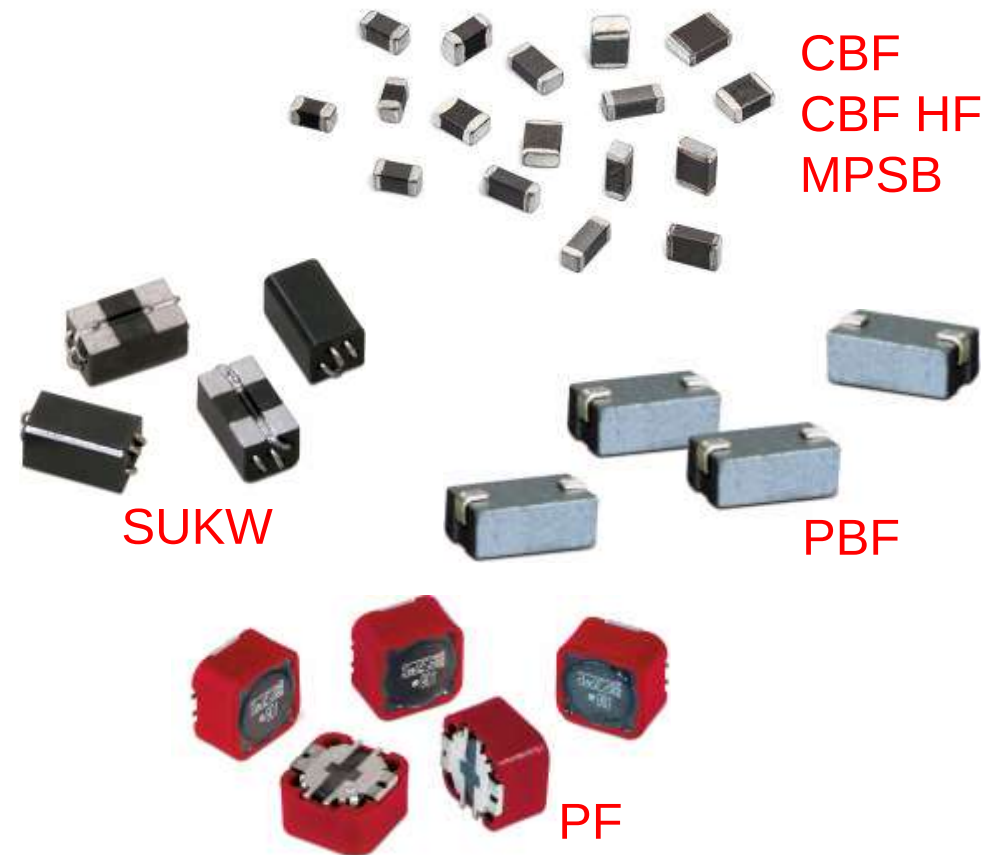


A collection of various electronic components, including resistors, capacitors, integrated circuits, and connectors, arranged on a red and white checkered surface. The components are scattered across the frame, with some larger components like a transformer and a large capacitor in the foreground, and many smaller components like resistors and capacitors in the background. The checkered surface is a red and white diamond pattern, creating a sense of depth and perspective. The components are of various shapes and sizes, representing a wide range of electronic parts.

lorandt.foelkel@we-online.de

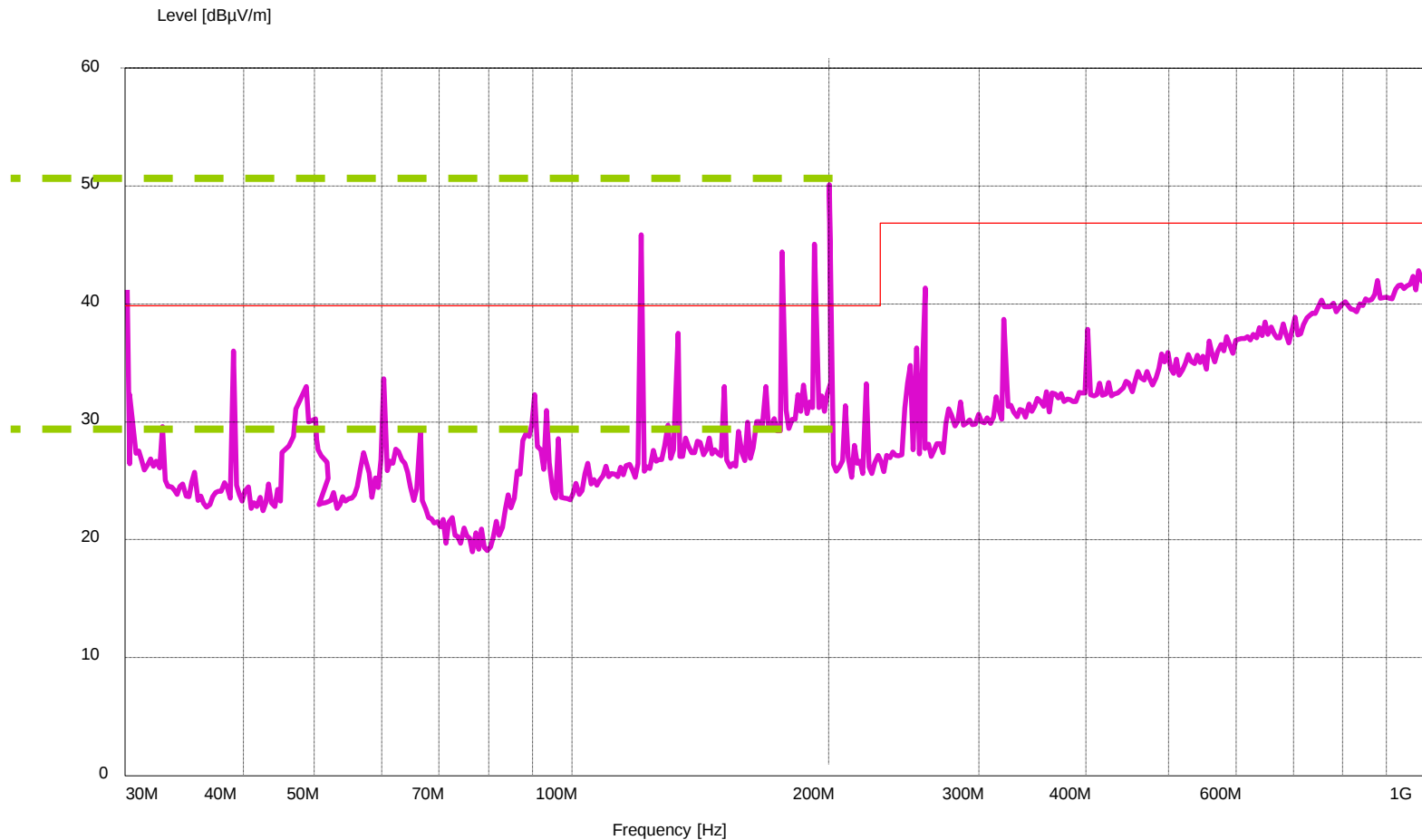
AGENDA

- **Filter Topologien mit SMD Ferriten**
 - Impedanz
 - Applikation
- **Datenleitungen**
 - Berechnen
 - Elektrische Parameter
- **Stromversorgung**
 - Klassifizierung
 - Elektrische Parameter
 - DC bias Einfluss
 - Pulse Strombelastbarkeit
- **Tools**
- **Layout Empfehlungen**



EMV Ergebnisse aus dem Labor

→ Gestrahlte Emission





FILTER TOPOLOGIE - IMPEDANZ

Filter Topologien

Quelle Impedanz

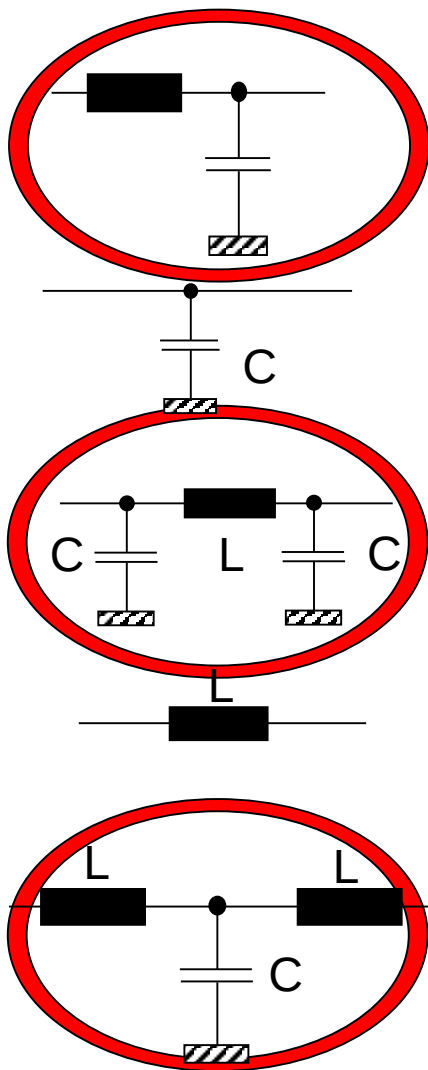
niedrig

hoch

hoch oder
unbekannt

niedrig

niedrig
oder
unbekannt



Senke Impedanz

hoch

hoch

hoch oder
unbekannt

niedrig

niedrig
oder
unbekannt

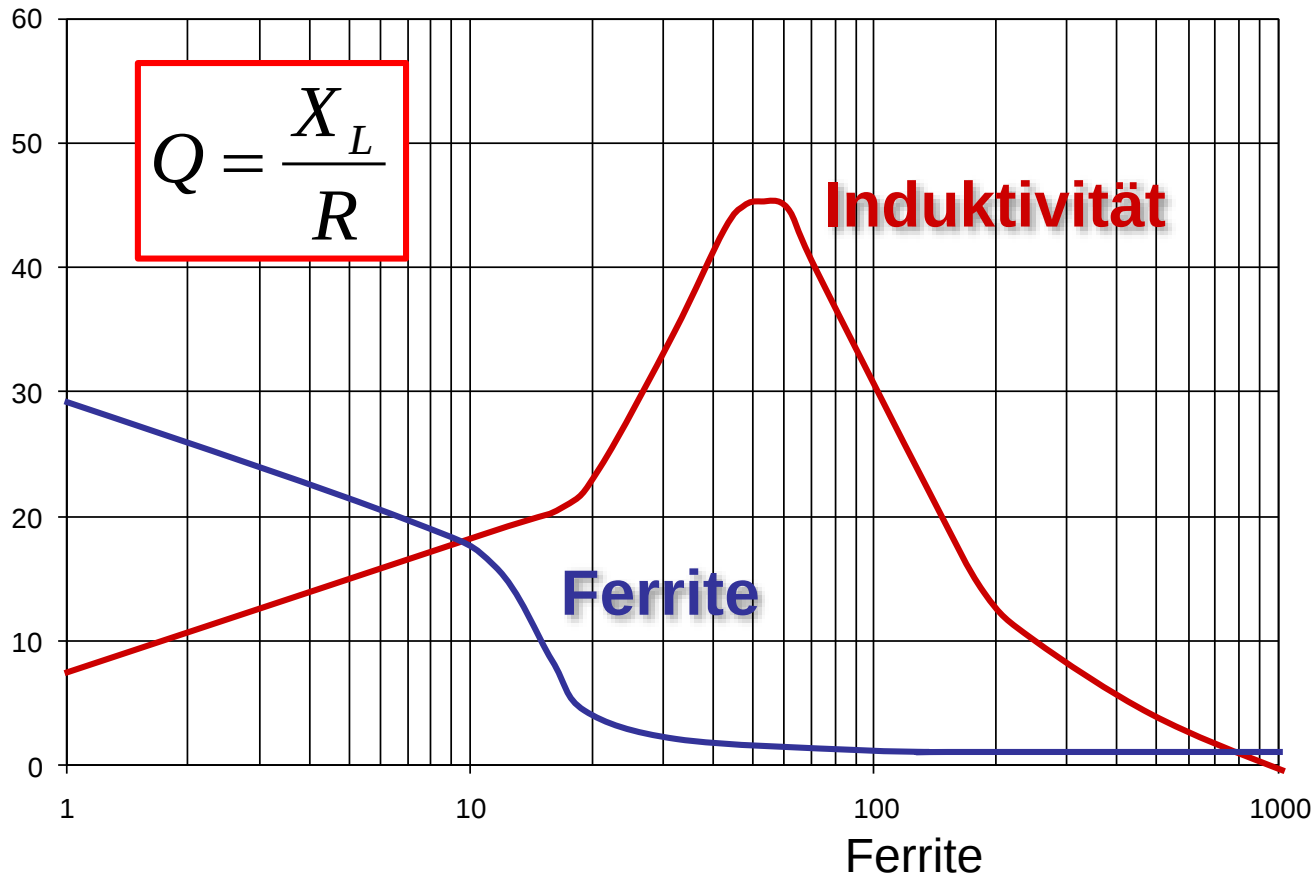
→ kleine C = höhere SRF

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

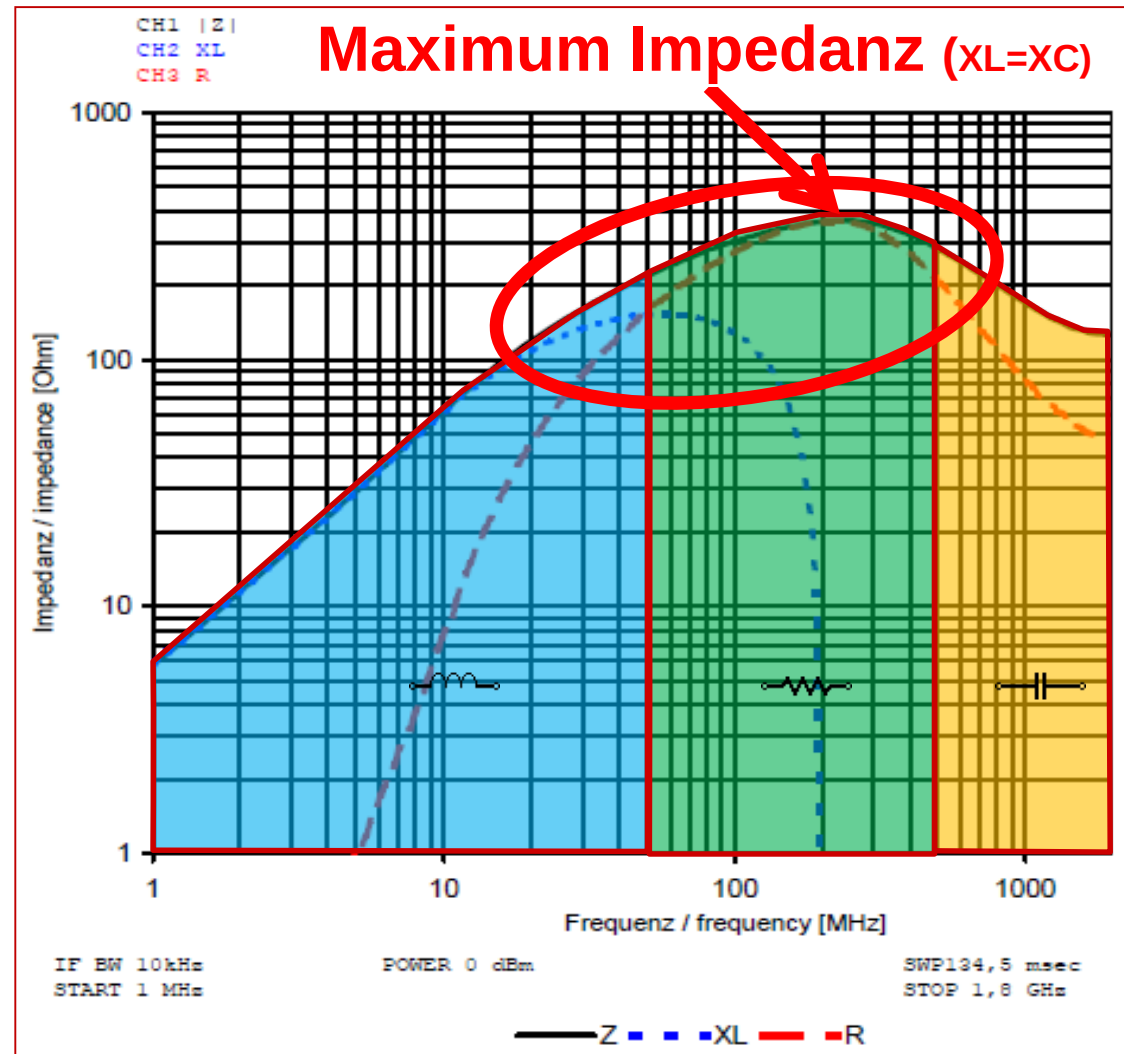
Anforderung: Hohe Kern Verluste
(KLEINE Q)

Wandelt Störungsenergie in Wärme um:
"Frequenz Abhängige Resistor"

