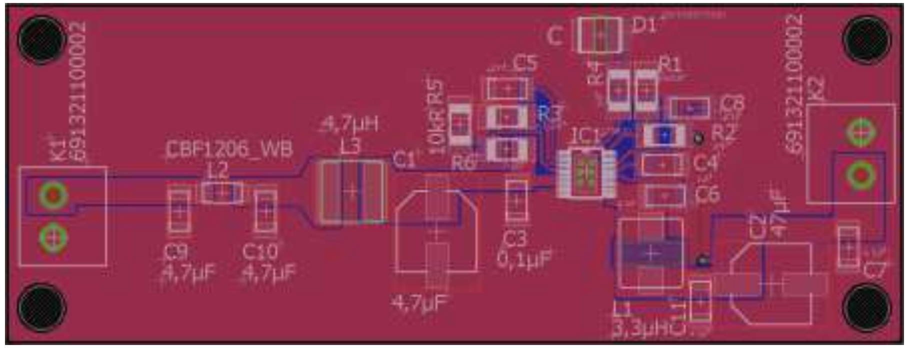
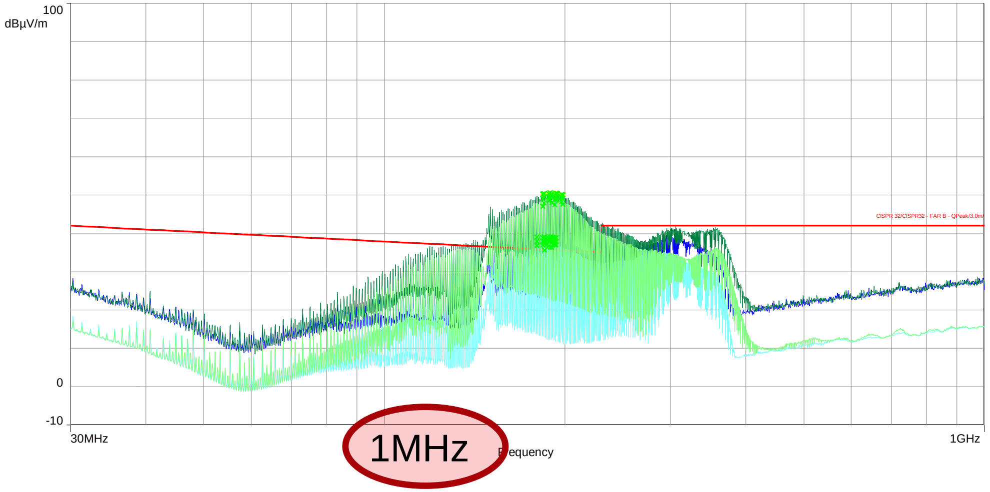
WÜRTH ELEKTRONIK

Do You Know Your Component?
Field behaviour of different passive components

Joanne Wu /
Frank Puhane

Do You Know Your Components?

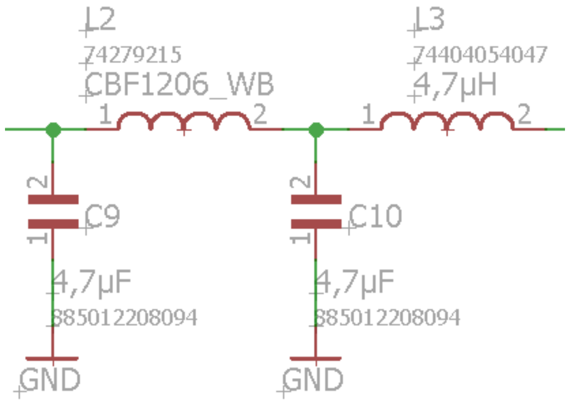




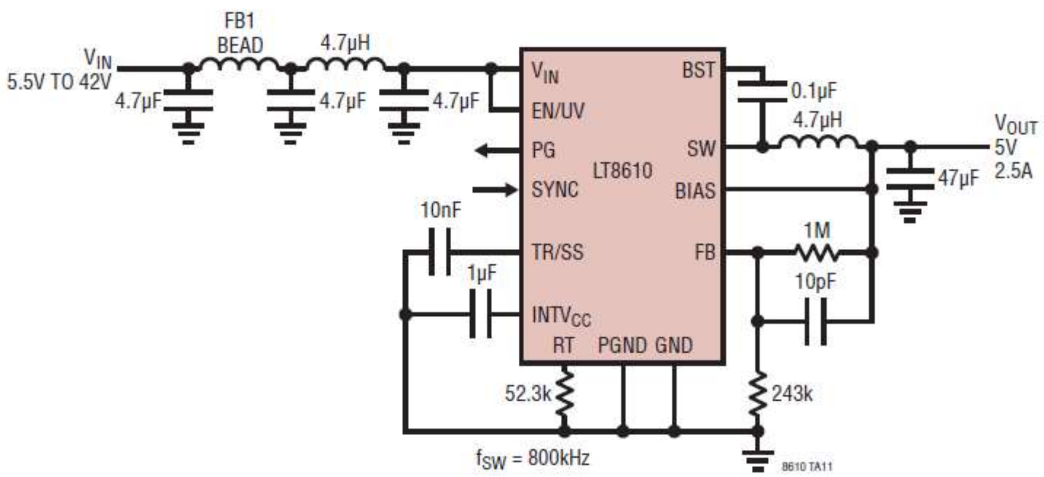
Do You Know Your Components?

- Setup of input filter according to the data sheet

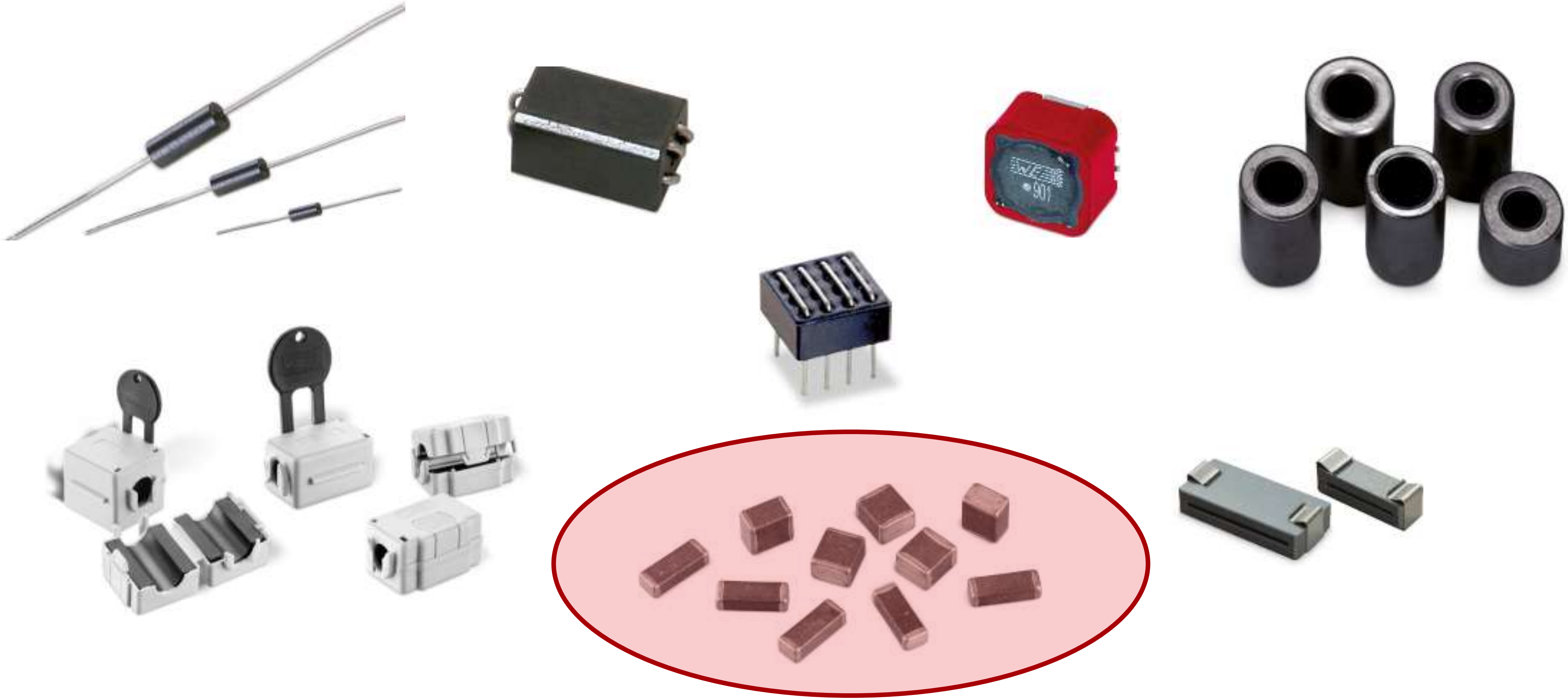
- Pi filter with downstream coil
  - Ceramic capacitors => WCAP-CSGP
  - Chip bead ferrite => WE-CBF
  - Filter inductor => WE-LQS



Ultralow EMI 5V 2.5A Step-Down Converter



Let’s Talk about Ferrites



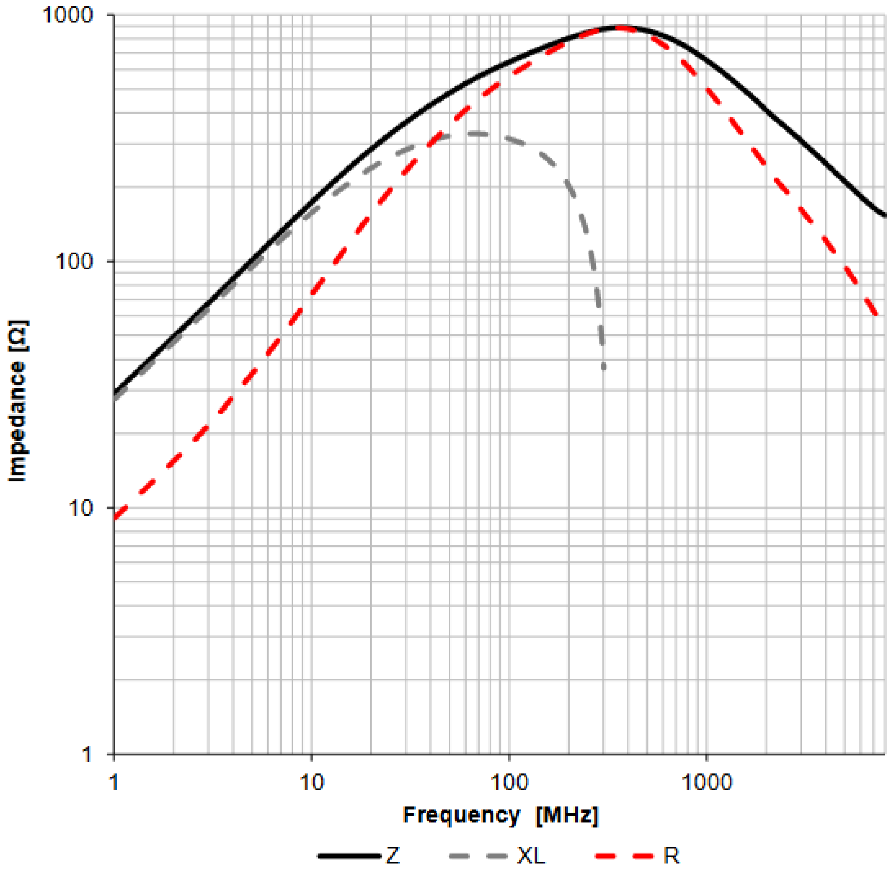
Ferrite Beads

WÜRTH ELEKTRONIK

Electrical Properties:

Properties		Test conditions	Value	Unit	Tol.
Impedance @ 100 MHz	Z	100 MHz	600	Ω	±25%
Impedance @ 1 GHz	Z	1 GHz	450	Ω	typ.
Maximum Impedance	Z_{max}	350 MHz	900	Ω	typ.
Rated Current 1	I_{R1}	ΔT = 20 K	200	mA	max.
Rated Current 2	I_{R2}	ΔT = 40 K	500	mA	max.
DC Resistance	R_{DC}	@ 20 °C	0.27	Ω	typ.
DC Resistance	R_{DC}	@ 20 °C	0.9	Ω	max.
Type	Wide Band				

Typical Impedance Characteristics:



Ferrite Beads – Characteristics

Which area should you consider?

Inductive

- Energy Storage

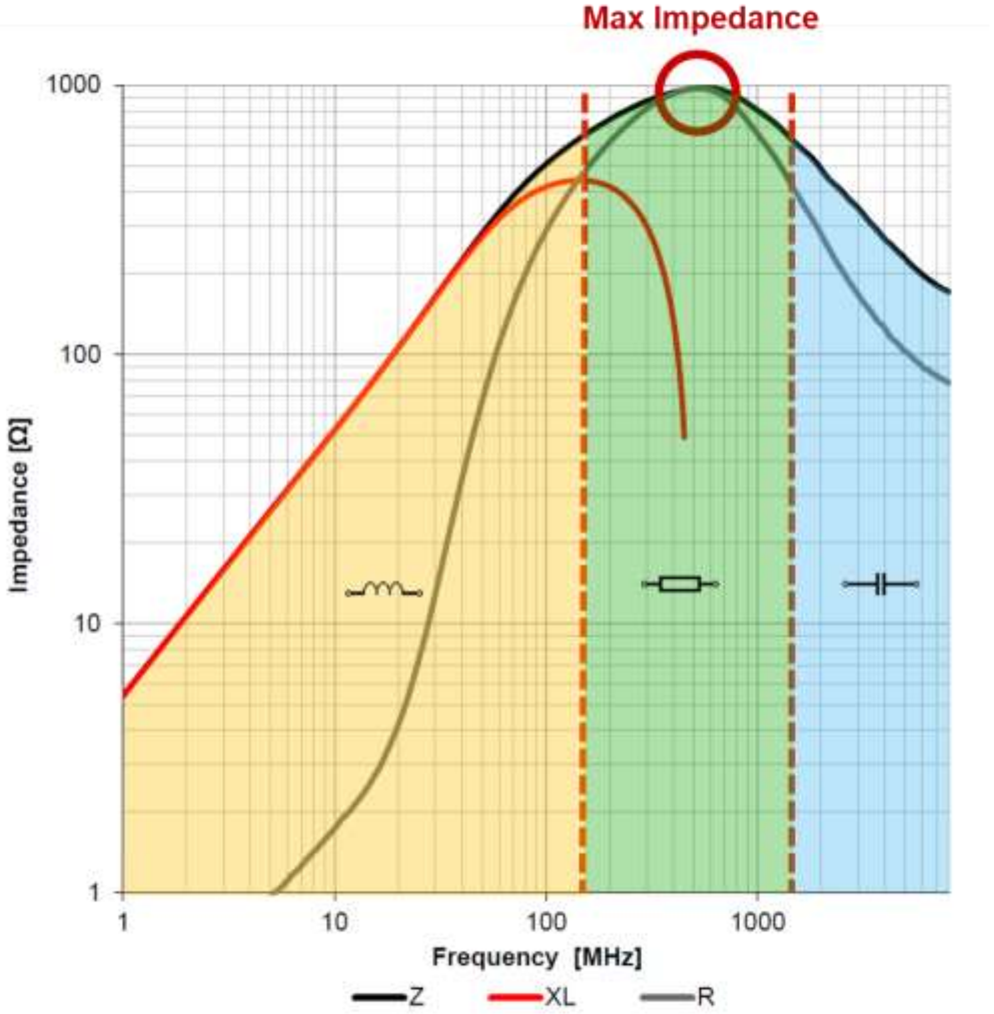
Resistive

- Absorbs impeded noise energy
- Filter usage

Capacitive

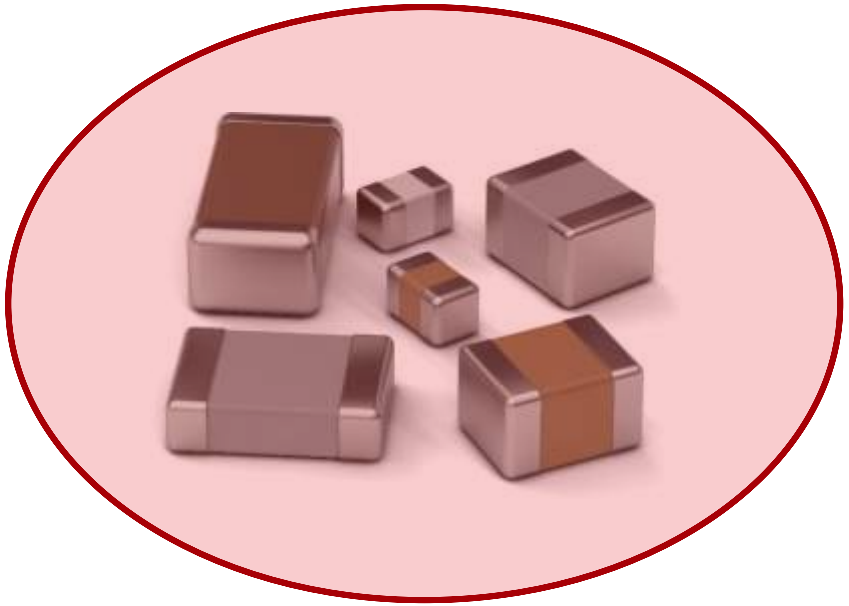
- Passes AC, Blocks DC

Ferrite beads main function is to dissipate the noise energy as heat.



