Die richtige Auswahl passiver Bauelemente

1. AC/DC
2. DC/DC

Mittwoch, 17. April 2024

Technical Disclaimer

Statements of suitability for certain applications are based on our knowledge of typical operating conditions for such applications, but are not intended to constitute – and we specifically disclaim – any warranty concerning suitability for a specific customer application or use. This Information is intended for use only by customers who have the requisite experience and capability to determine the correct products for their application. Any technical advice inferred from this Information or otherwise provided by us with reference to the use of our products is given gratis, and we assume no obligation or liability for the advice given or results obtained.

Presenter

- Alexander Nebel
  - Technical Marketing Manager EMEA
  - Sales of passive components since 2008
  - FAE for passive components 2010 – 2023
  - KEMET since 2017
  - YAGEO since 2020

Company Overview

YAGEO Group

NEC/TOKIN

EVOX RIFA

KEMET

ARCOTRONICS GROUP

YAGEO

VITROHM

CHILISIN

Pulse

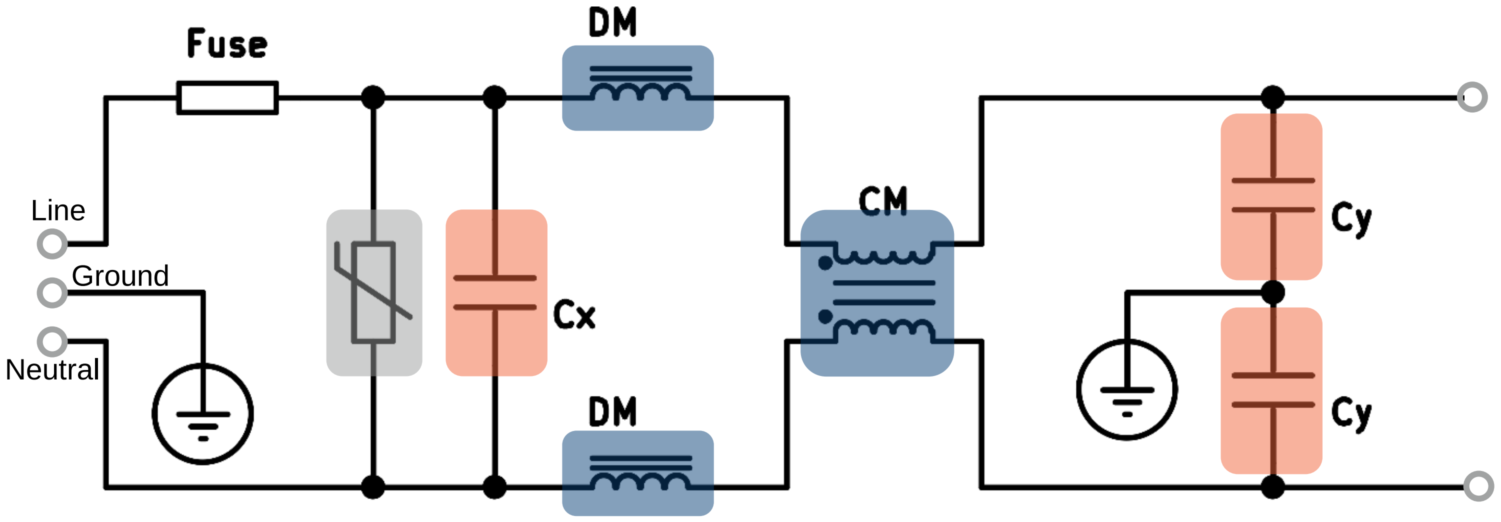
EGSTON POWER

YAGEO NEXENSOS

1. ACDC

AC Filtering

- AC Line Filter to reduce EMI

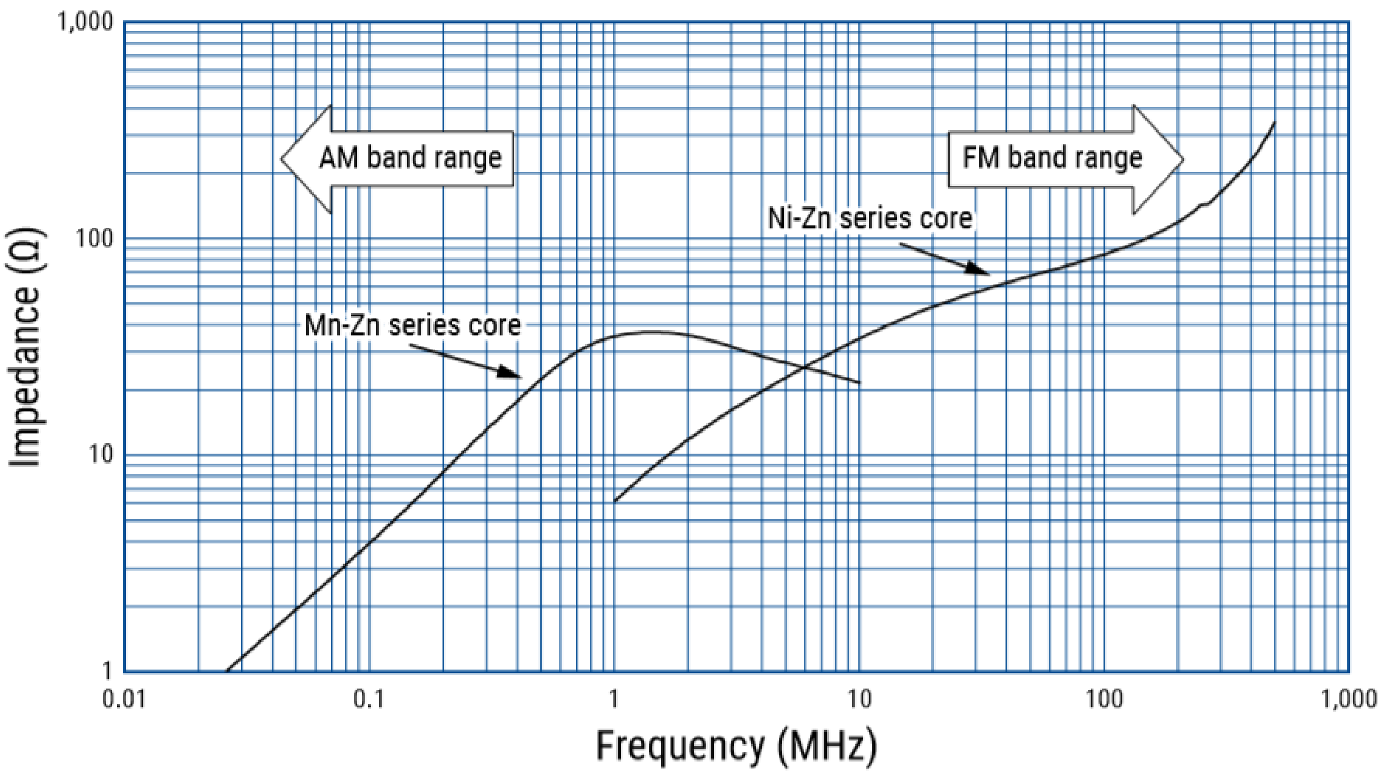


Common Mode Chokes

- Frequency Range

Frequency Range of different material

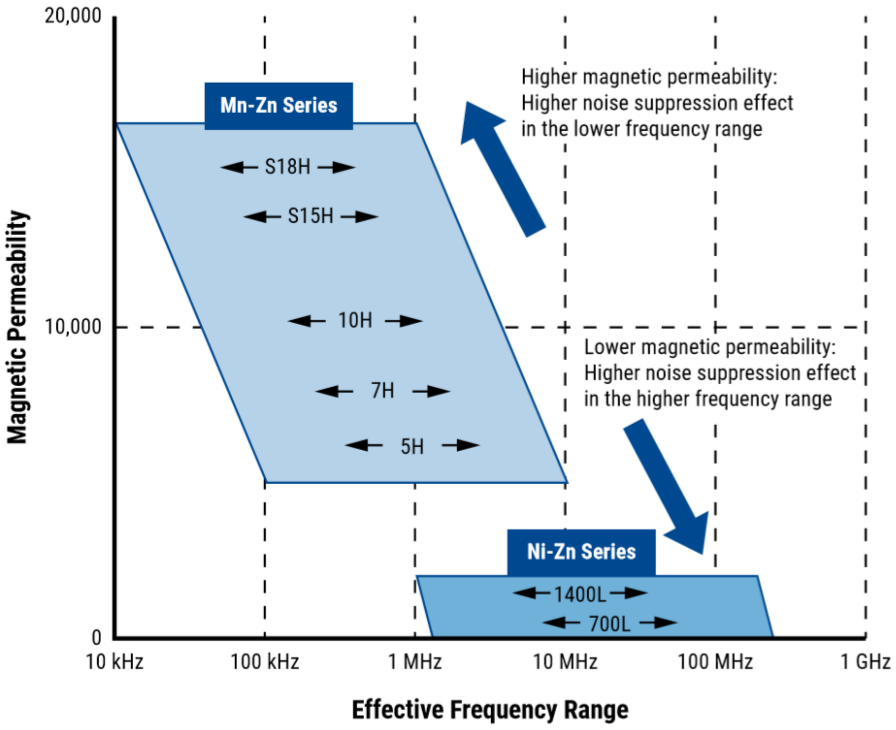
- Different Core Materials
  - MnZn → lower frequency range
  - NiZn → higher frequency range