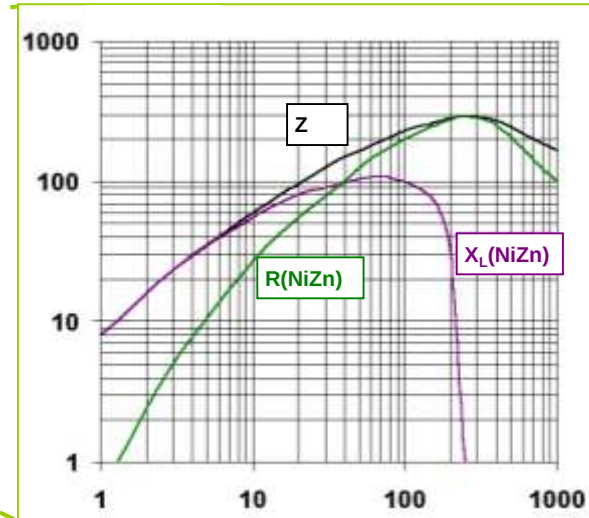


Ferrit Impedanz

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

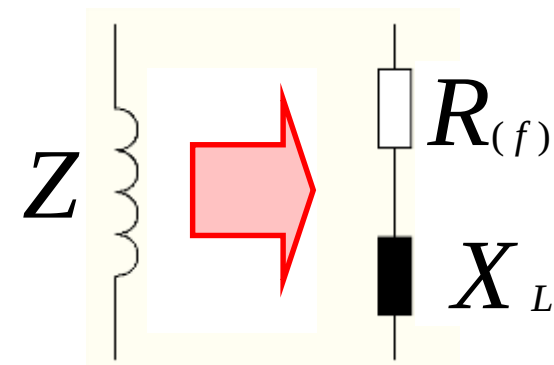


Ferrit Impedanz : Messung



Kernmaterial Parameter

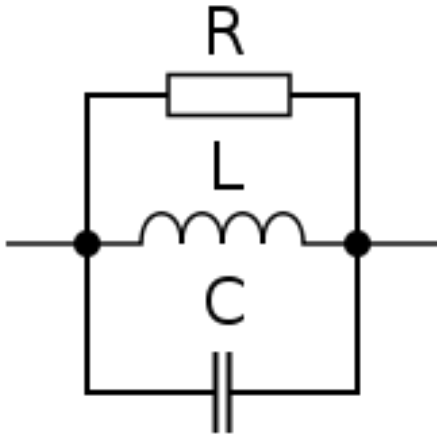
Ersatzschaltbild



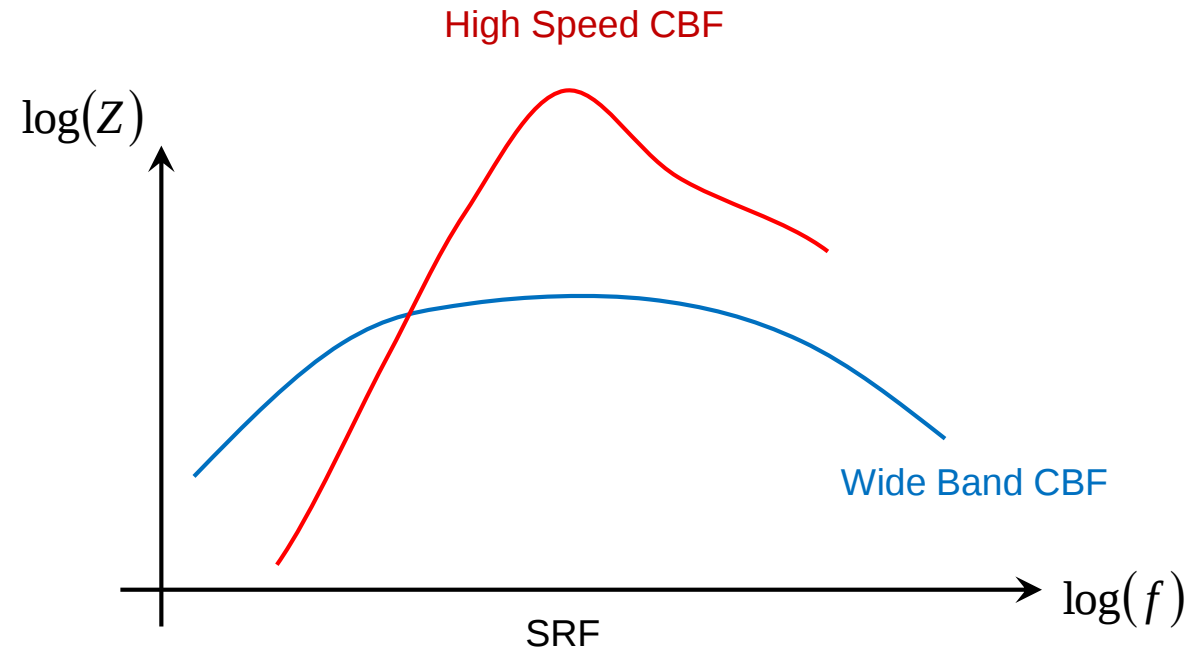
$$Z = \sqrt{R_{(f)}^2 + X_L^2}$$

SMD Ferrite: Ersatzschaltbild

Ersatzschaltbild für CBF



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

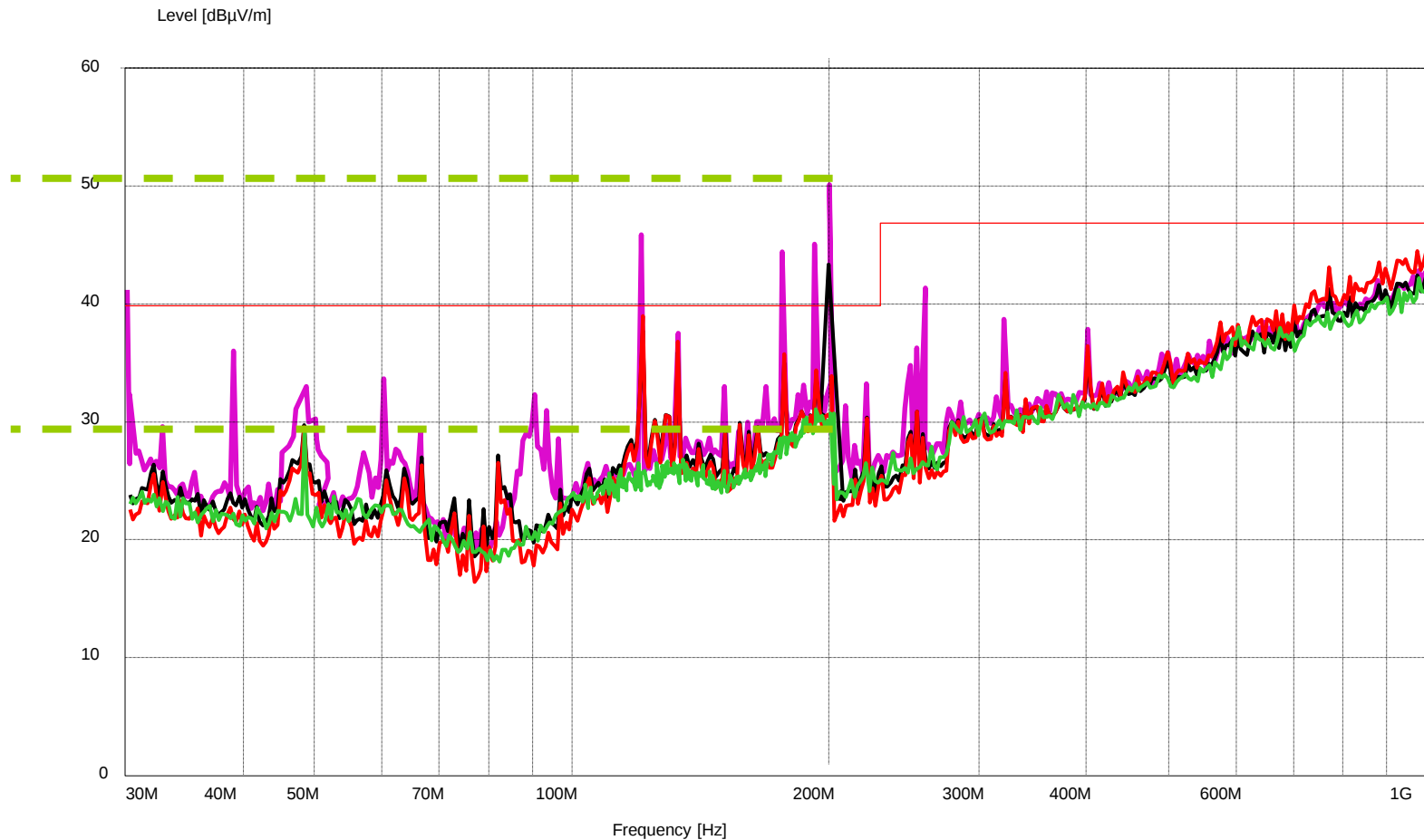




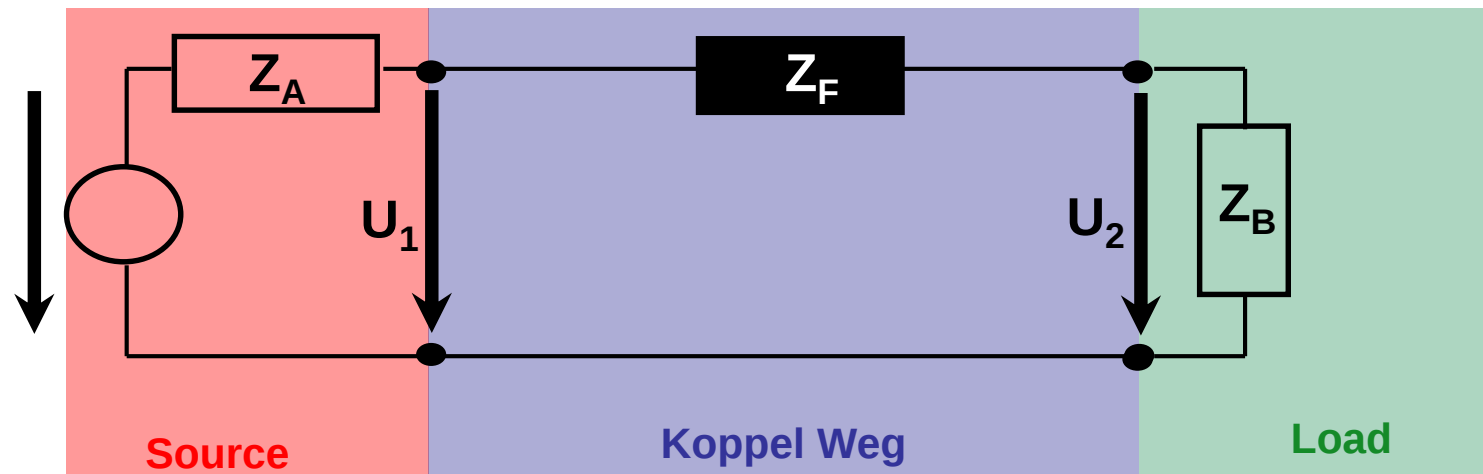
APPLIKATIONEN

EMV Ergebnisse aus dem Labor

→ Ergebnisse vergleichen



Einfügedämpfung vs. Impedanz



■ Einfügedämpfung

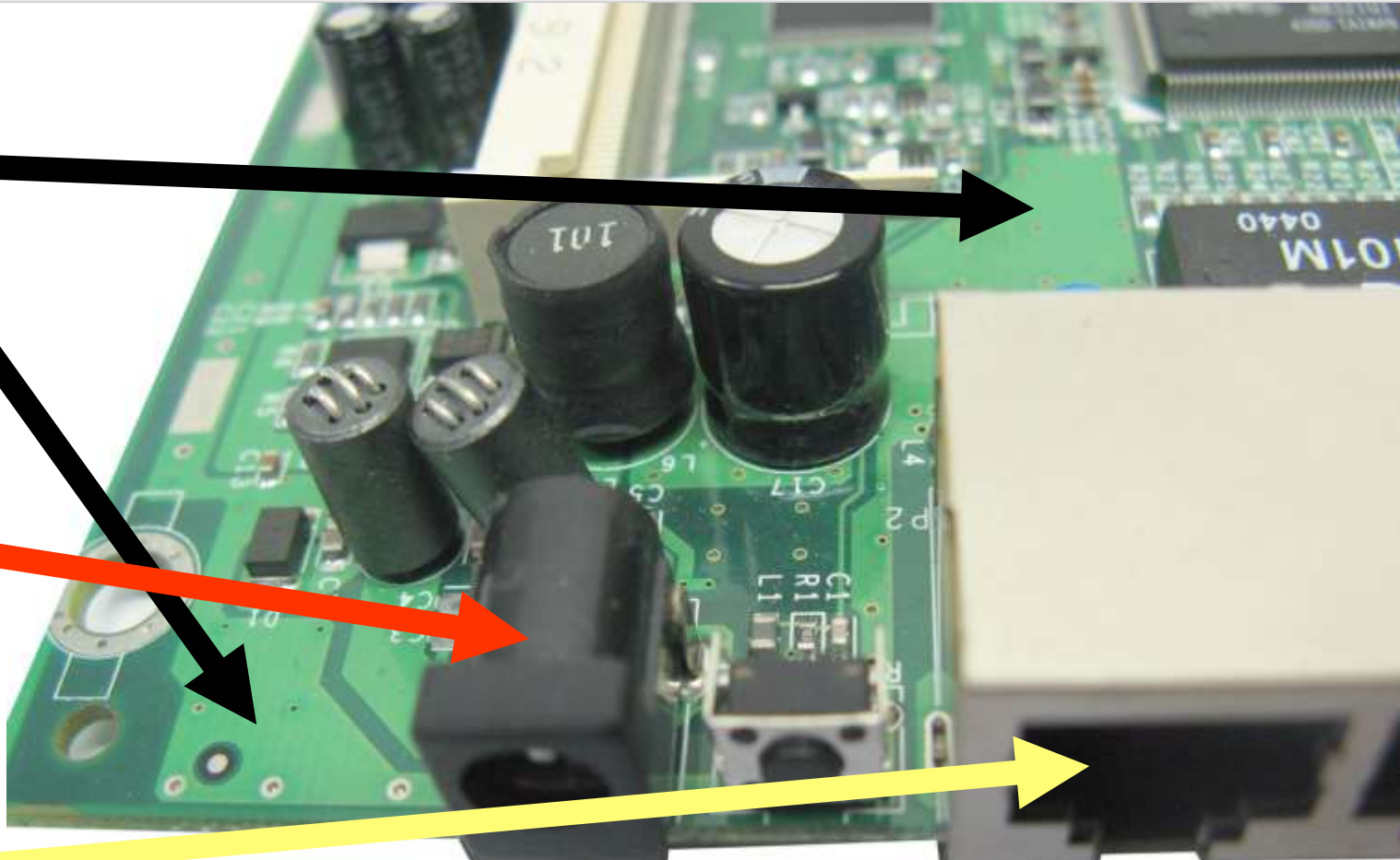
$$A = 20 \cdot \log \frac{Z_A + Z_F + Z_B}{Z_A + Z_B} \quad \text{in (dB)}$$

Praktische Werte

1 Ω

10 Ω

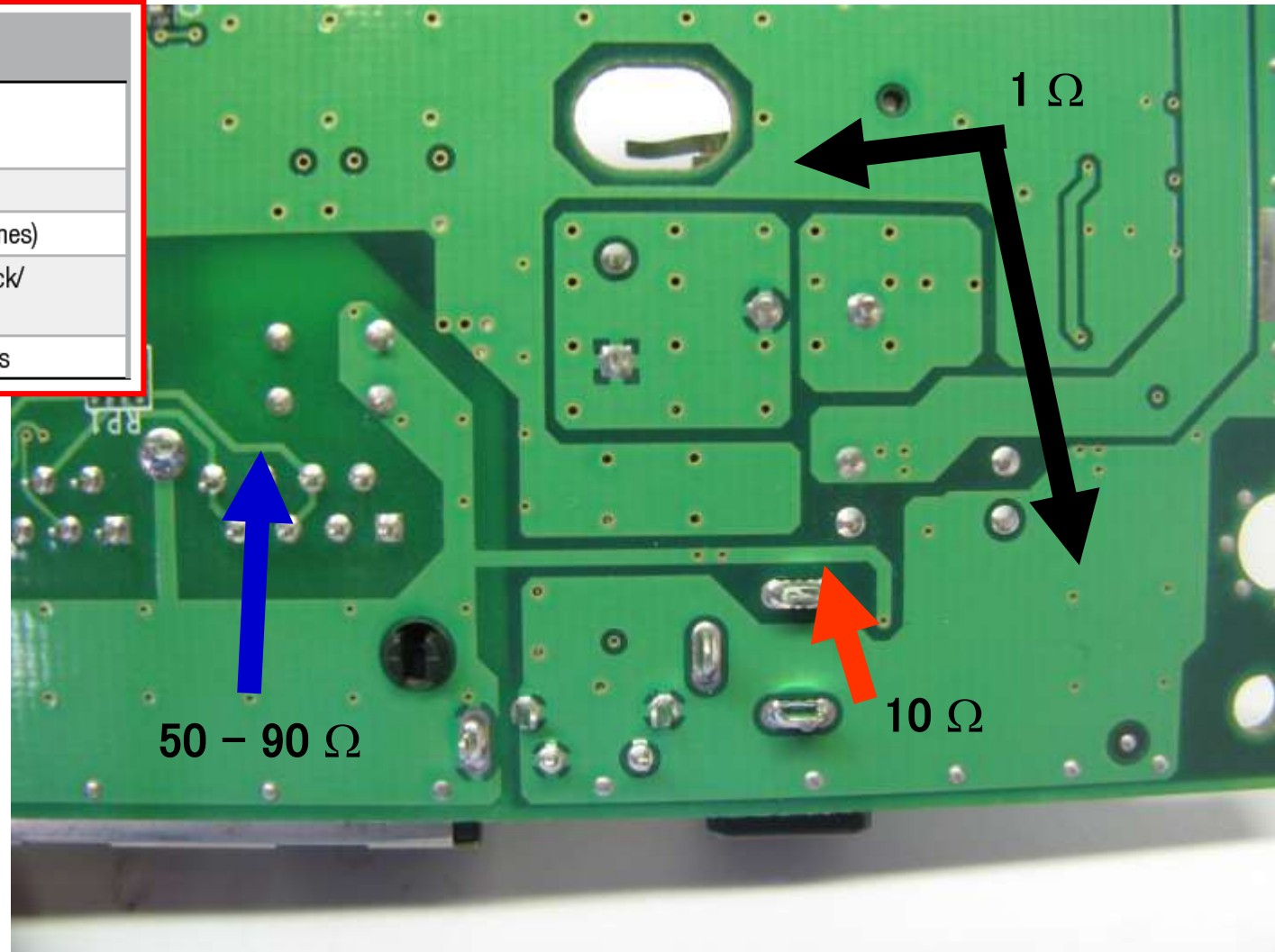
>90 Ω



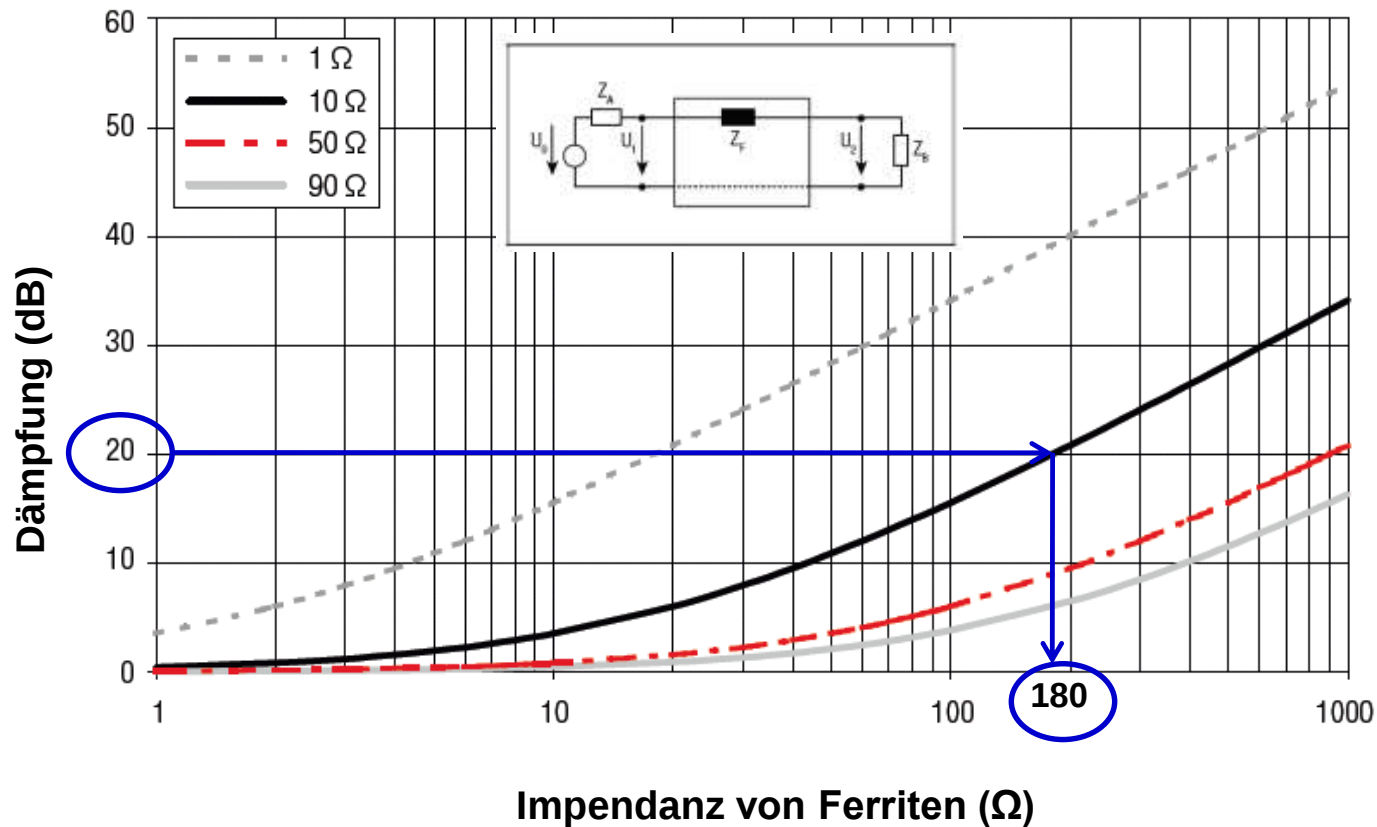
Praktische Werte

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 Spannungsversorgungskabel kommt
 3. Spannungsversorgung hat ca. 10 Ω Impedanz
- Resultat: Minimum Impedanz liegt bei 180 Ω

