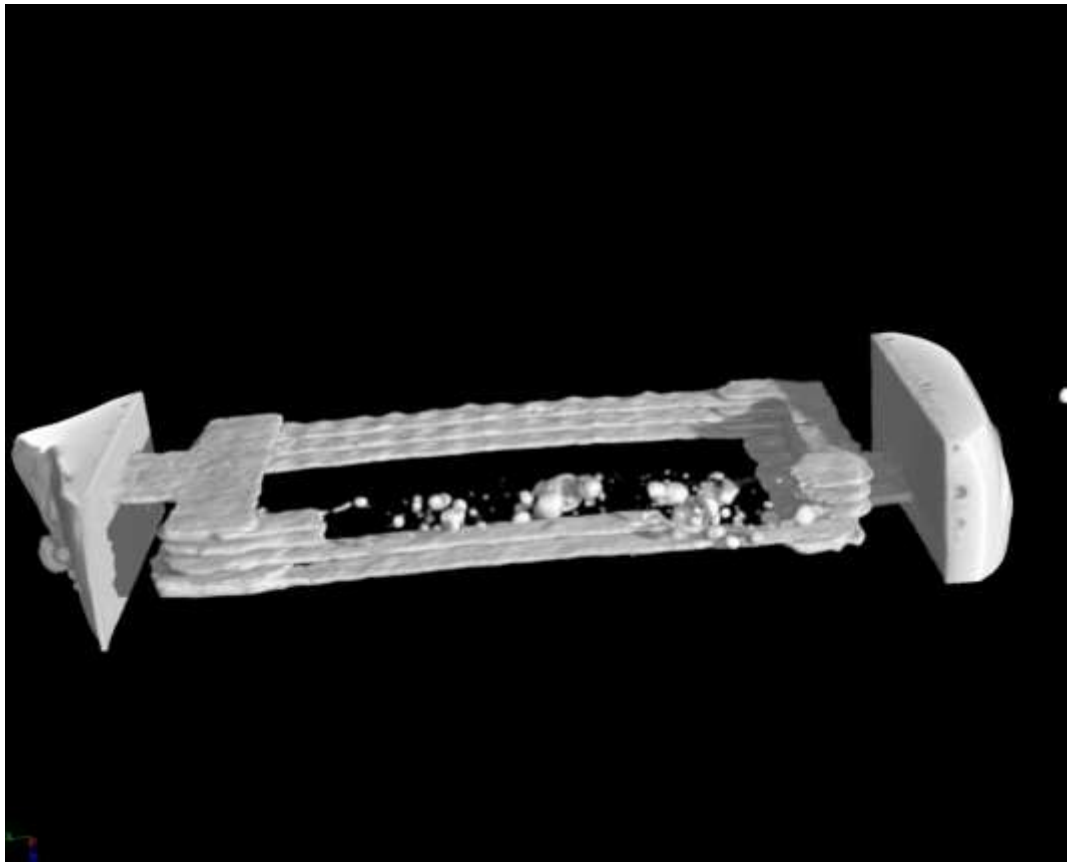
- **Multilayer Ferrite (0805)**
- **Beschädigung mit einem Pulse 1ms bei max. 40A Strom**