Core material and permeability

- Increased permeability
  - increases the Inductance / Impedance
  - <u>does not</u> increase the frequency range
  - lowers the resonant point

$$L = \frac{\mu_0 \mu_r A n^2}{l_{eff}}$$



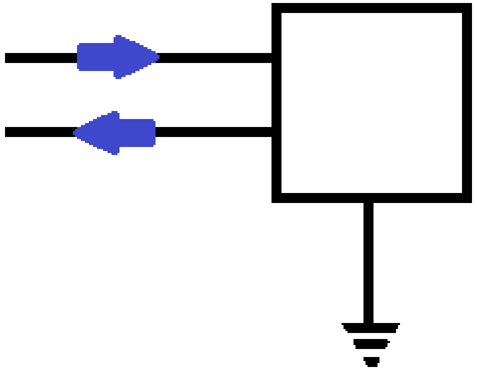
Common Mode Chokes

- Differential or Common Mode

Common Mode or Differential Mode

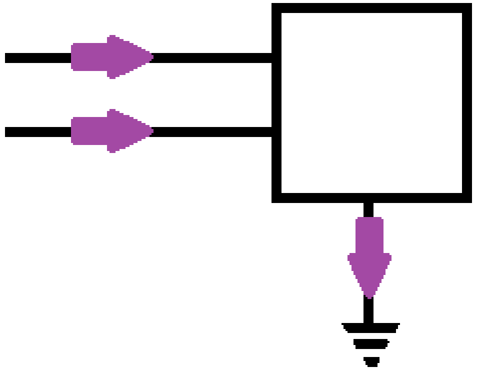
- Differential Mode
  - Signal or Interference goes in opposite directions

    + or Phase or Line and – or Neutral



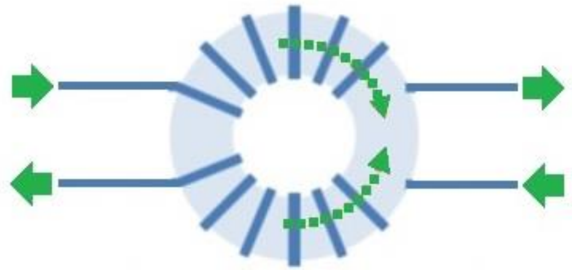
- Common Mode
  - Signal or interference goes in the same direction

    + or Phase or Line and – or Neutral
  - Path over Earth or Ground

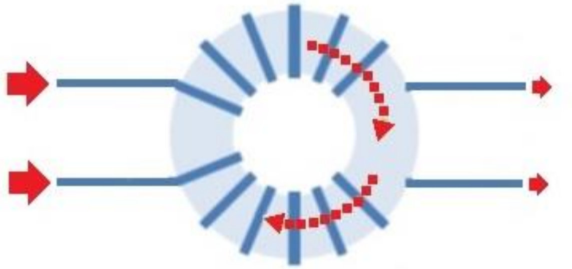


Differential Mode vs. Common Mode

- Differential Mode signal is identical on both lines
- This creates no magnetic field in the core
- No losses for Differential Mode Signal



- Common Mode Interference creates magnetic field
- Magnetic Field creates heat in the core
- Common Mode Inteference is reduced

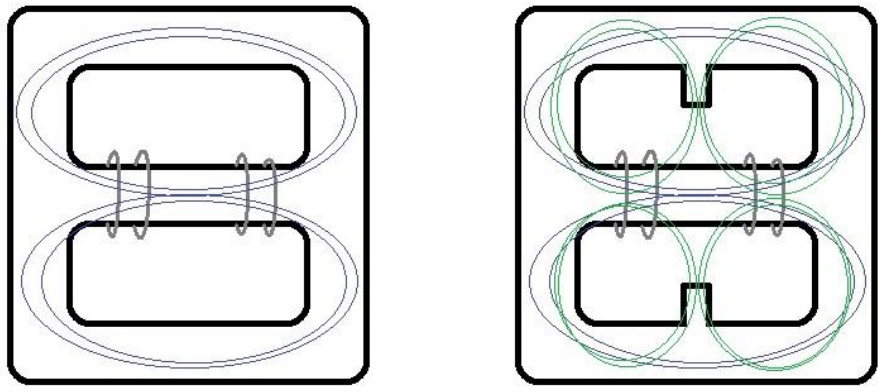


Common Mode Chokes

- Core Style

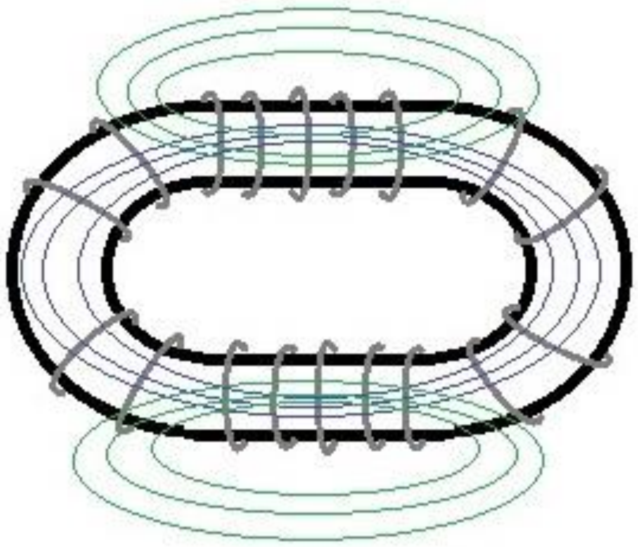
Common Mode Choke types

- Hybrid Mode Choke – SSHB series
  - Additional „noses“ in magnetic core
  - Magnetic fields through „noses“ create differential mode attenuation
  - Higher Differential mode attenuation than standard shape



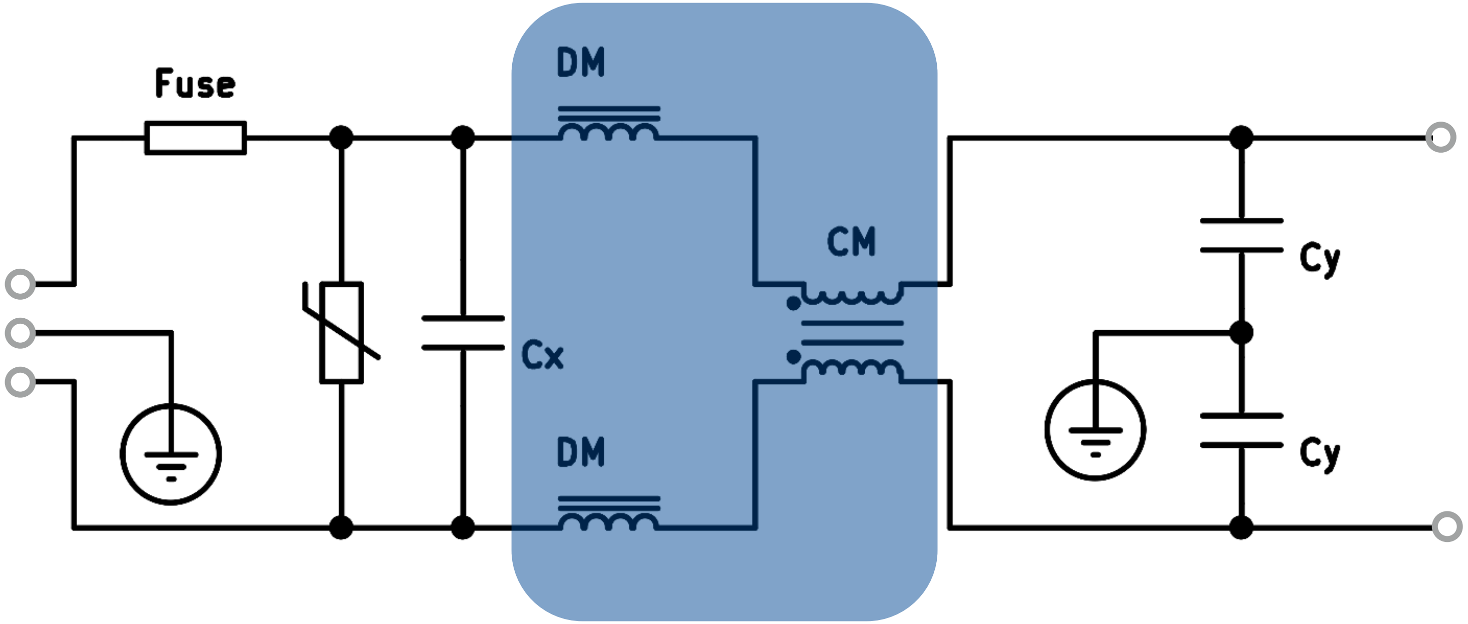
Common Mode Choke types

- Dual Mode Choke – SCN series
  - Oval shape core
  - Magnetic fields through air create differential mode attenuation
  - Higher Differential mode attenuation than round shape