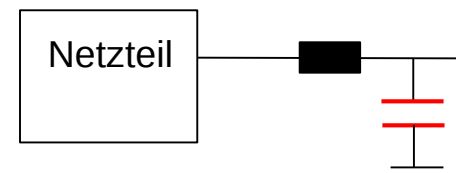
Applikationen

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



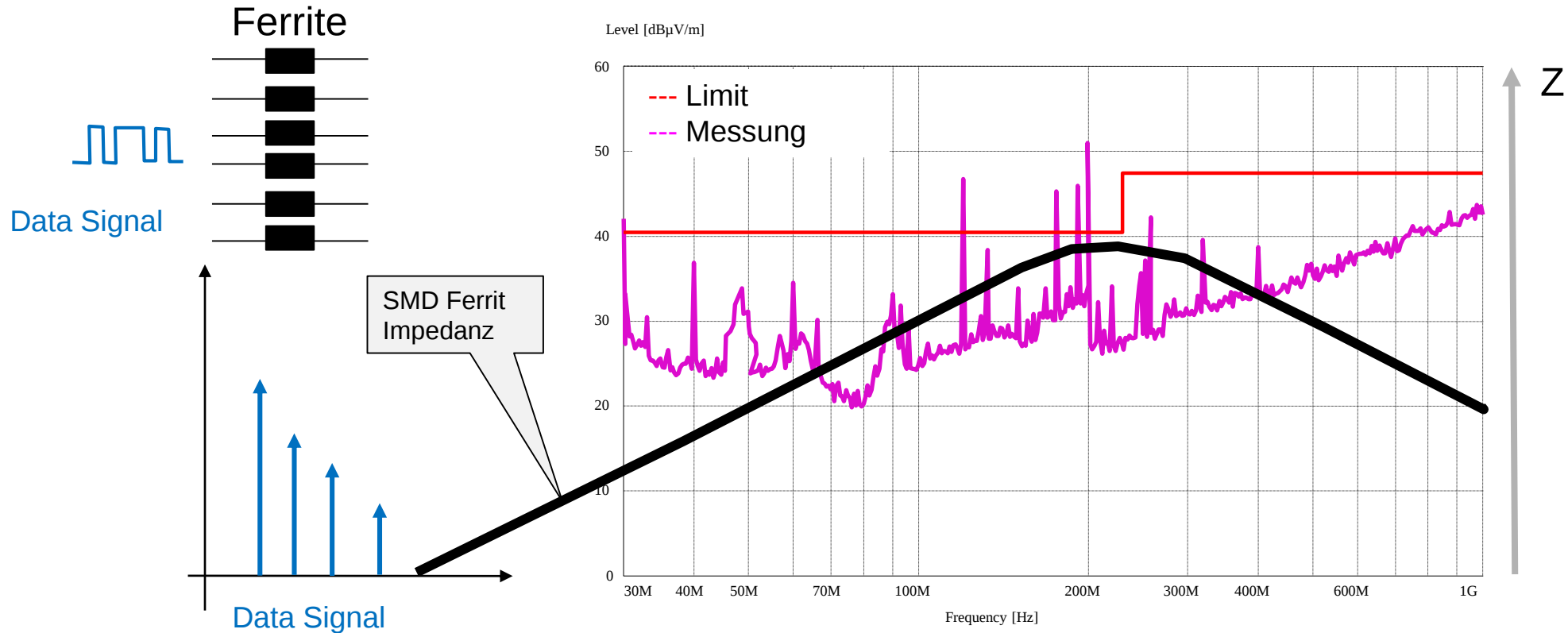


FERRITSELEKTION FÜR DATENLEITUNGEN



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

CBF		High Speed	Wide Band	High Current		CBF
	Haupteinsatz	Datenleitungen	Datenleitung / Spannungsversorgung	Spannungsversorgung	Haupteinsatz	
	μ r	50 - 80	200 - 250	200 - 250	μ r	
	Nennstrom I_r [mA]	100 - 700	50 - 500	1000 - 6000	Nennstrom I_r [mA]	
	I_r Testcondition [ΔK]	20	20	40	I_r 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	
CBF HF	Anwendungen	Filterschaltungen, USB 2.0, USB 3.0, HDMI, IEEE (Fire Wire) Rundfunk, CB Funk, TV, DAB	Filterschaltungen, RS232, RS422, Navigation, Industrieller Funk DC/DC Konverter für geringe Ströme	Filterschaltungen, DC/DC Konverter für Ströme bis 6A, USB Spannungsversorgung	Anwendungen	CBF HF
	Anzahl an Katalogartikeln	54	53	52	Anzahl an Katalogartikeln	
	Haupteinsatz	Datenleitungen	Datenleitung / Spannungsversorgung	Spannungsversorgung	Haupteinsatz	
	μ r	50 - 80	200 - 250	200 - 250	μ r	
CBF HF	Nennstrom I_r [mA]	100	50 - 500	500 - 600	Nennstrom I_r [mA]	CBF HF
	I_r Testcondition [ΔK]	20	20	40	I_r 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	$\pm 25\%$
Maximum impedance	400 MHz	Z	200	Ω	typ.
Rated current	$\Delta T = 20K$	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:
 $\Delta T = 20K$ Eigenerwärmung

CBF HF – High Speed

D Electrical Properties: 742862160

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	600	Ω	$\pm 25\%$
Impedance @ 1 GHz	1 GHz	Z	850	Ω	min.
Maximum impedance	700 MHz	Z	1700	Ω	typ.
Rated current	$\Delta T = 20K$	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	$\pm 25\%$
Impedance @ 1 GHz	1 GHz	Z	1100	Ω	min.
Maximum impedance	550 MHz	Z	2200	Ω	typ.
Rated current	$\Delta T = 20K$	I_R	50	mA	max.
DC Resistance		R_{DC}	1.80	Ω	max.
Type			Wide Band		

1GHz Impedanz

Beispiel: Langsame Datensignale

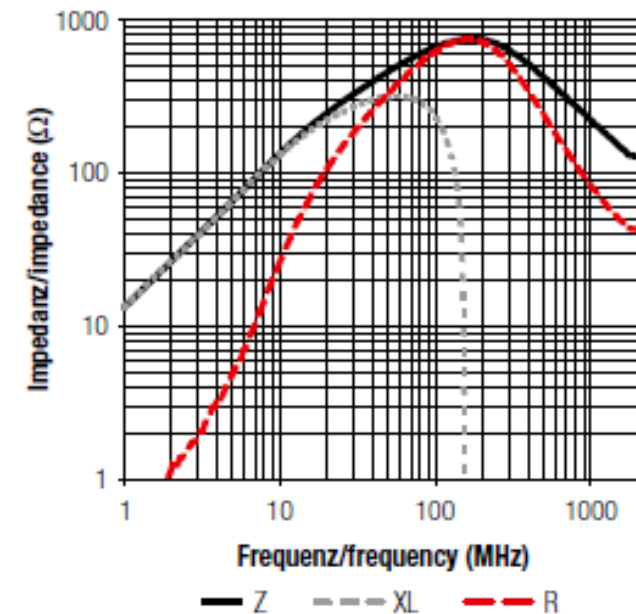
- RS232/RS485: 75 bits/sec – 115200 bits/sec (slow speed)
 - z.B. Einwahlmodem (14.4k / 56k)