Let’s Talk about Capacitors

WÜRTH ELEKTRONIK



Capacitors – MLCC

WÜRTH ELEKTRONIK

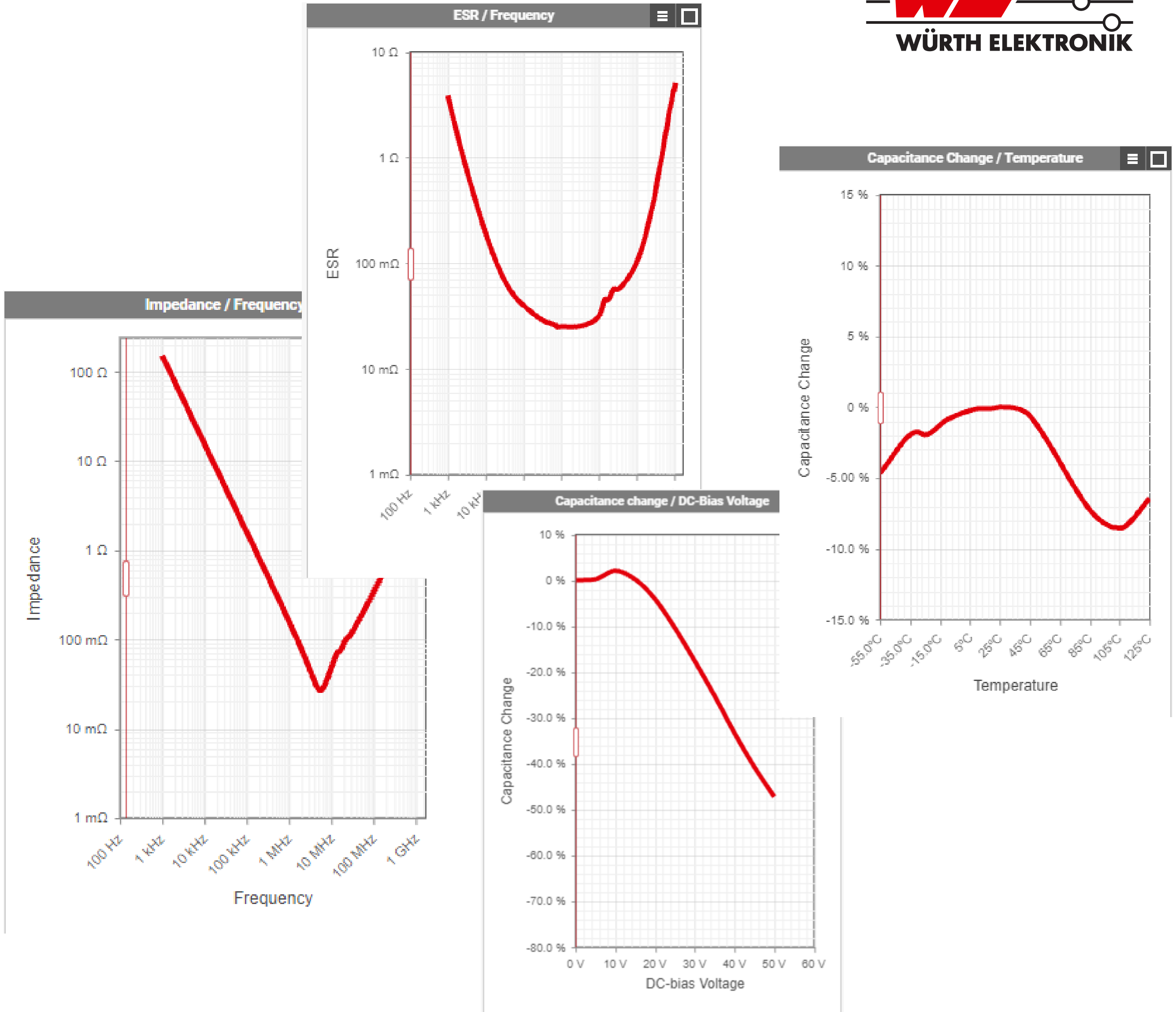
Electrical Properties:

Properties		Test conditions	Value	Unit	Tol.
Capacitance	C	1 ±0.2 V_{RMS}, 1 kHz ±10% @25 °C	1	µF	±10%
Rated Voltage	V_R		50	V (DC)	max.
Dissipation Factor	DF	1 ±0.2 V_{RMS}, 1 kHz ±10% @25 °C	2.5	%	max.
Insulation Resistance	R_{ISO}	Apply V_R for 120 s max.	0.5	GΩ	min.

Precondition for Class II MLCC measurement: Apply a preheat treatment @150 ±10 °C for 1 hour.
The measurement should be applied after 24 ±2 hrs the part was stored under ambient conditions.
There is not any precondition necessary for Class I MLCC.

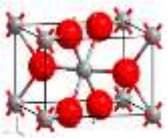
General Information:

General Purpose MLCC	
Ceramic Type	X7R Class II
Temperature Coefficient	± 15 % max.
Operating Temperature	-55 up to +125 °C
Storage Conditions (in original packaging)	5 °C up to + 35 °C; 10 % up to 75 % RH
Moisture Sensitivity Level (MSL)	1
Dielectric Strength	5 sec. @250 % V_R; Charge & Discharge Current <50 mA
Test conditions of Electrical Properties: +20 °C, 35 % RH if not specified differently	
FIT according to separate documentation	



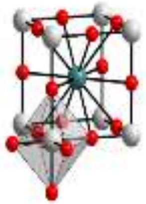
Capacitors – MLCC

- <u>Class 1 (e.g.: NP0 or C0G -> titanium oxide)</u>



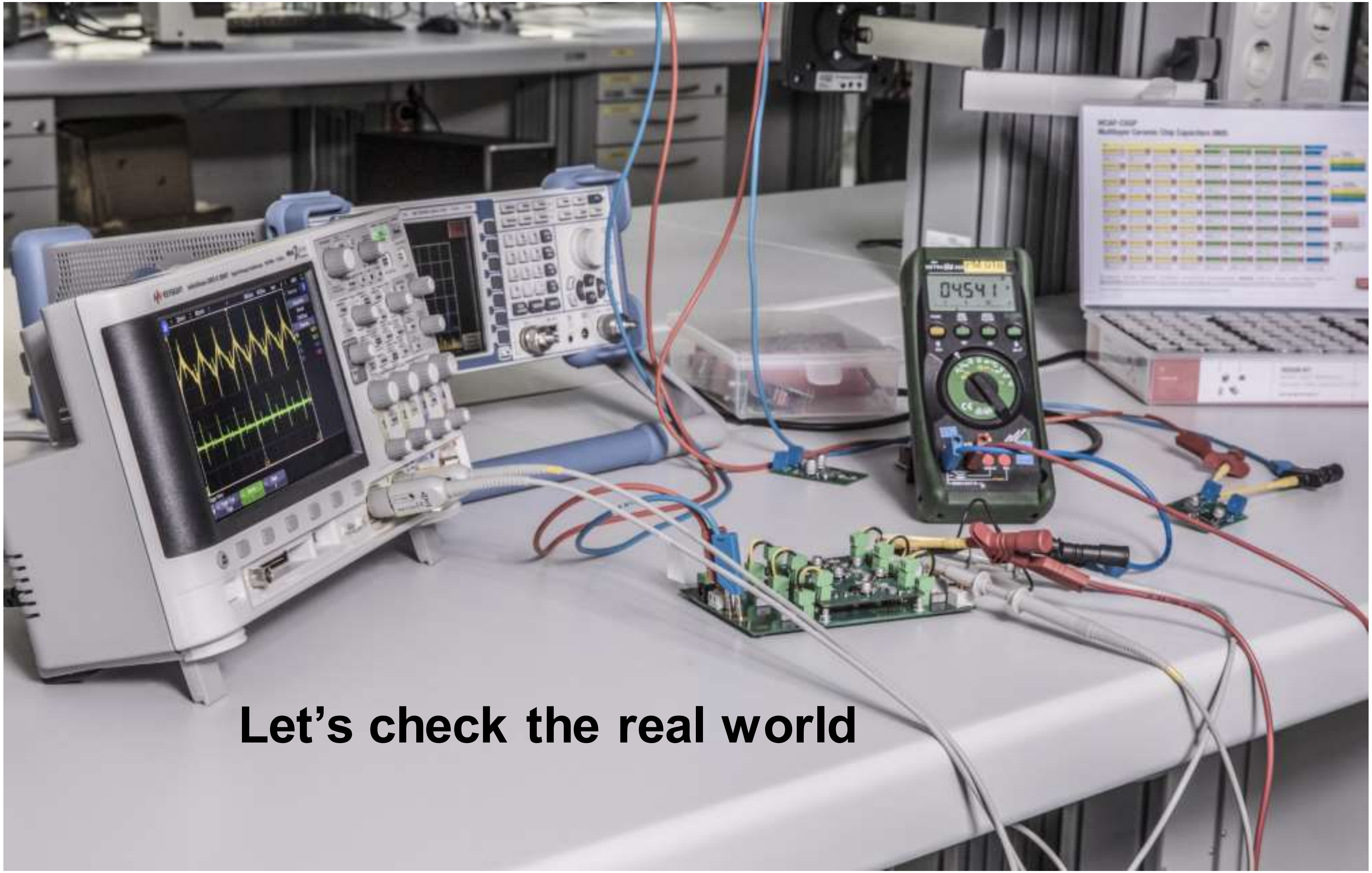
  - Smaller relative permittivity εr => lower capacitance
  - Depending on the type no temperature dependence (e.g. C0G / NP0)
  - Otherwise there are no derating
  - **They offer stable / precise C-values**
  - **For applications where fixed / stable capacitance value is needed**

- <u>Class 2 (e.g.: X7R, X5R, Y5V -> barium titanate)</u>



  - Higher relative permittivity εr => higher capacitance
  - Non-linear temperature dependence (manufacturer specific due to material mix / design)
  - DC bias and aging behavior
  - **The capacitance value in the DB is not explicitly available in the application**
  - **Manufacturer's data must be checked in order to estimate the resulting capacitance**

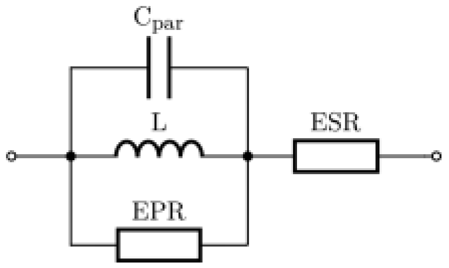
WÜRTH ELEKTRONIK



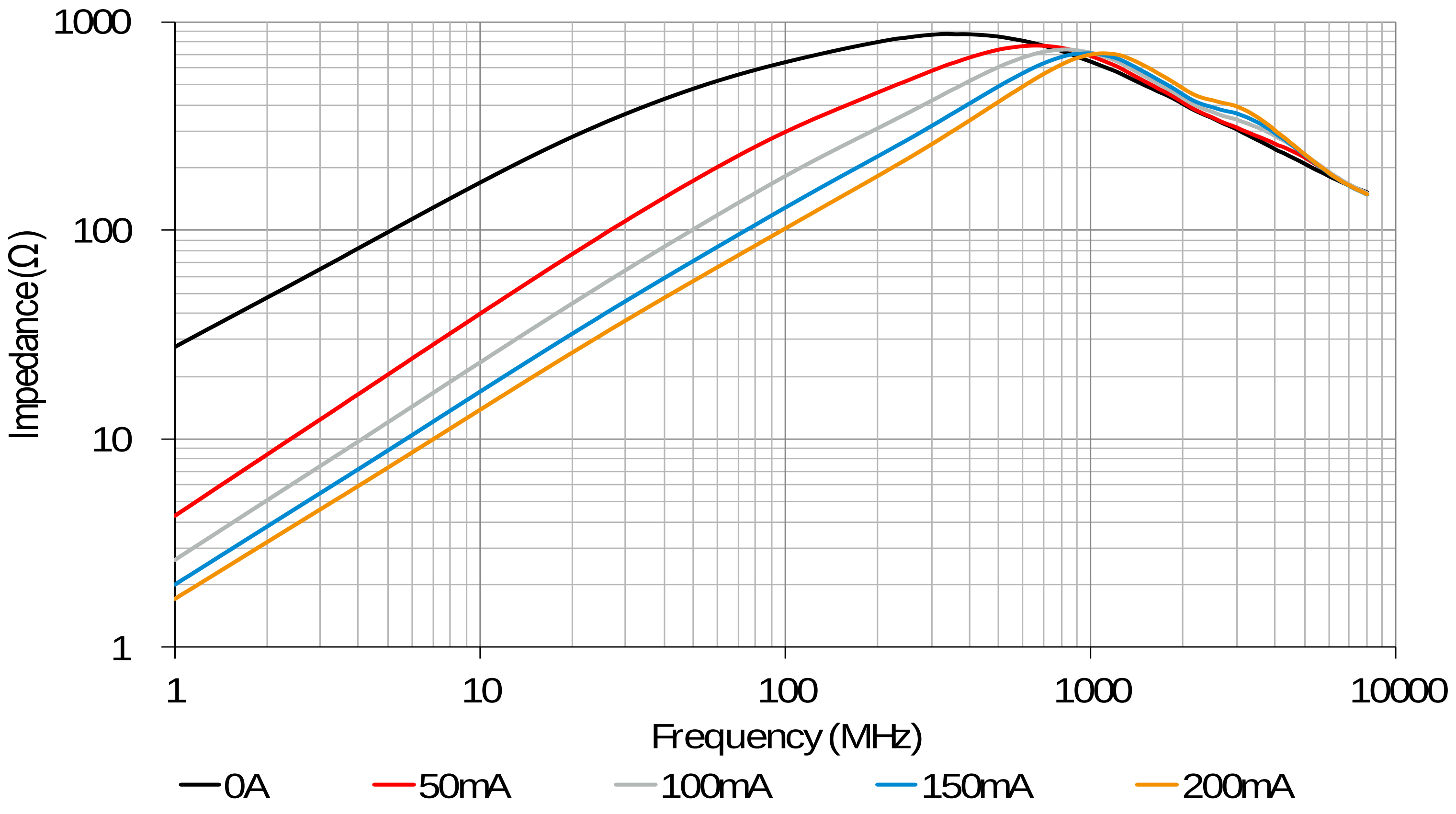
Let’s check the real world

Ferrite Beads - Real Conditions

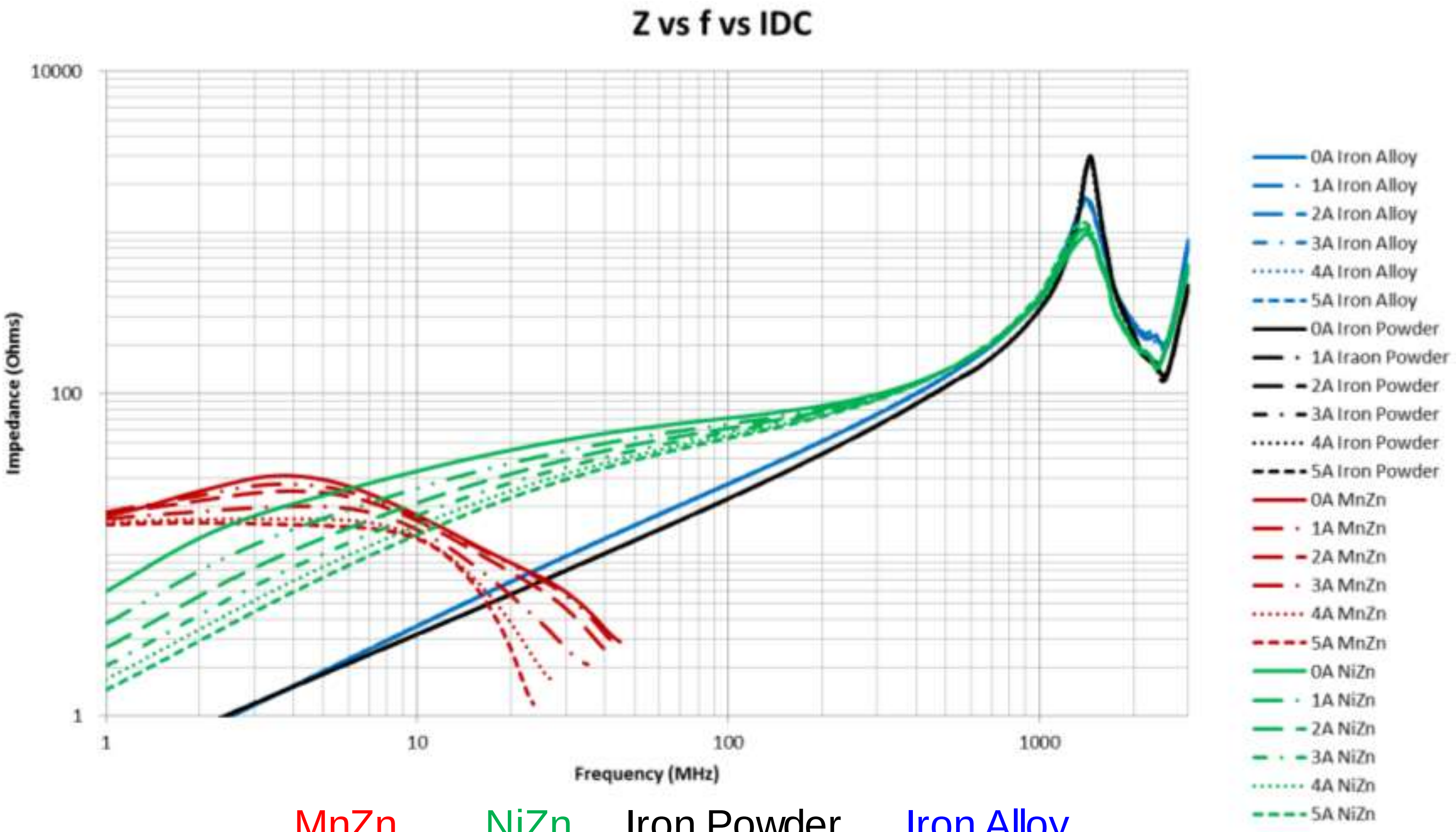
- **Equivalent circuit**



- **Material**
  - Temperature
  - Magnetic
  - DC bias
    - Reduce inductance
    - Shifted SRF