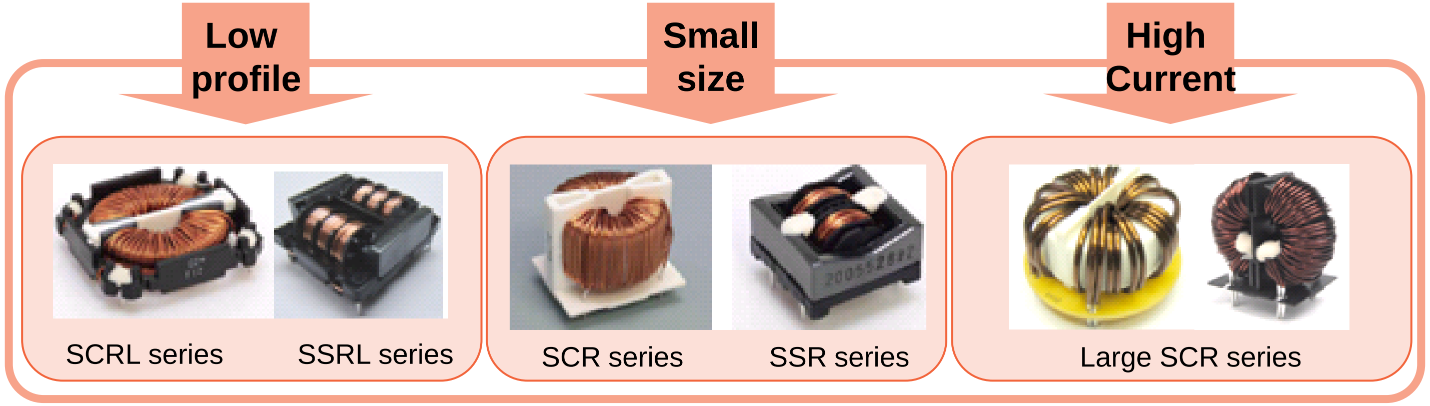
Common Mode Choke types

- Dual Mode and Hybrid Mode Chokes



Choice of the right Choke

- What is important to find the choke:
  - Frequency Range to filter → Core Material
  - Attenuation → to calculate Impedance / Inductance
  - Maximum Current → Size and Style of the Choke (Wire cross section)
  - Maximum Size recommendations → Type or style of the Choke (horizontal / vertical …)

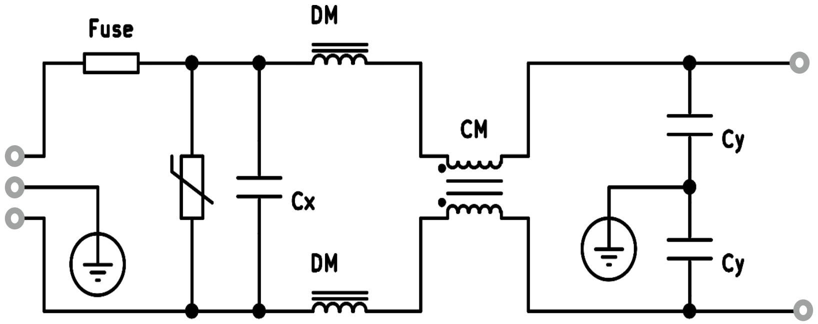


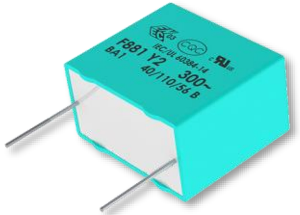
Safety Capacitors

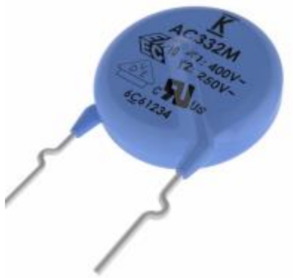
- Film Capacitors

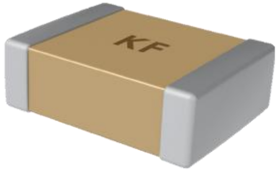
Safety Capacitors

- A safety capacitor is a capacitor that is designed to aid in the filtering of AC line voltages
- It can be safely used on line-to-line, line-to-neutral, and line-to-ground applications
- Primary Functions
    - Aid in the filtering of AC line voltages
    - Survive high voltage transients due to lightning
    - Reliable under constant high AC voltages



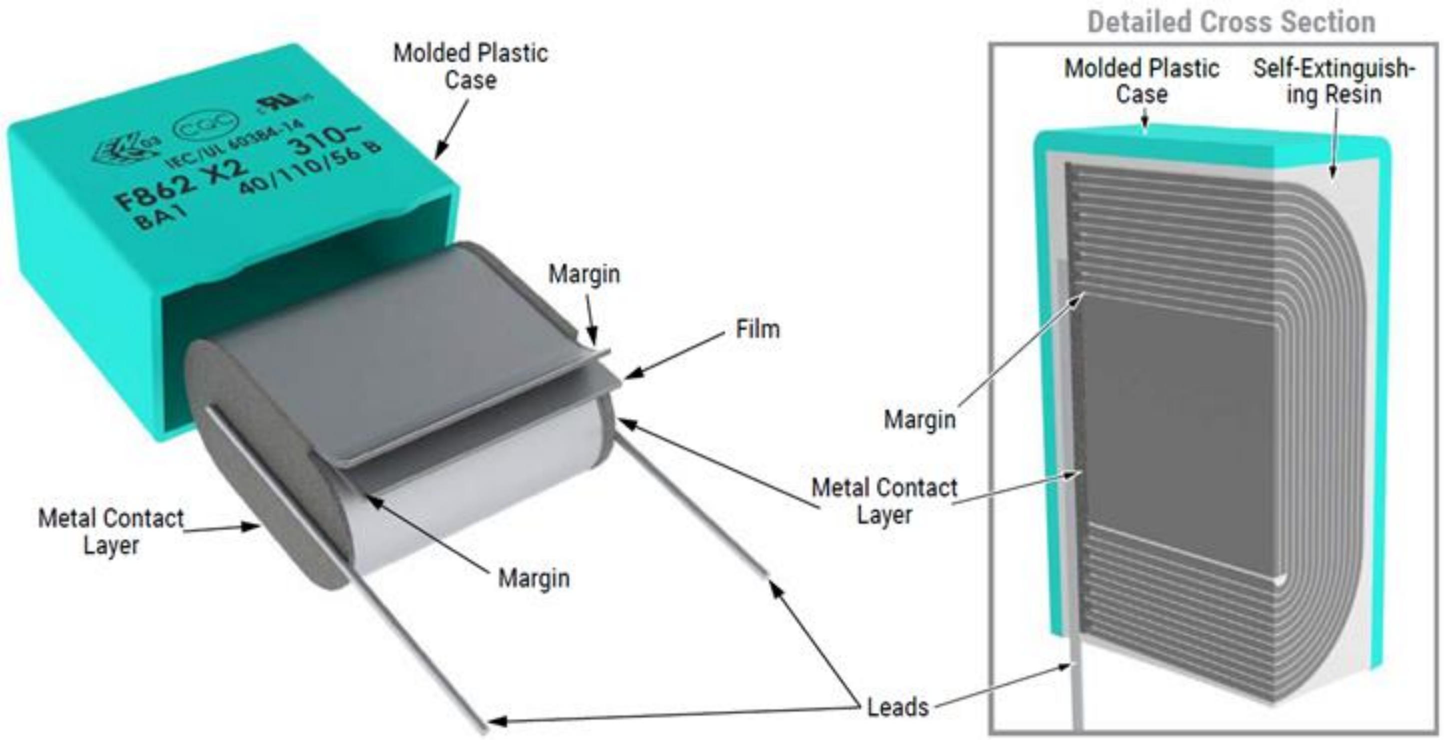






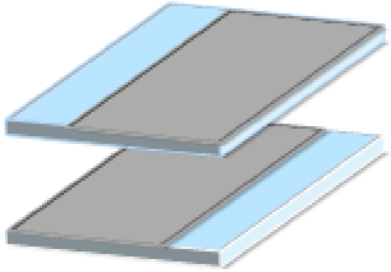
Film Capacitor Basics

- Wound Capacitor Construction



Film Capacitor Basics

- Metalized Film employs two plastic films which are chemical vacuum deposited with aluminium
- The Vacuum deposited aluminium provides an extremely thin metal layer (10nm to 20nm)
- The Metallization process can occur on a single side or both sides of the dielectric material
- Advantages:
  - High volume efficiency
  - Good self-healing properties
  - Higher Capacitance (per volume)
  - Less moisture ingress