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



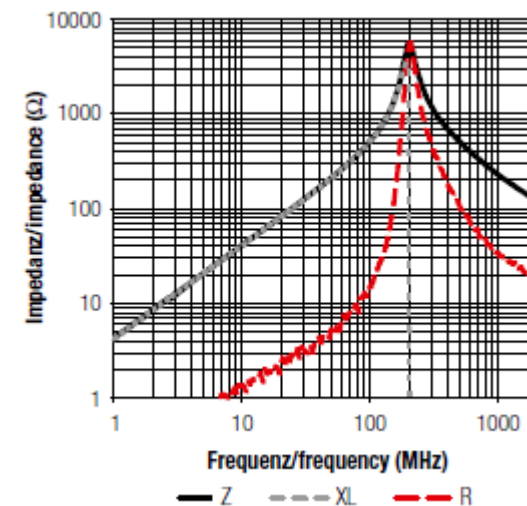
Wide Band CBF



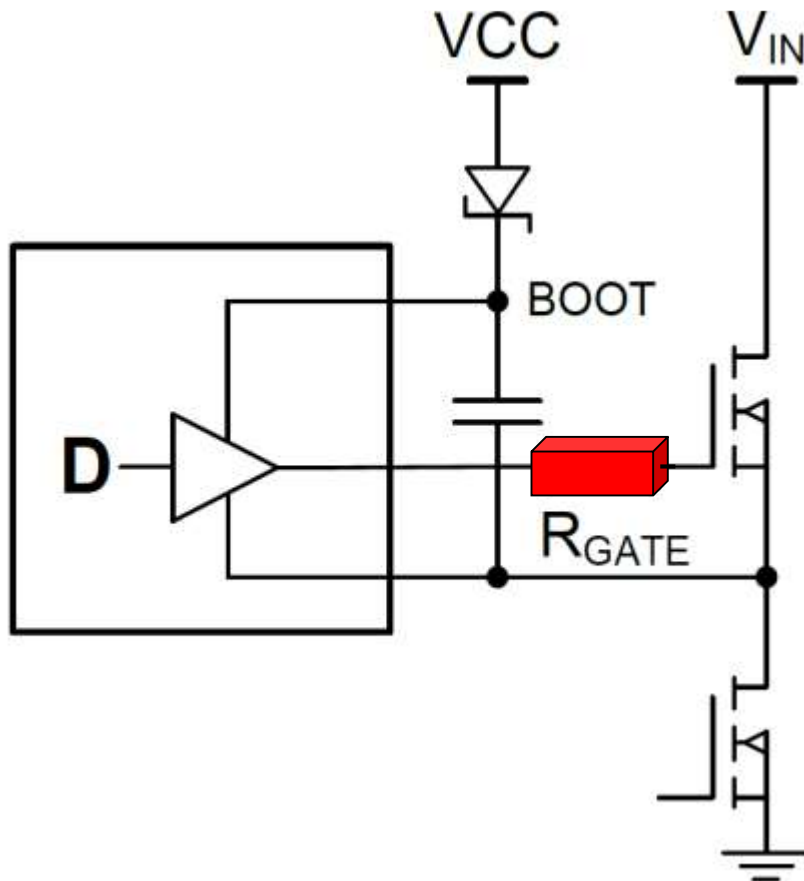
Beispiel : High Speed Signale

- 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

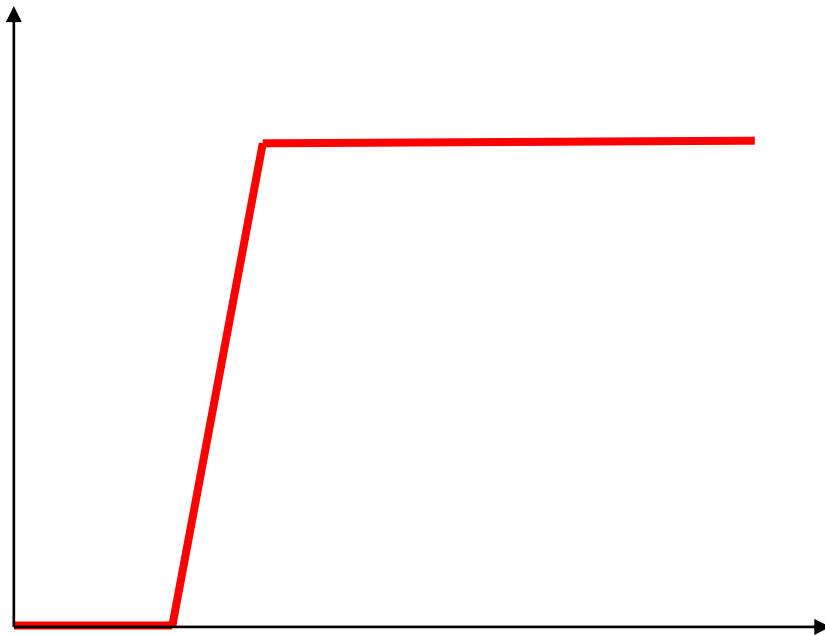




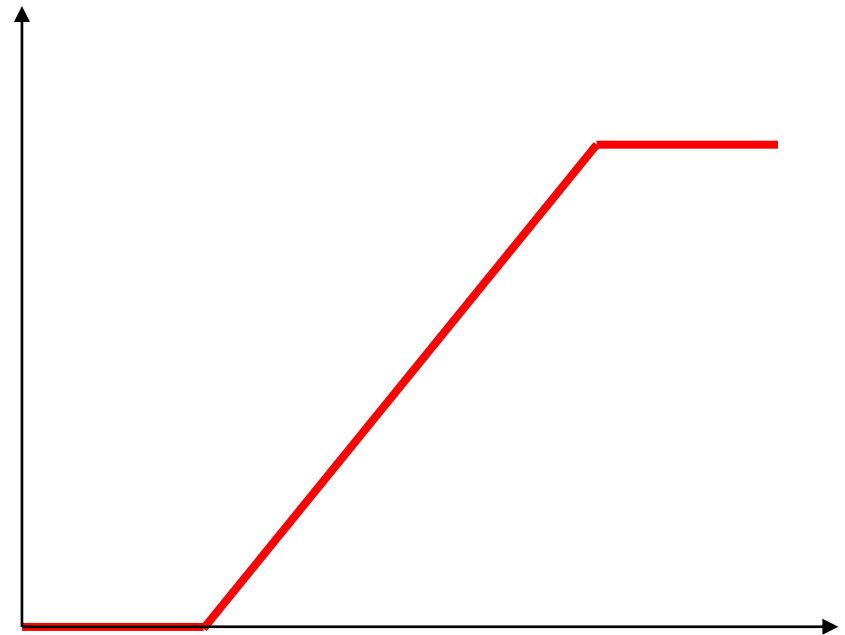


**FERRITE FÜR
ANSTIEGSGESCHWINDIGKEIT
LIMITIEREN
&
RINGING CONTROL**

Anstiegsgeschwindigkeit

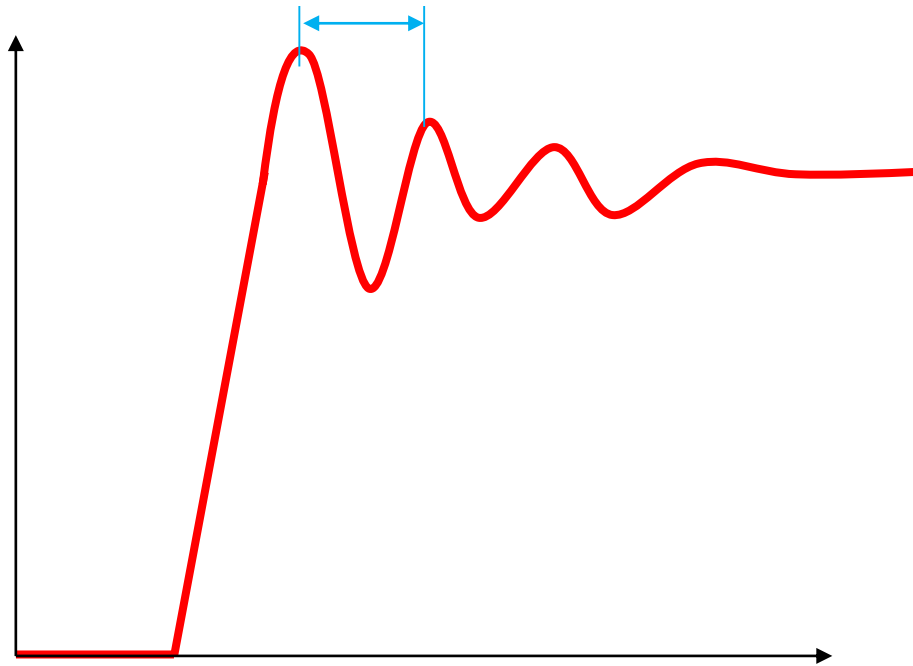


Hohe Anstiegsgeschwindigkeit

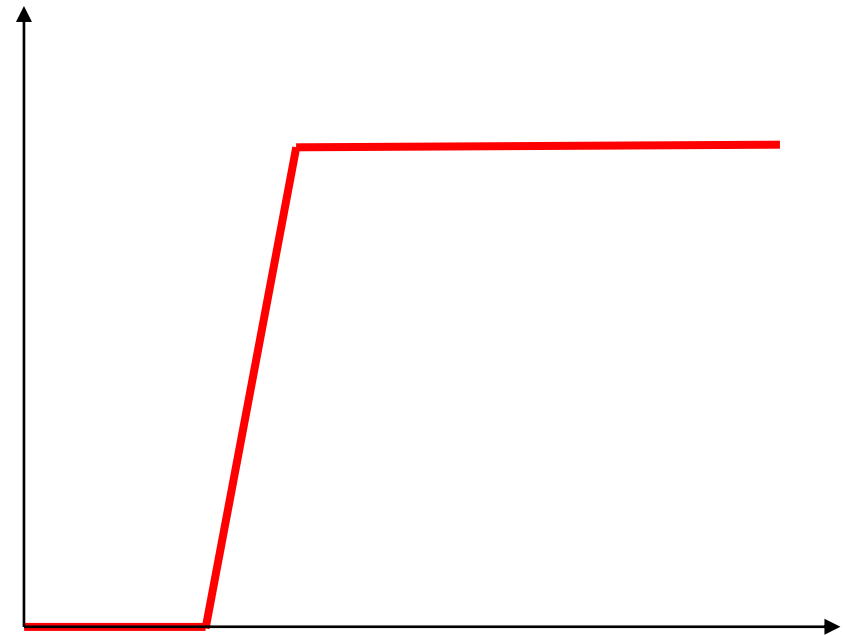


Langsame Anstiegsgeschwindigkeit

Ringling / Nachschwingen

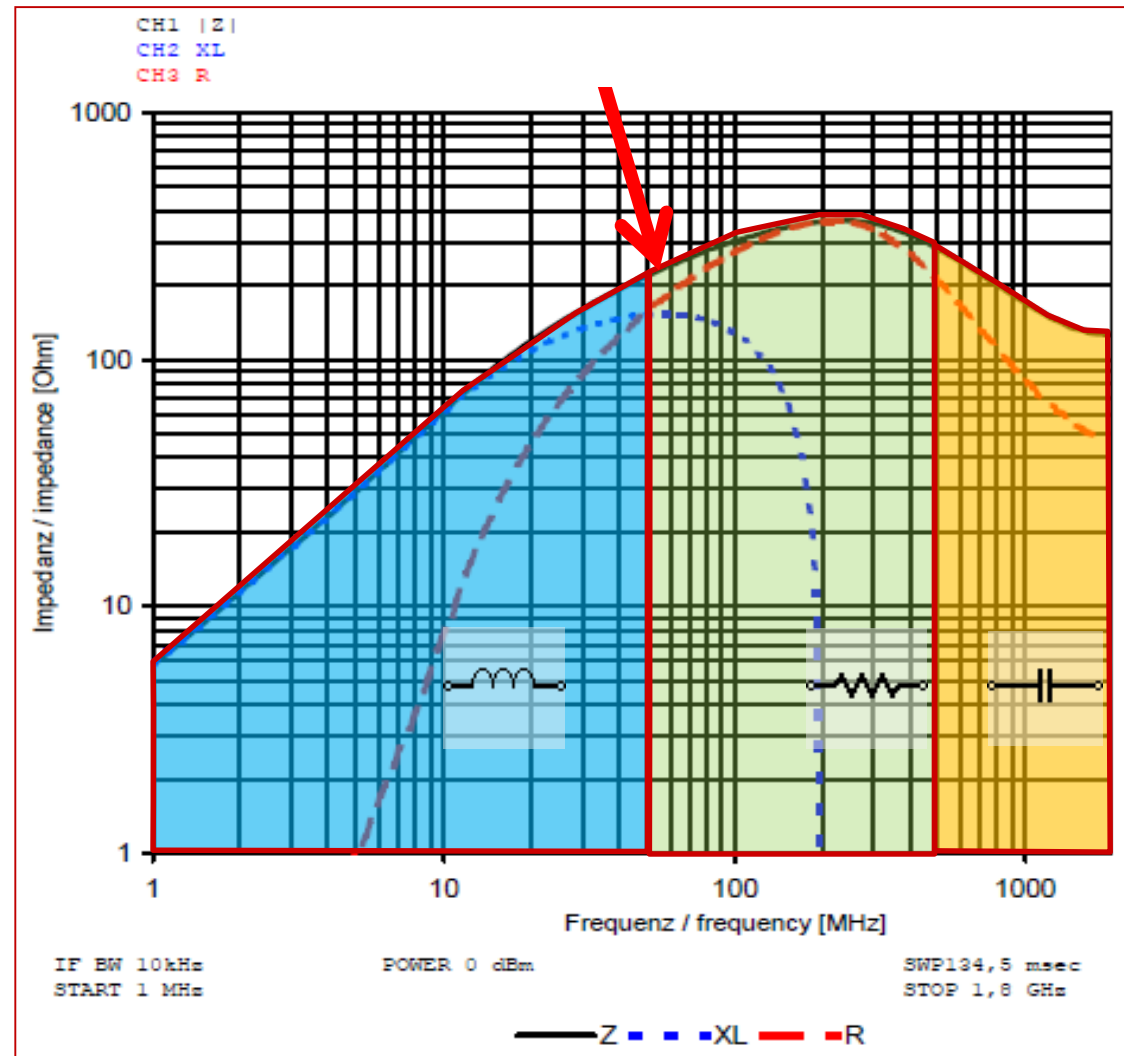
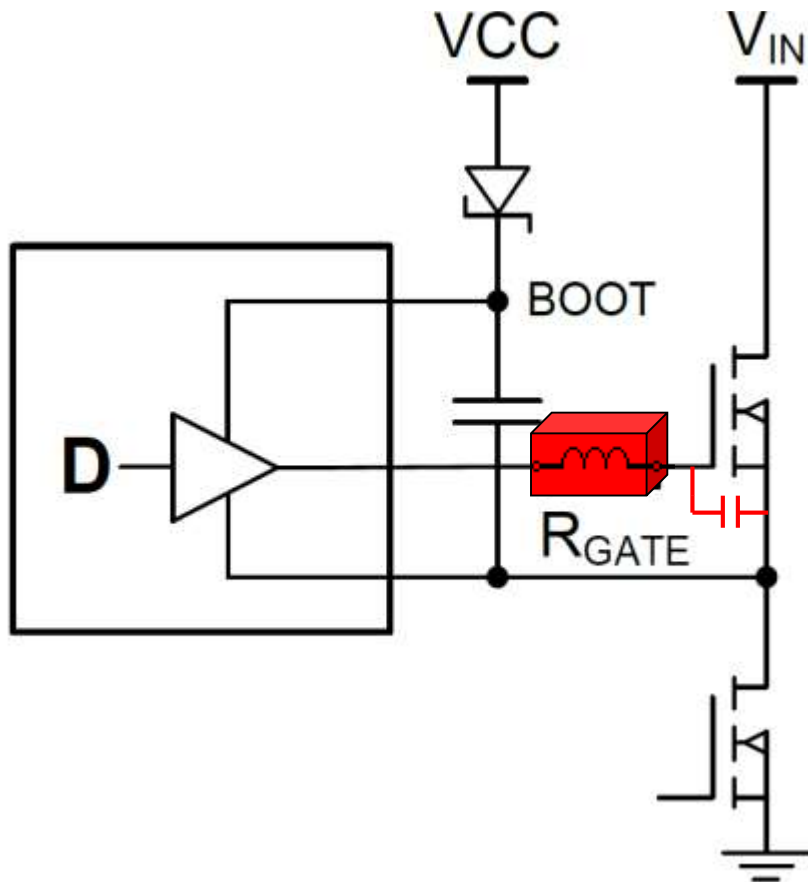


Ringling / Nachschwingen

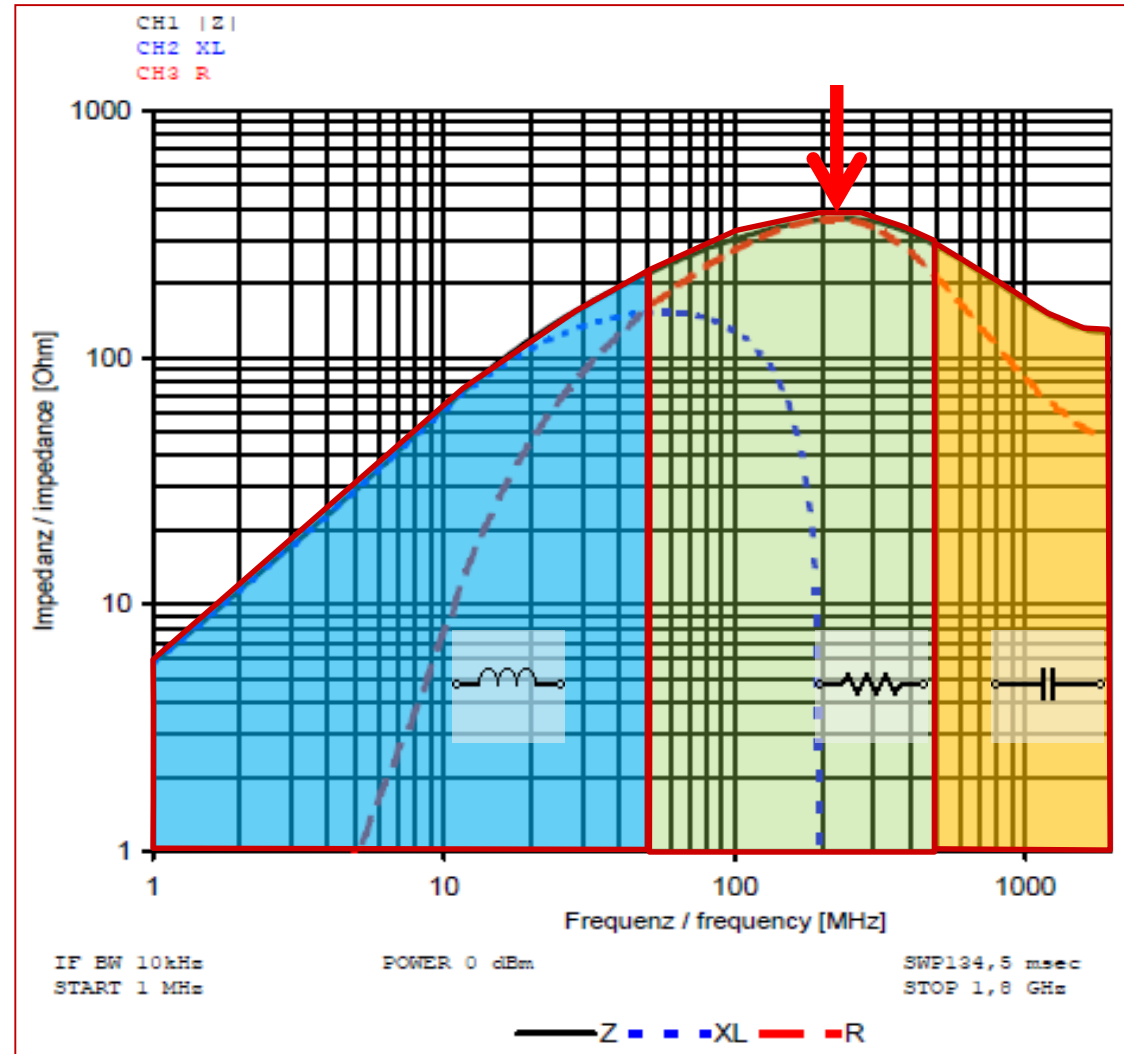
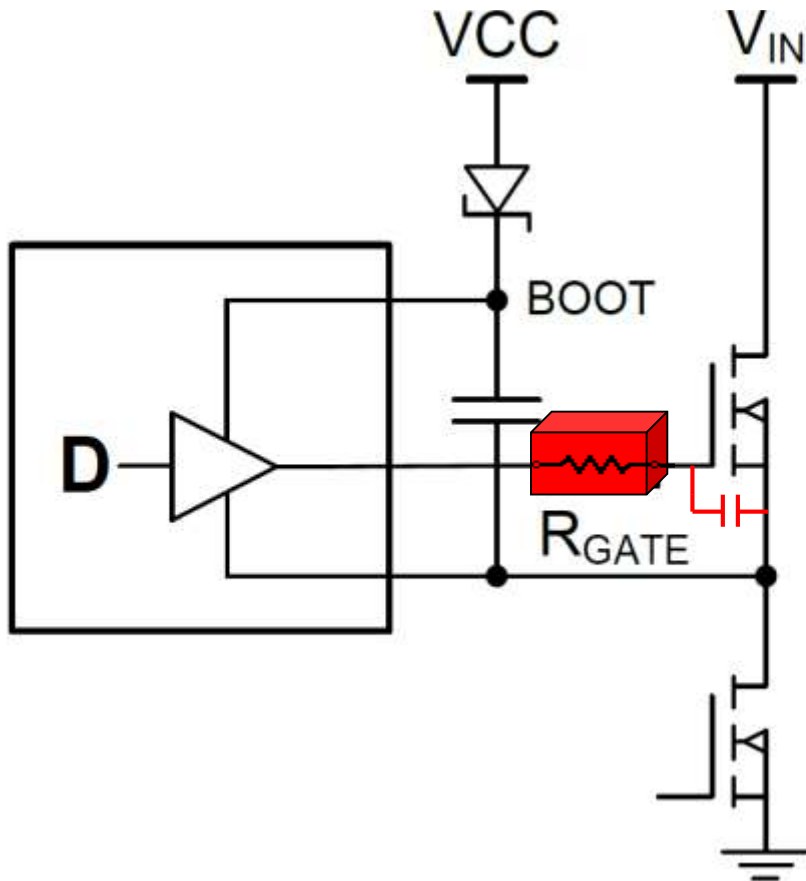


Keine Ringling / Nachschwingen

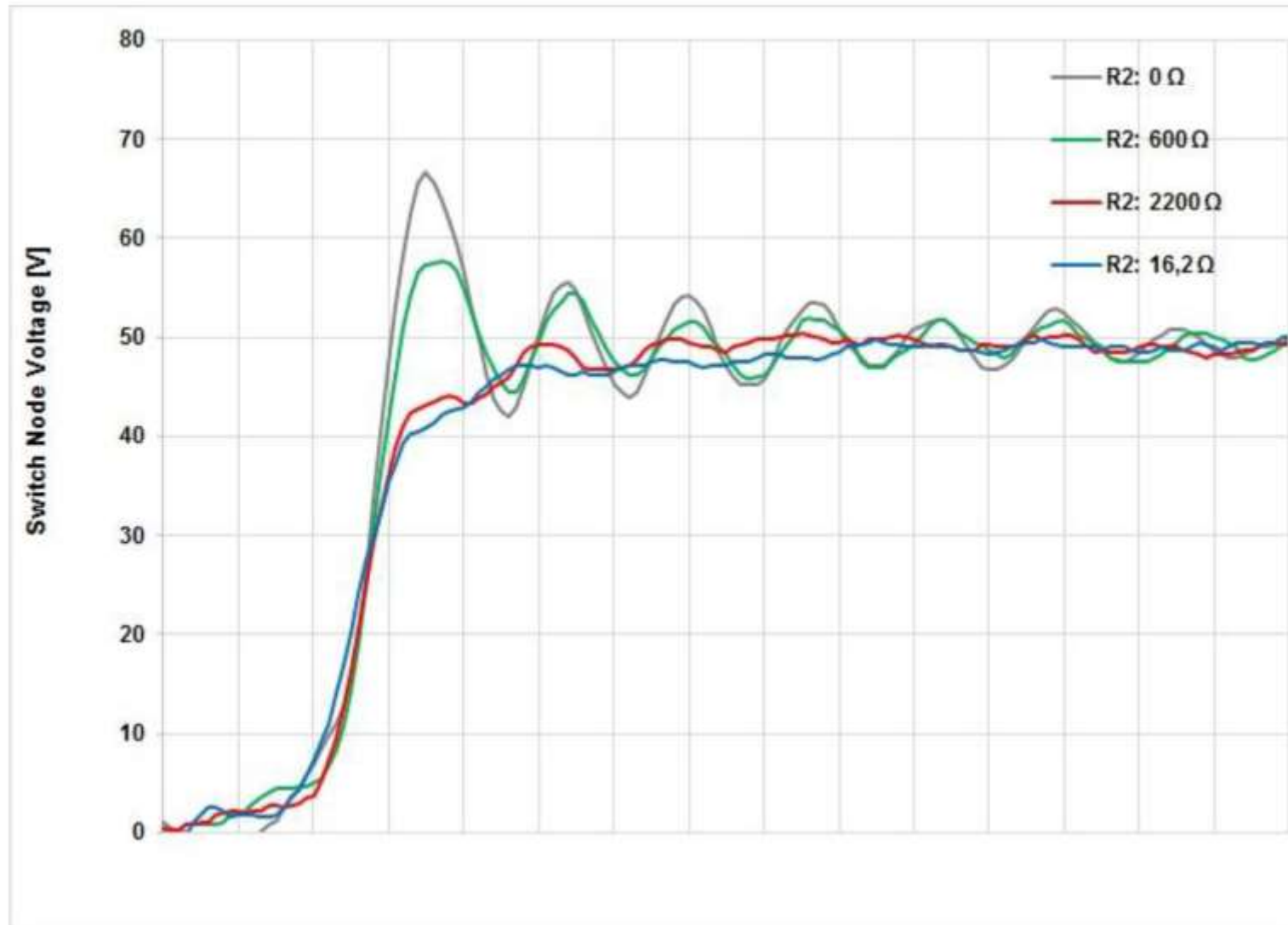
Falsche Auswahl: (L+R)-C Ringing



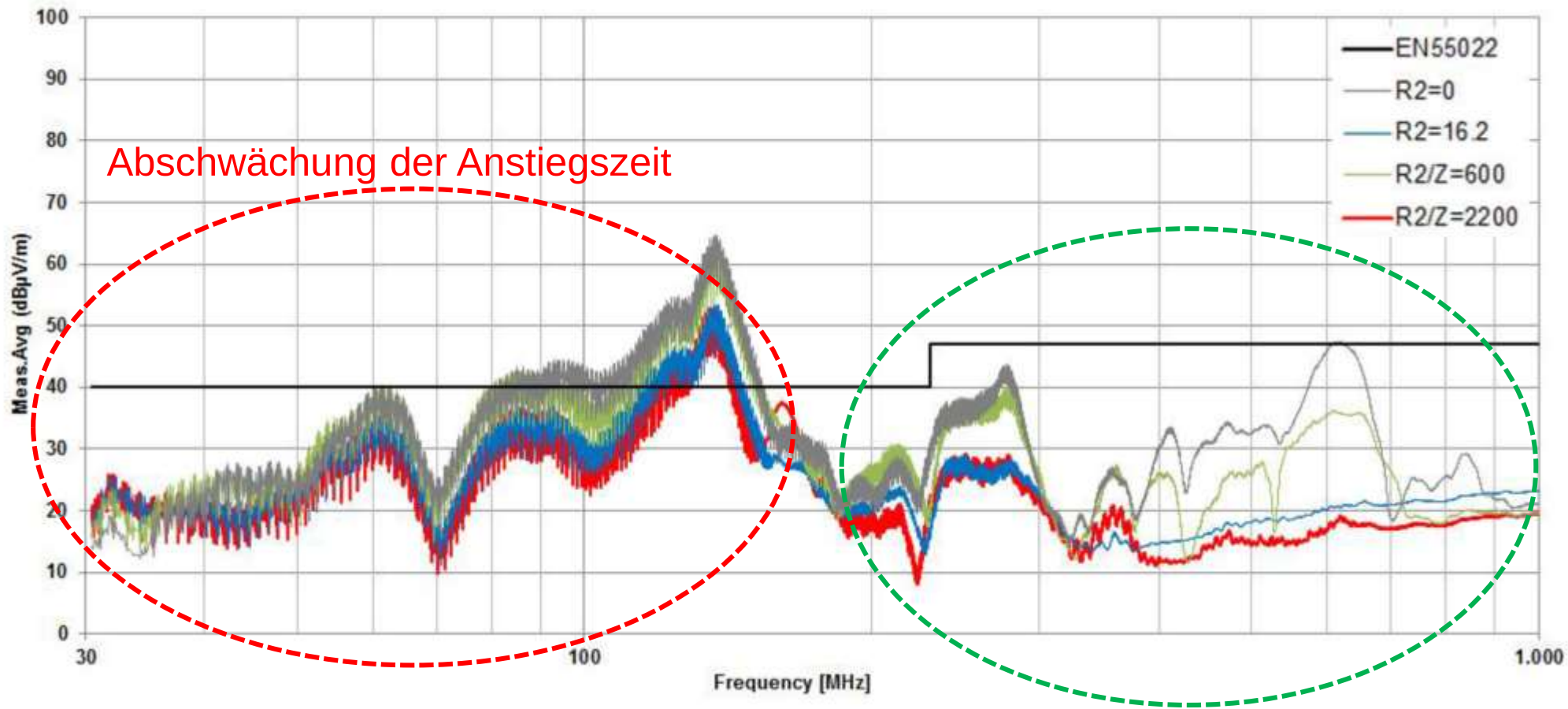
Richtige Auswahl: R-C



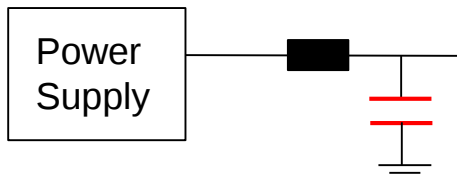
Vergleich unterschiedliche Ferrite und Widerstand



Ausgestrahlte Emissionsscans



Abschwächung des
Nachschwingen / Ringing



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	$\pm 25\%$
Maximum impedance	150 MHz	Z	700	Ω	typ.
Rated current	$\Delta T = 40K$	I_R	2000	mA	max.
DC Resistance		R_{DC}	0.15	Ω	max.
Type			High Current		