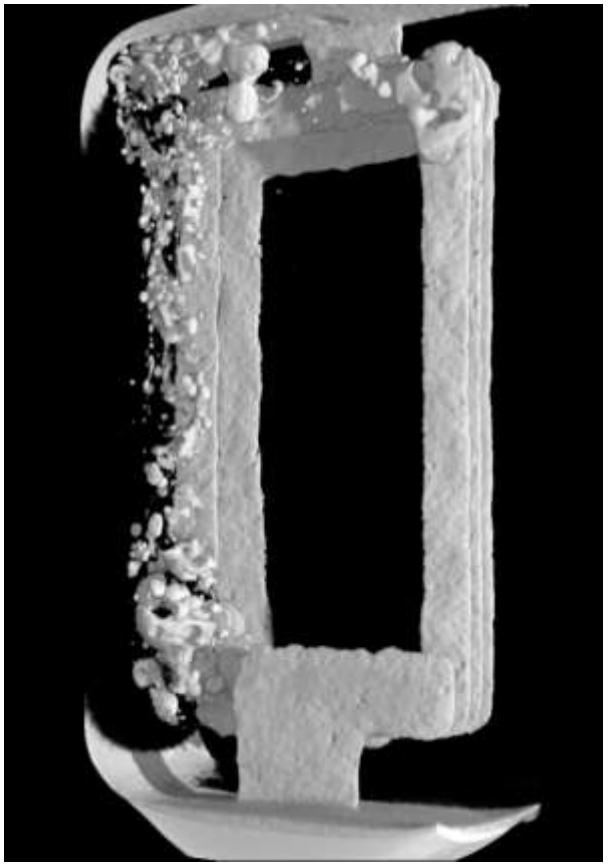




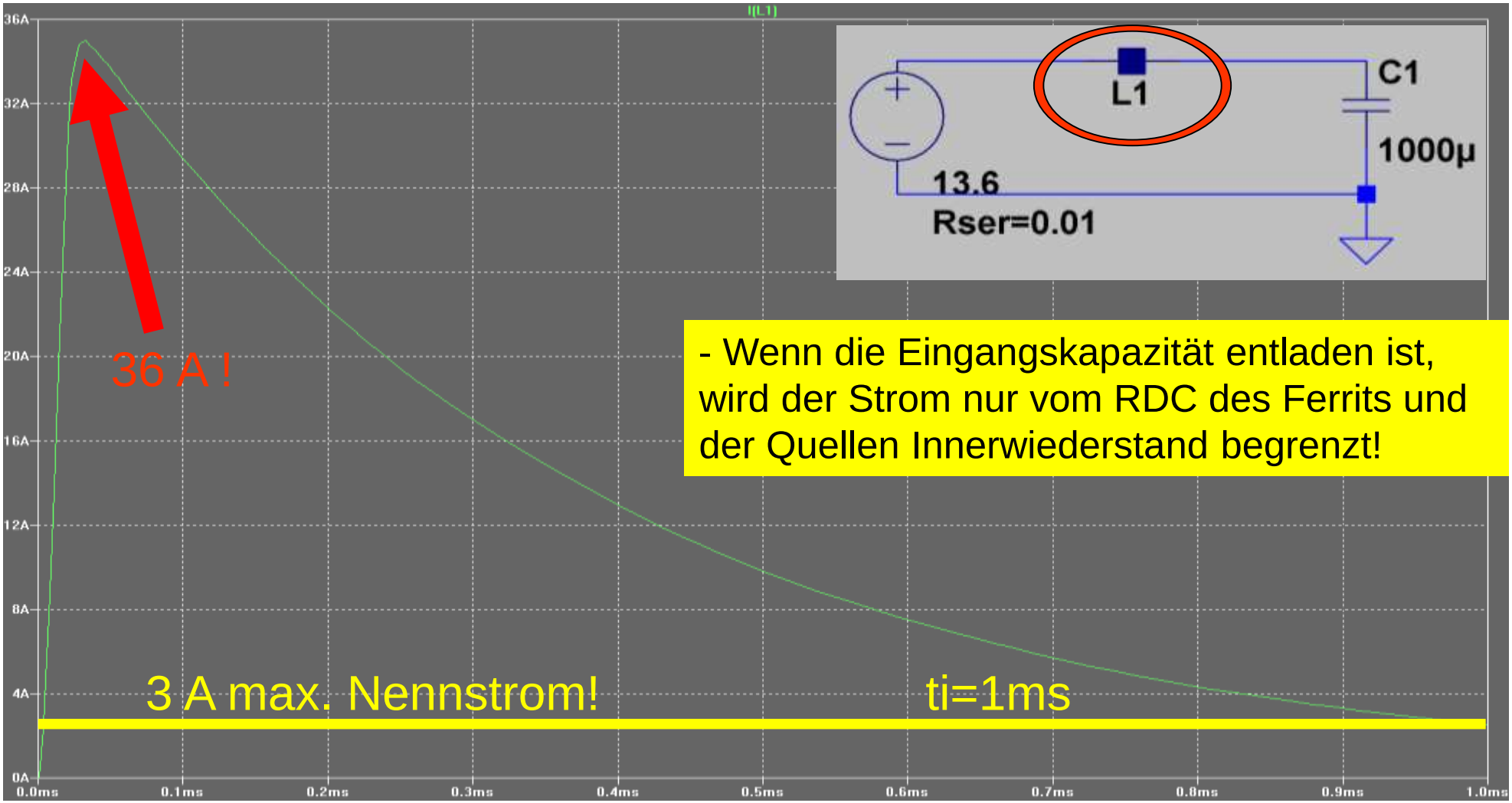
Einschaltstrom

- **Multilayer Ferrite (0805)**
- **Beschädigung mit einem Pulse 1ms bei max. 40A Strom**