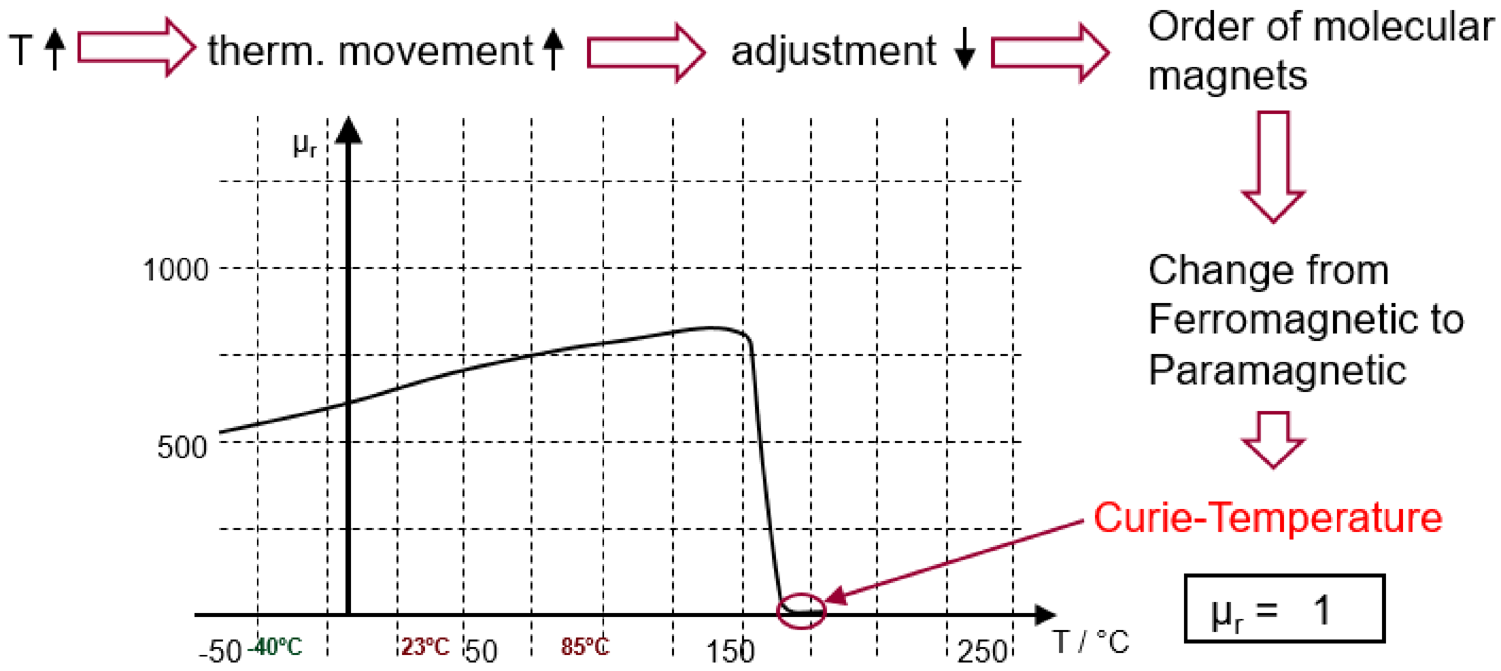
Material Curves (Typical)



MnZn NiZn Iron Powder Iron Alloy

Temperature Influence

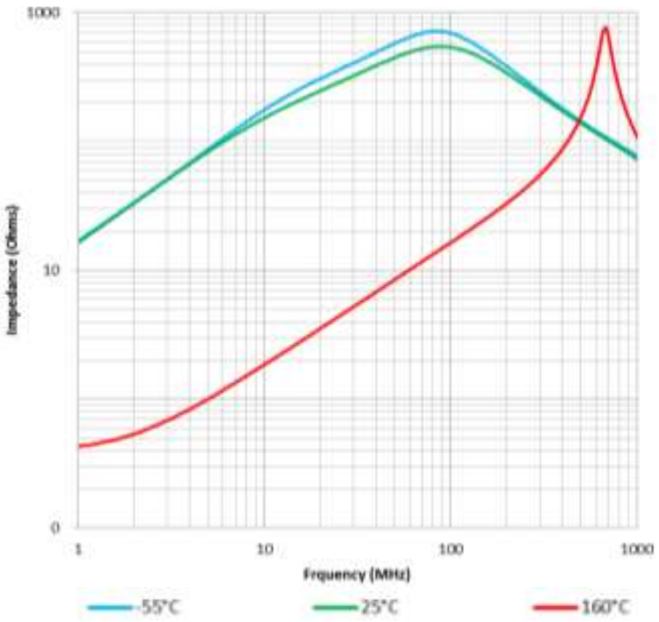
- Magnetic field is temperature dependant
- Curie temperature depends on material
- CT reached, permeability of ferrite material is lost



Ferrite Beads - Temperature Influence

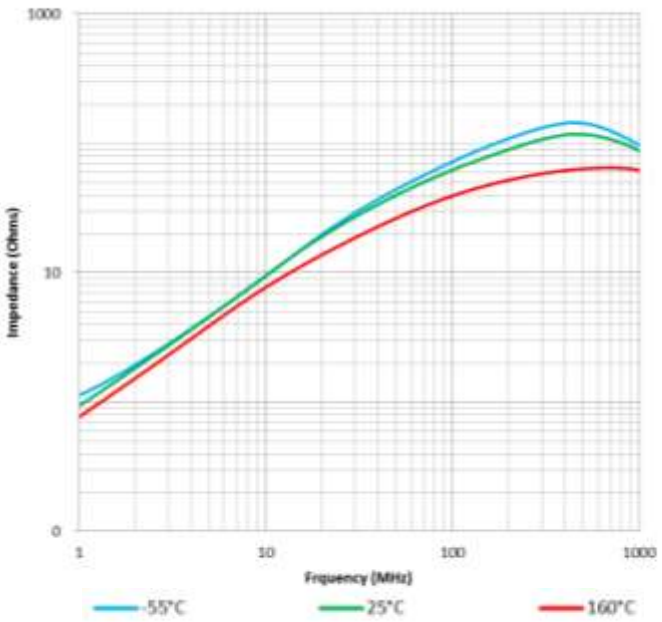
- Temperature behaviour according to material
  - Different levels of impedance drop as temperature increase
  - Huge impedance drop over curie temperature

CBF optimised for 85ºC



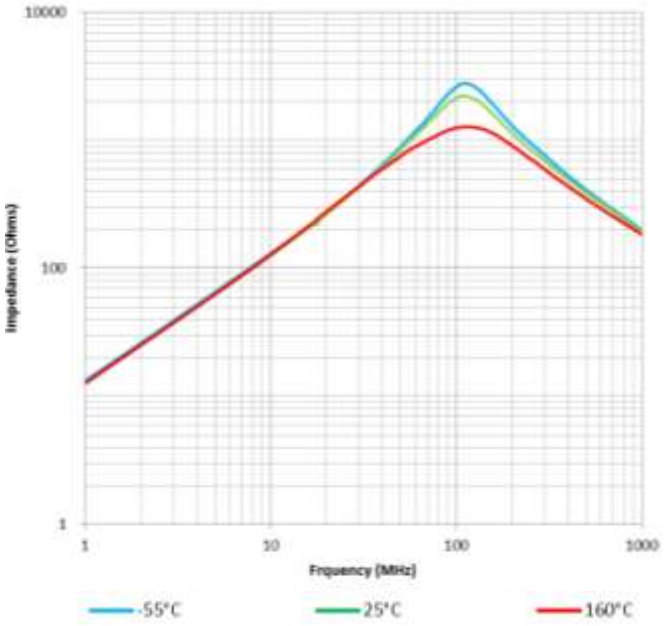
Curie Temp. <130°C

CBF optimised for 125ºC



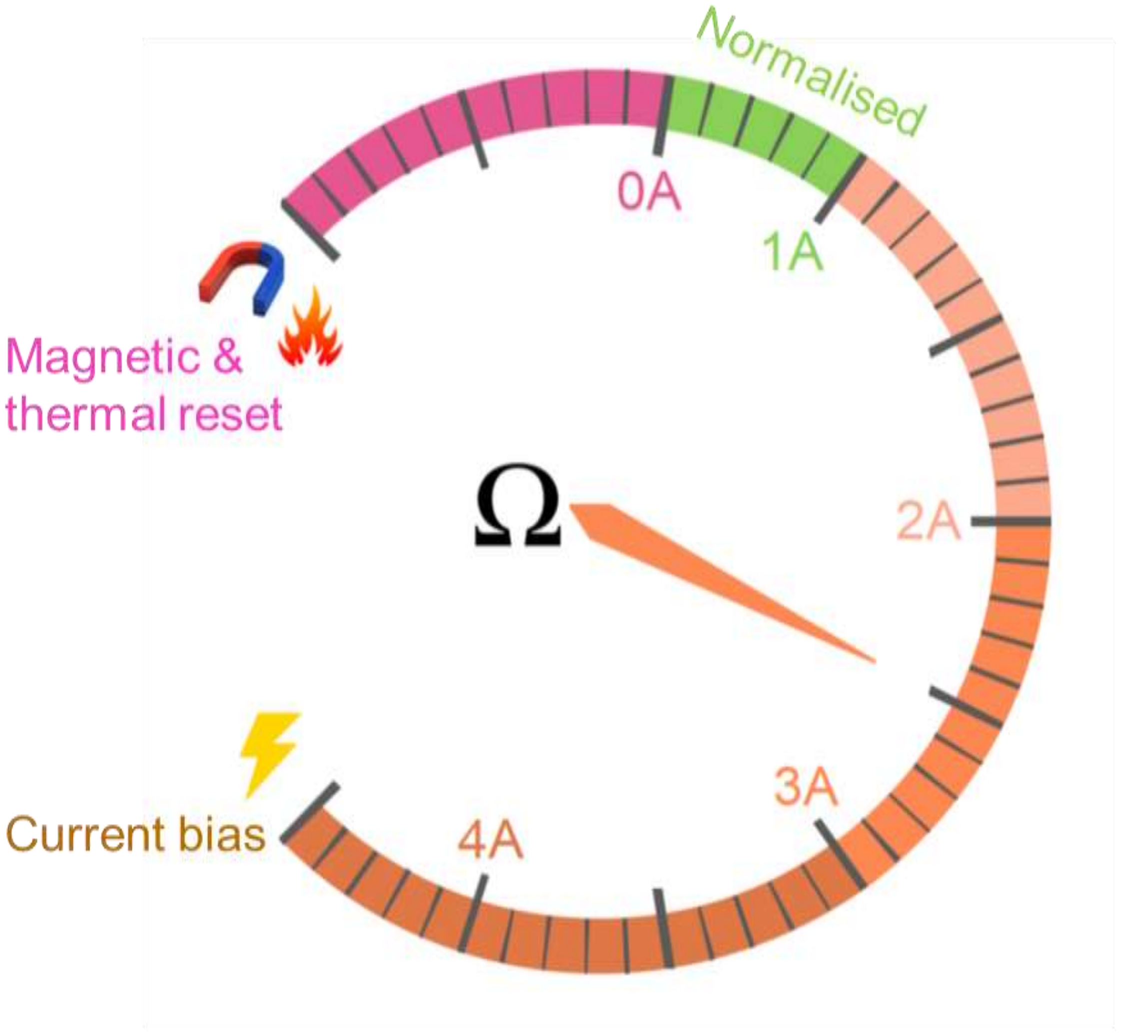
Curie Temp. >130°C

CBF optimised for 160ºC



Curie Temp. >180°C

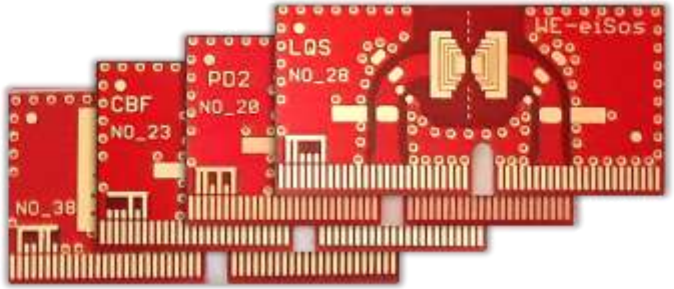
Magnetic Influence



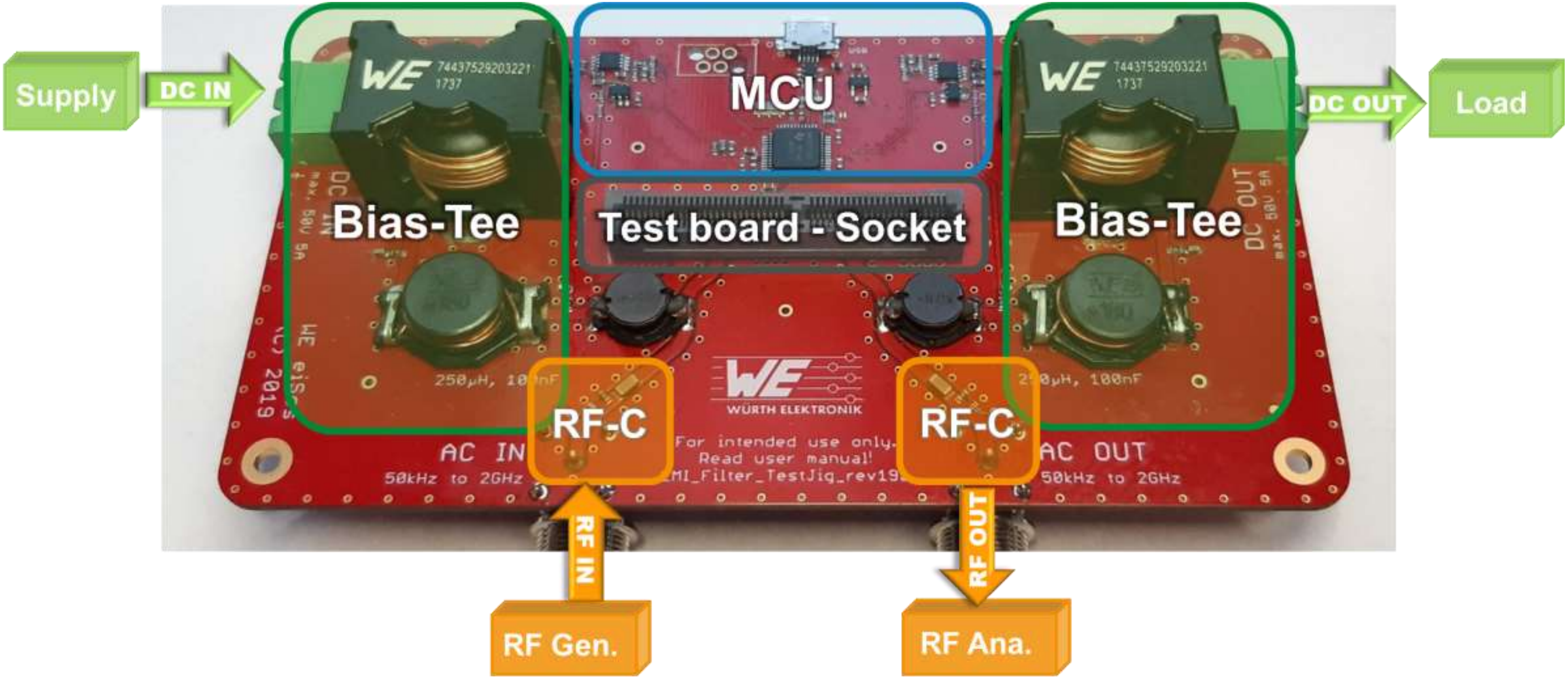
Magnetic Influence - Setup

- **Specs**
  - Separated DC & RF ports
  - Various DUTs
  - Up to 50V & 5A
  - From 50kHz to 2 GHz
  - Any RF-source & analyzer