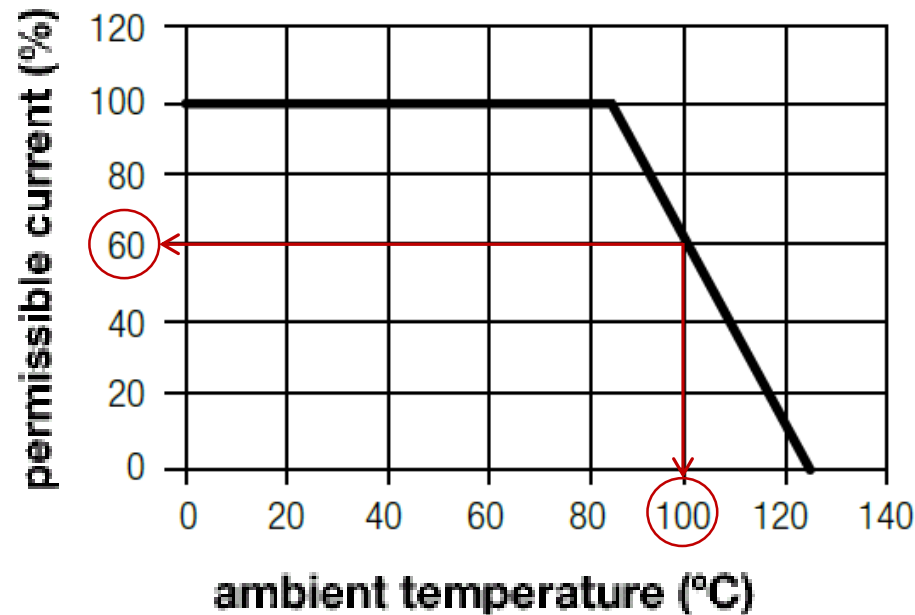


CBF Hochstrom: Ferrite mit über 1A oder höherem Nennstrom

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

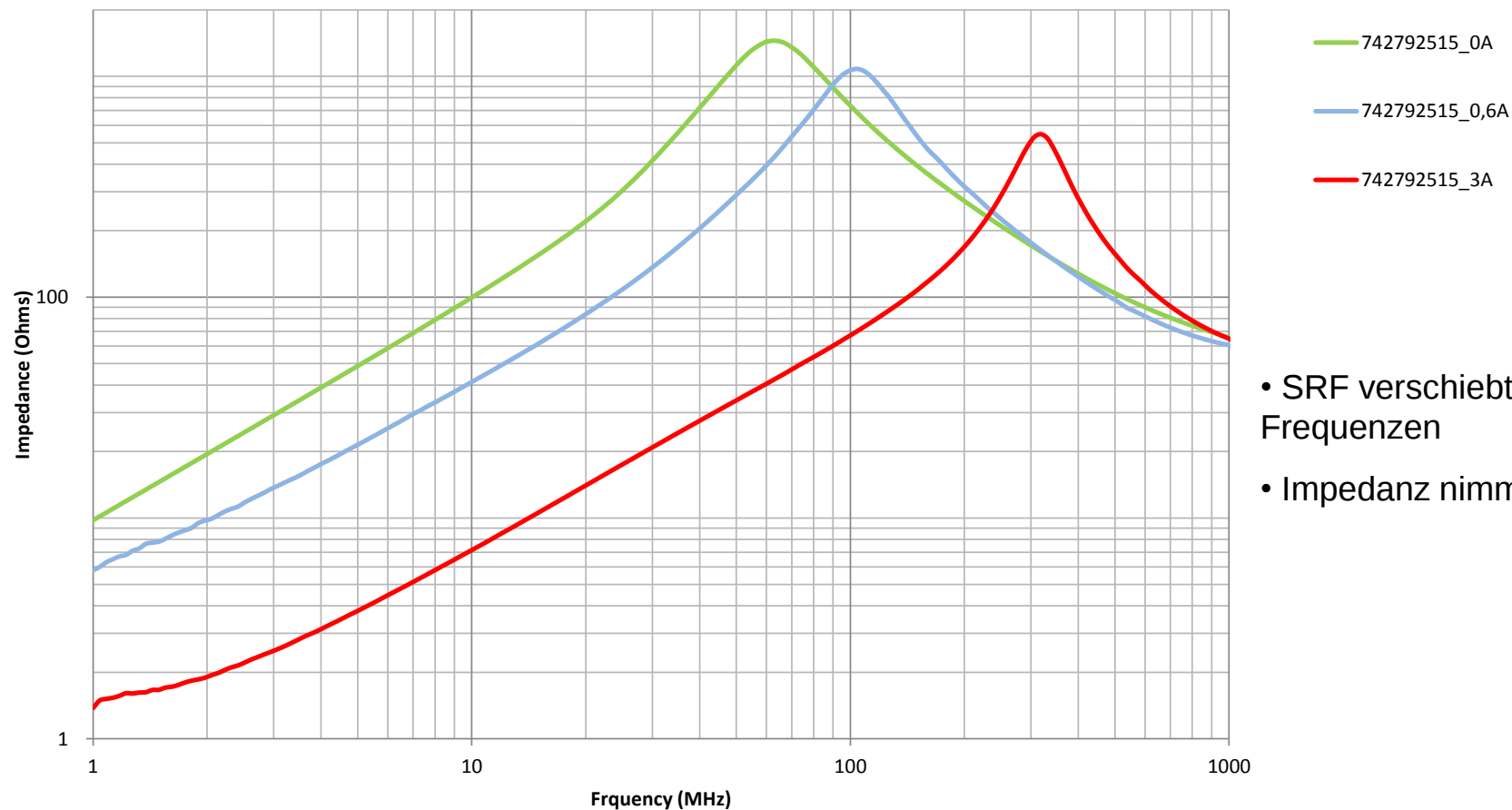
Strom Derating

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



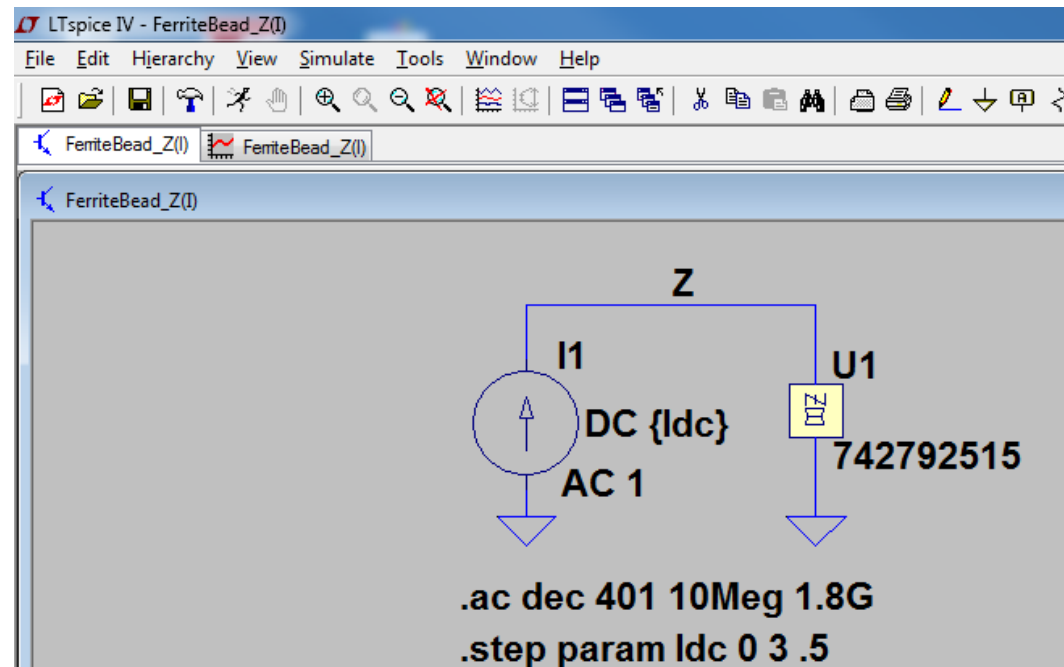
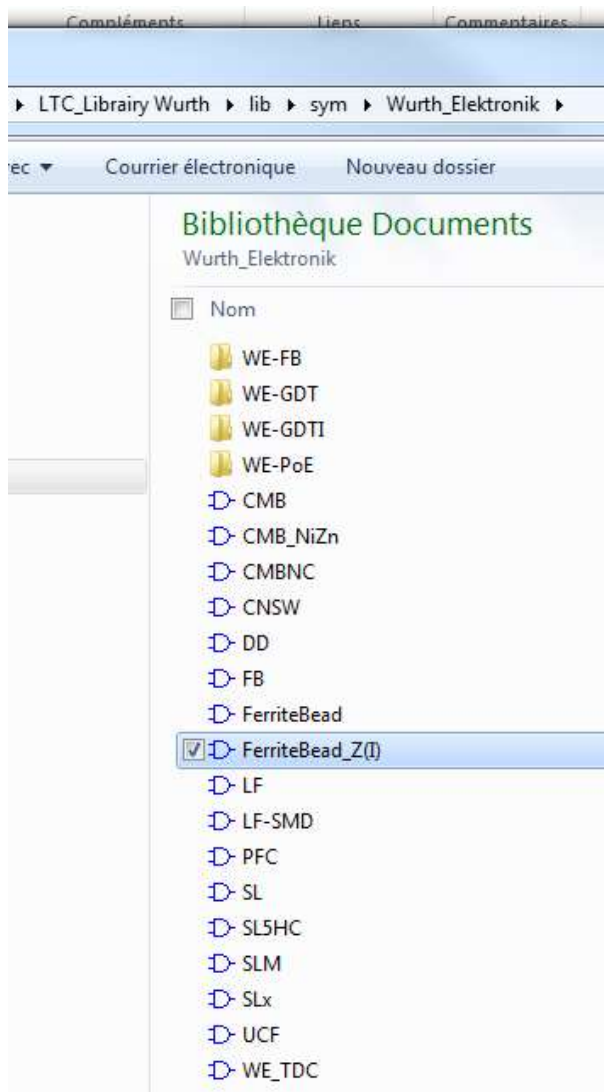
DC Bias Load: Messung

742792515 Z vs f vs I

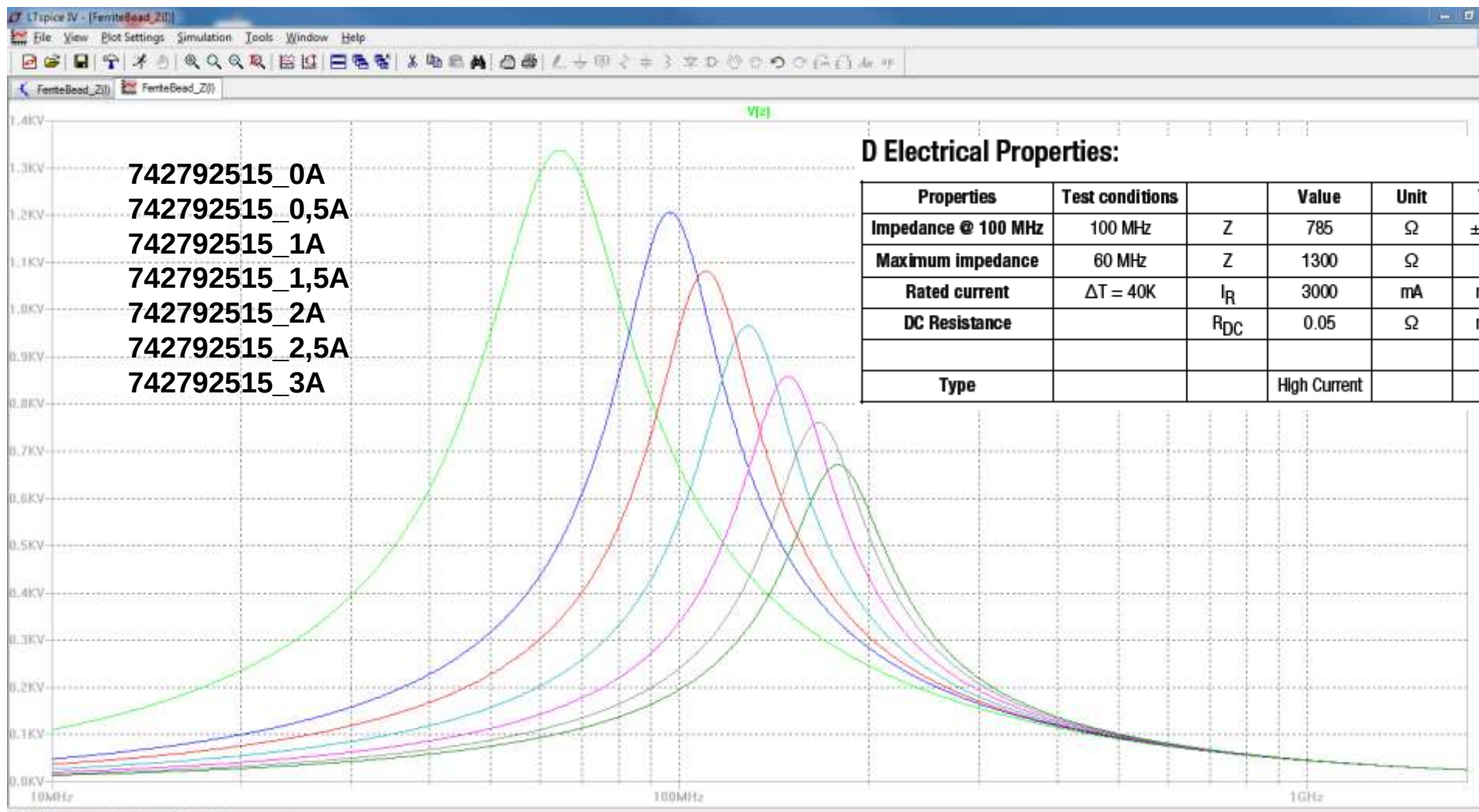


- SRF verschiebt sich in höhere Frequenzen
- Impedanz nimmt ab

DC Bias: Simulation LTspice®

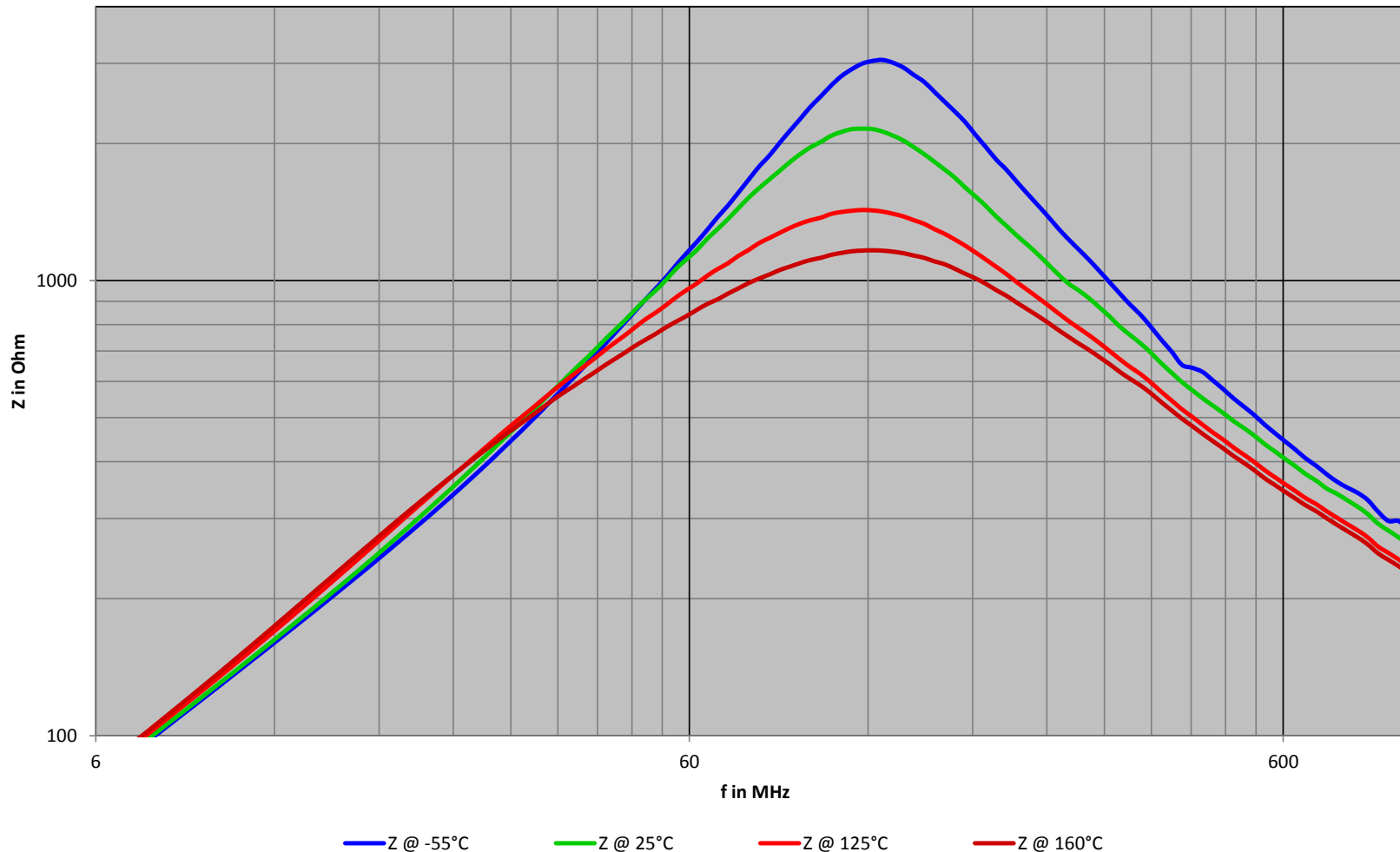


DC Bias: Simulation LTspice®



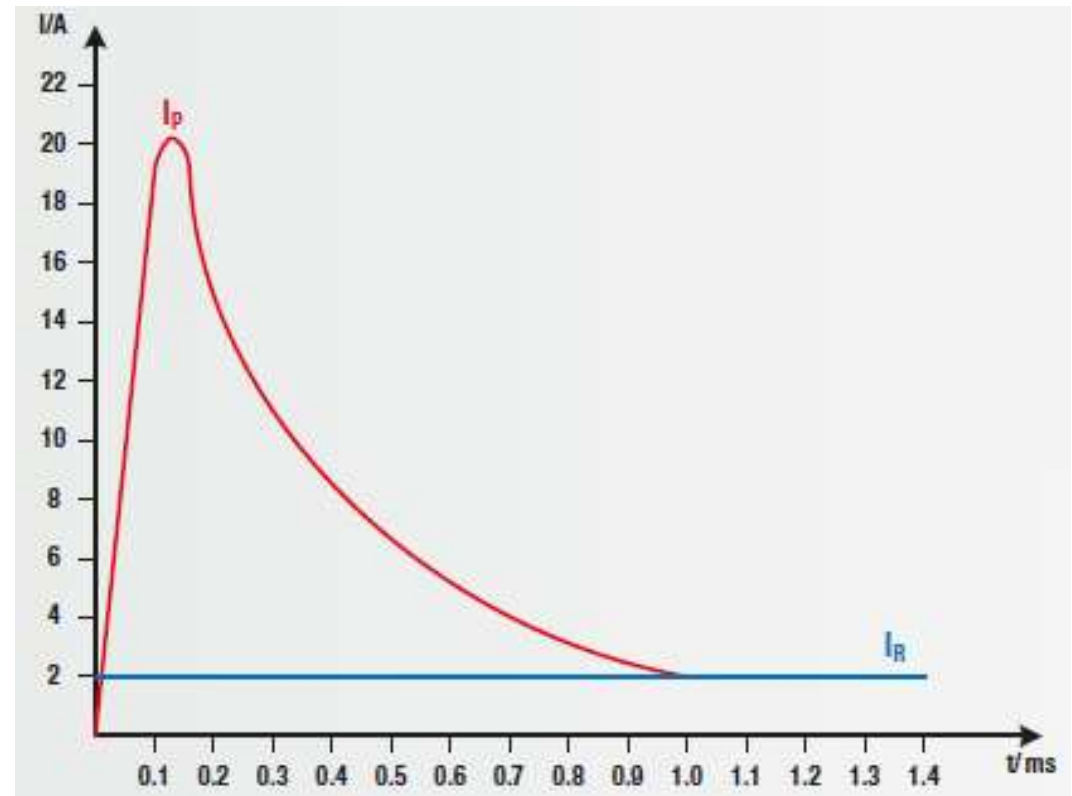
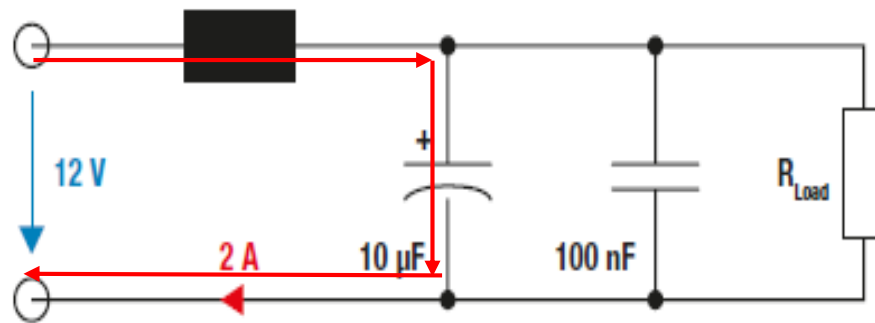
Beeinflussung der Temperatur auf die Impedanz

742792693 Z_vs_Temperature

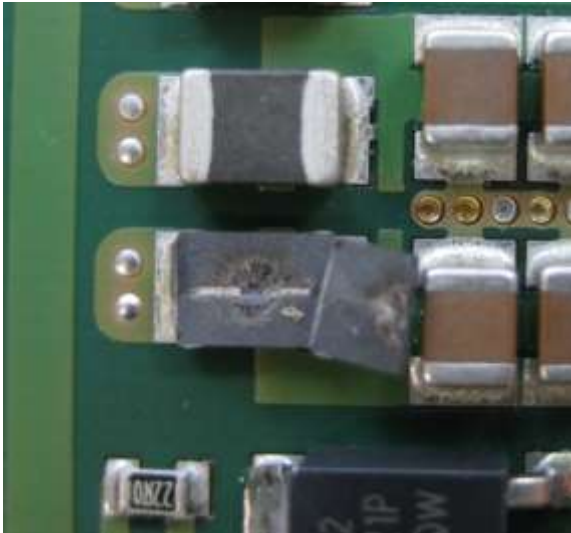


Mit steigender Temperatur nimmt die Impedanz ab.