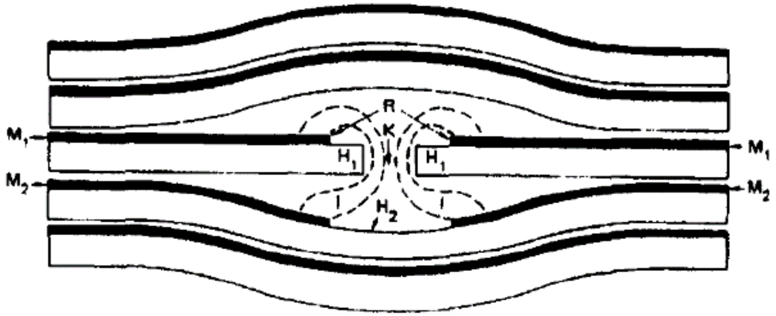


Self Healing

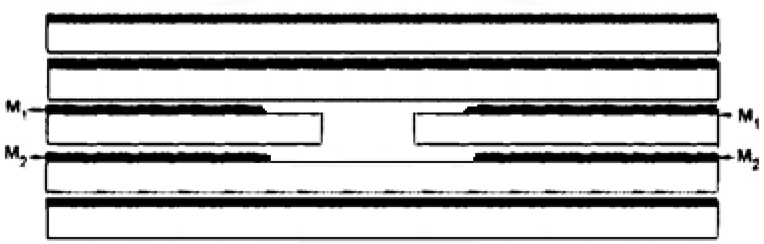
- Process

1. Defect Density

2. Evaporization

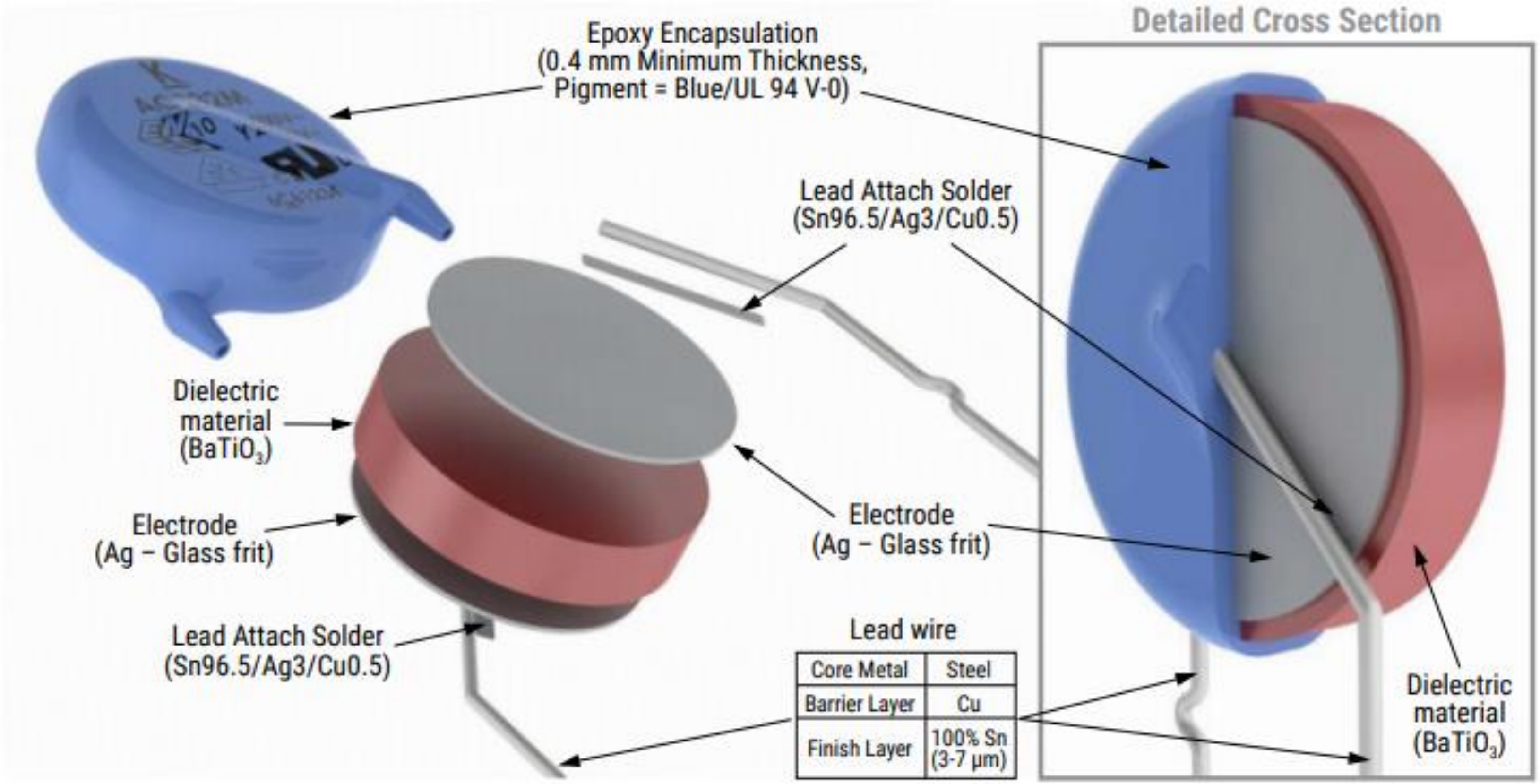


3. Isolated Area



Safety Capacitors

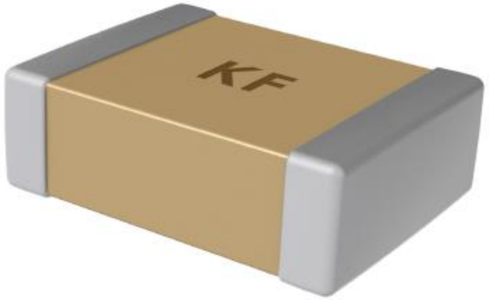
- THT Construction

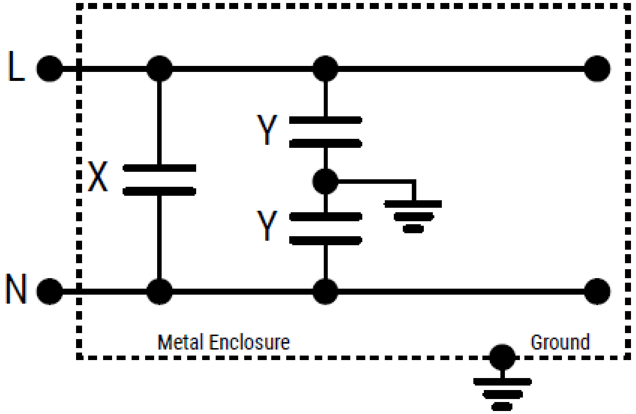


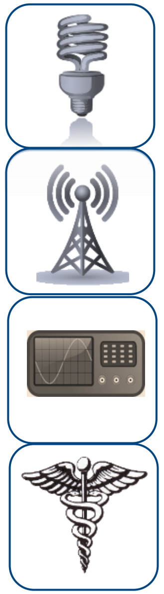
SMD Safety Certified Capacitors

CAS Series

- Safety Standard Recognized
- X1/Y2 and X2 Classifications
- High Reliability / BME Technology
- 250 VAC Rated Voltage
- Peak Impulse Voltage Capable up to 5KV
- C0G and X7R Dielectrics
- 1808 – 2225 Case Sizes