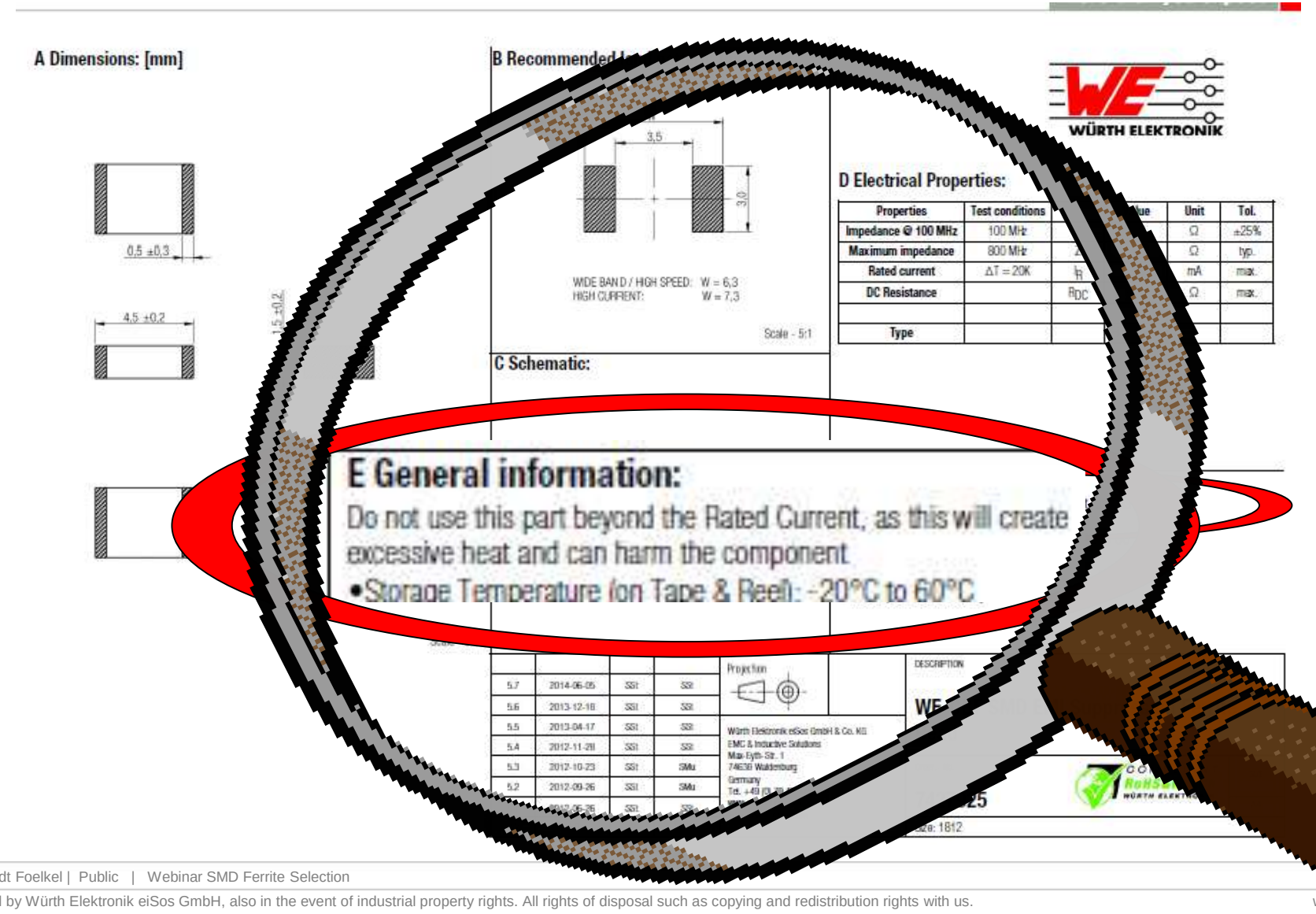




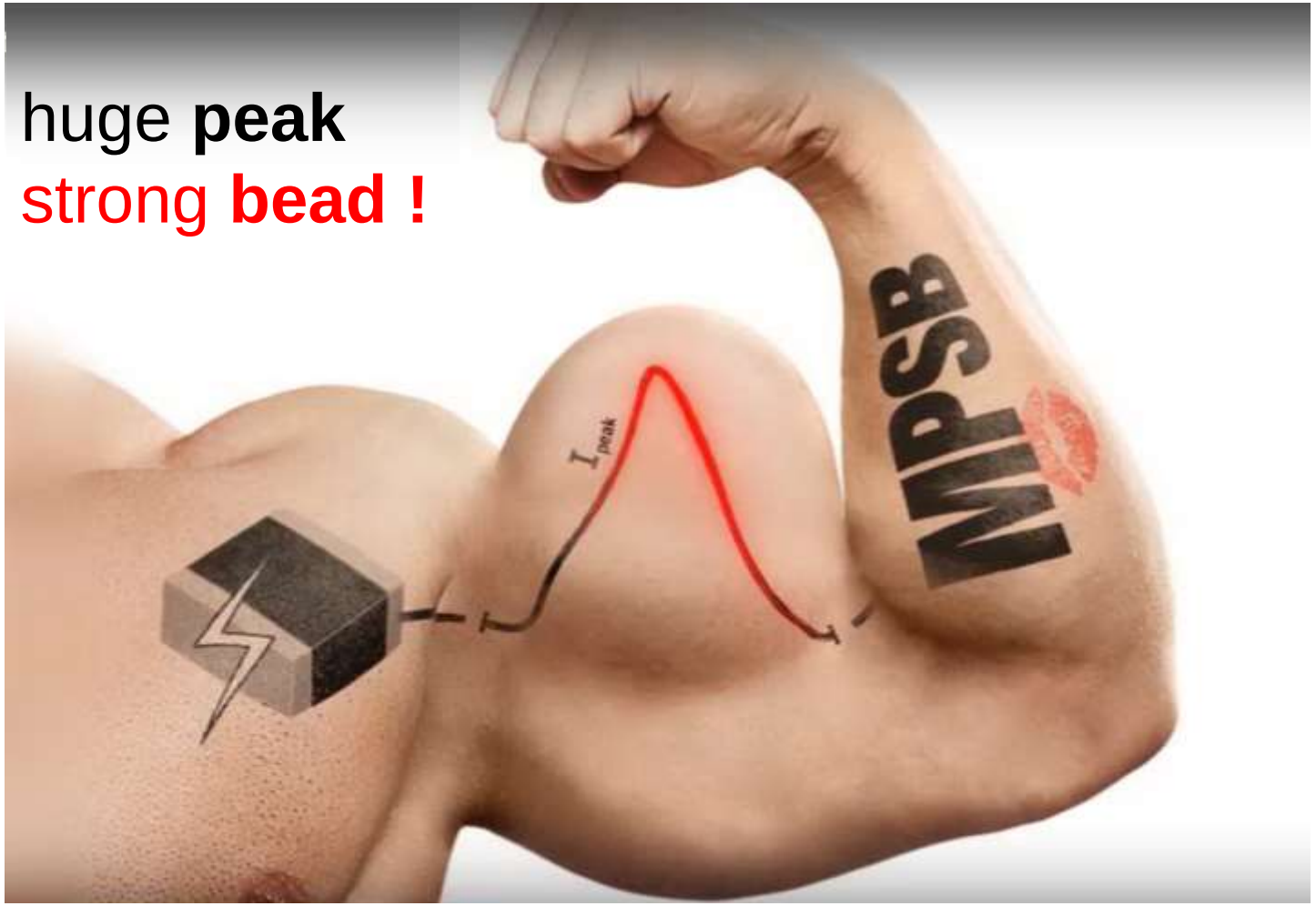
Einschaltstrom: Simulation



CBF Nennstrom im Datenblatt



MPSB ist die Lösung



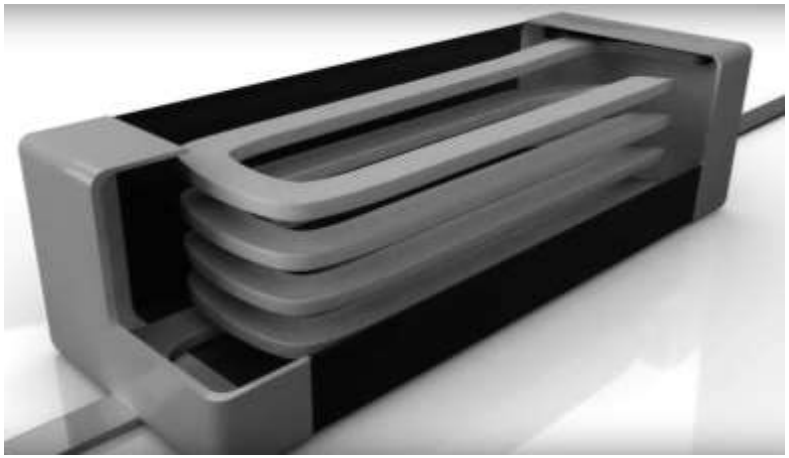
www.we-online.de/we-mpsb und www.we-online.com/we-mpsb

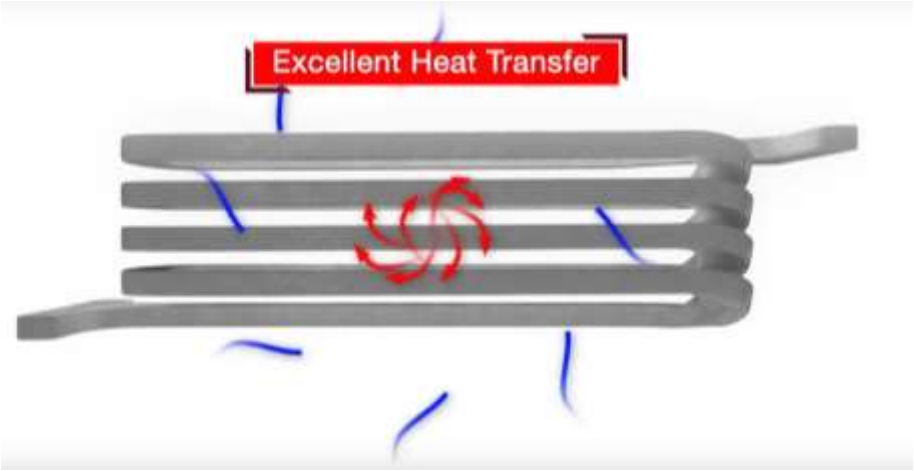
WE-MPSB Multilayer Power Suppression Bead