Einschaltstrom

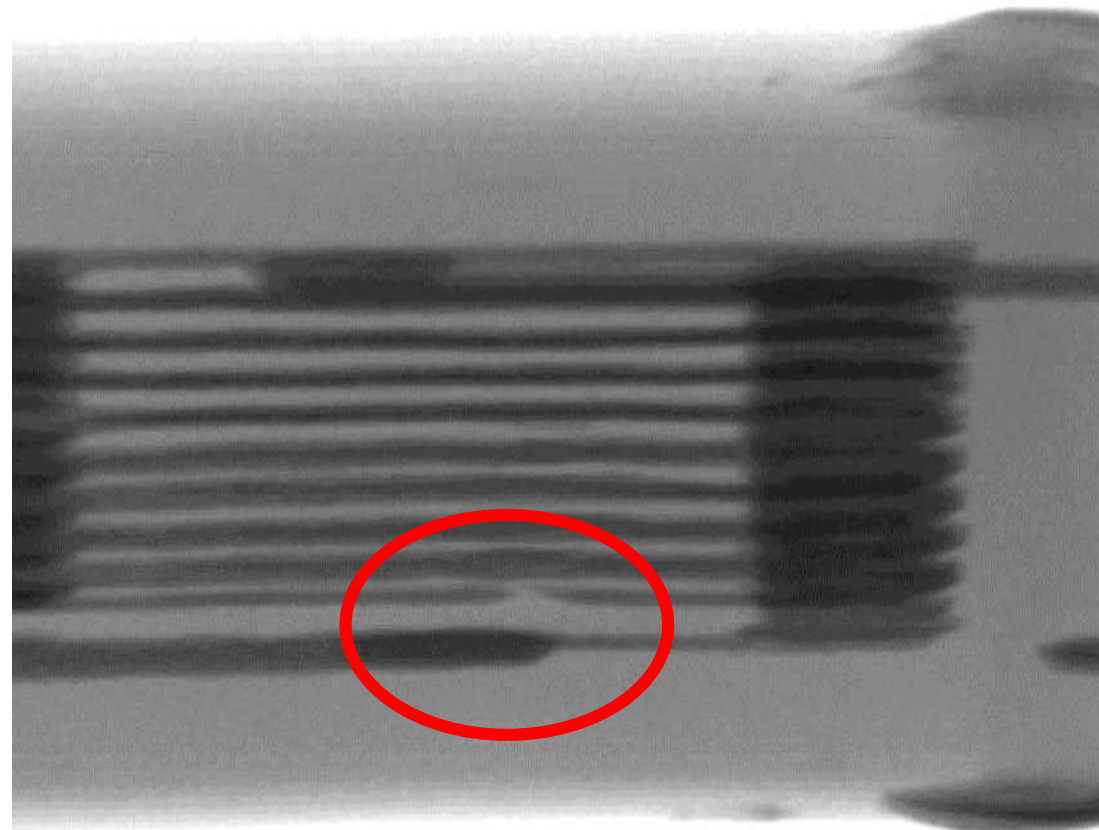
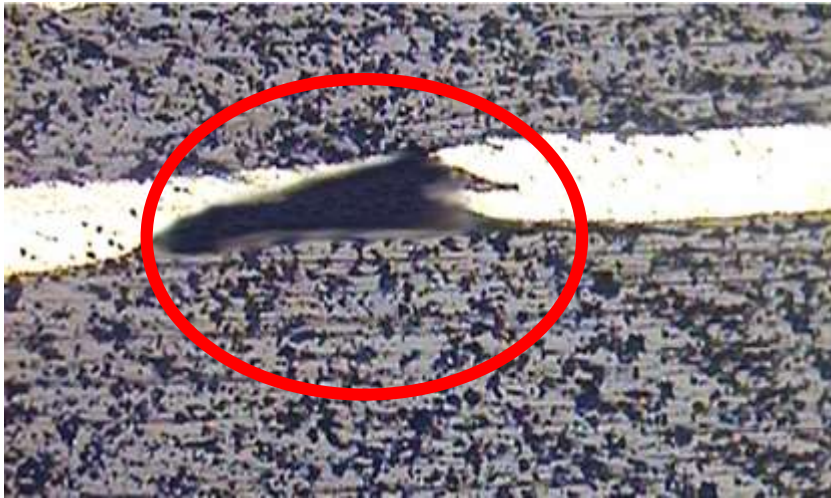


Einfluss von Überstrom



Einschaltstrom

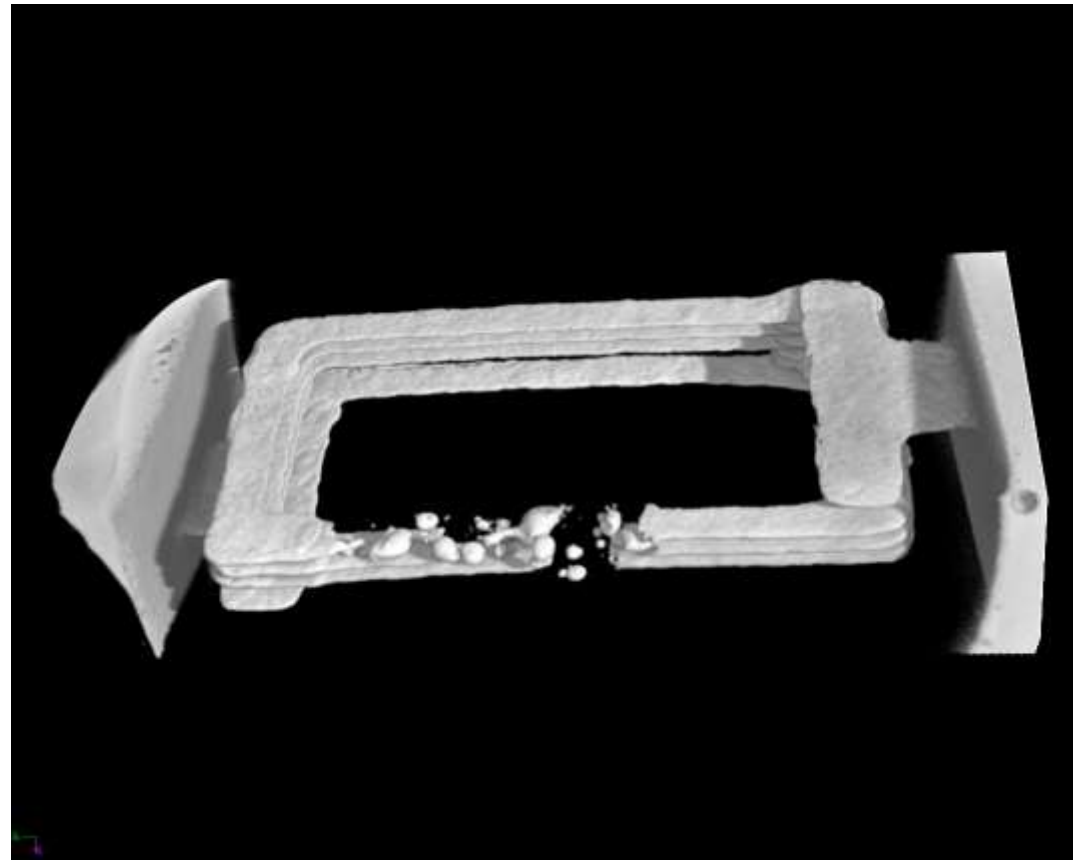
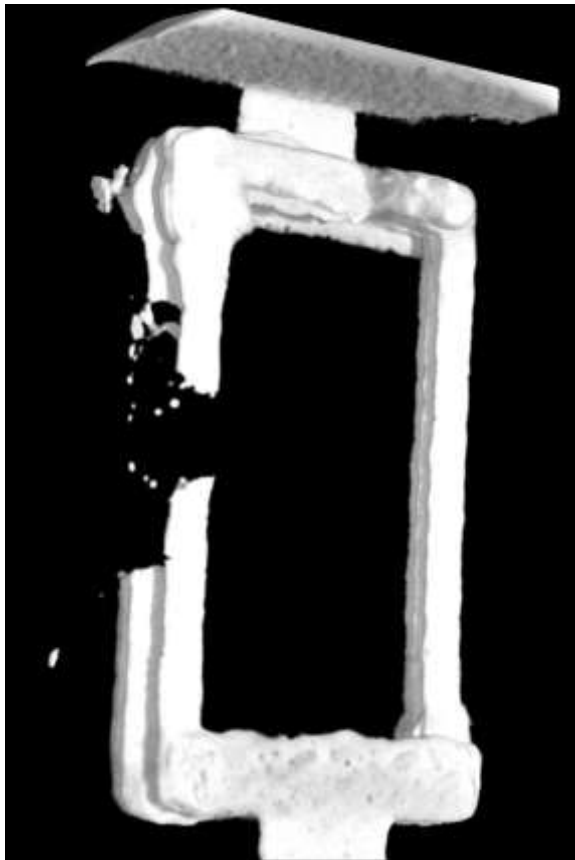
- Unterbrechung wegen zu hohem Strom



130 kV 20 μ A Z0

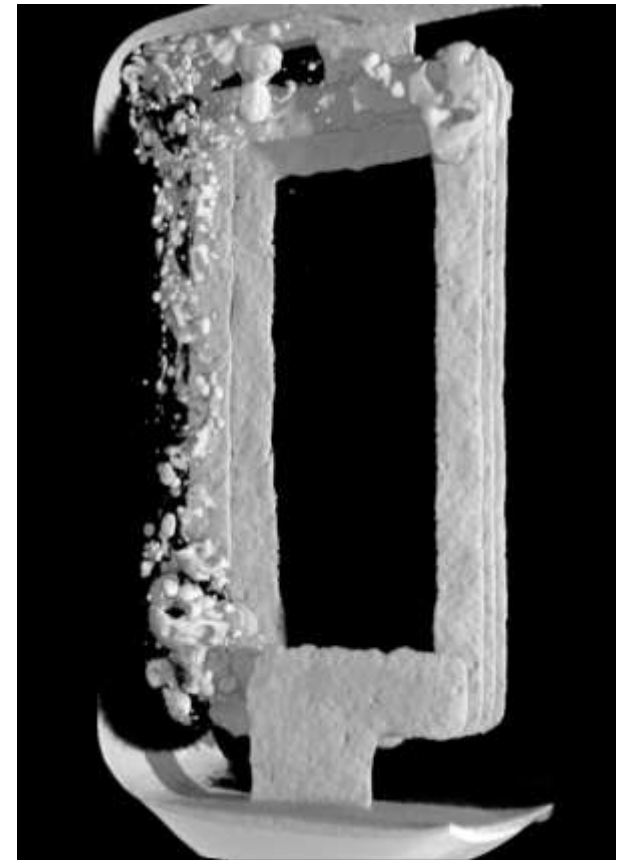
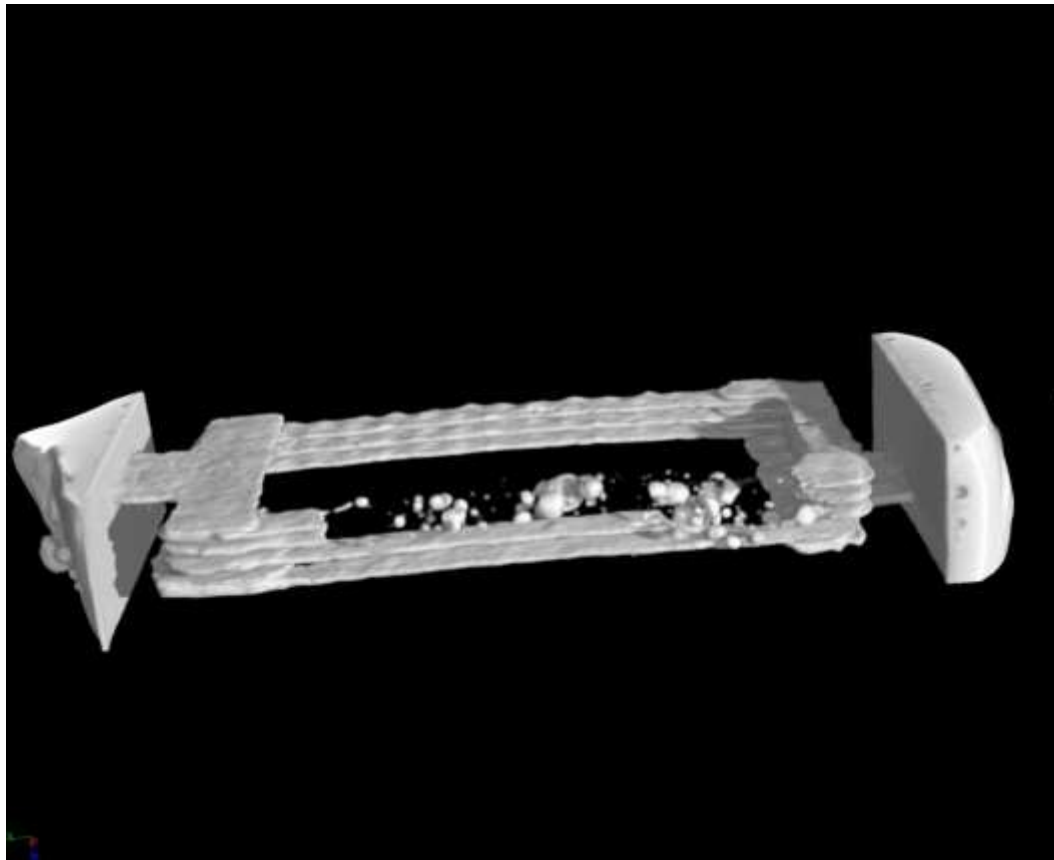
Einschaltstrom

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

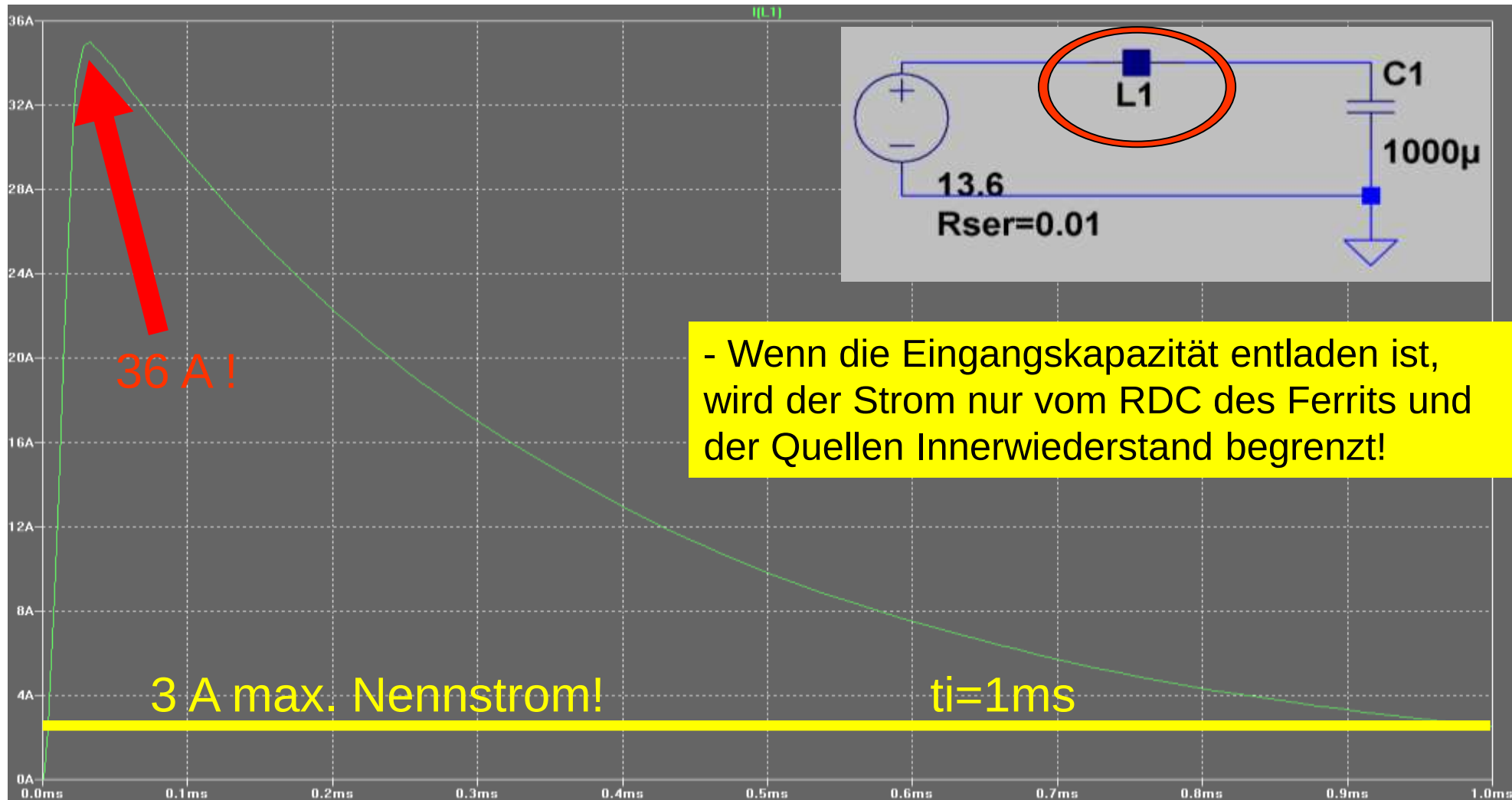


Einschaltstrom

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



Einschaltstrom: Simulation

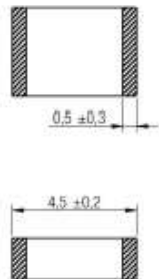


- Wenn die Eingangskapazität entladen ist, wird der Strom nur vom RDC des Ferrits und der Quellen Innerwiderstand begrenzt!