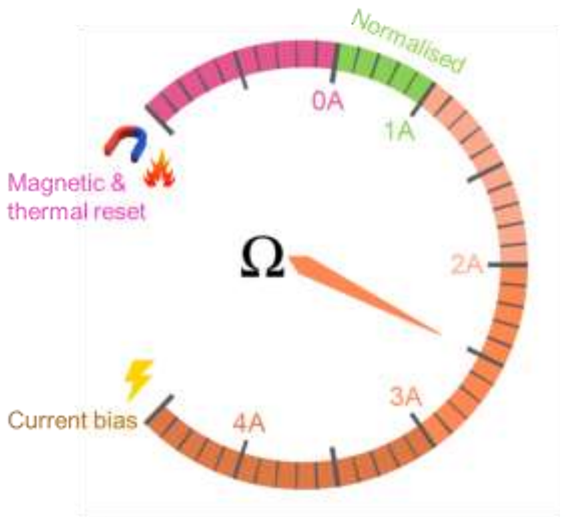
- **Setup**
  - Test fixture as “double LISN”
  - Test boards with DUT

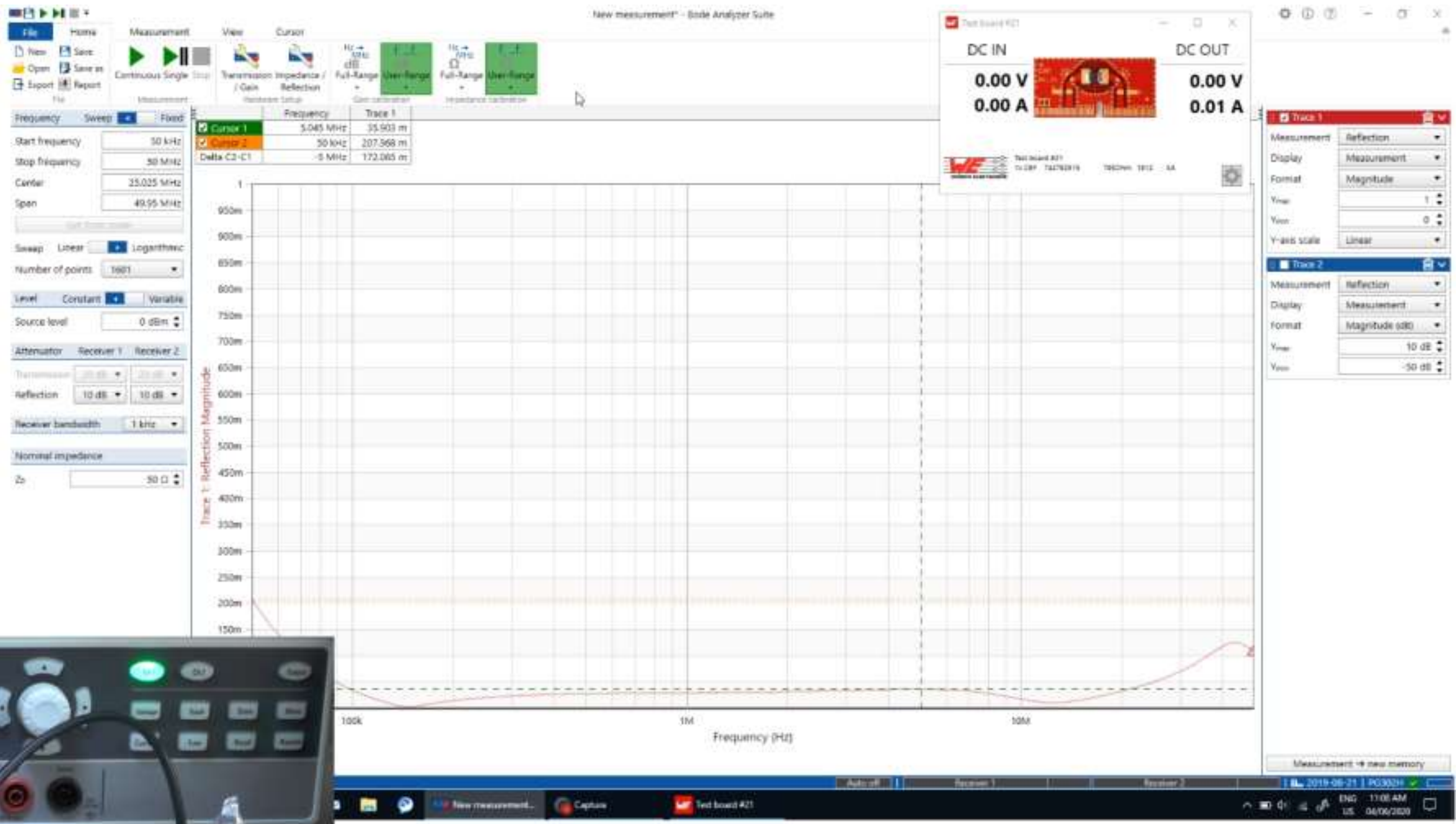


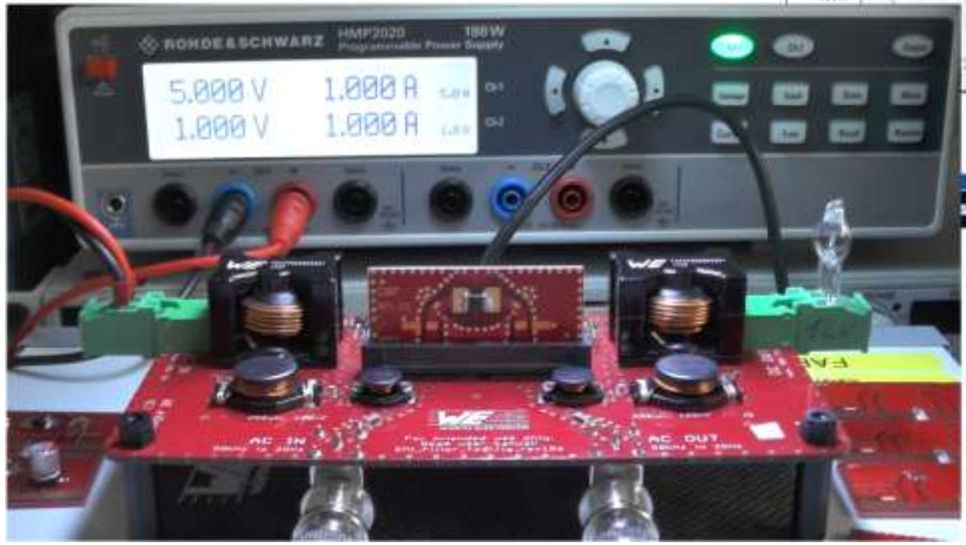
Magnetic Influence - Setup



Magnetic Influence

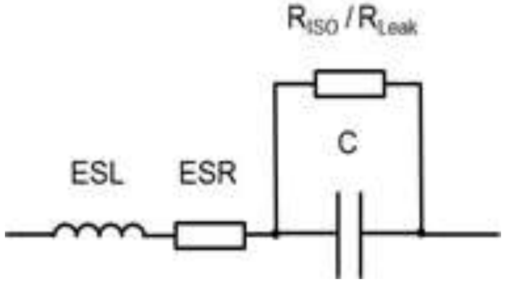




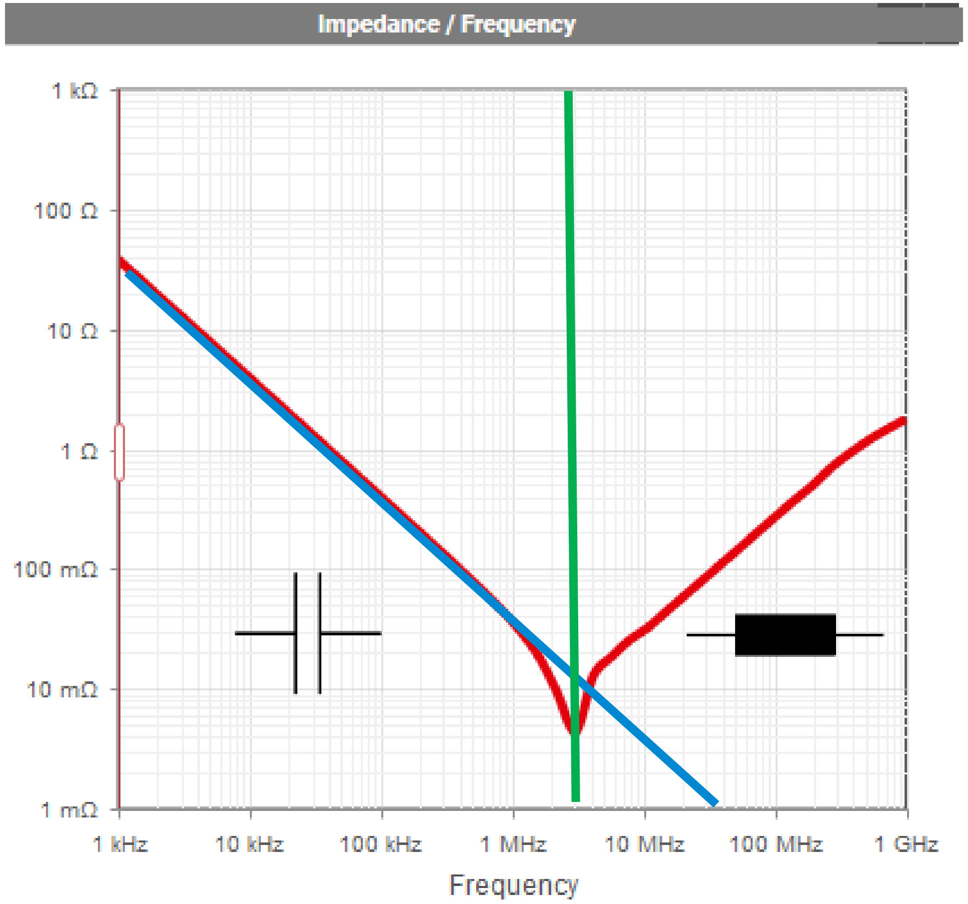


Capacitors – MLCC Real Conditions

- **Equivalent circuit**



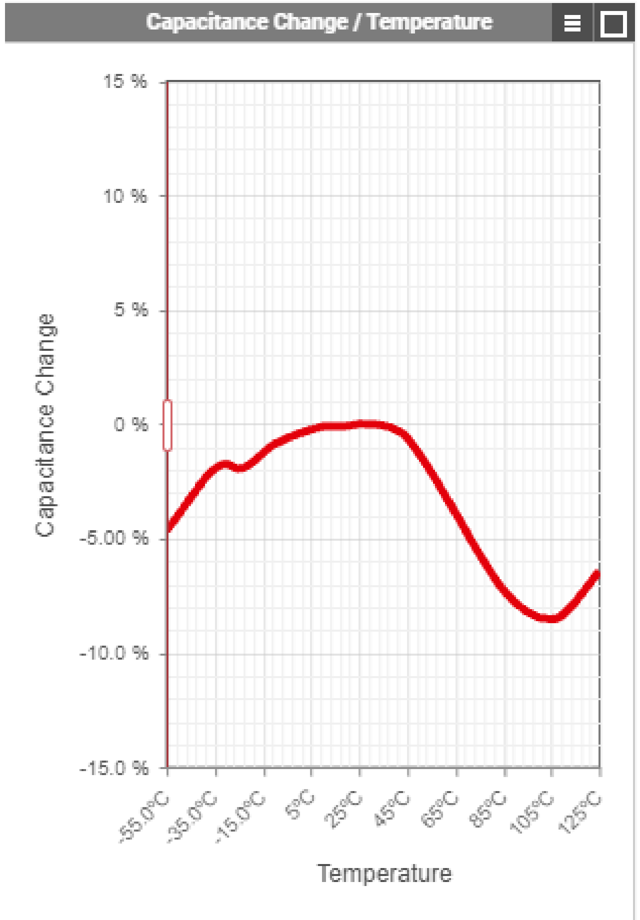
- Voltage
  - Capacitance loss
  - Shifted SRF
- Temperature
  - De-aging
- Time
  - Capacitance loss over time