Size 0805

WE-MPSB Multilayer Power Suppression Bead

- Speziell entwickelte innere Layer und Pulsbelastbarkeit

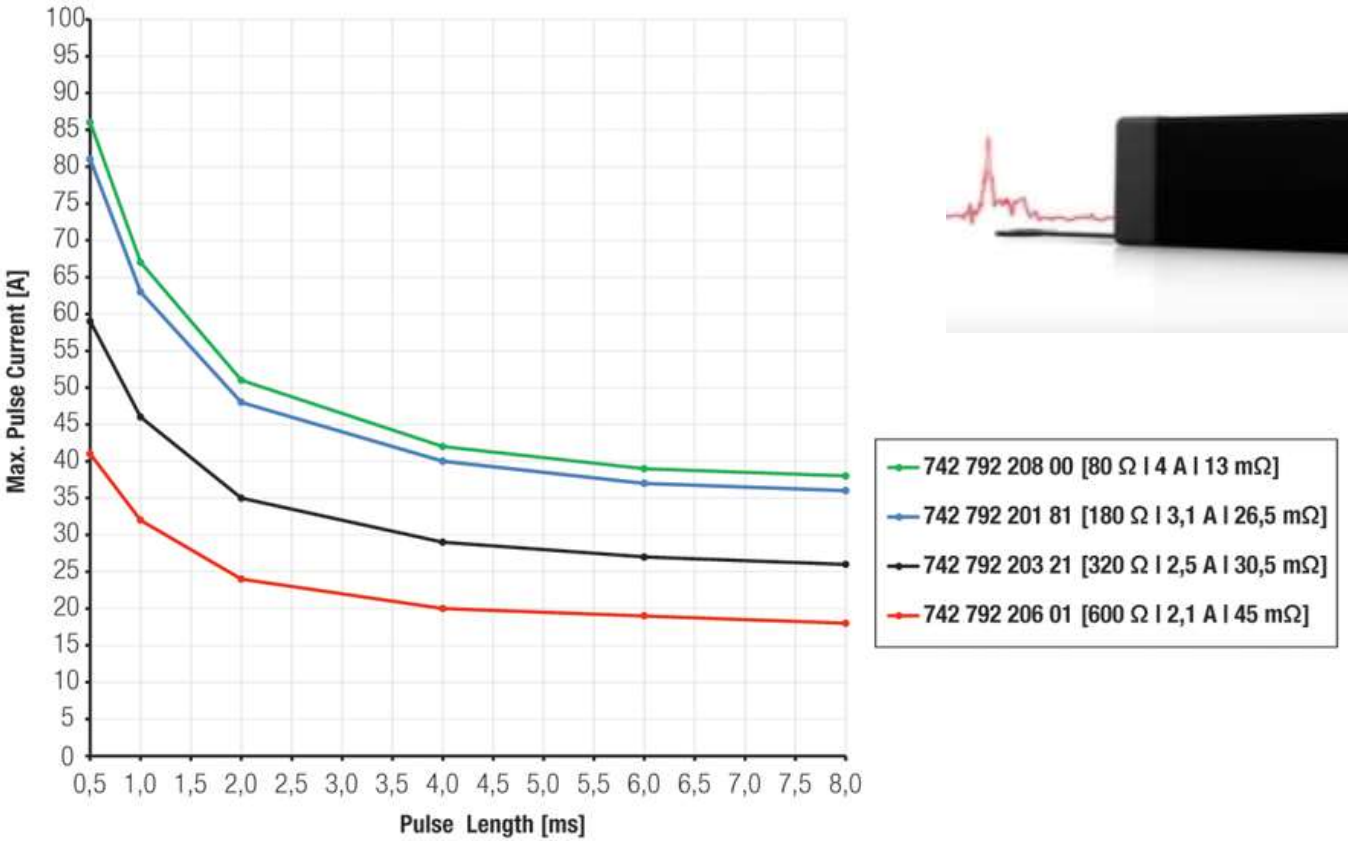




High Rated Current

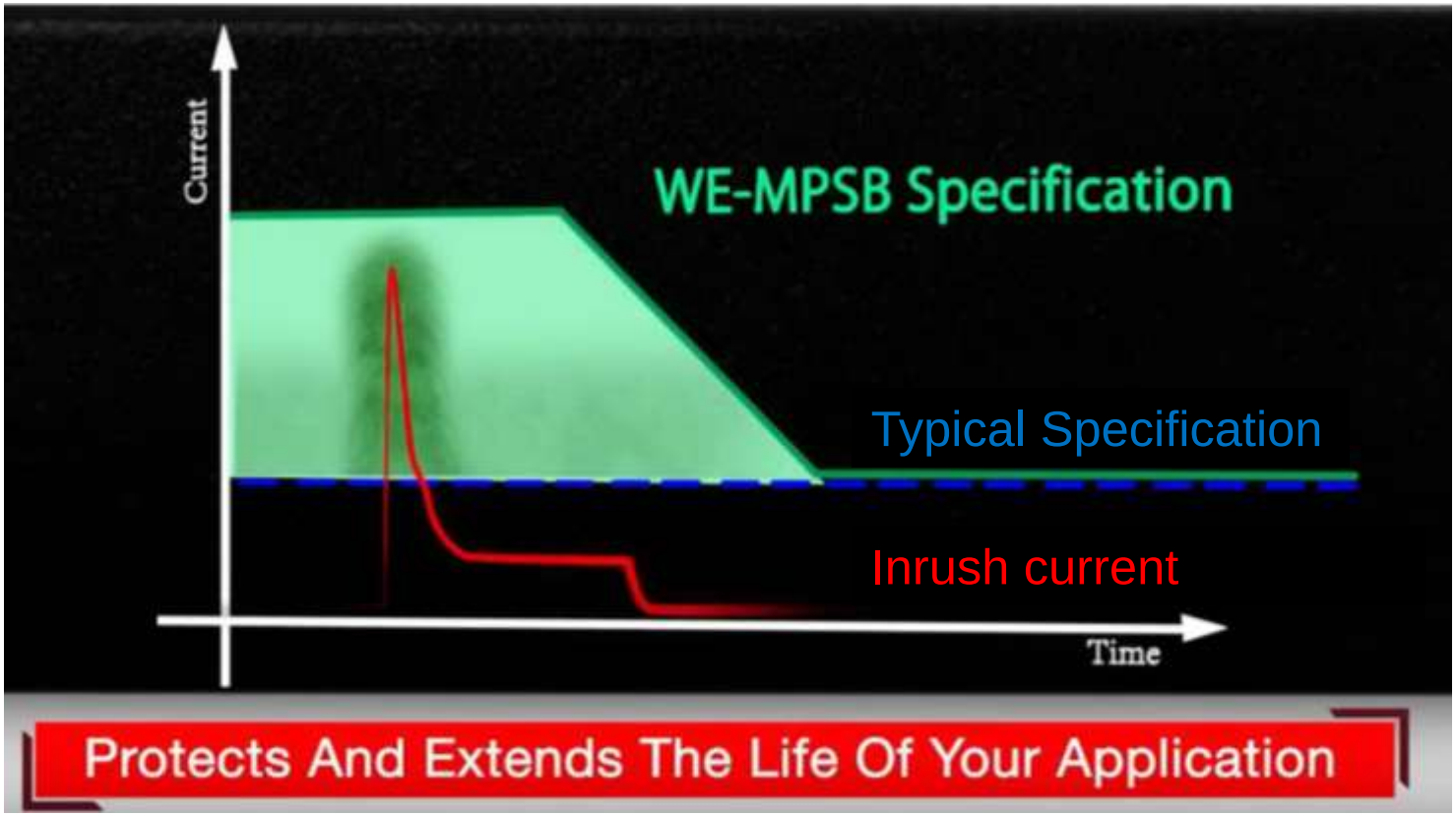
WE-MPSB Multilayer Power Suppression Bead