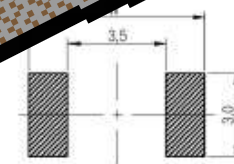
CBF Nennstrom im Datenblatt



A Dimensions: [mm]



B Recommended



WIDE BAND / HIGH SPEED: $W = 6,3$
HIGH CURRENT: $W = 7,3$

Scale: 5:1

C Schematic:

E General information:

Do not use this part beyond the Rated Current, as this will create excessive heat and can harm the component.

- Storage Temperature (on Tape & Reel): -20°C to 60°C

D Electrical Properties:

Properties	Test conditions	Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz		Ω	±25%
Maximum impedance	800 MHz		Ω	typ.
Rated current	$\Delta T = 20K$	I_R	mA	max.
DC Resistance		R_{DC}	Ω	max.
Type				

Rev.	Date	SS1	SS2	Projection	DESCRIPTION
5.7	2014-06-05	SS1	SS2		WE
5.6	2013-12-10	SS1	SS2		
5.5	2013-04-17	SS1	SS2		
5.4	2012-11-20	SS1	SS2		
5.3	2012-10-23	SS1	SMu		
5.2	2012-09-26	SS1	SMu		
5.1	2012-05-26	SS1	SS2		

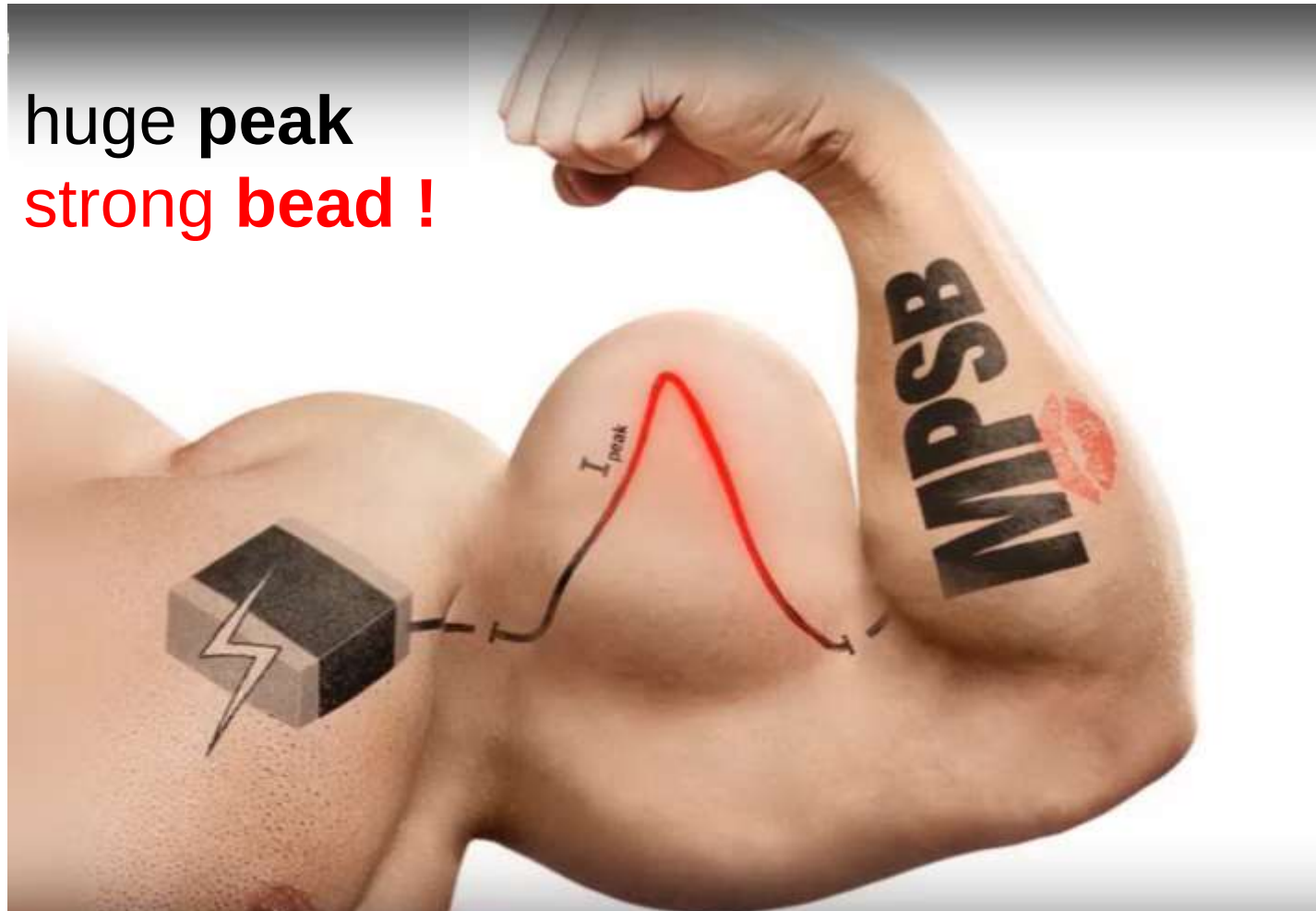
Wüth Elektronik eSos GmbH & Co. KG
EMC & Inductive Solutions
Max-Eyth-Str. 1
74638 Waldenburg
Germany
Tel.: +49 (0) 71 43 93 10 0

25

1812

MPSB ist die Lösung

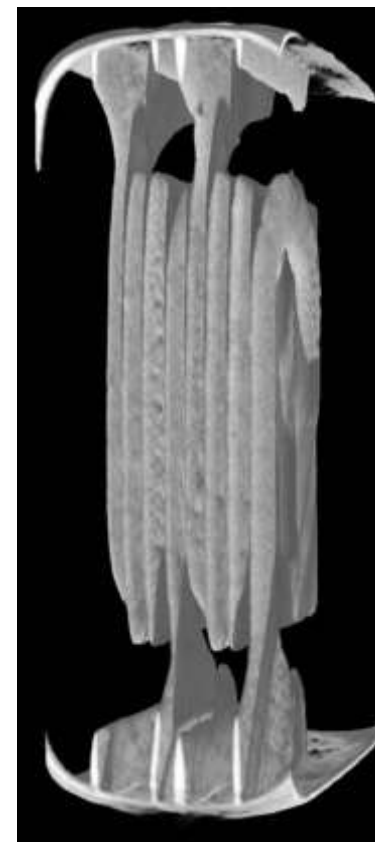
huge peak
strong bead !



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

WE-MPSB

Multilayer Power Suppression Bead

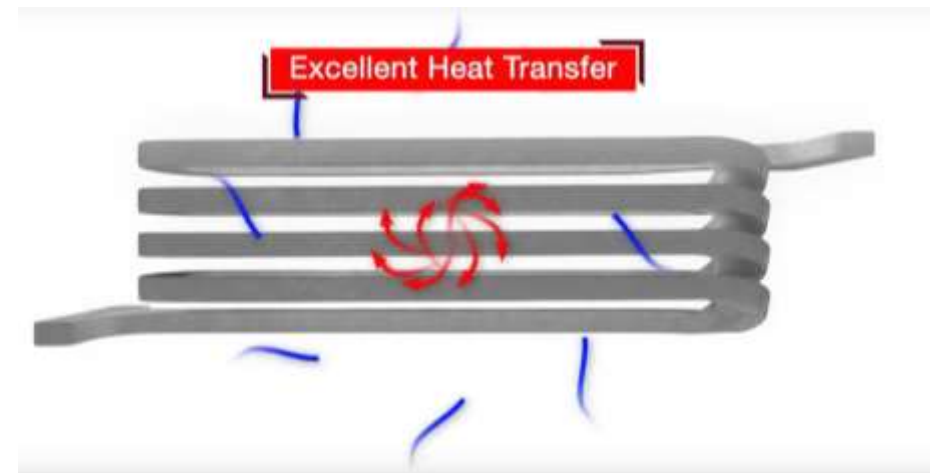
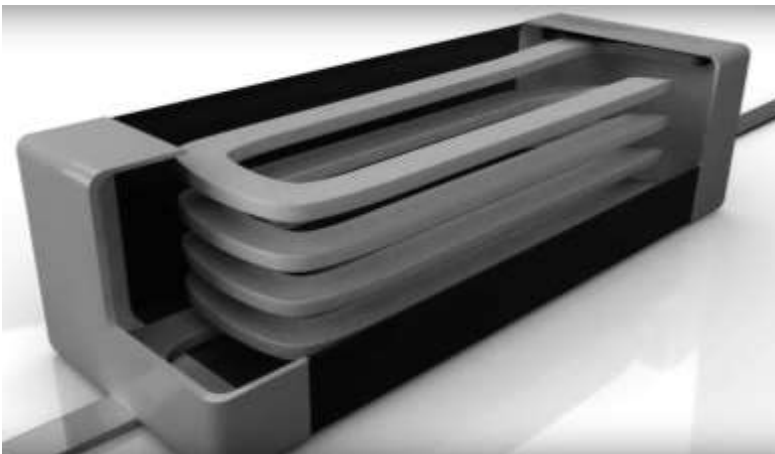


Size 0805

WE-MPSB Multilayer Power Suppression Bead



- Speziell entwickelte innere Layer und Pulsbelastbarkeit

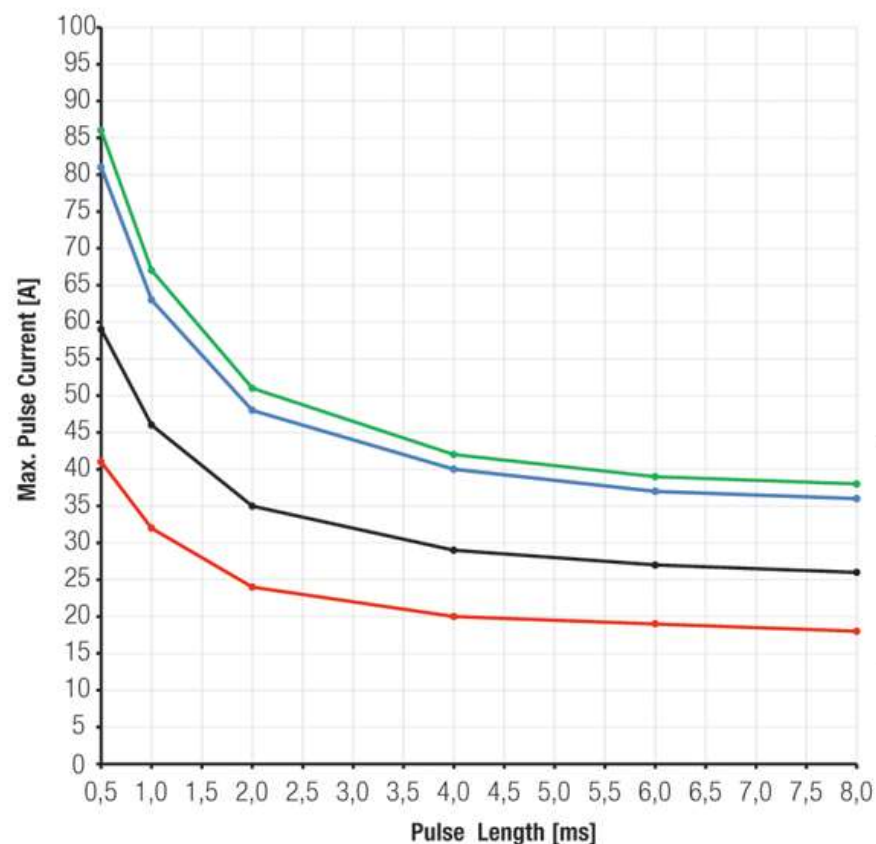


WE-MPSB

Multilayer Power Suppression Bead



Current vs Pulse Length – Single Pulse – Size 0805



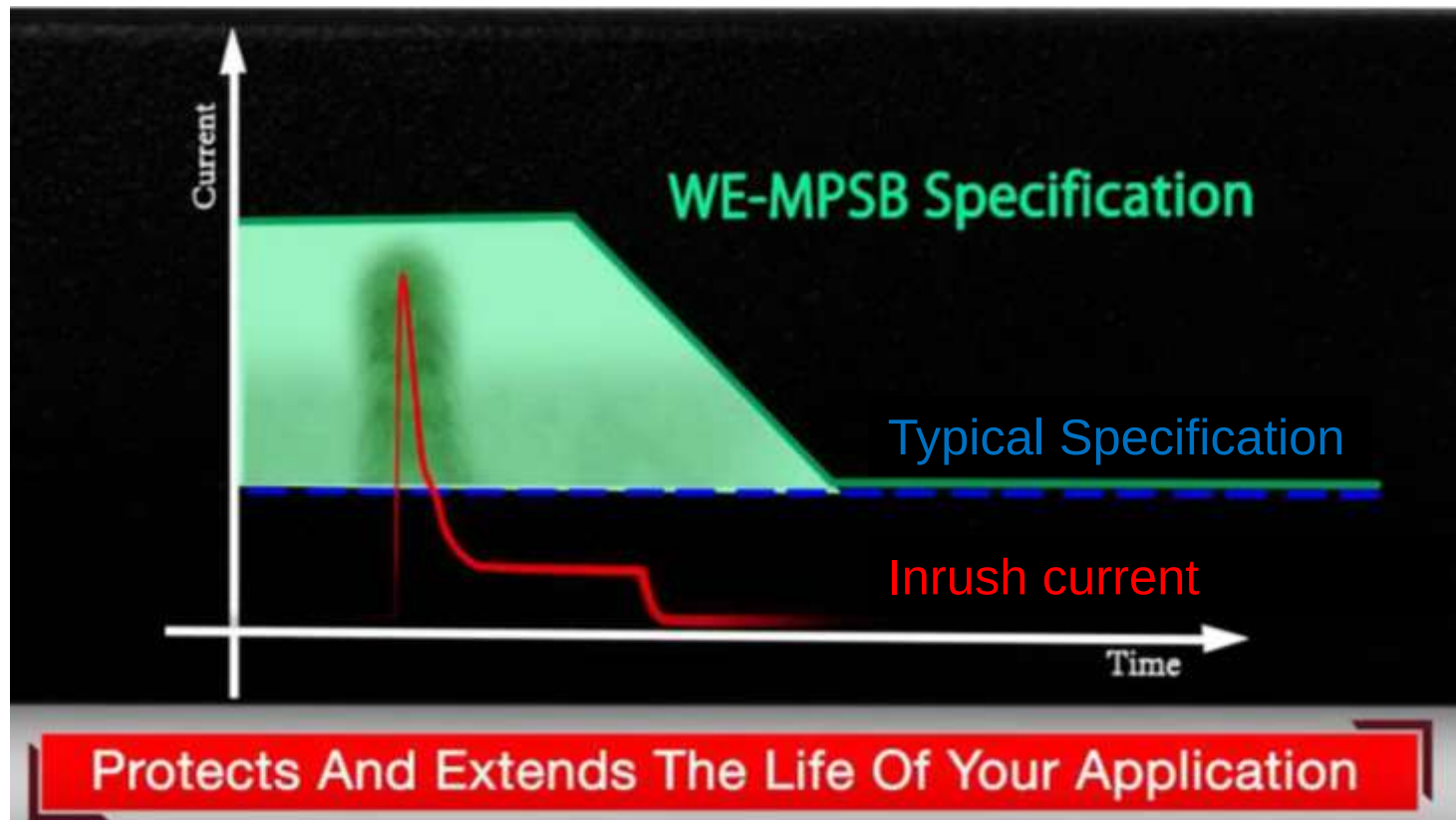
20 Times Higher Peak Current Rating



- 742 792 208 00 [80 Ω | 4 A | 13 mΩ]
- 742 792 201 81 [180 Ω | 3,1 A | 26,5 mΩ]
- 742 792 203 21 [320 Ω | 2,5 A | 30,5 mΩ]
- 742 792 206 01 [600 Ω | 2,1 A | 45 mΩ]

WE-MPSB

Multilayer Power Suppression Bead

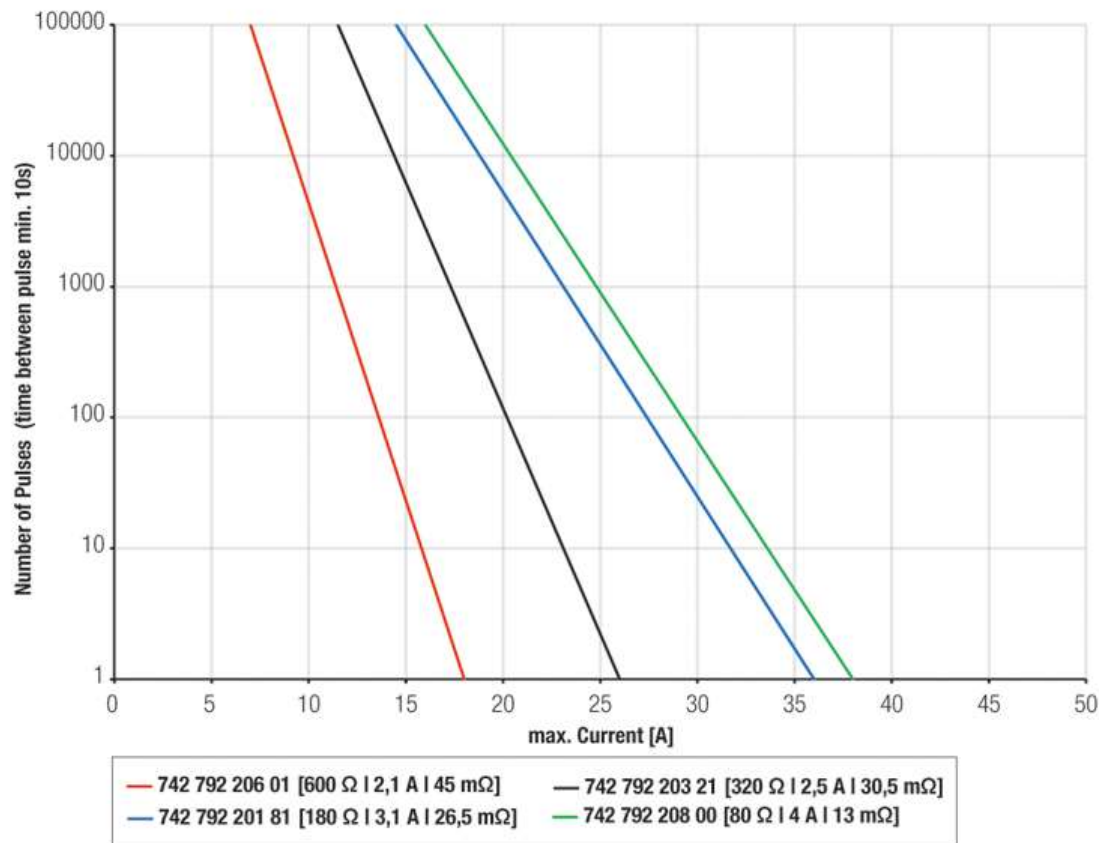


WE-MPSB Multilayer Power Suppression Bead



■ Strombelastbarkeitsmessungen:

No. of Pulse vs Current – 8 ms Pulse – Size 0805



MPSB Nennstrom



more than you expect



A Dimensions: [mm]

B Recommended land pattern: [mm]

D Electrical Properties

Properties	Value	Unit	Tol.
Impedance @ 100 MHz	180	Ω	$\pm 25\%$
Maximum impedance	202	Ω	typ.
Rated current	3100	mA	max.
DC Resistance	26.5	m Ω	typ.
DC Resistance	37.0	m Ω	max.
Type of application	High Current		

C Schematic:

Do not use this part constantly beyond the Rated Current,
excessive heat and can harm the component

Scale - 10:1



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EMC & Inductive Solutions
Max-Eyth-Str. 1
74630 Waldenburg
Germany
Tel.: +49 (0) 71 41 14-0
www.wuerth-elektronik.de

EMC
Bead

279220181

Size: 0805



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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	$\pm 25\%$
Rated current	$\Delta T = 40K$	I_R	5.0	A	max.
DC Resistance	@ 20°C	R_{DC}	12	m Ω	max.