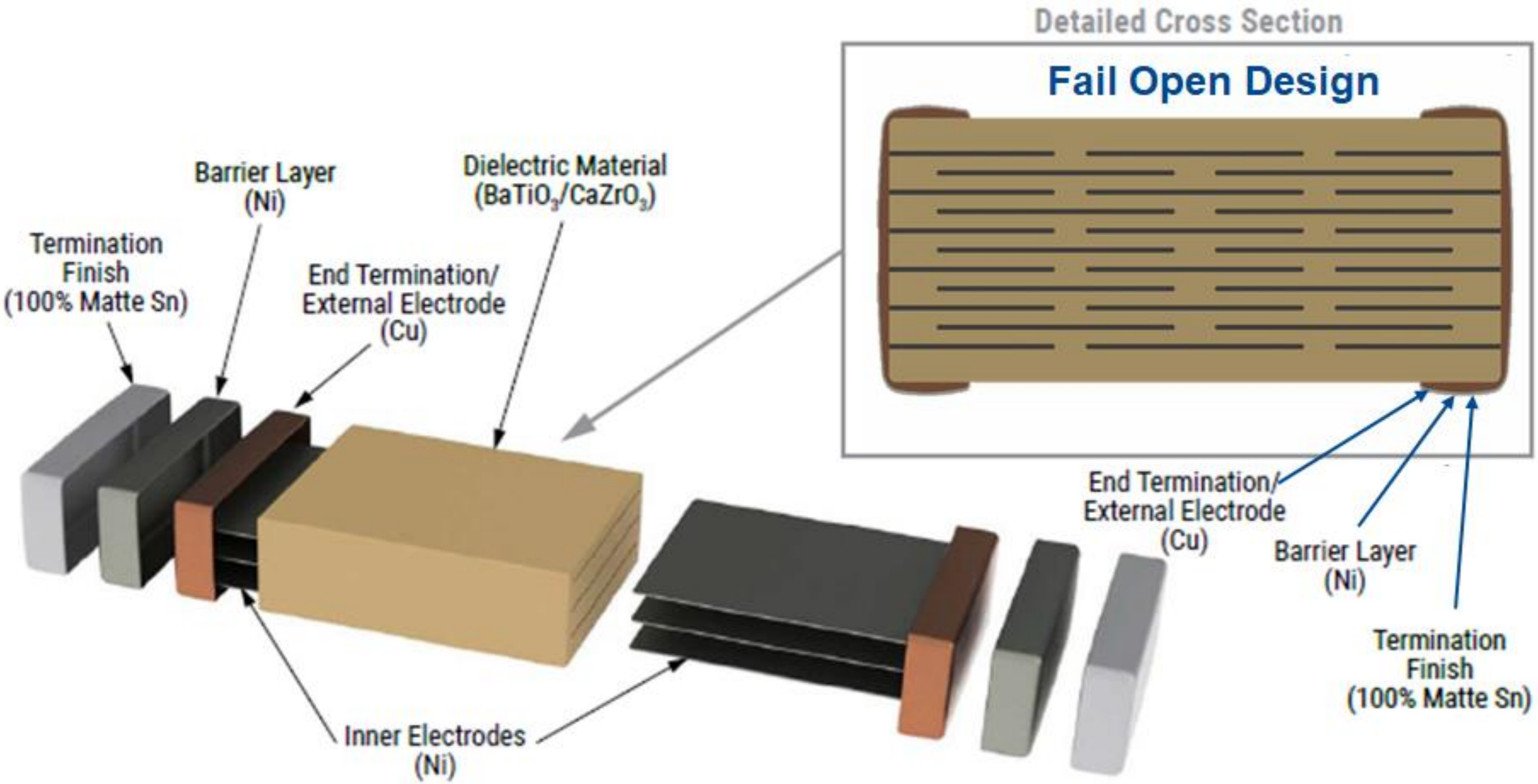






Safety Capacitors

- MLCC Construction



Circuit Protection

Circuit Protection Products

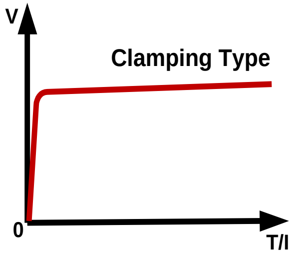
- Electrical Characteristics

Clamping Type Over-voltage Protection

TVS

MOV

ESD



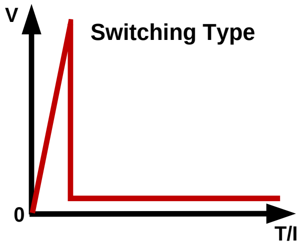
For Power Line Protection

Switching Type Over-voltage Protection

GDT

SPG

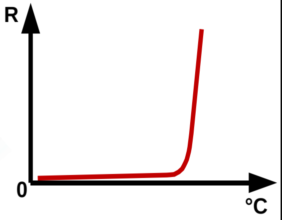
TSS



For Communication Line Protection

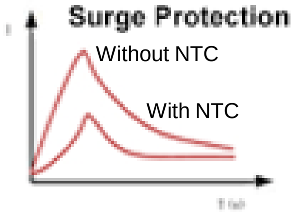
Over-current Protection

PPTC



Surge-current Protection

NTC

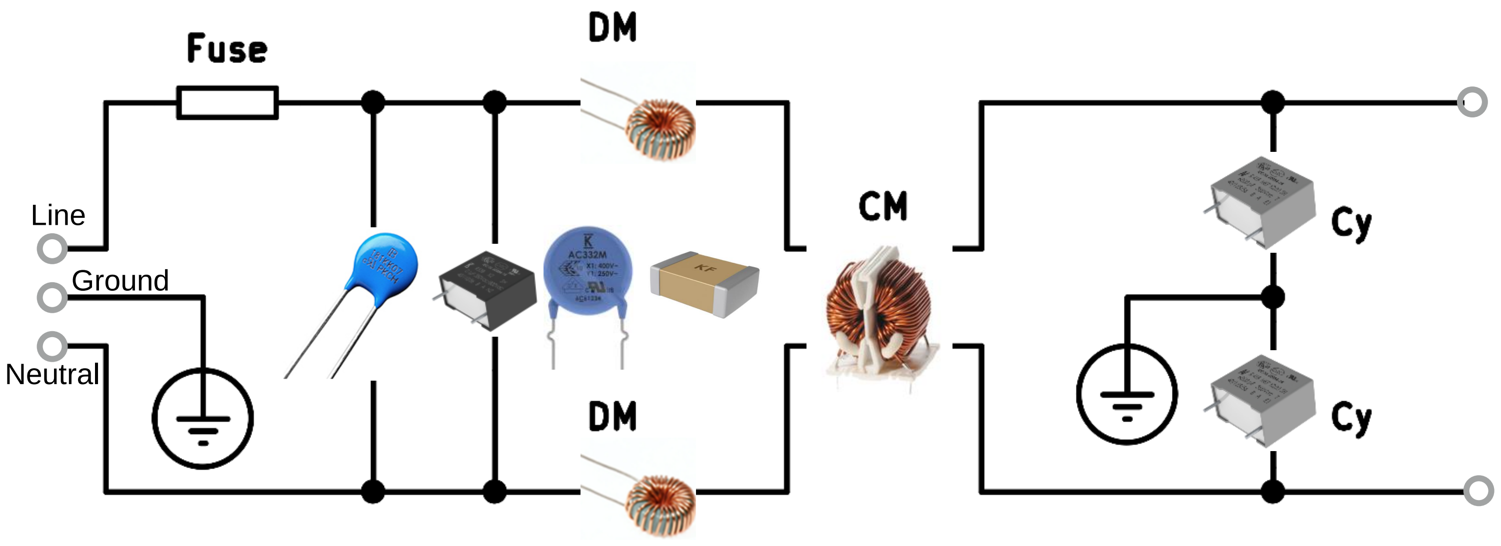


MOV (Metal Oxide Varistors)

- MOV (Metal Oxide Varistors)
- fast response speed to protect sensitive electronic equipment from voltage transients induced by lightning and other transient voltage events
- high voltage and large withstanding surge current capacity
- AC input of different power supply for surge or lightning protection
- different working temperature up to 140°C
- Size from 5mm to 53mm

Summary

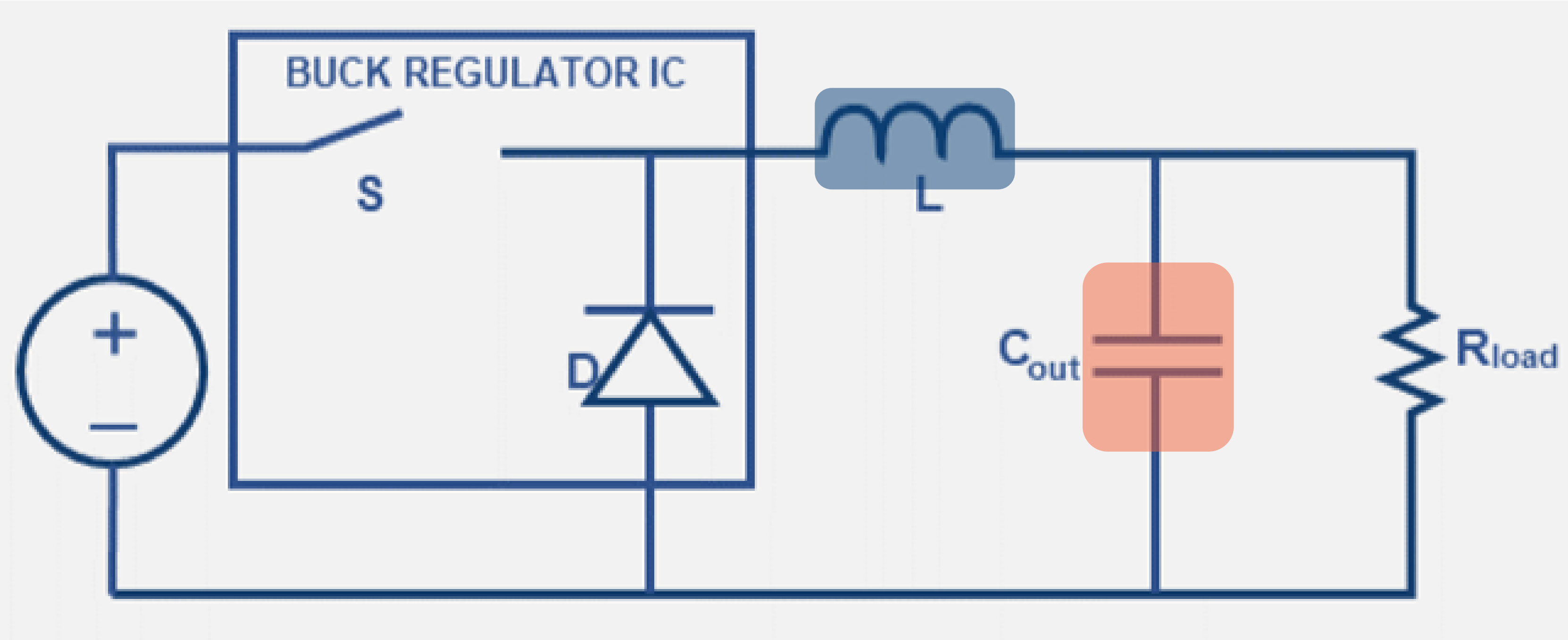
- YAGEO Product Solutions



2. DCDC

DC-DC Converter

- Buck Converter



DC-DC Converter

- Buck Converter

$$L = \frac{(V_{in} - V_{out}) \cdot (V_{out} + V_D)}{(V_{in} + V_D) \cdot r_{cr} \cdot I_{out} \cdot f}$$

V_D	Diode Voltage Loss (~0,5V for Schottky)
V_{in}	Maximum Input Voltage

- Example: V_{in} = 36V / V_{out} = 5V / I_{out} = 1A / V_{ripple} = 40mV / I_{ripple} = 300mA / f = 350kHz

$$di = \frac{V_{ripple}}{ESR} = \frac{40mV}{120m\Omega} = 0{,}33A$$

$$r_{cr} = \frac{di}{dt} = \frac{0{,}33A}{1A} = 0{,}33$$

DC-DC Converter

- Inductor Calculation

$$L = \frac{(36V - 5V) \cdot (5V + 0{,}5V)}{(36V + 0{,}5V) \cdot 0{,}33 \cdot 1A \cdot 350kHz} = 40{,}44\mu H$$

DC-DC Converter

- Inductor Calculation

$$L = \frac{(36V - 5V) \cdot (5V + 0{,}5V)}{(36V + 0{,}5V) \cdot 0{,}33 \cdot 1A \cdot 350kHz} = 40{,}44\mu H$$

- Which Inductance? 33µH? 47µH? 39µH?
  - 47µH: „*The max current is low, R_{DC} is too high, the item is too big…*“
  - 39µH: „*It is a special item, not available from all manufacturers …*“
  - 33µH: „*Let‘s try this one!*“

Inductor Selection

- Let‘s assume we have 10% Inductance loss (Saturation, Tolerance …)
- So our remaining Inductance = 30µH
- 30µH Inductance is 25% less than calculated (40,44µH)!

$$L = \frac{(V_{in} - V_{out}) \cdot (V_{out} + V_D)}{(V_{out} + V_D) \cdot r_{cr} \cdot I_{out} \cdot f}$$

- V, I and f are constant, so 25% lower Inductance means 33% higher ripple current!
- Higher Inductance Value should be prefered!