Current vs Pulse Length – Single Pulse – Size 0805



20 Times Higher Peak Current Rating

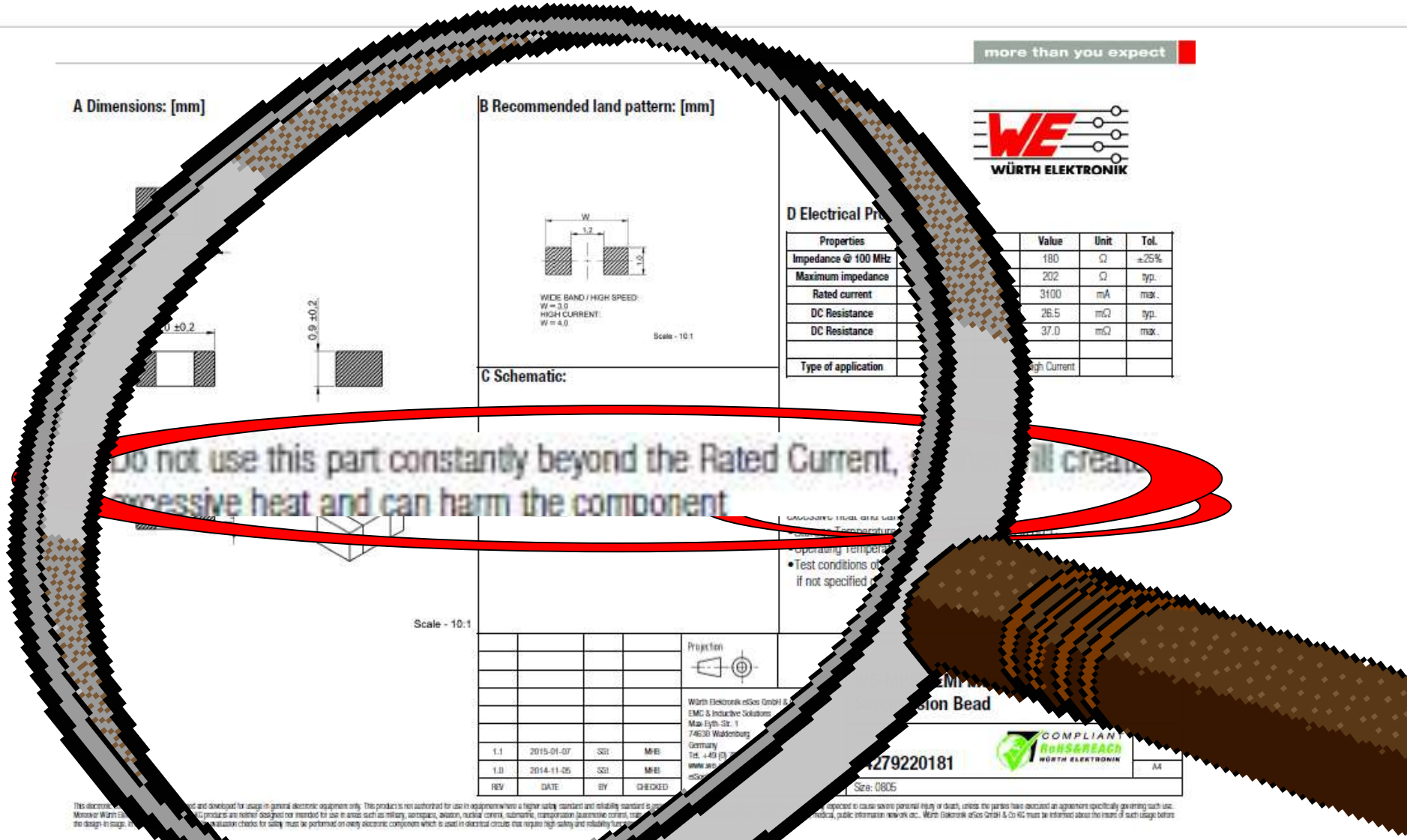
WE-MPSB Multilayer Power Suppression Bead



WE-MPSB Multilayer Power Suppression Bead

- **Strombelastbarkeitsmessungen:**

MPSB Nennstrom



WE-SUKW, WE-PBF

Vorteile:

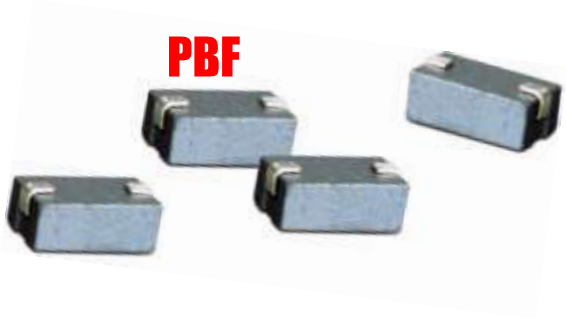
SUKW

D Electrical Properties:

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 25 MHz	25 MHz	Z	425	Ω	typ.
Impedance @ 100 MHz	100 MHz	Z	580	Ω	±25%
Rated current	ΔT= 40K	I_R	5.0	A	max.
DC Resistance	@ 20°C	R_{DC}	12	mΩ	max.

High impedance in lower frequency

PBF



D Electrical Properties:

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 25 MHz	25 MHz	Z	65	Ω	±25%
Impedance @ 100 MHz	100 MHz	Z	98	Ω	±25%
Rated current	ΔT= 40K	I_R	6.0	A	max.
DC Resistance		R_{DC}	0.9	mΩ	max.

Very low DCR

WE-PF Vorteile:

PF

D Electrical Properties:

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	1180	Ω	±25%
Maximum impedance	90 MHz	Z	2900	Ω	typ.
Rated current	ΔT= 40K	I_R	10.0	A	max.
DC Resistance		R_{DC}	0.009	Ω	max.

High impedance and high current

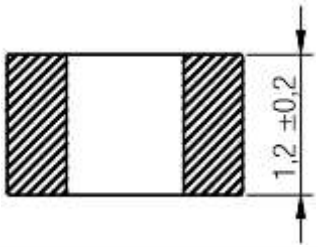
D Electrical Properties:

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	185	Ω	±25%
Maximum impedance	15 MHz	Z	15000	Ω	typ.
Rated current	ΔT= 40K	I_R	4.5	A	max.
DC Resistance		R_{DC}	0.030	Ω	max.

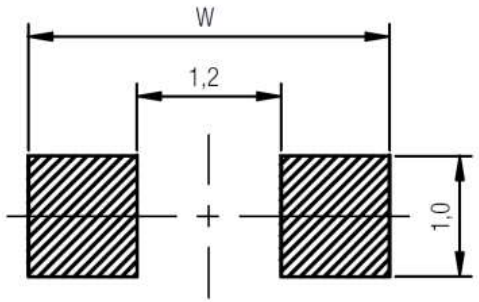
High impedance in very low Frequency

EMPFEHLUNGEN

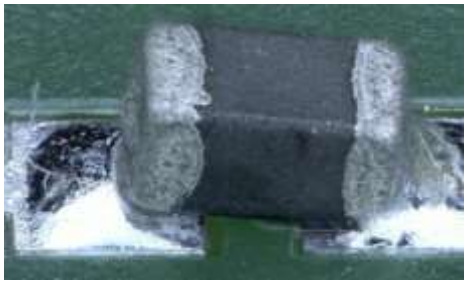
Land pattern Empfehlungen



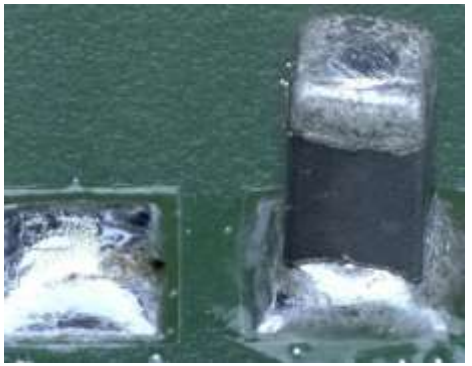
Land pattern (in mm)



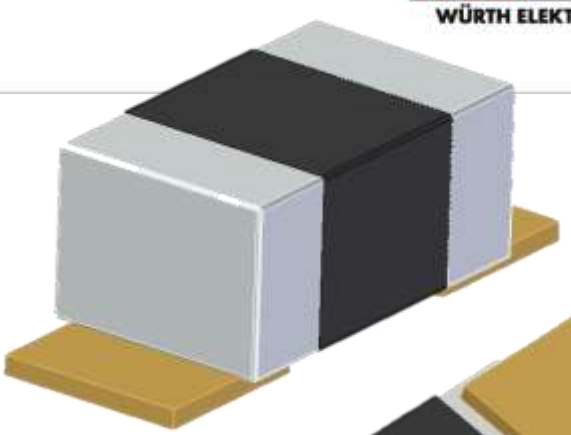
WIDE BAND / HIGH SPEED: W = 3,0
HIGH CURRENT: W = 4,0