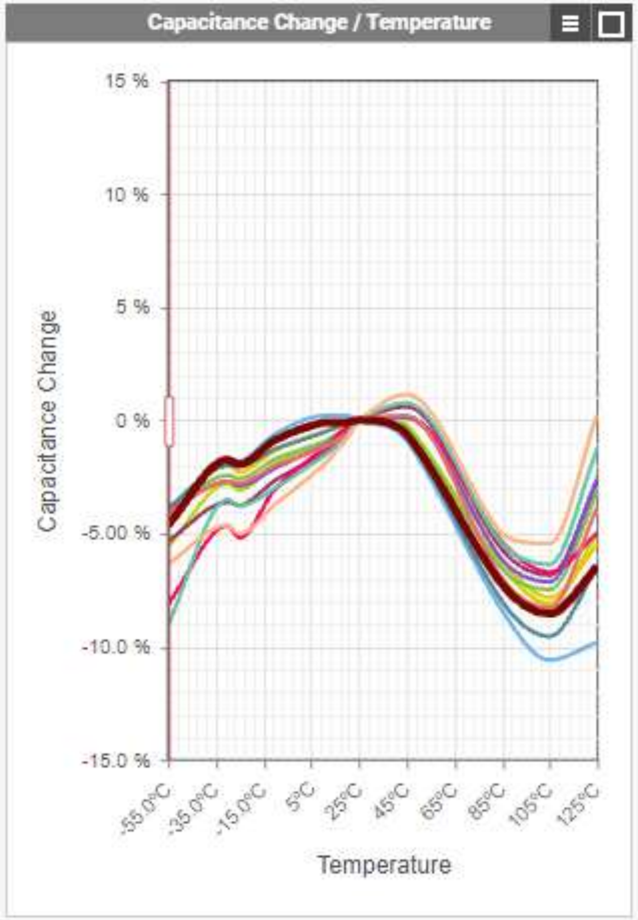


Capacitors – MLCC Temperature

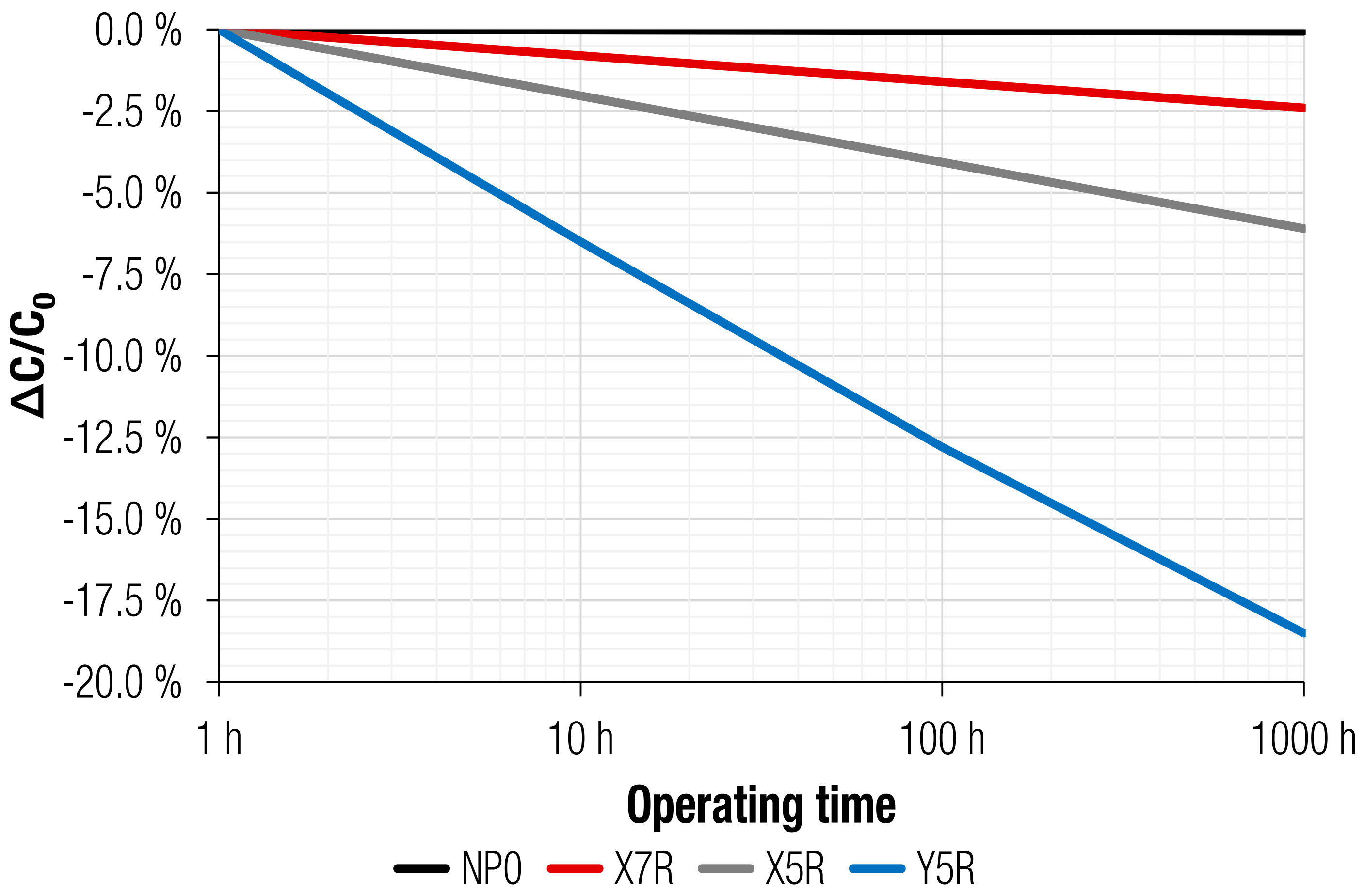
WÜRTH ELEKTRONIK

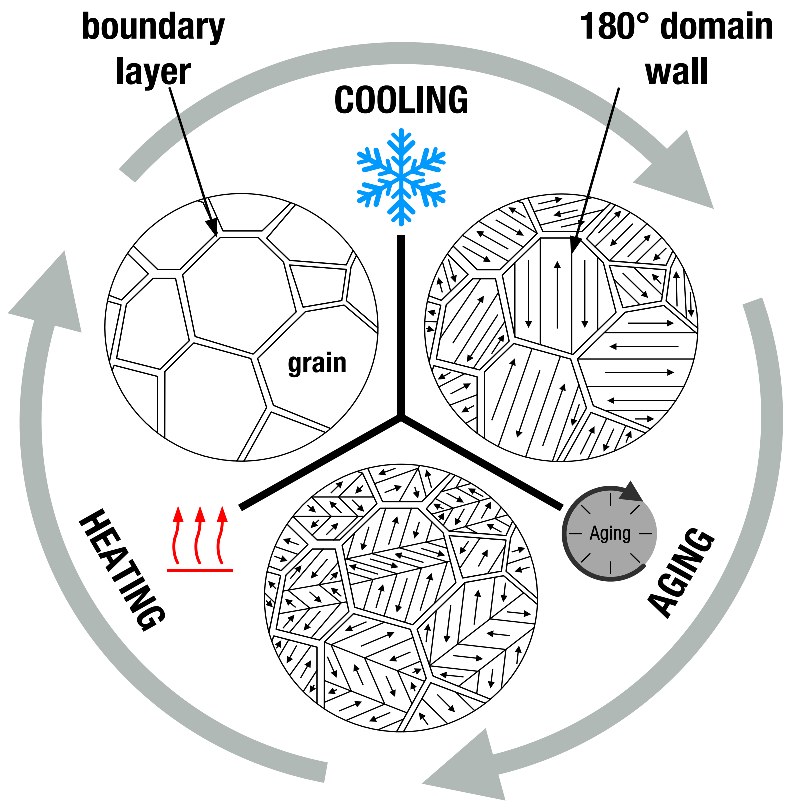
EIA-RS-198 Codierung für Klasse 2 Keramikkondensatoren					
1. Zeichen		2. Zeichen		3. Zeichen	
Buchstabe	untere Temperaturgrenze	Nummer	obere Temperaturgrenze	Buchstabe	Kapazitätsänderung über den zulässigen Temperaturbereich
X	−55 °C	2	+45 °C	A	±1,0 %
Y	−30 °C	4	+65 °C	B	±1,5 %
Z	+10 °C	5	+85 °C	C	±2,2 %
		6	+105 °C	D	±3,3 %
		7	+125 °C	E	±4,7 %
		8	+150 °C	F	±7,5 %
		9	+200 °C	P	±10 %
				R	±15 %
				S	±22 %
				T	+22 / −33 %
				U	+22 / −56 %
				V	+22 / −82 %





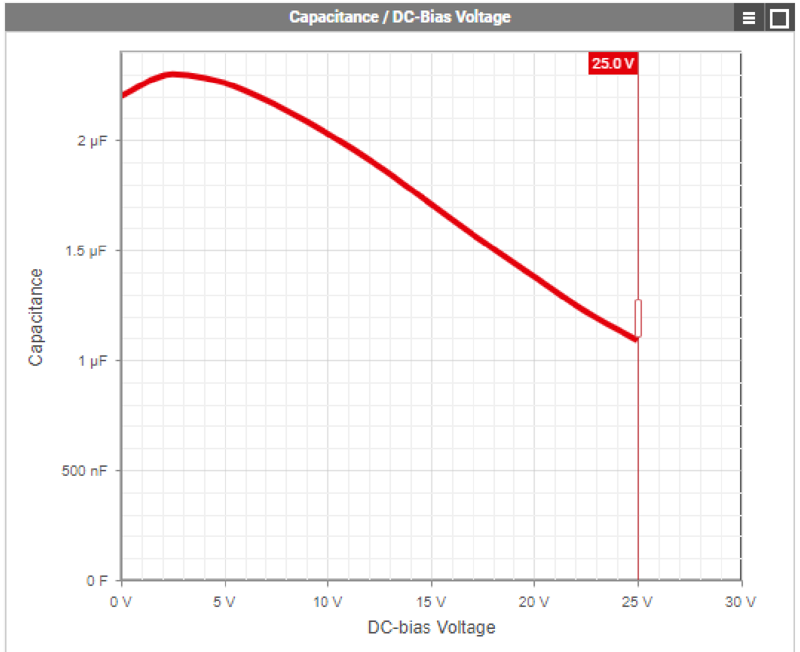
Capacitors – MLCC Aging

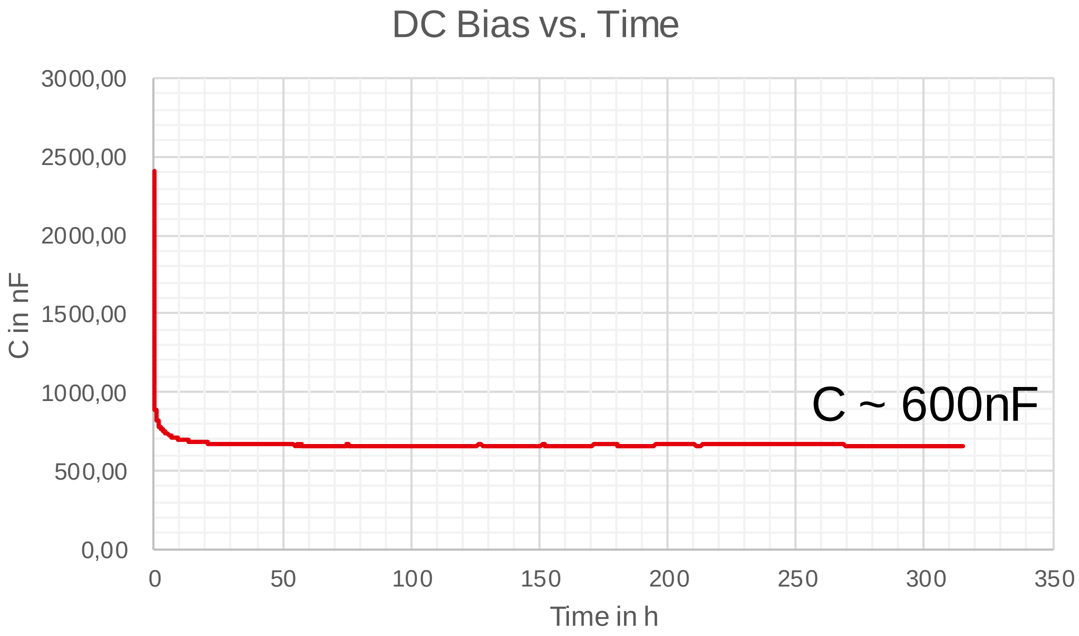




Capacitors – MLCC DC Bias

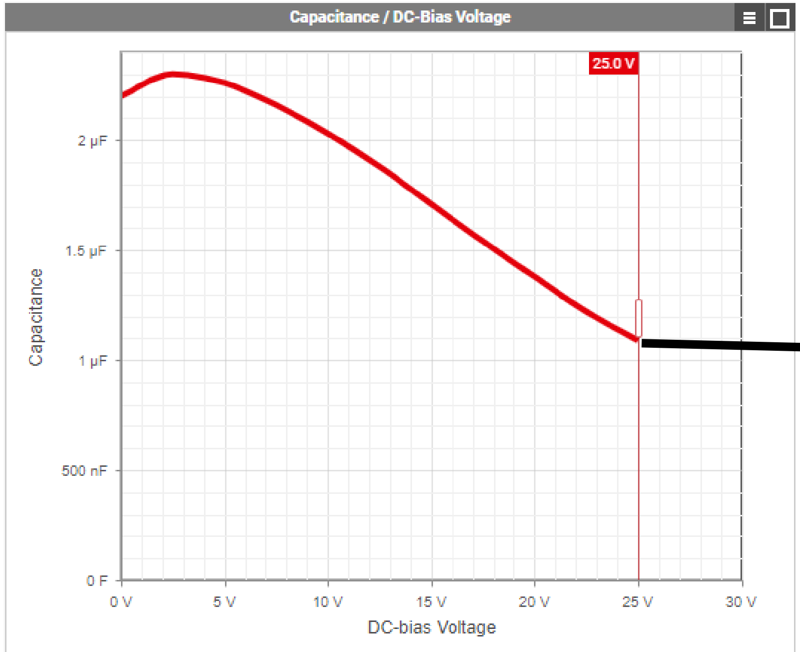
- 885012208066 => 2.2µF / 25V / X7R / 1206
- ΔC@25V = 50% = 1.1µF