- Why 25% lower Inductance is not 25% higher ripple current???
  - Because: 25% lower L is 75% = 0.75 = $^3/_4$ → $^4/_3$ i_{ripple} = 1.33 i_{ripple}

Inductor Current

Inductor Selection

YAGEO Group

- Reading the Datasheet

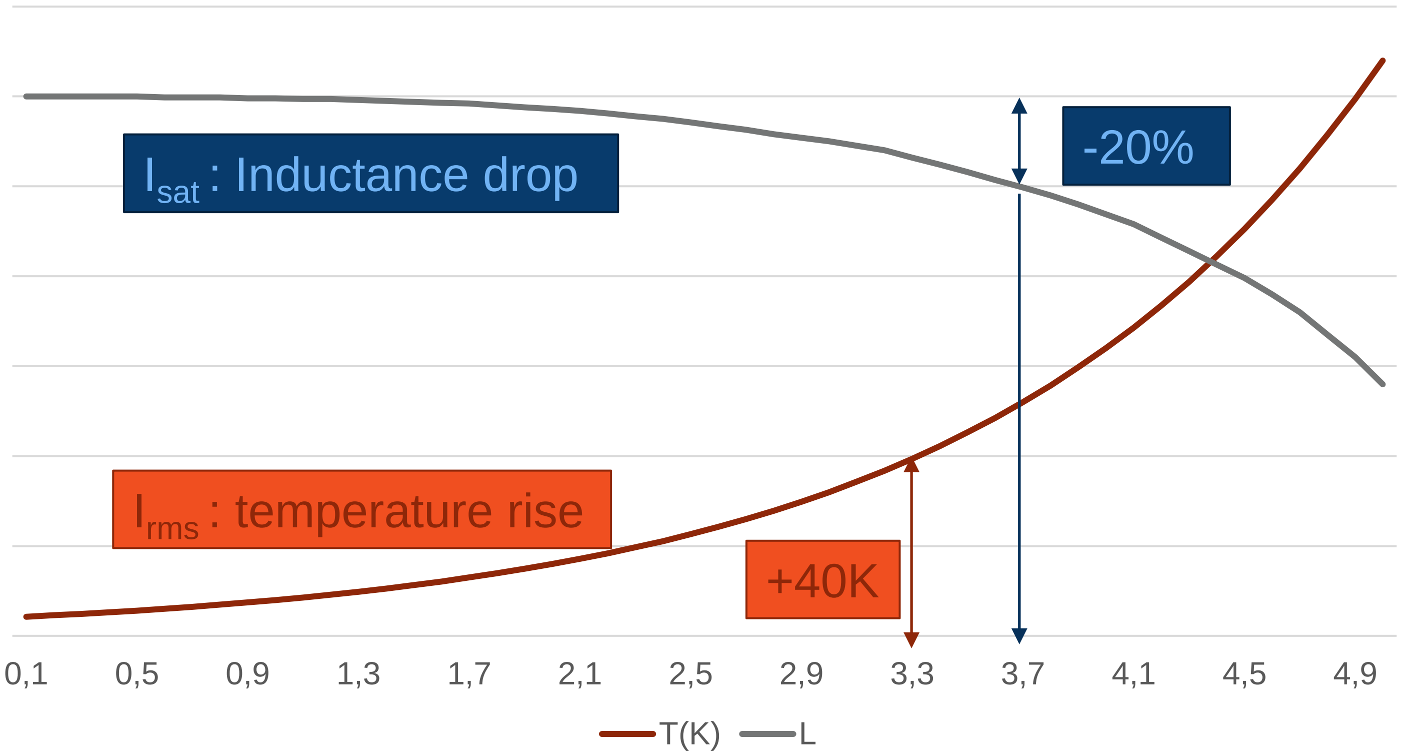
Part Number	Inductance (µH) at 100 kHz, 1 mA	Inductance Tolerance	DC Resistance (mΩ) Typical	DC Resistance (mΩ) Maximum	Rated Current (A)			Self-Resonance Frequency (MHz)
					Irms[1] (Reference)	Isat[2] (Reference)	Isat[3] (Reference)	
MPX1D1250L470	47.00	±20%	91.60	105.40	4.5	4.0	5.5	4.0
Part Number	Inductance (µH) at 100 kHz, 1 mA	Inductance Tolerance	DC Resistance (mΩ) Typical	DC Resistance (mΩ) Maximum	Irms[1]	Isat[2]	Isat[3]	
					Rated Current (A)			

[1] *T = 40 K rise at rated current*
[2] *Inductance drop 20% at rated current*
[3] *Inductance drop 30% at rated current*

- 3 Current Values are given
- What is the difference between rated current and Saturation Current?

Rated Current

- I_{rms} is when the temperature rise of of the inductor is 40K above ambient temperature
- I_{sat} is when the inductance drops by 20% (saturation)



Rated Current: I_{rms}

- What is the maximum self heating and the maximum current?
- The influence of the ambient temperature
  - The allowable maximum self heating is the operating temperature of the inductor minus the ambient temperature of the application:

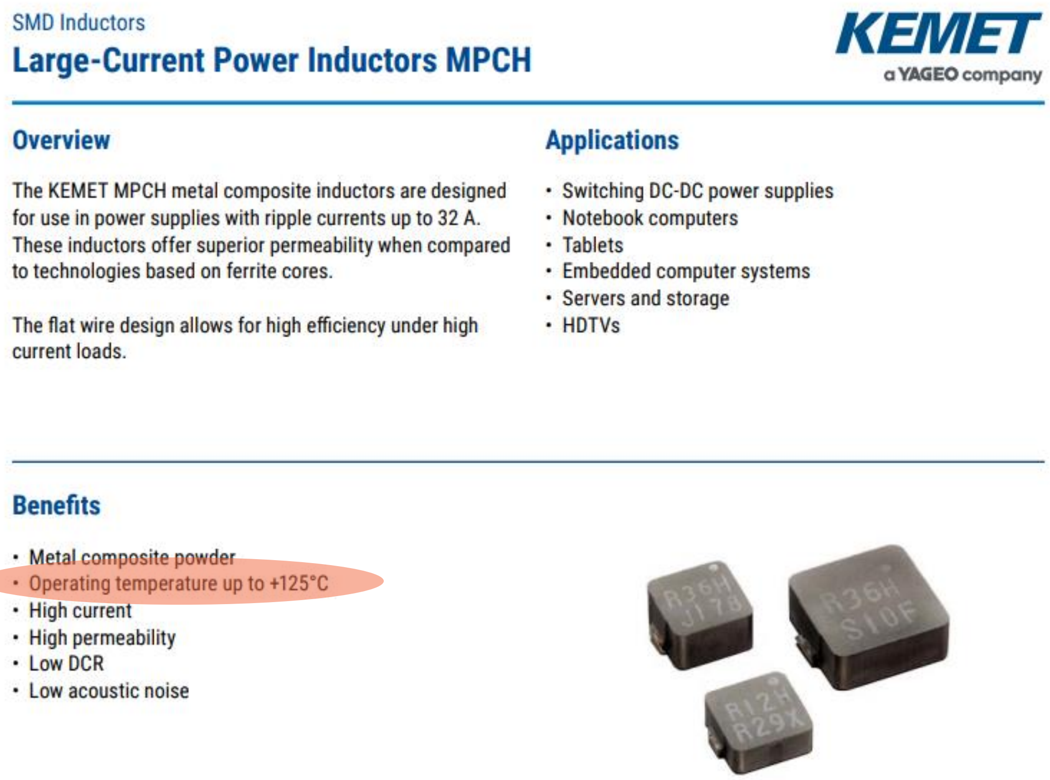
$$\Delta\vartheta = \vartheta_{Inductor} - \vartheta_{ambient}$$

- Scenario:
  - Application Temperature / Ambient Temperature: 85°C

Rated Current: I_{rms}

- Old KEMET series
  - Max. temperature: 125°C

$$\Delta\vartheta = 125°C - 85°C = 40°C$$


SMD Inductors

Large-Current Power Inductors MPCH

KEMET a YAGEO company

Overview

The KEMET MPCH metal composite inductors are designed for use in power supplies with ripple currents up to 32 A. These inductors offer superior permeability when compared to technologies based on ferrite cores.

The flat wire design allows for high efficiency under high current loads.