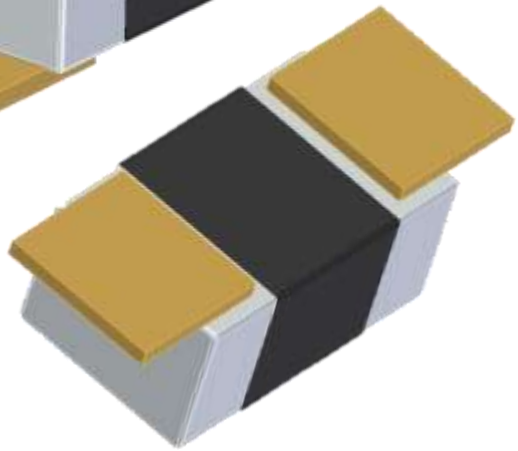


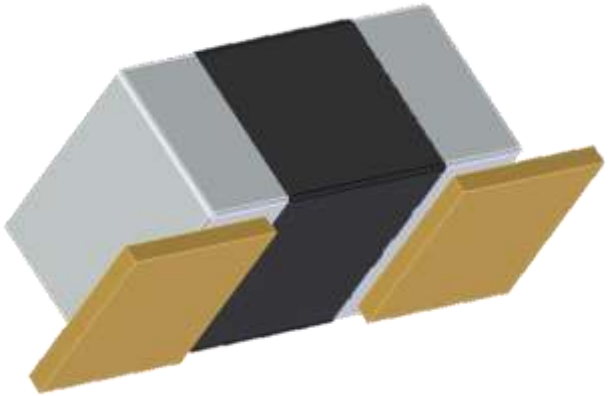
Kleiner Tombstone Effekt



Voller Tombstone Effekt

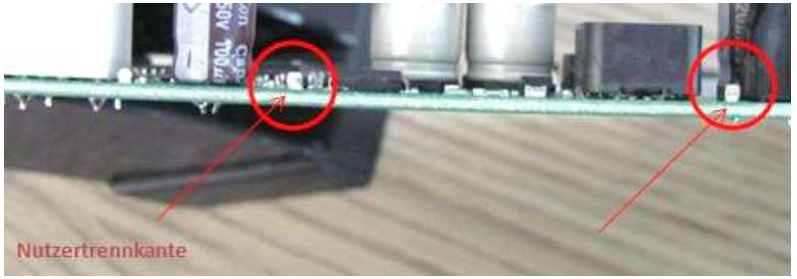






Empfehlungen – Biege Stress

- **Biege Stress auf dem PCB**
  - **Es wird nicht empfohlen CBF an folgende Positionen zu platzieren:**
    - **Am Rand des PCBs**
    - **Nah an Konnektoren**
- **Empfehlung:**
  - **Orientierung des Ferrits senkrecht zur Biege-Richtung der Karte**