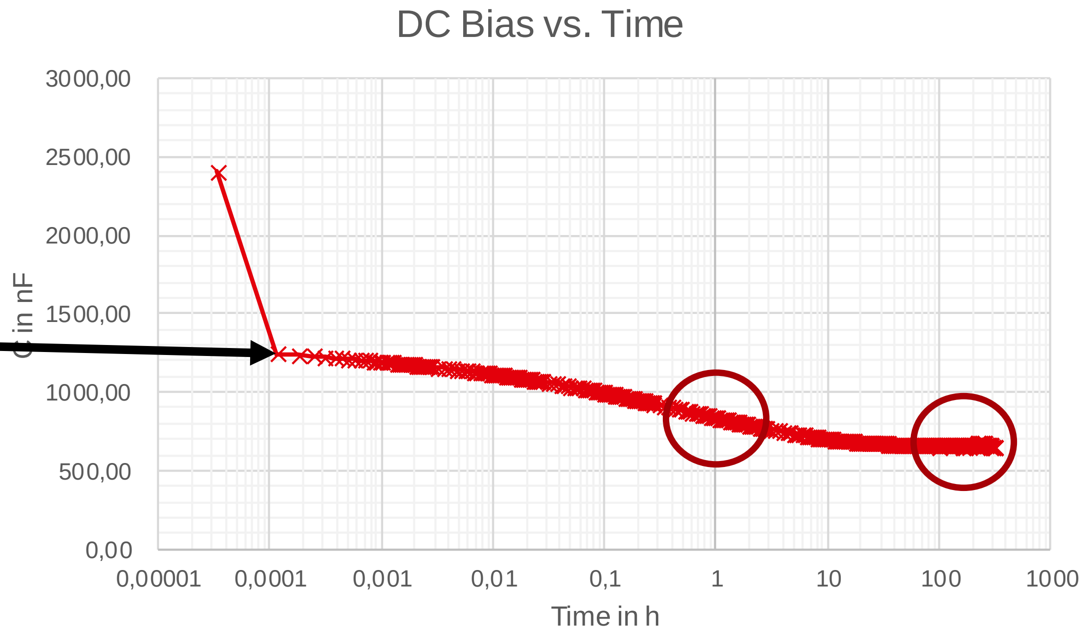




Capacitors – MLCC DC Bias

- 885012208066 => 2.2µF / 25V / X7R / 1206
- ΔC@25V = 50% = 1.1µF

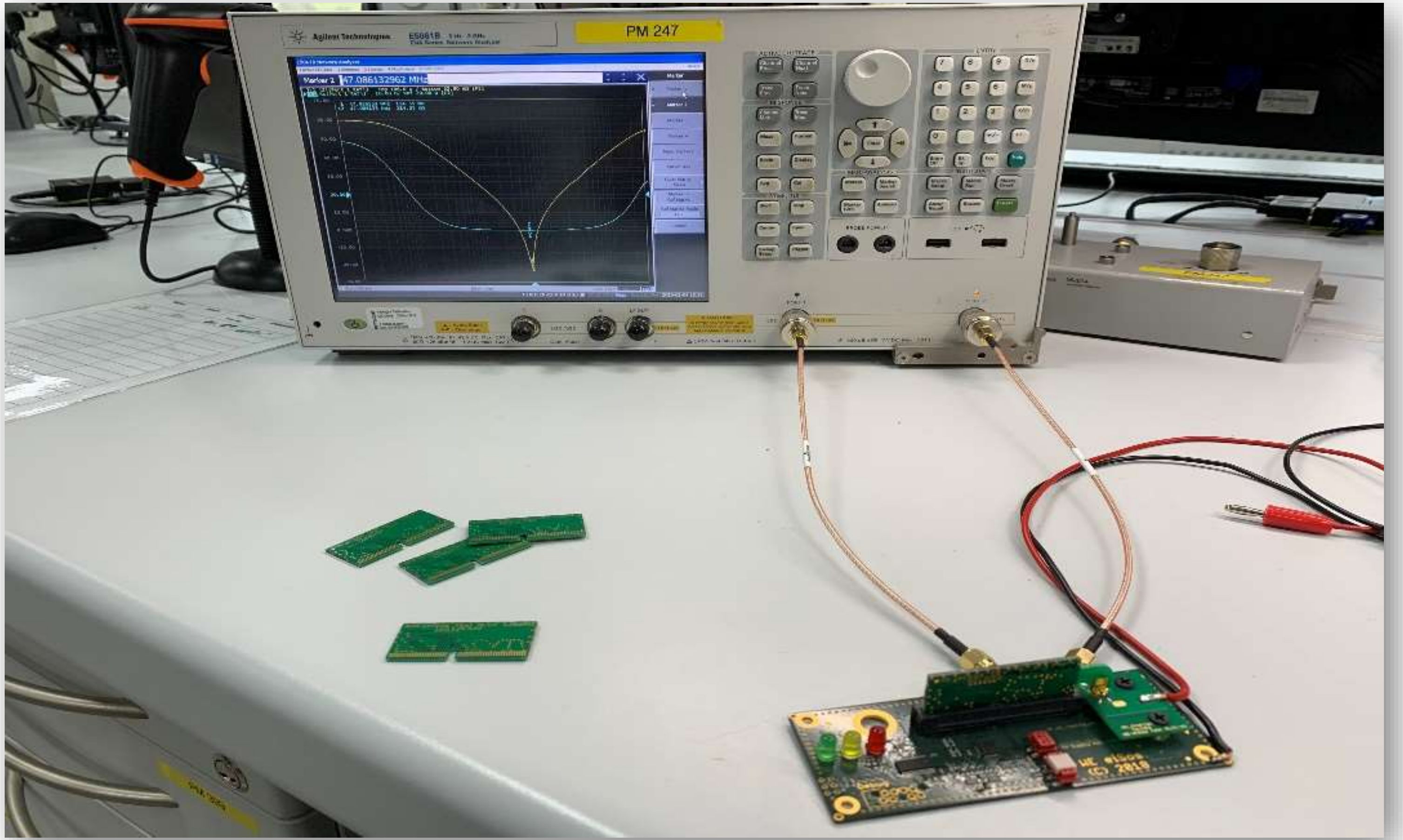




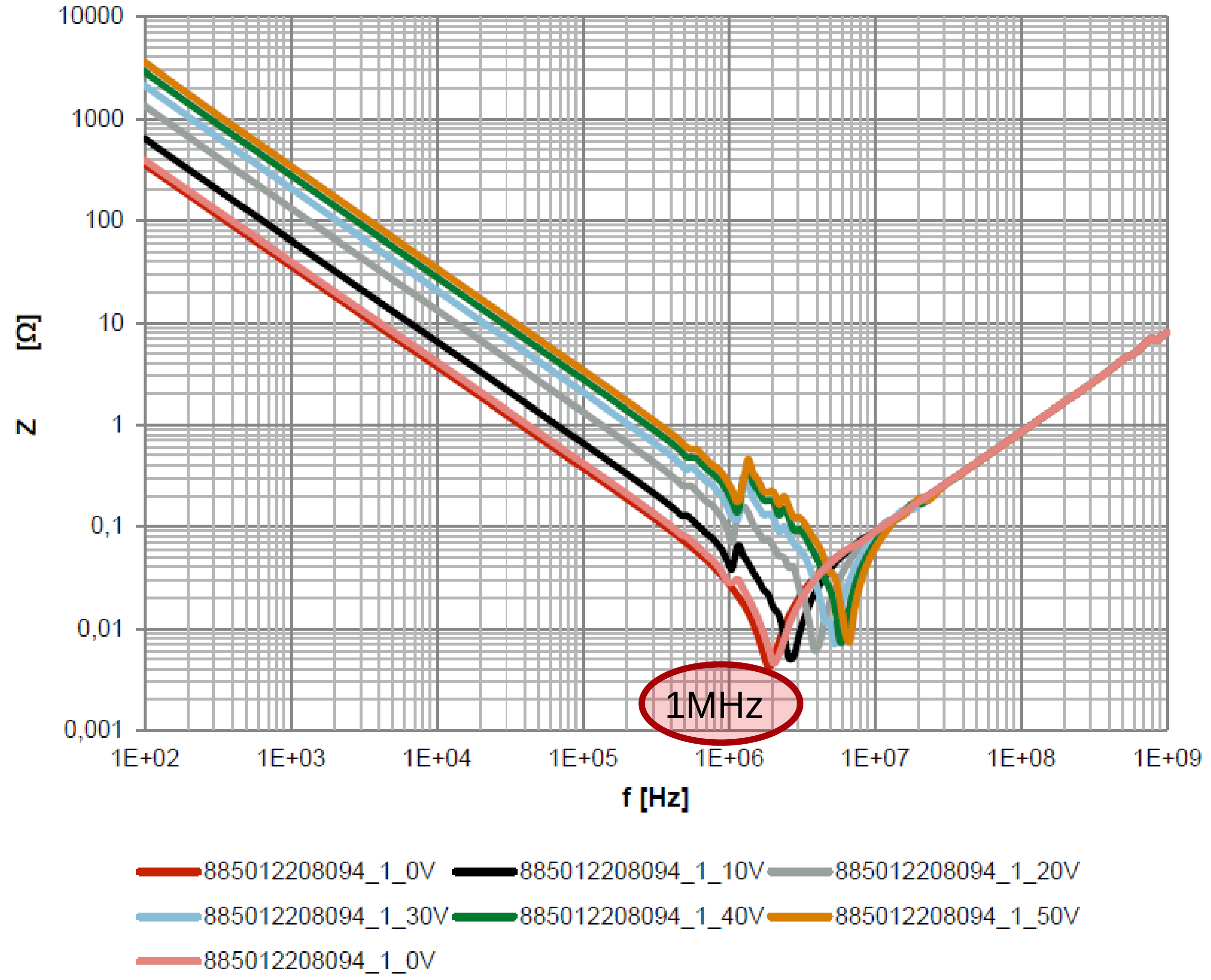
Capacitors – MLCC DC Bias

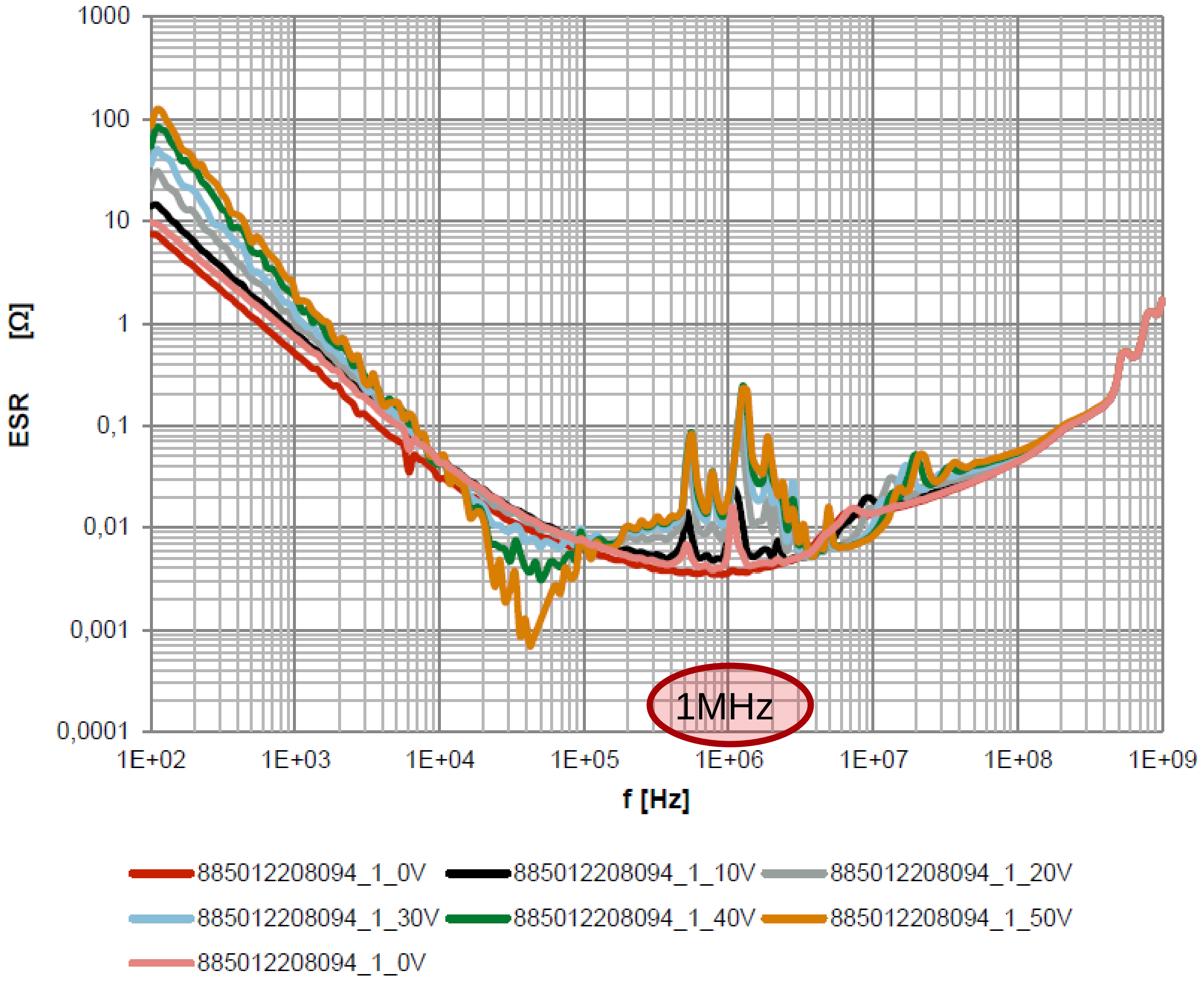
- Requirements:
  - For capacitors
  - Highly precise measurement
  - Separated DC & RF ports
  - Up to 10.5 GHz

- Solution:
  - Same test jig as current meas.
  - Other test boards with capacitor

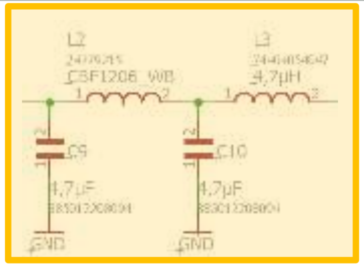


Capacitors – MLCC DC Bias





Input Filter for LT8610



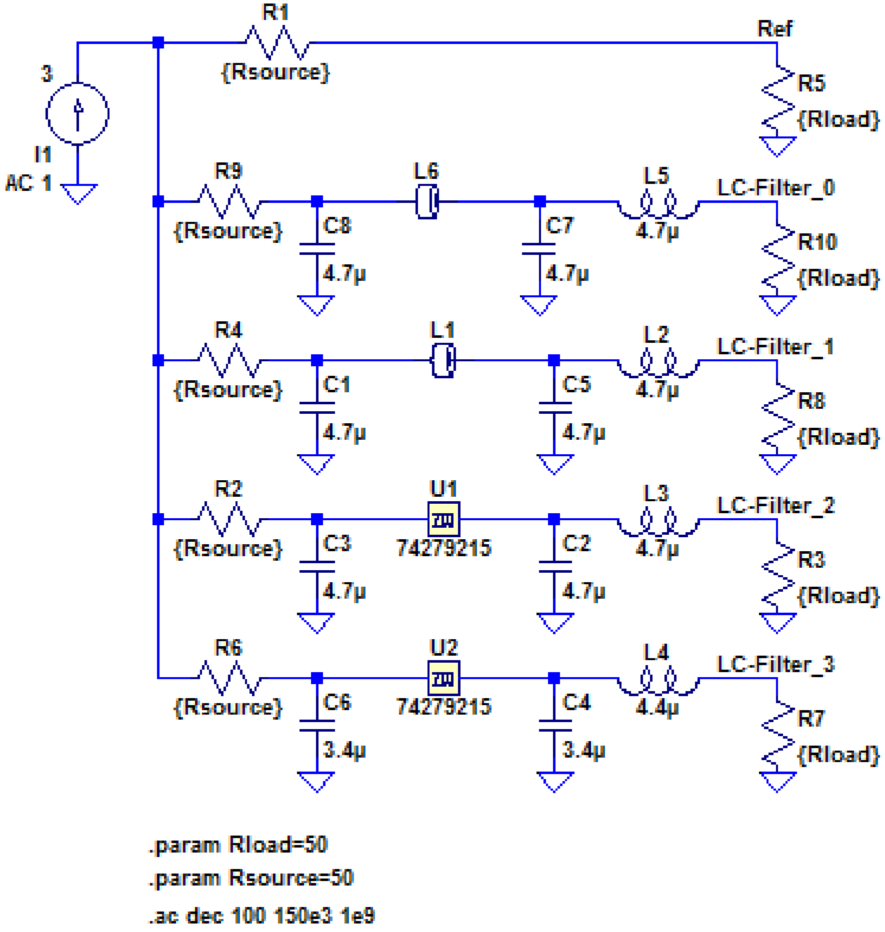
- Simulation of different filters specification
- Relative to 50Ω source and sink impedance

  0 => Ideal components

  1 => With parasitic effects

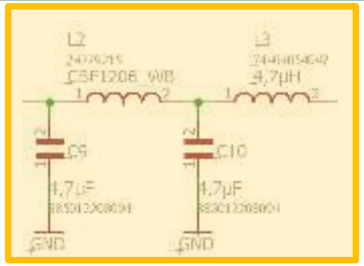
  2 => DC Bias MLCC

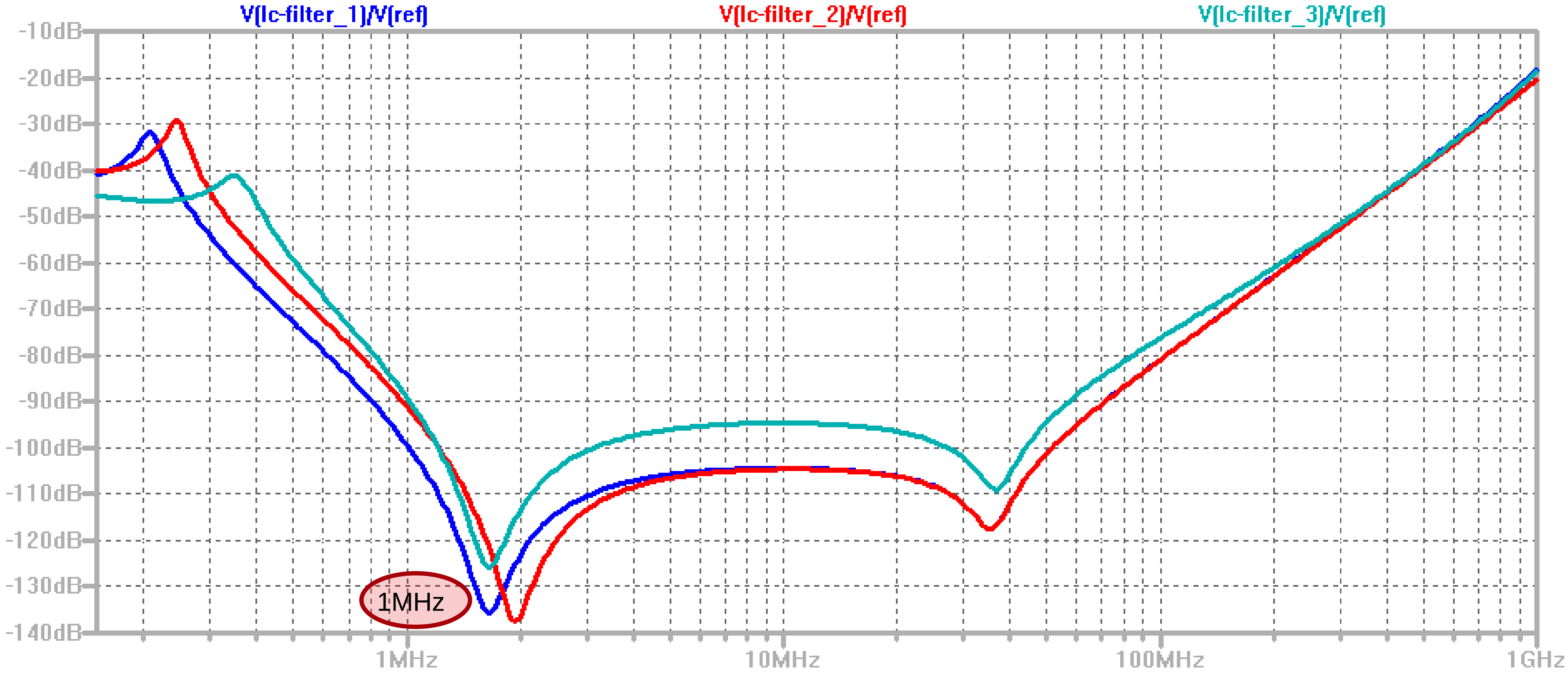
  3 => DC bias MLCC + current dependence ferrite and coil



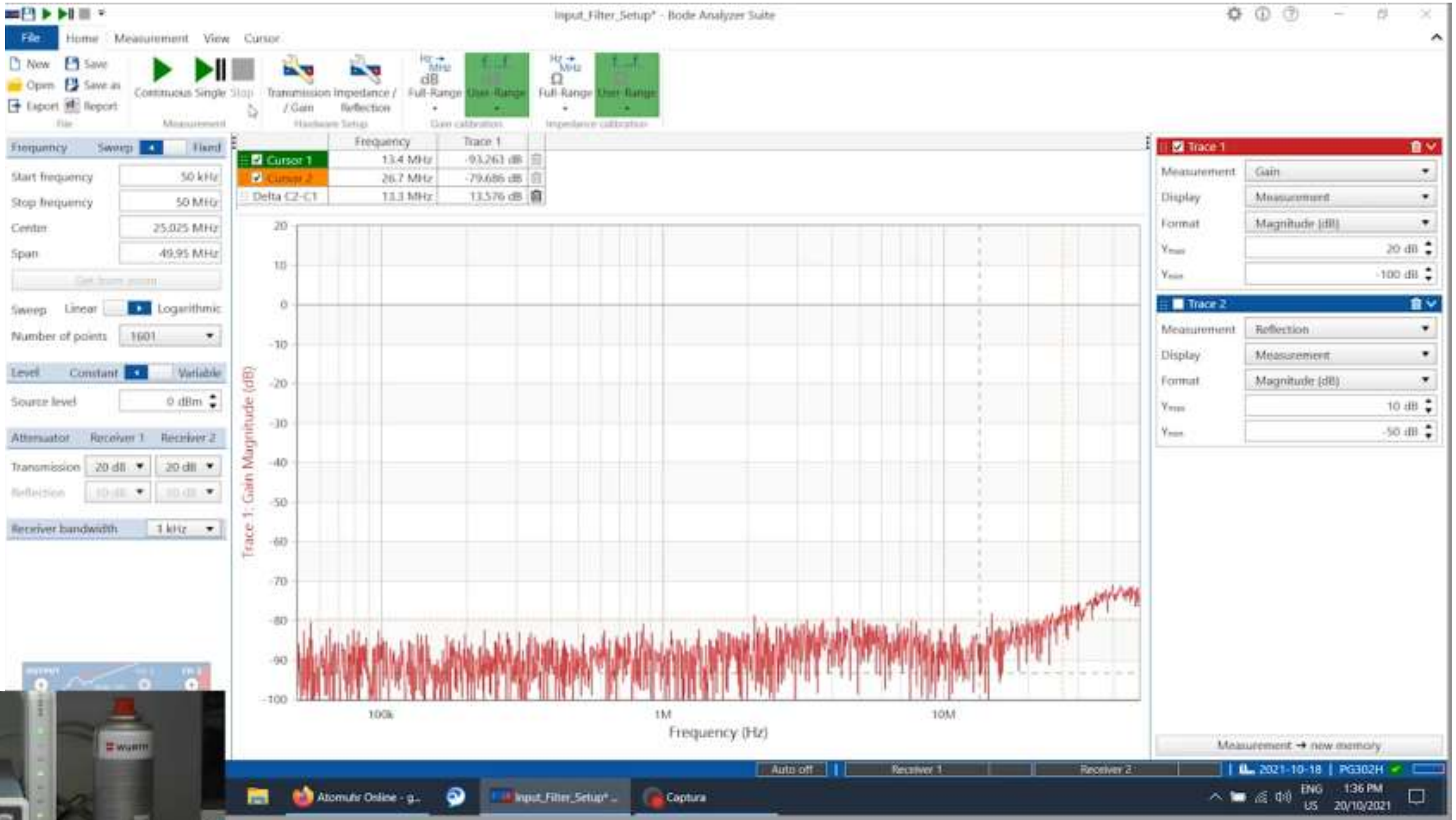
- REDEXPERT:
  - WCAP-CSGP: http://we-online.com/re/48VNPluS6zN
  - WE-CBF: http://we-online.com/re/48VQLRAE
  - WE-LQS http://we-online.com/re/48VOVubq