Applications

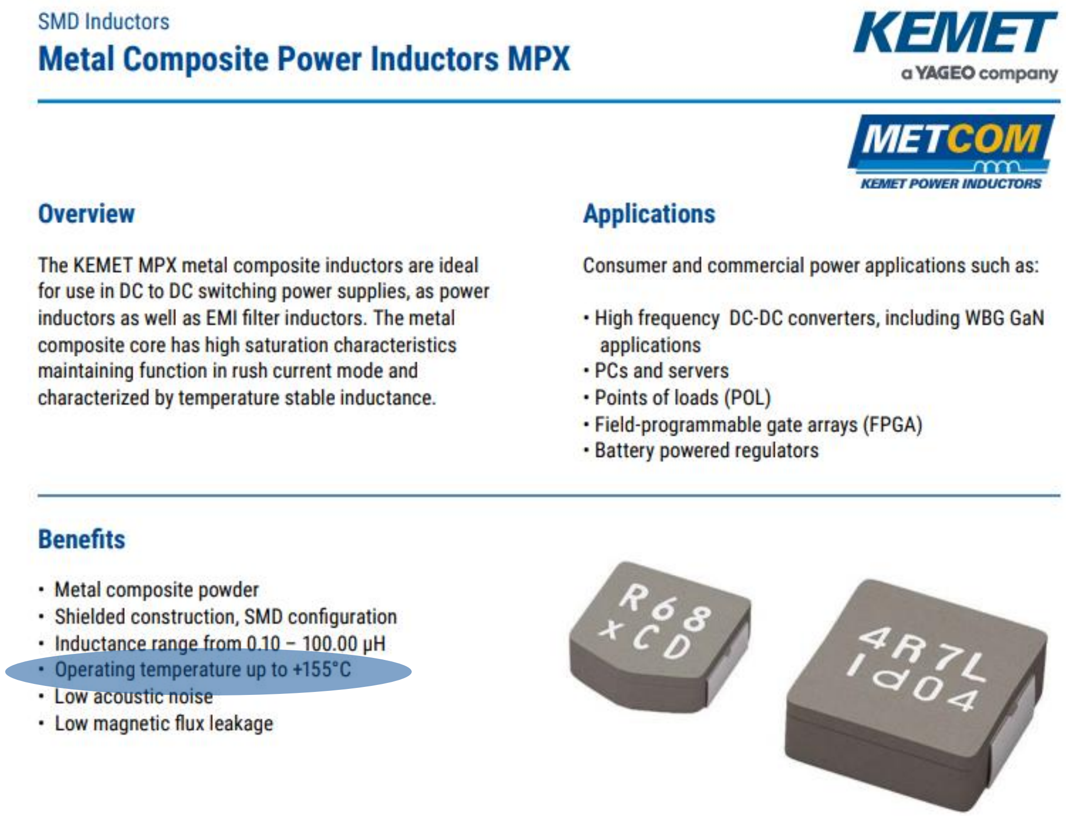
- Switching DC-DC power supplies
- Notebook computers
- Tablets
- Embedded computer systems
- Servers and storage
- HDTVs

Benefits

- Metal composite powder
- Operating temperature up to +125°C
- High current
- High permeability
- Low DCR
- Low acoustic noise

- New KEMET series
  - Max. temperature: 155°C

$$\Delta\vartheta = 155°C - 85°C = 70°C$$


SMD Inductors

Metal Composite Power Inductors MPX

KEMET a YAGEO company

METCOM KEMET POWER INDUCTORS

Overview

The KEMET MPX metal composite inductors are ideal for use in DC to DC switching power supplies, as power inductors as well as EMI filter inductors. The metal composite core has high saturation characteristics maintaining function in rush current mode and characterized by temperature stable inductance.

Applications

Consumer and commercial power applications such as:

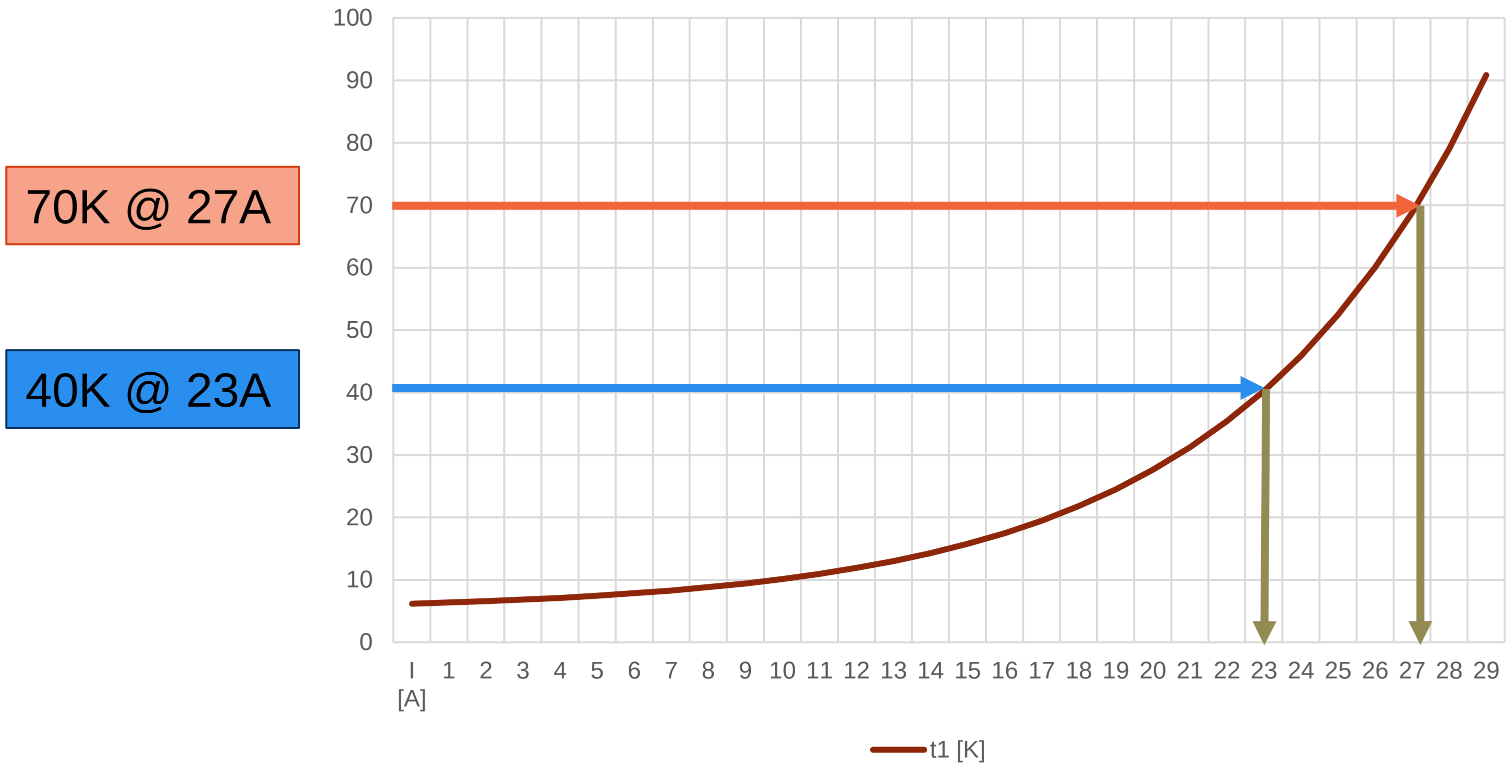
- High frequency DC-DC converters, including WBG GaN applications
- PCs and servers
- Points of loads (POL)
- Field-programmable gate arrays (FPGA)
- Battery powered regulators

Benefits

- Metal composite powder
- Shielded construction, SMD configuration
- Inductance range from 0.10 – 100.00 µH
- Operating temperature up to +155°C
- Low acoustic noise
- Low magnetic flux leakage