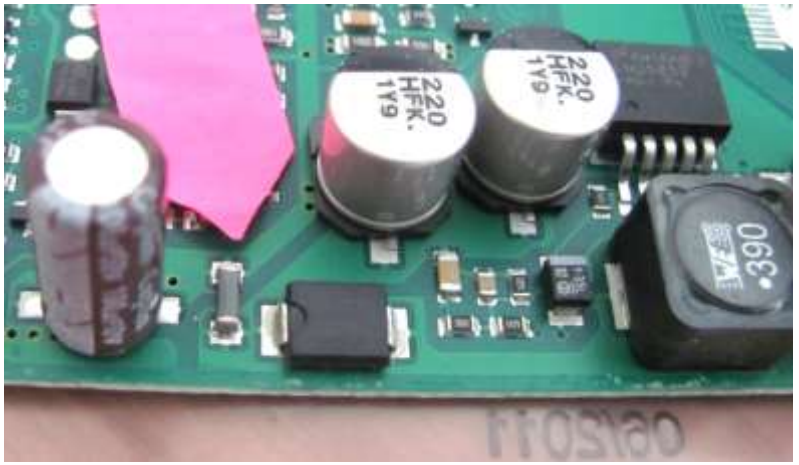


Bild Quelle: WE PM & TQM

Mechanischer Bruch eines SMD Ferrits verursacht durch Trennung des PCB Nutzens

Empfehlungen – Biege Stress

- **Biege Stress**
  - **Unterbrechung / Open circuit**

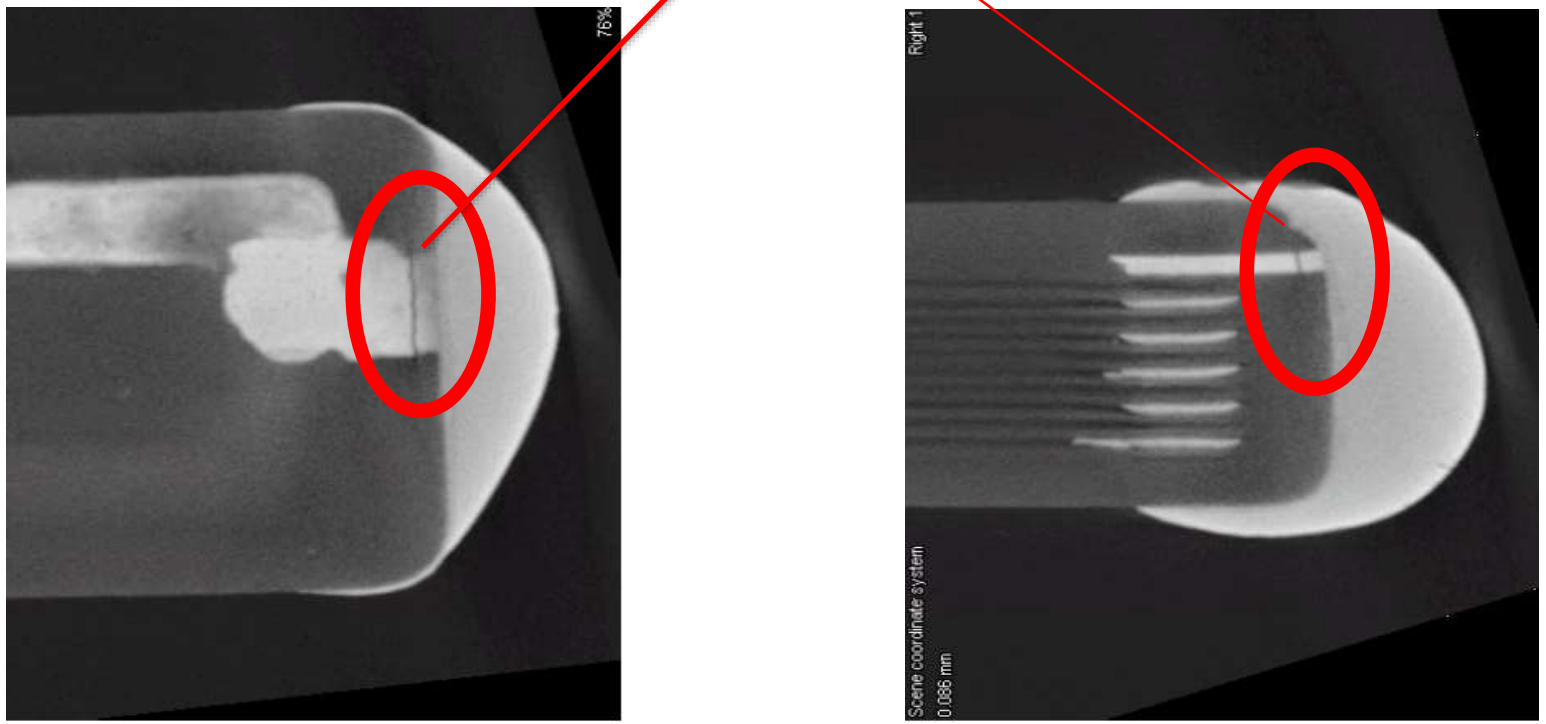
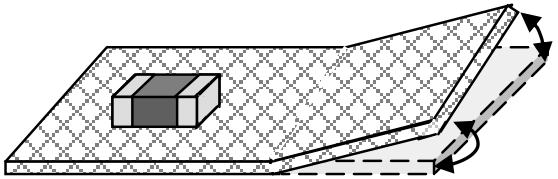
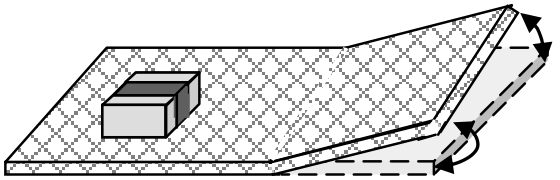
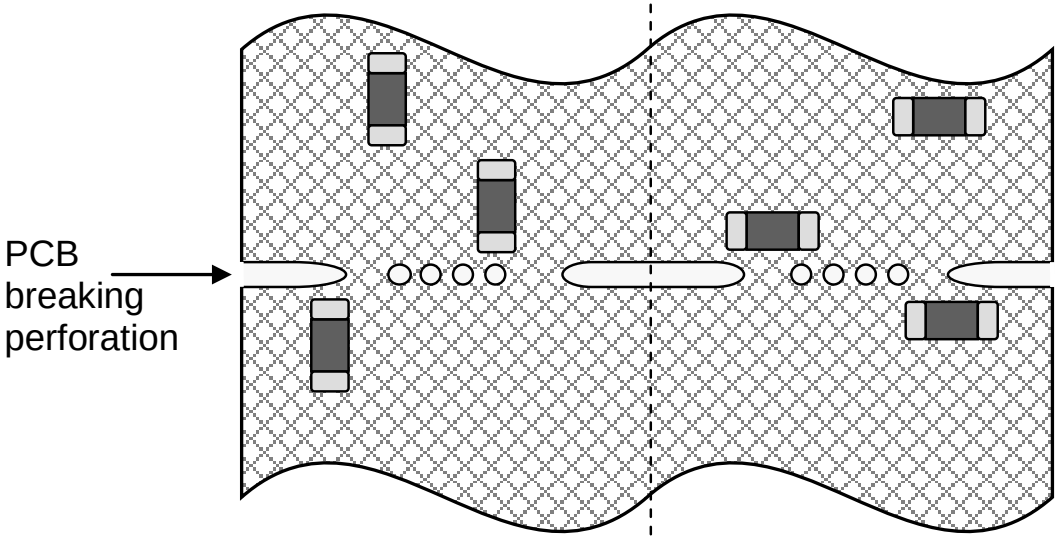


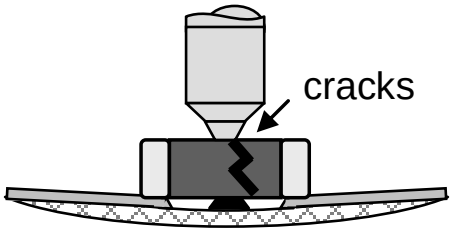
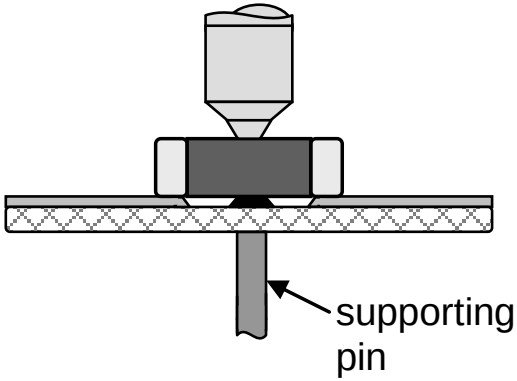
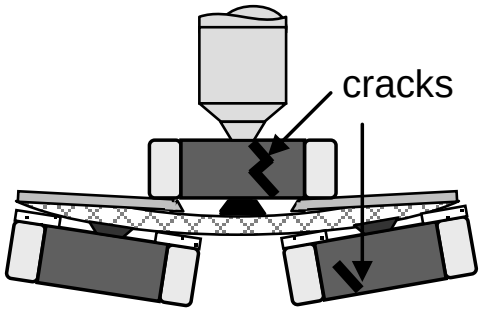
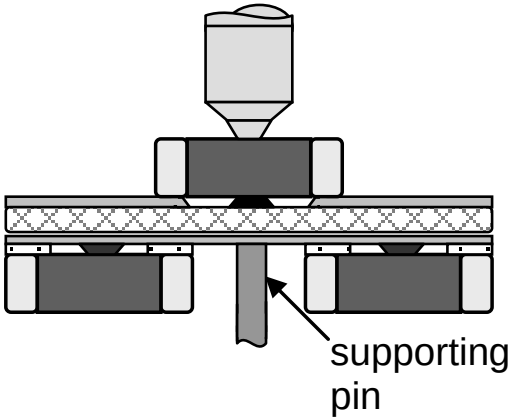
Bild Quelle: TQM Department

Biegen

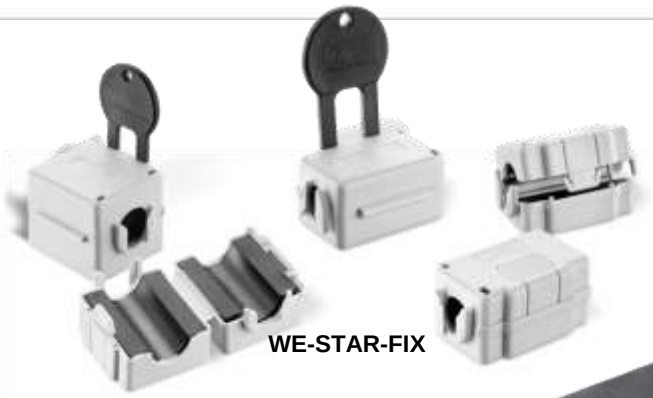
Not recommended	Recommended
	



Montage

	Not recommended	Recommended
Single – sided mounting		
Double – sided mounting		

Auswahl EMV Ferrite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WE-STAR-BUENO