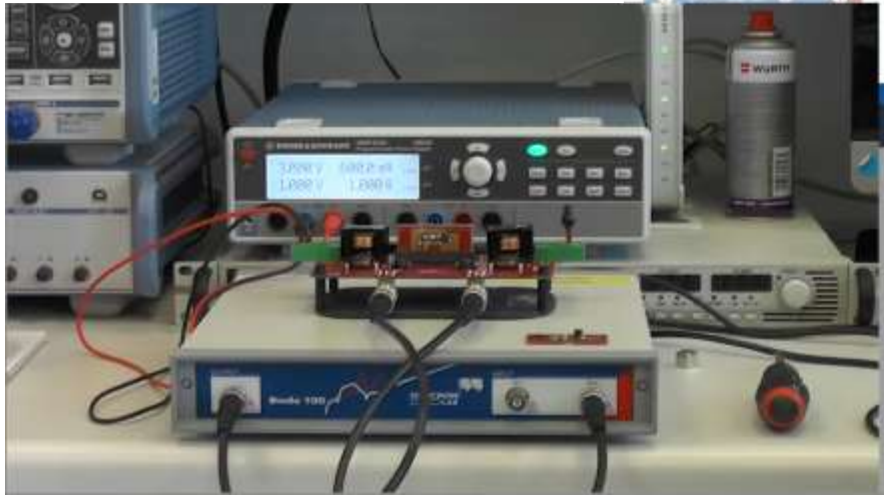
Input Filter for LT8610



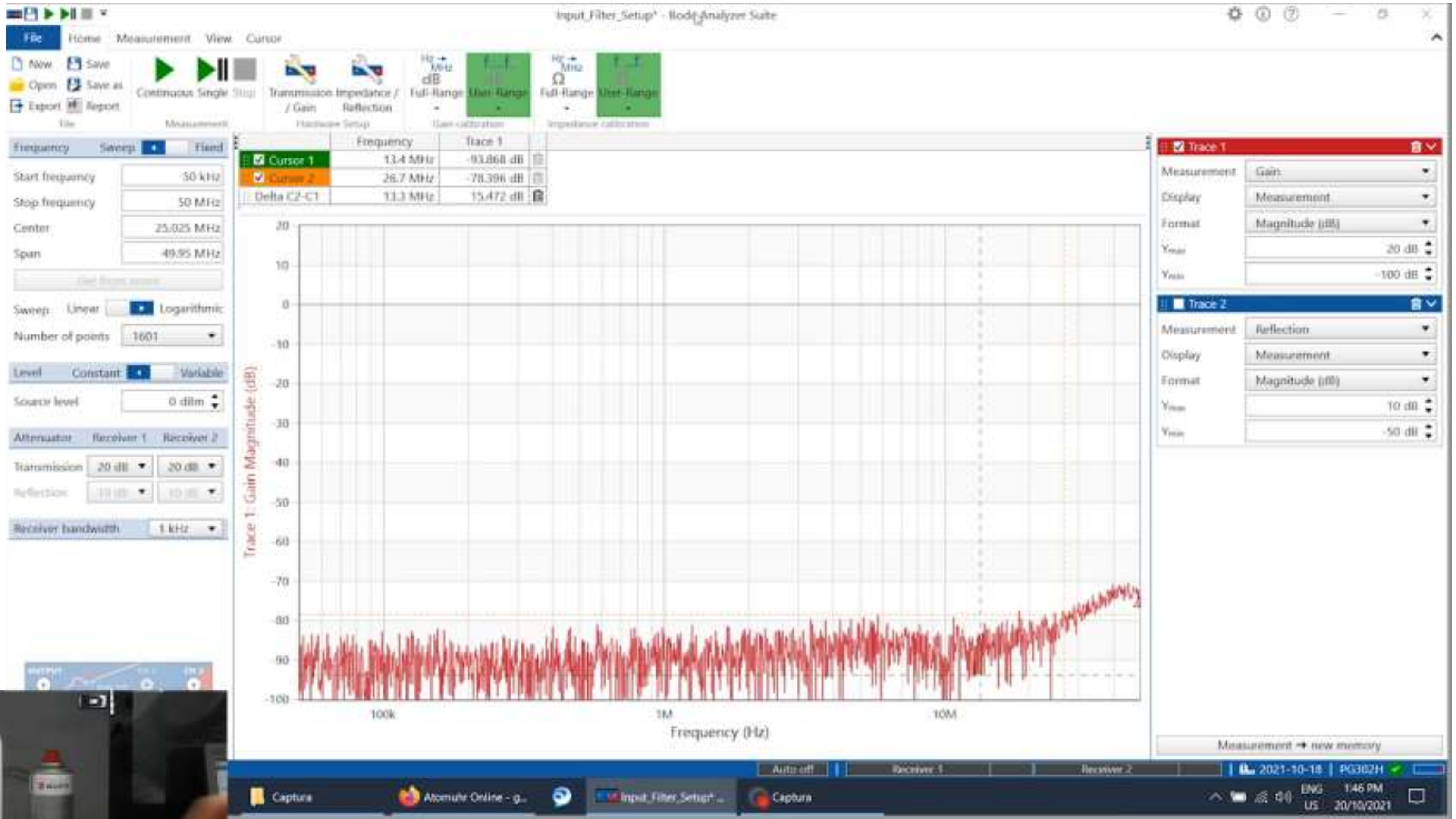


Field behavior of the Input Filter – Demo 1

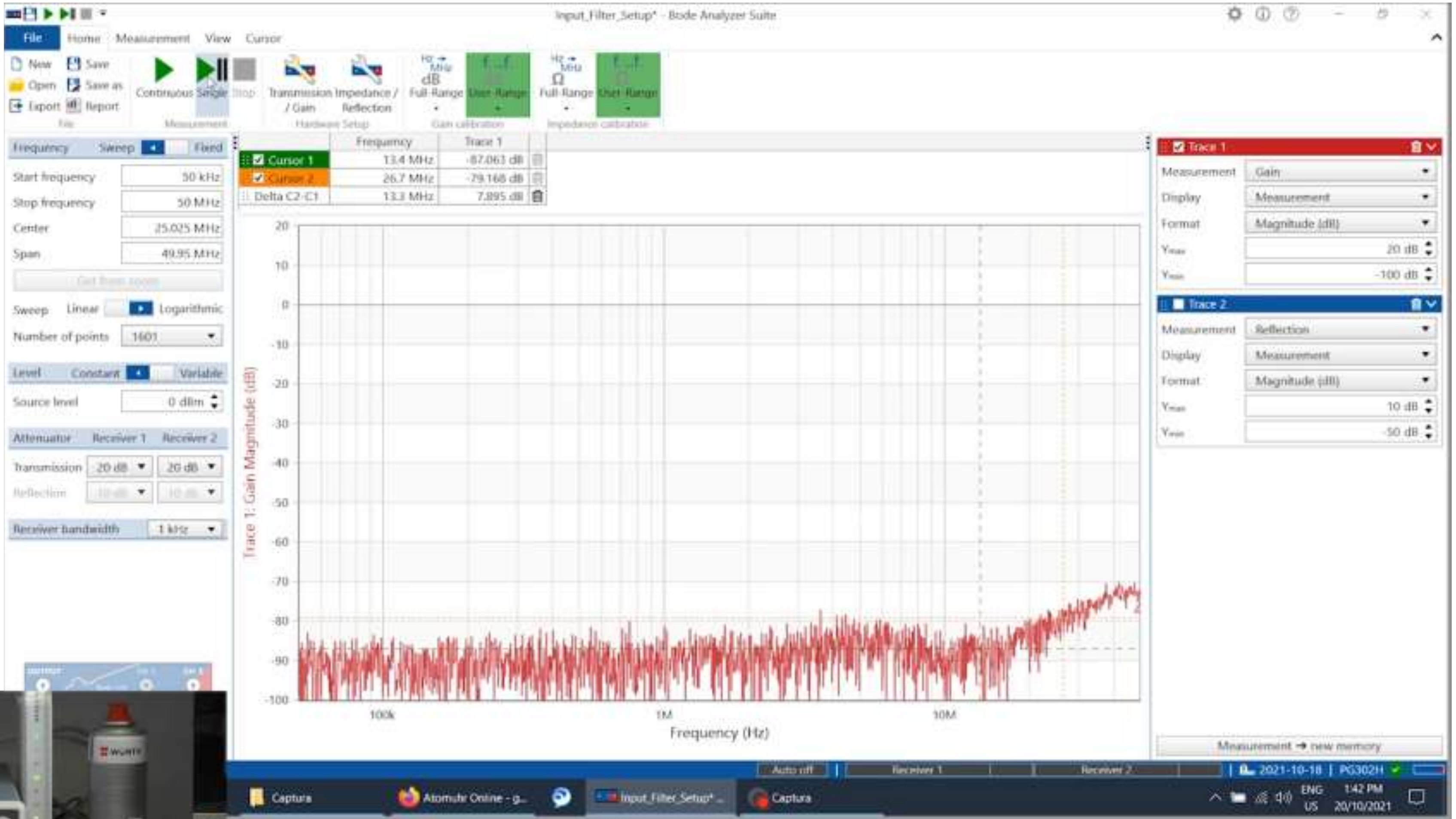


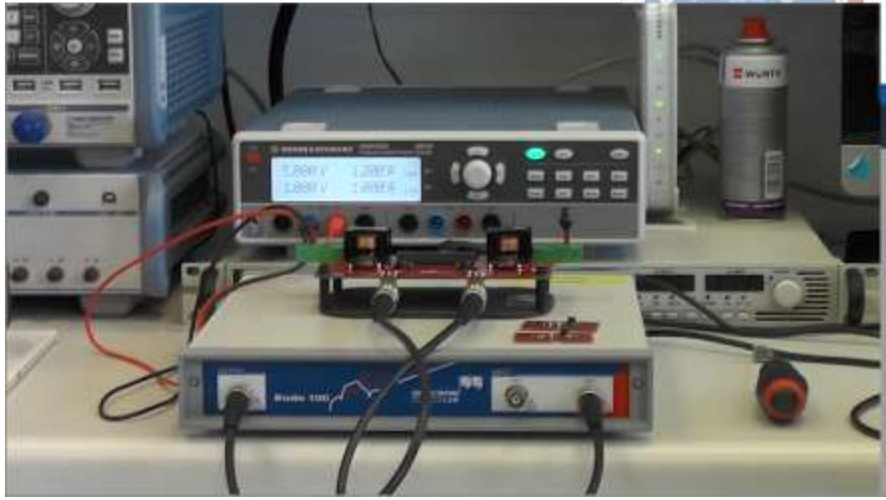


Field behavior of the Input Filter – Demo 2

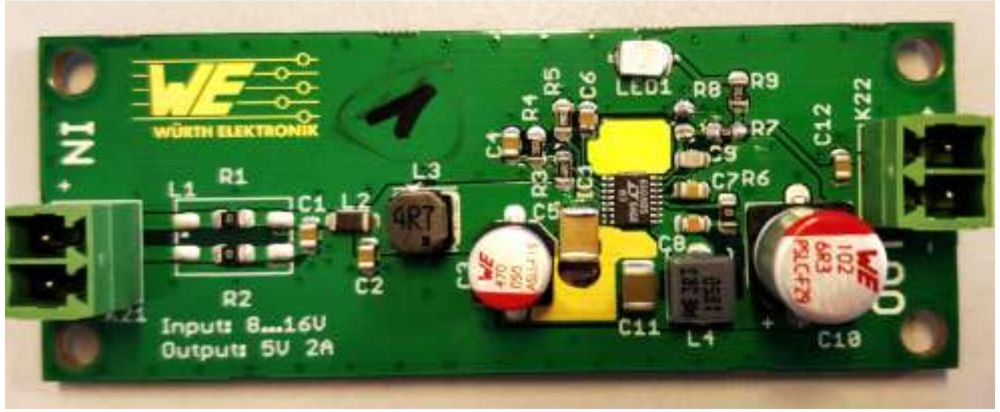


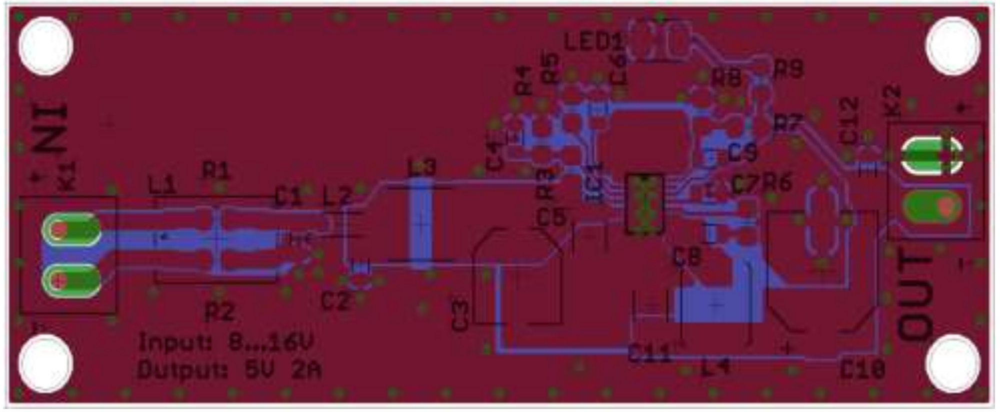
Field behavior of the Input Filter – Demo 3

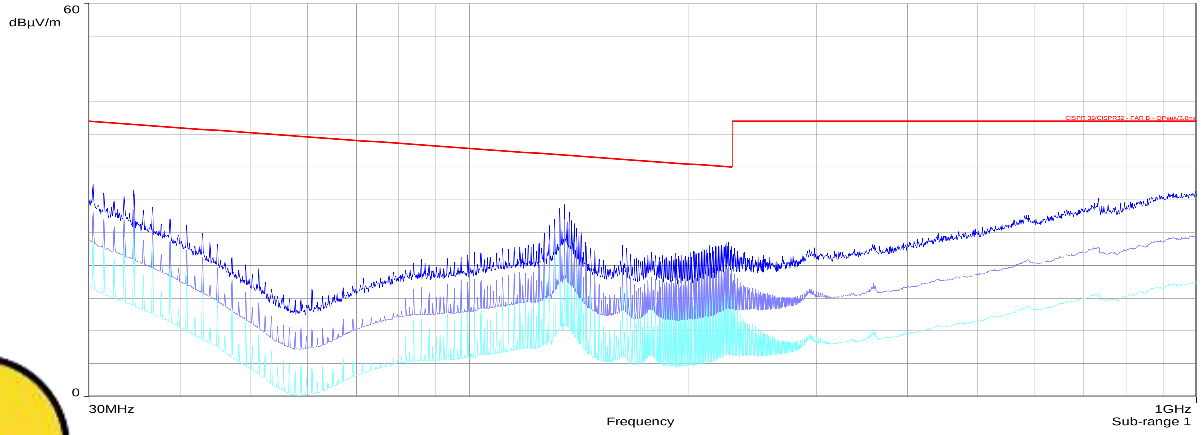


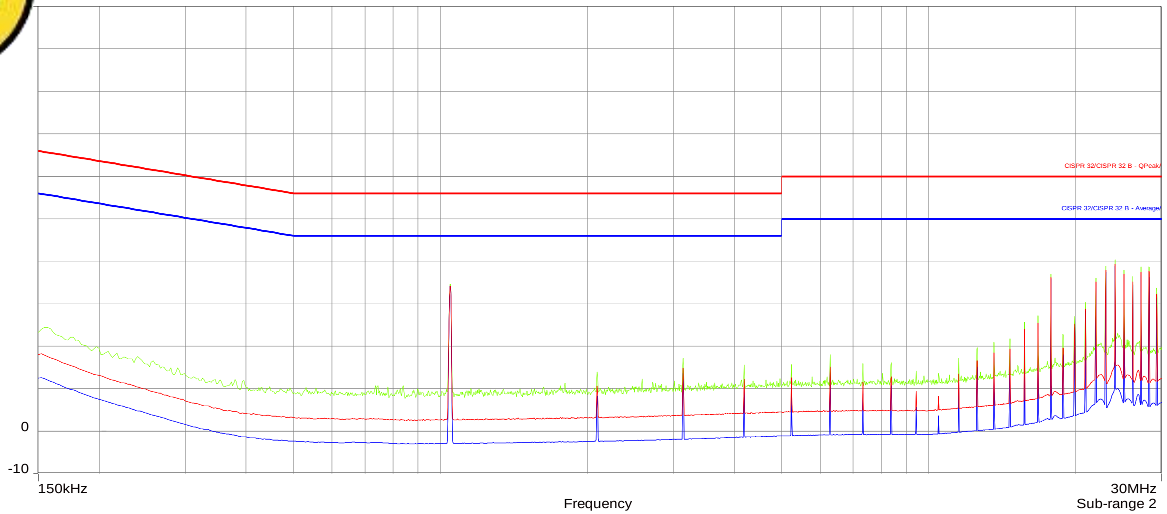


You Know Your Components!