High impedance in lower frequency

PBF



D Electrical Properties:

Properties	Test conditions		Value	Unit	Tol.
Impedance @ 25 MHz	25 MHz	Z	65	Ω	$\pm 25\%$
Impedance @ 100 MHz	100 MHz	Z	98	Ω	$\pm 25\%$
Rated current	$\Delta T = 40K$	I_R	6.0	A	max.
DC Resistance		R_{DC}	0.9	m Ω	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	$\pm 25\%$
Maximum impedance	90 MHz	Z	2900	Ω	typ.
Rated current	$\Delta T = 40K$	I_R	10.0	A	max.
DC Resistance		R_{DC}	0.009	Ω	max.

High impedance and high current

D Electrical Properties:

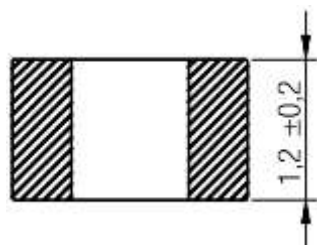
Properties	Test conditions		Value	Unit	Tol.
Impedance @ 100 MHz	100 MHz	Z	185	Ω	$\pm 25\%$
Maximum impedance	15 MHz	Z	15000	Ω	typ.
Rated current	$\Delta T = 40K$	I_R	4.5	A	max.
DC Resistance		R_{DC}	0.030	Ω	max.

High impedance in very low Frequency

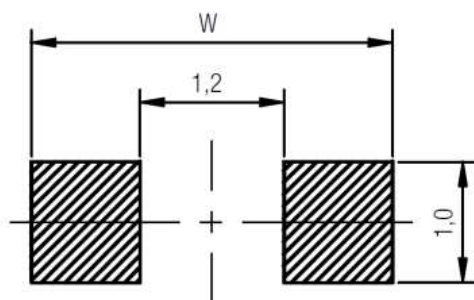


EMPFEHLUNGEN

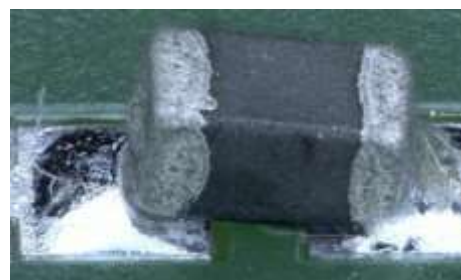
Land pattern Empfehlungen



Land pattern (in mm)



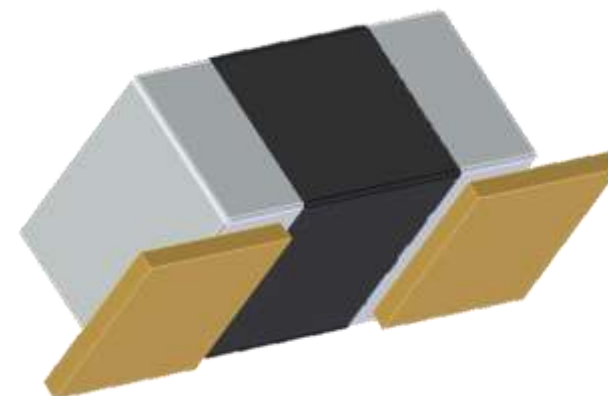
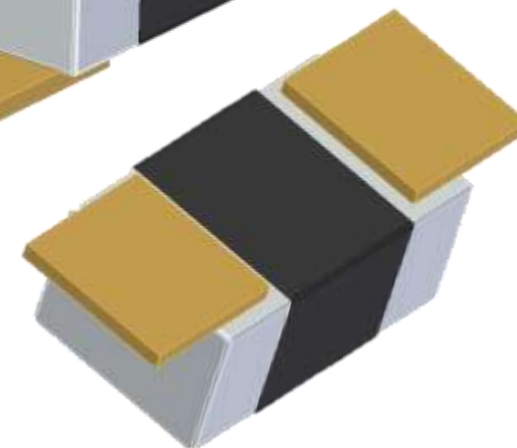
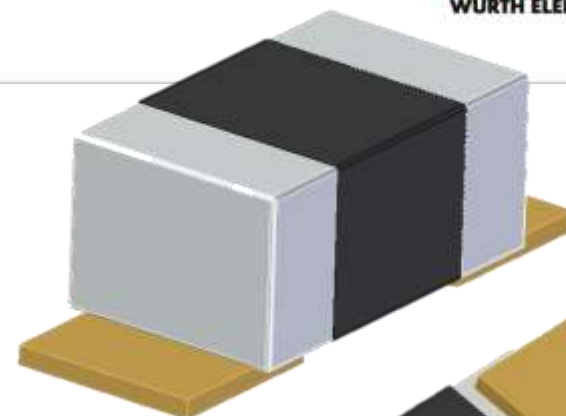
WIDE BAND / HIGH SPEED: $W = 3,0$
HIGH CURRENT: $W = 4,0$



**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



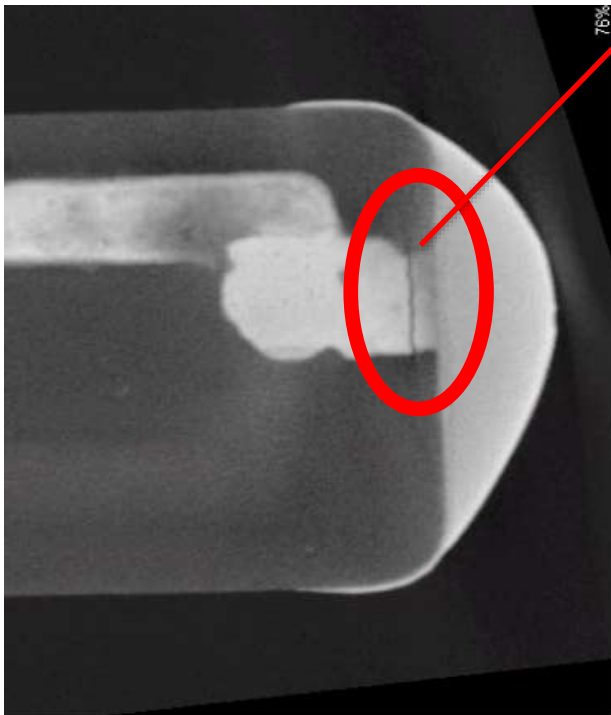
Mechanischer Bruch
eines SMD Ferrits
verursacht durch
Trennung des PCB
Nutzens



Bild Quelle: WE PM & TQM

Empfehlungen – Biege Stress

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



Cracks

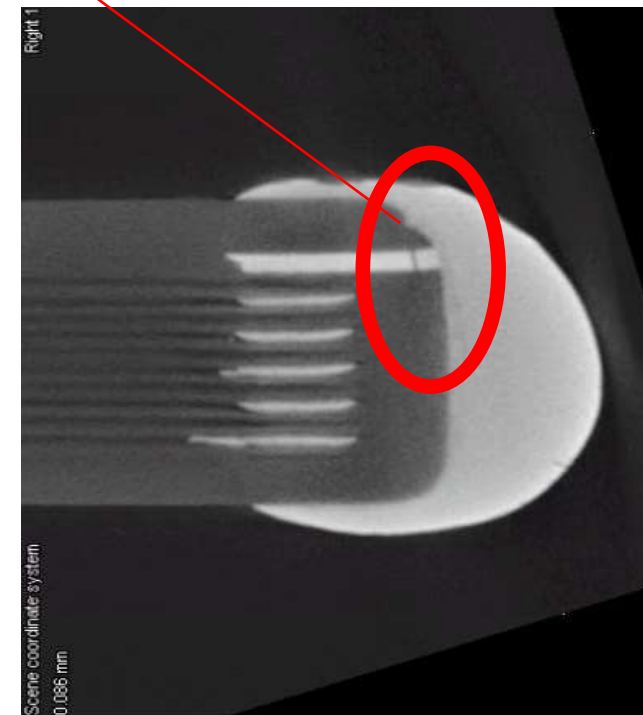
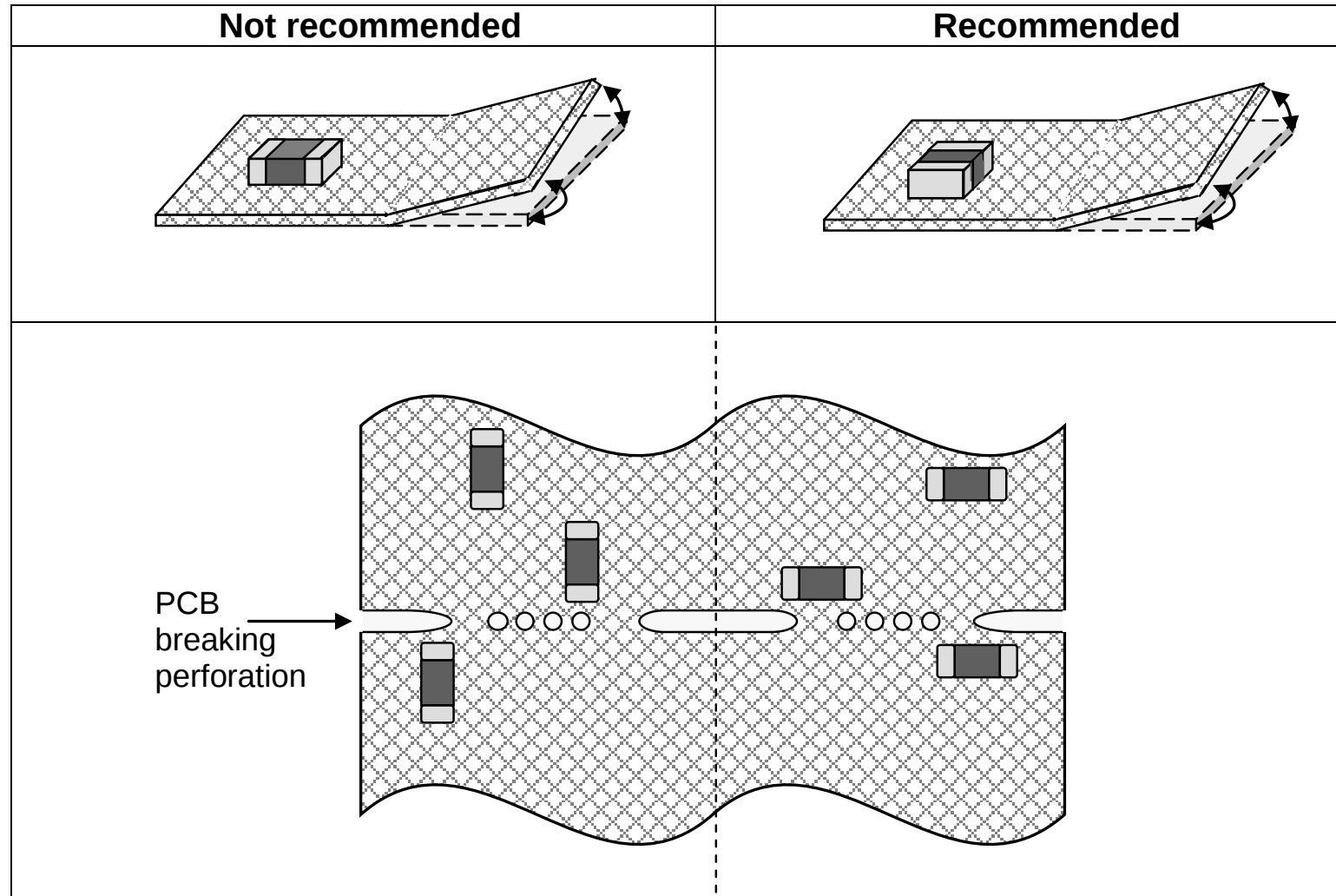
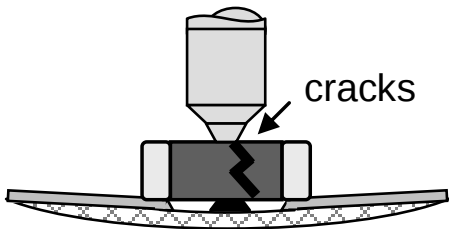
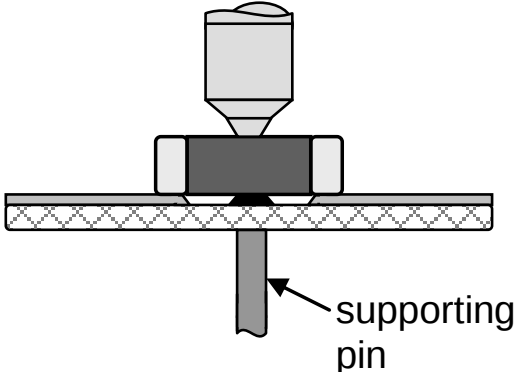
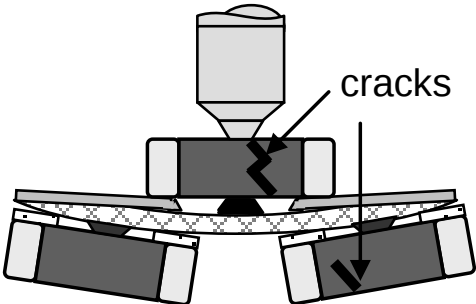
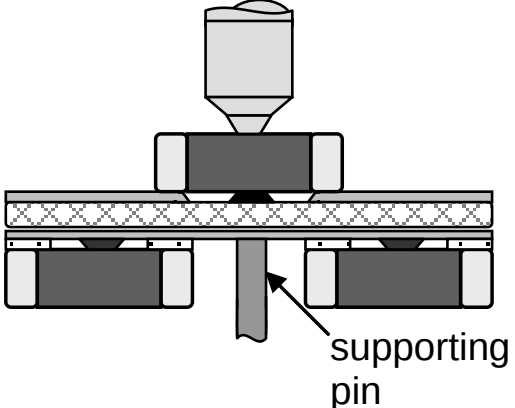


Bild Quelle: TQM Department

Biegen



Montage

	Not recommended	Recommended
Single – sided mounting		
Double – sided mounting		

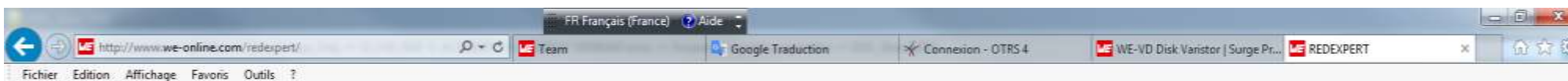
Auswahl EMV Ferrite





TOOLS & DESIGN HILFE

REDEXPERT



Würth Elektronik Group Sébastien English more than you expect

EMC & Inductive Solutions **REDEXPERT**

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EMC Components

Ferrites for PCB Assembly

Ferrites for Cable Assembly

Common Mode Chokes for Power Lines

Common Mode Chokes for Data and Signal Lines

Power Products

Enter your input parameter

PARAMETERS				
Input	Output	Switch	Inductor	Diode
12.0 V	5.00 V	500 kHz	40 %	0.30 V
10.0-15.0 V	2.00 A		Single	

START SIMULATION

Power Inductors

Wireless Power Transmission

MagI²C Power Module

Signal & Communications



Capacitors

Interference Suppression capacitors

MLCC's

Capacitors

ic

Sink / Source System

PARAMETERS

Applications Hints

- Long Datasignal Lines: 120 Ω
- Datasignal Lines/Clock/Video/USB: 70 Ω
- Supply Voltage Lines (VCC): 15 Ω
- Ground Planes (GND): 1 Ω
- User defined

Noise attenuation

Att 15 dB f 250 MHz

Source (Z_A)

Z 1 Ω

Sink (Z_B)

Z 1 Ω

Display details



Probiert es live:

www.we-online.com/redexpert

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



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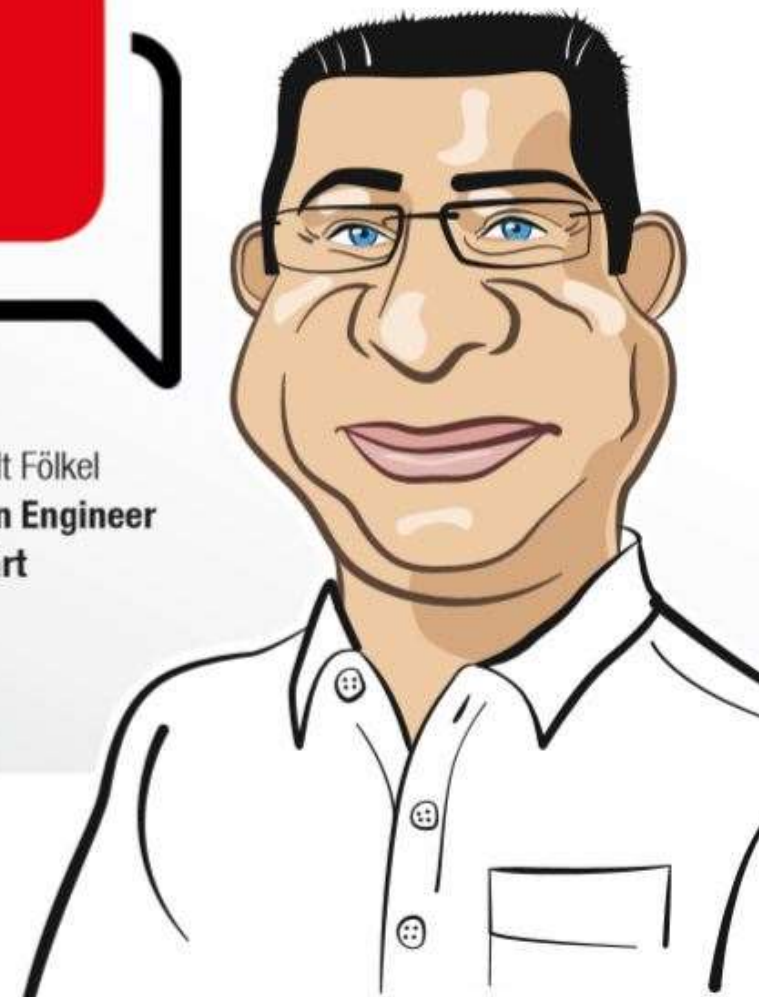
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Lorandt Fölkel
**Design Engineer
at heart**



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