WE-SFA


WE-FLAT


WE-RIB


WE-UKW


WE-WAFB

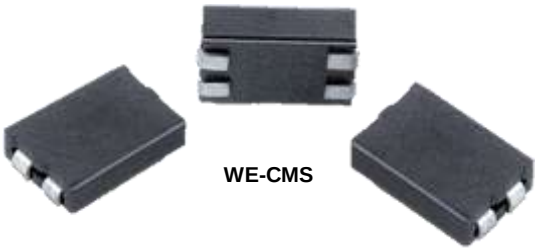

WE-MLS


WE-PBF


WE-CBF / WE-MPSB


WE-PF


WE-SUKW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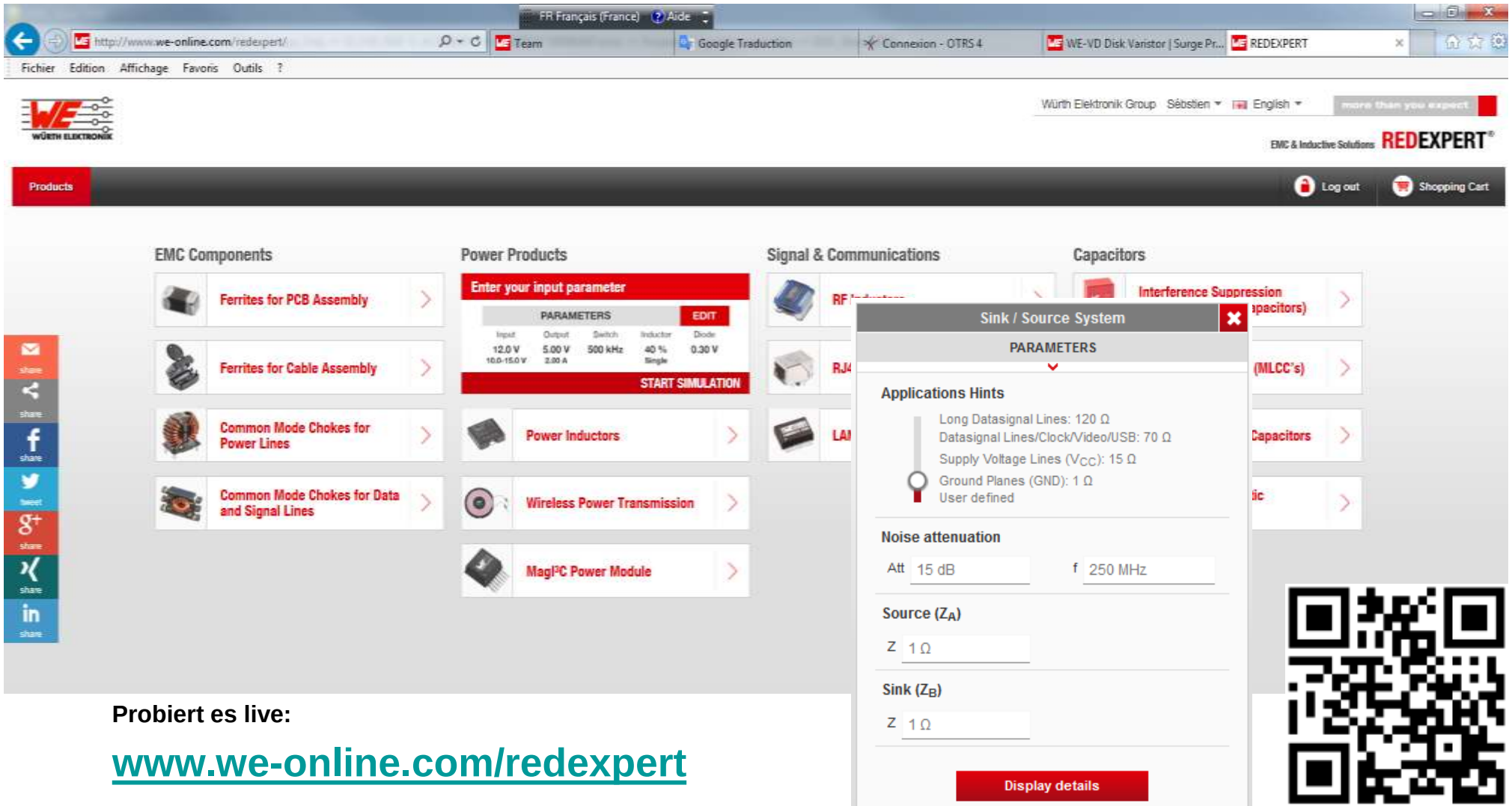

Probiert es live:

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Trilogie der induktiven Bauelemente

- 1. LTspice Buch
  → Anwendungshandbuch für Simulationen in LTspice IV
- 2. Trilogie der induktiven Bauelemente
  → Applikationshandbuch für EMV-Filter, getaktete Stromversorgungen & HF-Schaltungen
- 3. Trilogie der Steckverbinder
  → Applikationshandbuch zur optimierten Steckverbinderauswahl
- 4. ABC der Power Module
  → Funktionsweise, Aufbau und Handling eines Power Modules
- 5. ABC der Kondensatoren
  →Grundlagen, Kenngrößen und Kondensatortypen

Labor Musterregal & Design Kits

Technical support needed?

Ask our design engineer Lorandt Fölkel

WÜRTH ELEKTRONIK

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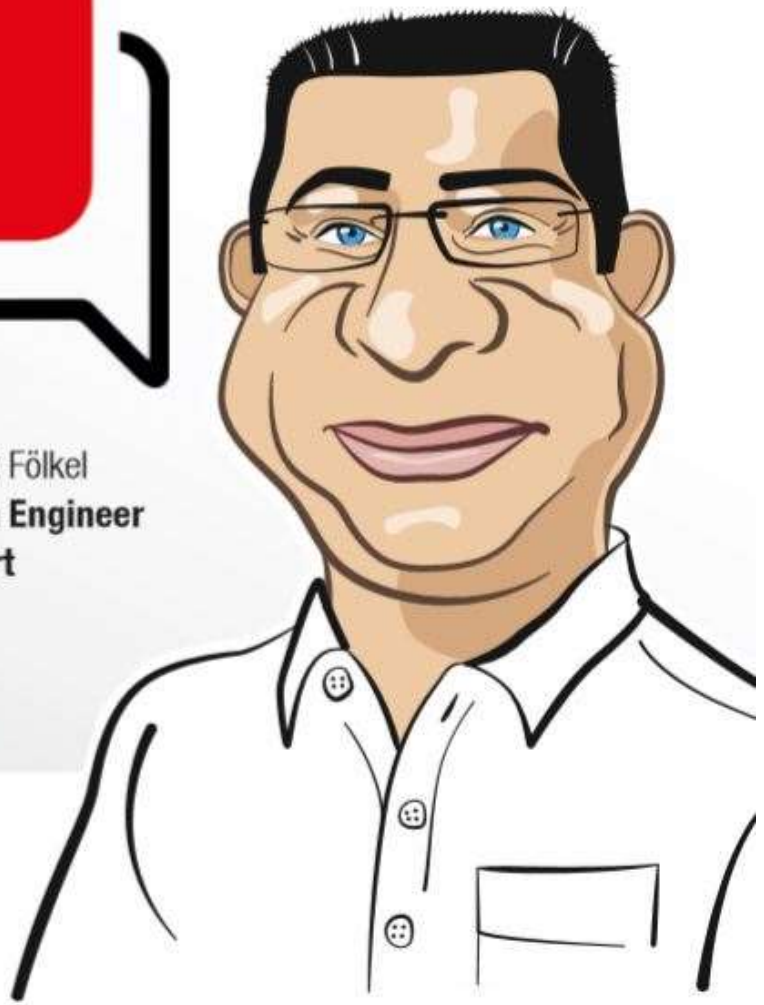

Lorandt Fölkel
Design Engineer at heart

or contact me directly:
askLorandt@we-online.com