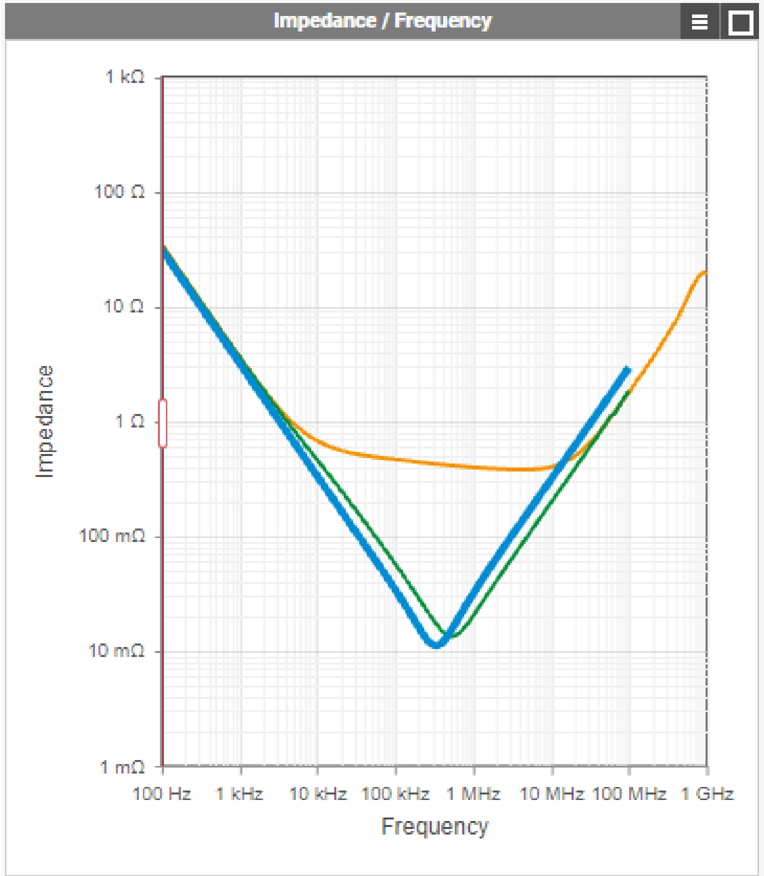


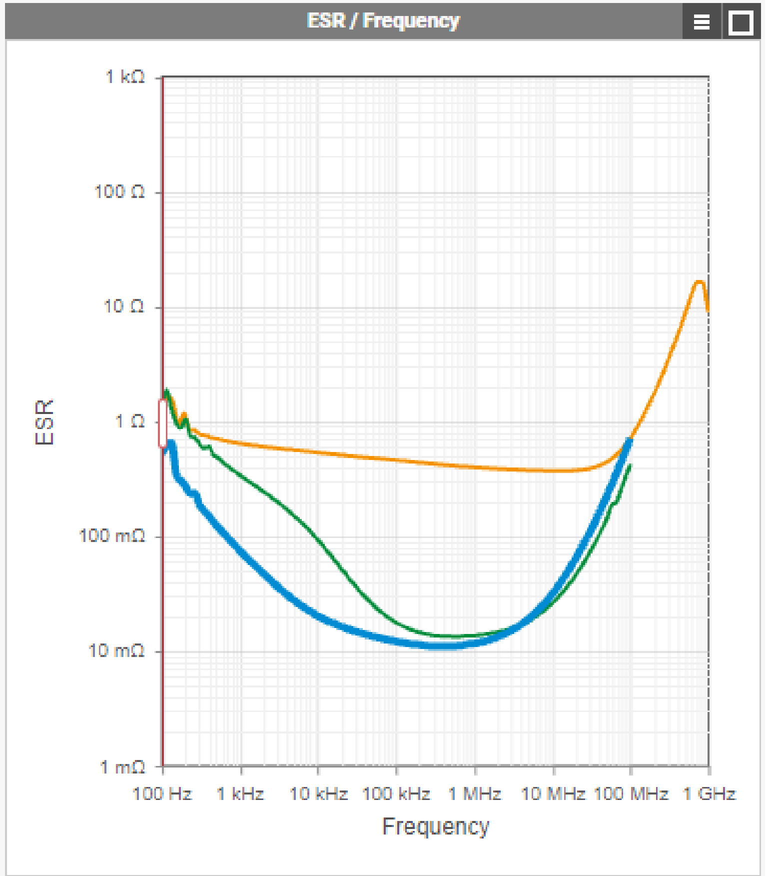




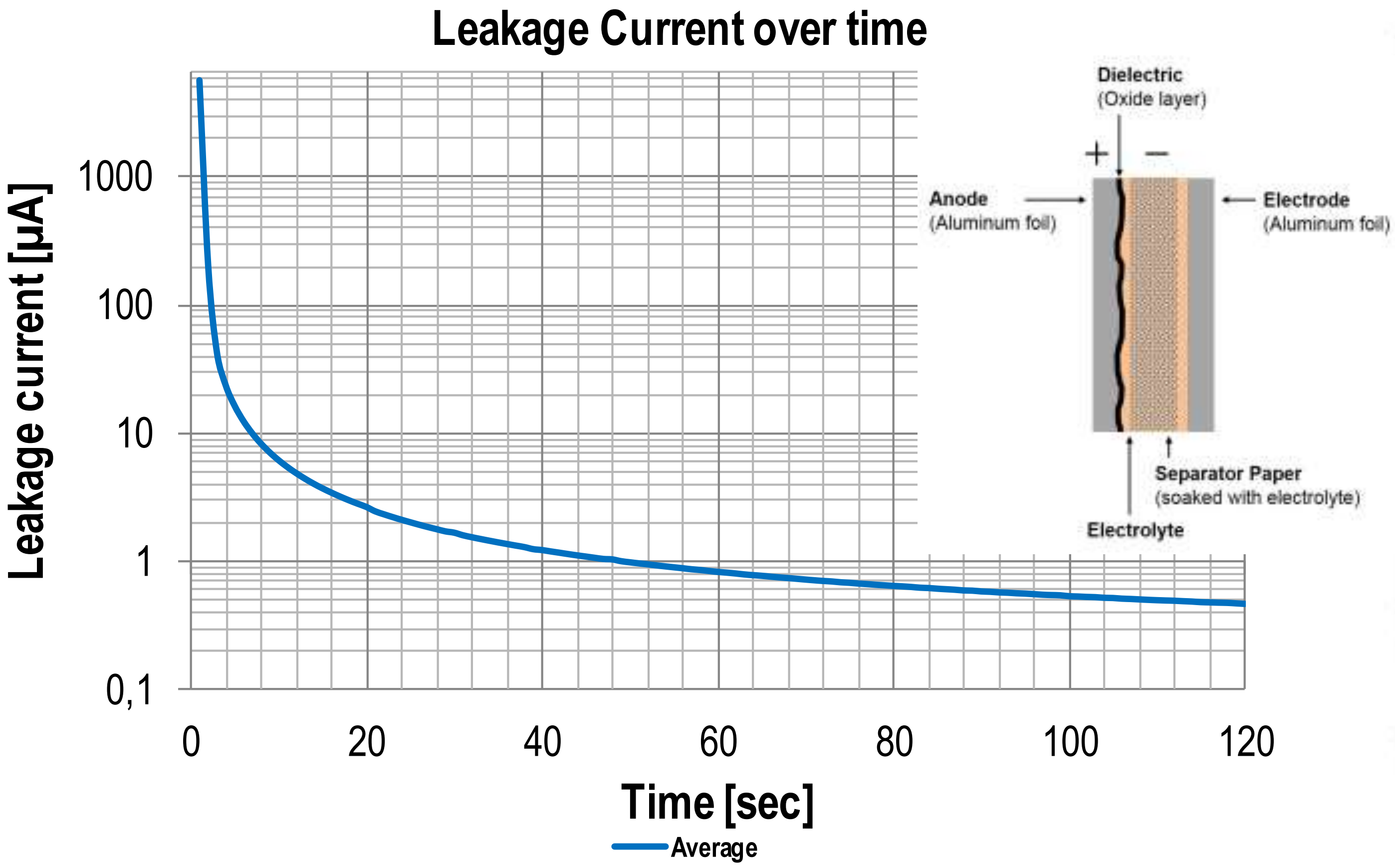
Capacitors – Aluminum Electrolytic

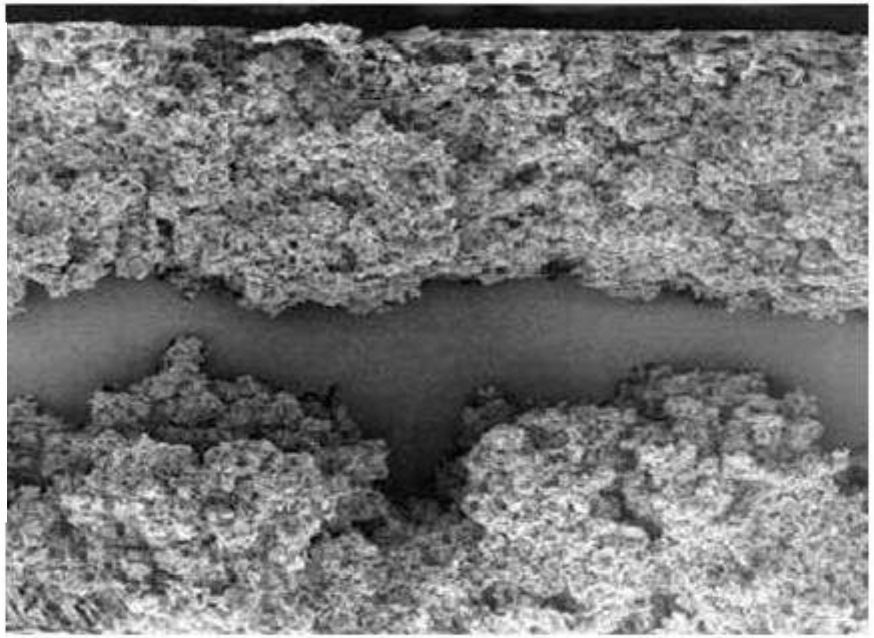
- Different electrode material
  - Aluminum
  - Tantal
  - Niob
- Different specification
  - Wet
  - Solid





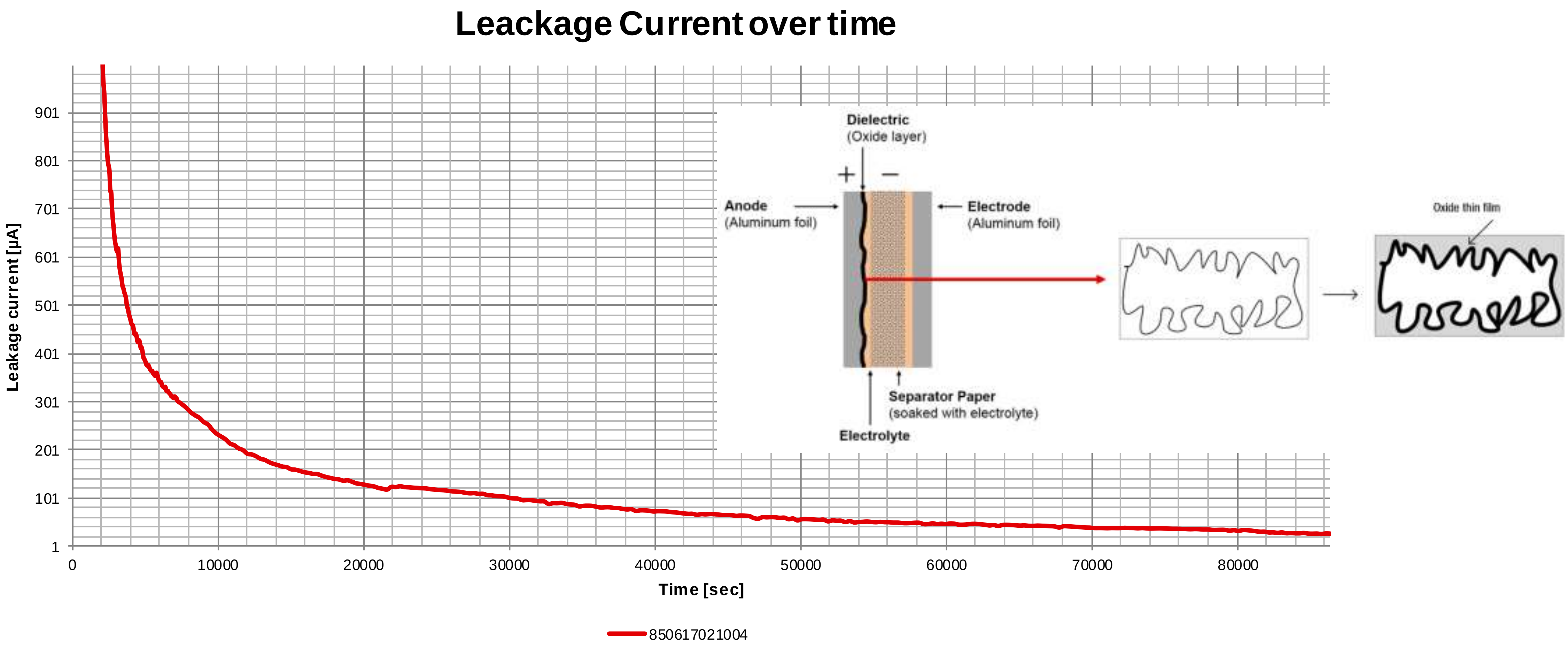
Capacitors – Aluminum Electrolytic





Cross-section low voltage anode foil

Capacitors – Aluminum Electrolytic

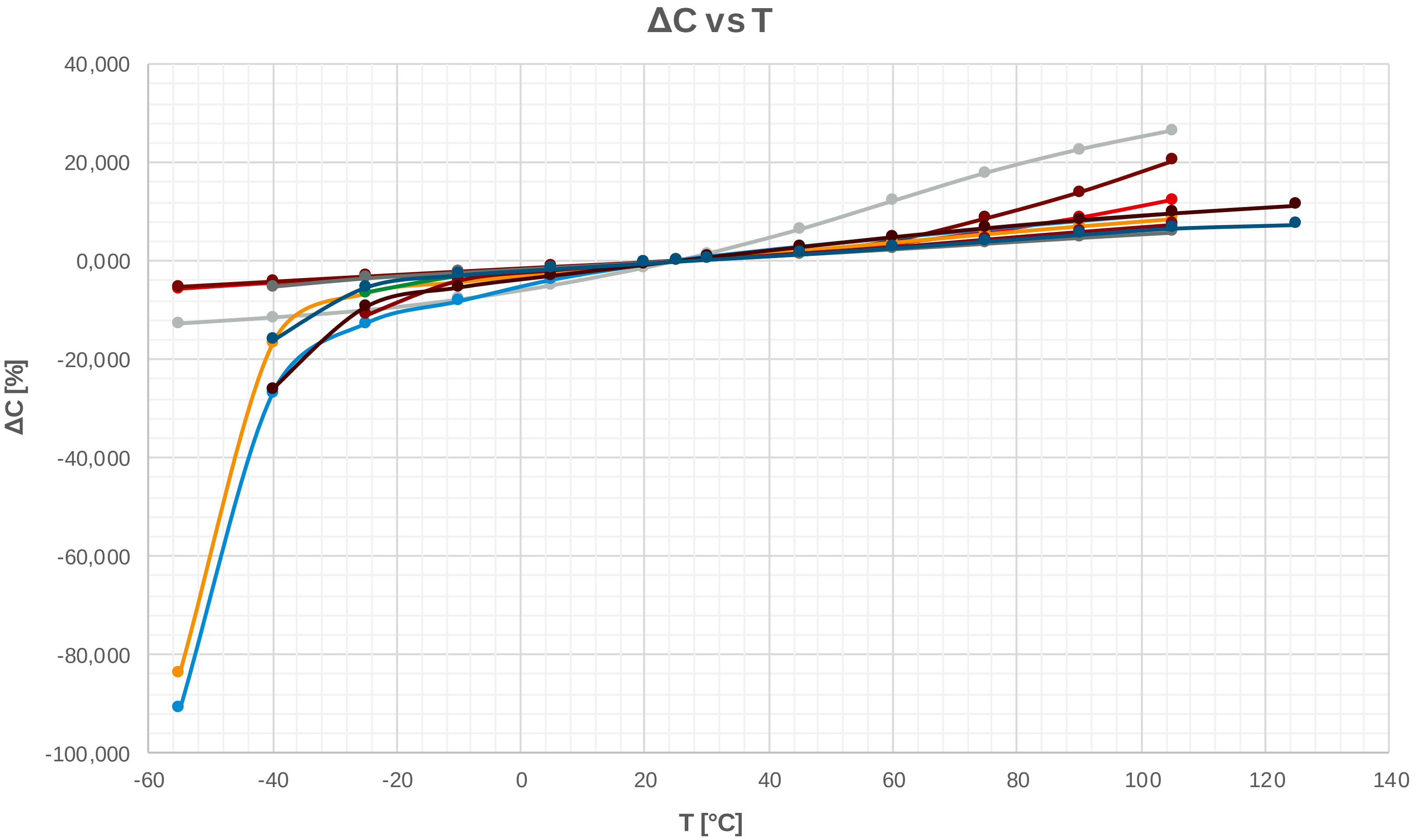


Capacitors – Aluminum Electrolytic

WÜRTH ELEKTRONIK

Temperature influence

- Operating temperature is important
- Going below the datasheet values lead to dramatic results
- Different electrolyte are used



Summary

- Datasheet definitions are generic definition
- Difference between datasheets
  - Check the different vendors
- Extended information available
  - Visit our Redexpert for more information
  - Simulation models available

- **Ferrites**
  - Temperature
  - Magnetic
  - DC bias
    - Reduce inductance
    - Shifted SRF

- **Capacitors**
  - Voltage (MLCC)
    - Capacitance loss
    - Shifted SRF
  - Temperature
    - De-aging (MLCC)
    - Capacitance change
  - Time
    - Capacitance loss over time

Thank You for your attendance

Picture: Freepik.com