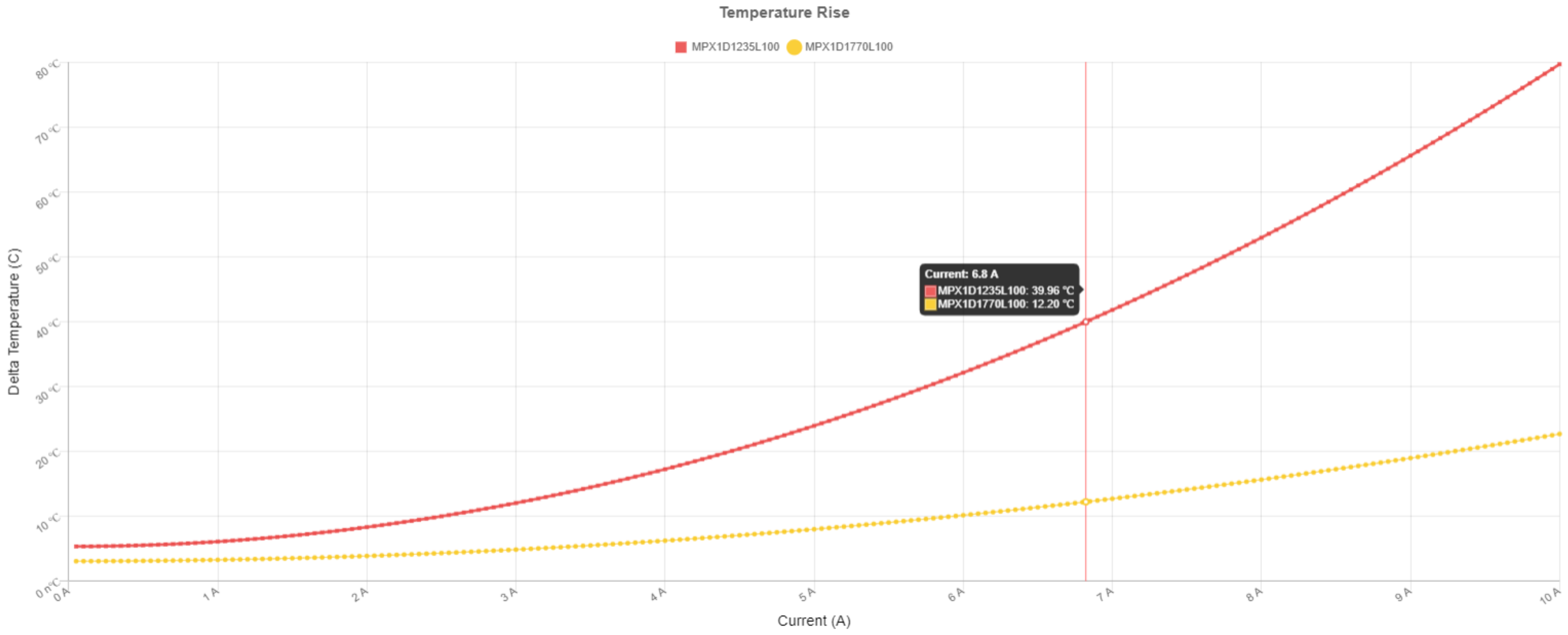
Rated Current: I_{rms}

- Scenario: *Different max. inductor temperature, same application temperature*



Rated Current: I_{rms}

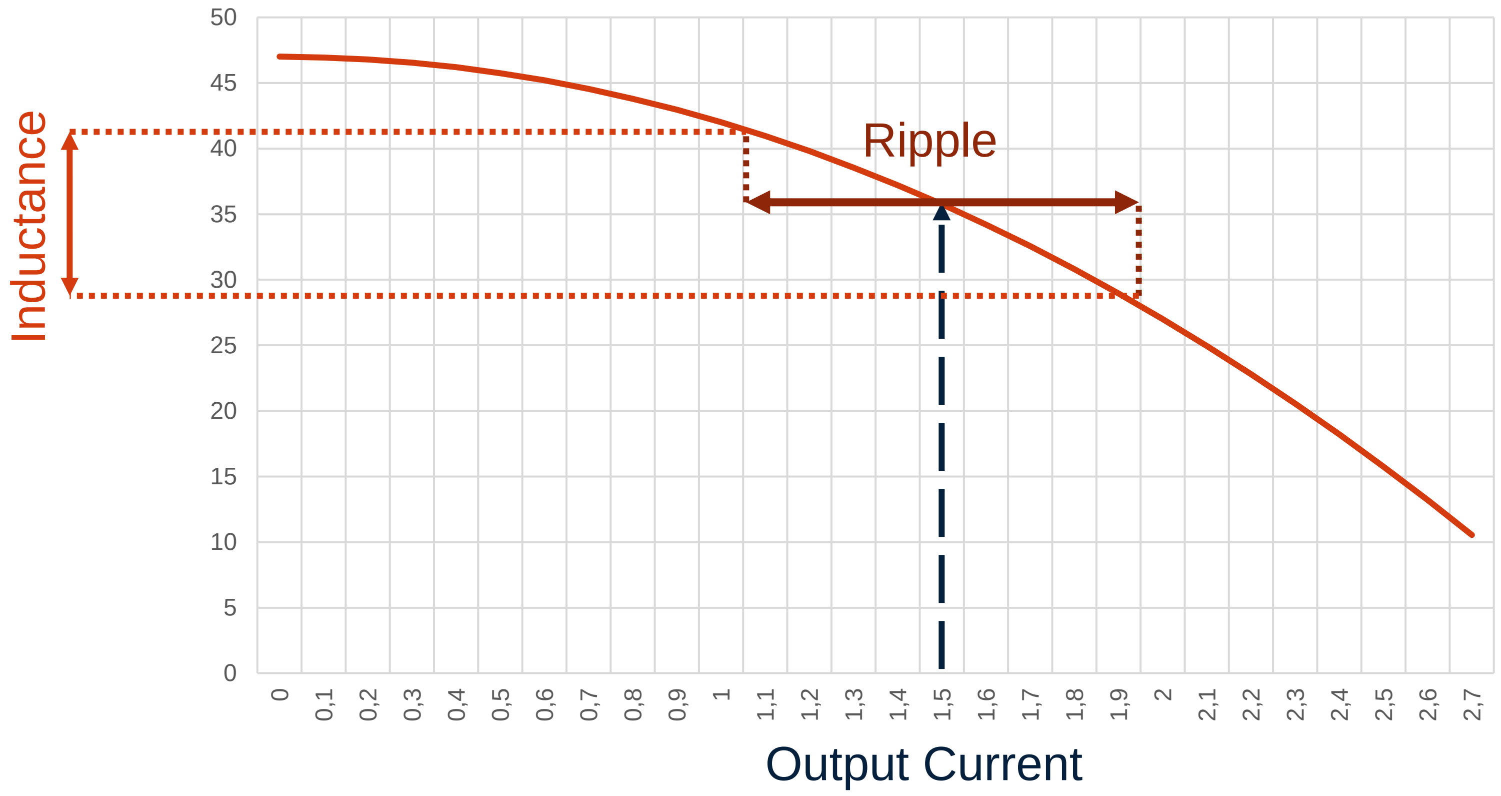
- Full Product comparison by simulation or measuremet graph:



Info	Legend	Size	Ind.	Part Number	Freq. (kHz)	V_{in}	V_{out}	I_{out}	Amb. (°C)	Duplicate	Remove
›	■	**12.5mm**	**10 uH**	**MPX1D1235L100**	100	12	5	10	25	+	✕
›	●	17.1mm	10 uH	MPX1D1770L100	100	12	5	10	25	+	✕

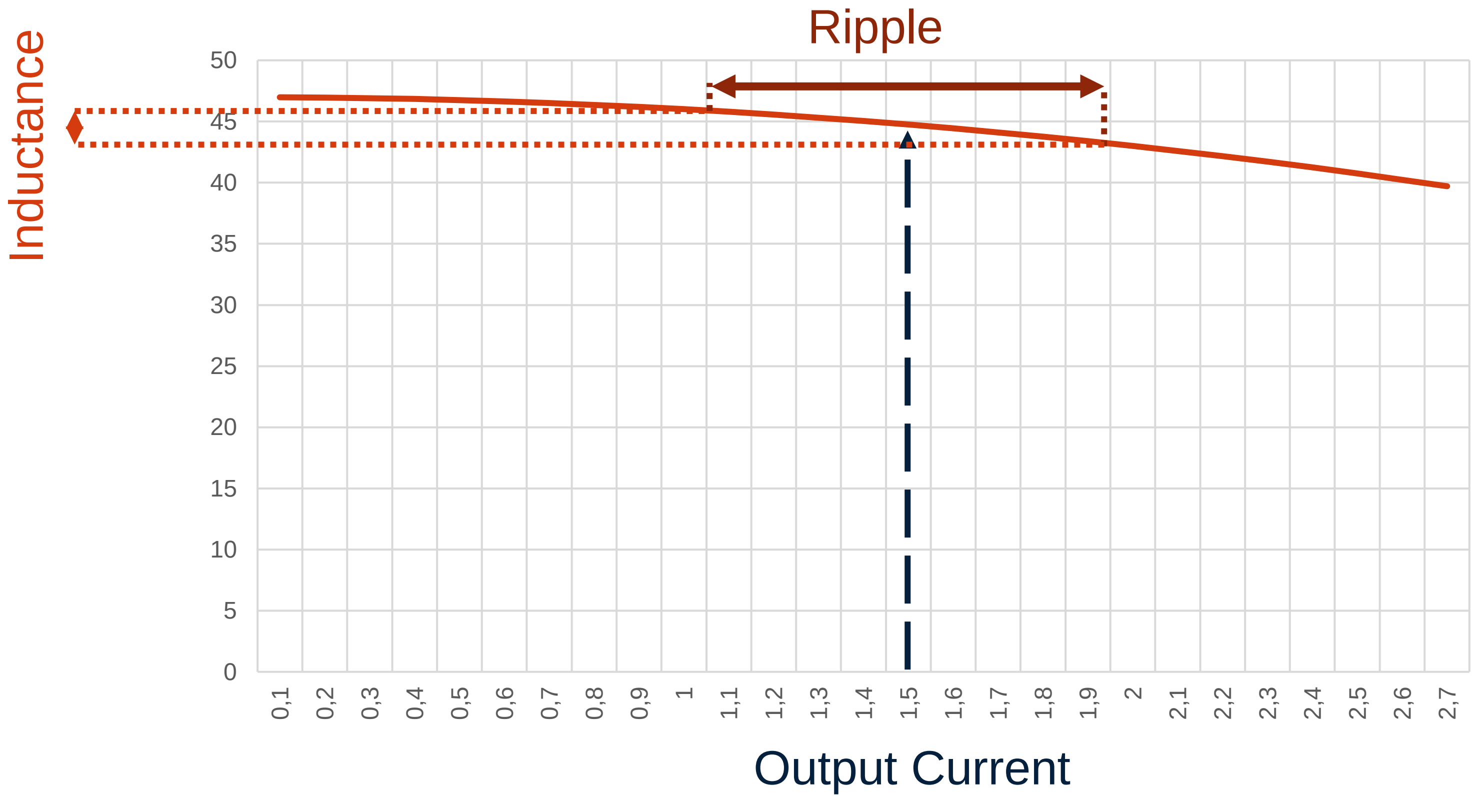
Rated Current: I_{sat}

- Influence of Ripple
- Example @ 1.5A



Rated Current: I_{sat}

- Influence of Ripple with Soft Saturation Inductor
- Example @ 1.5A



Saturation Current: I_{sat}

- Old KEMET series
  - I_{sat} @ 30% Inductance drop

- New KEMET Series
  - I_{sat} @ 20% Inductance drop
  - I_{sat} @ 30% Inductance drop

Table 1 – Ratings & Part Number Reference

Part Number	Inductance (µH) at 100 kHz, 1 mA	Inductance Tolerance	DC Resistance (mΩ) ±10%	Rated Current (A)	
				Irms[1] (Ref.)	Isat[2] (Ref.)
MPLCV1054L100	10.0	±20%	25	7.1	12.0
MPLCV1054L220	22.0	±20%	47	5.5	7.0

[1] T = 40 K rise at rated current
[2] Inductance drop 30% at rated current
All electrical characteristics data is referenced to 20°C.

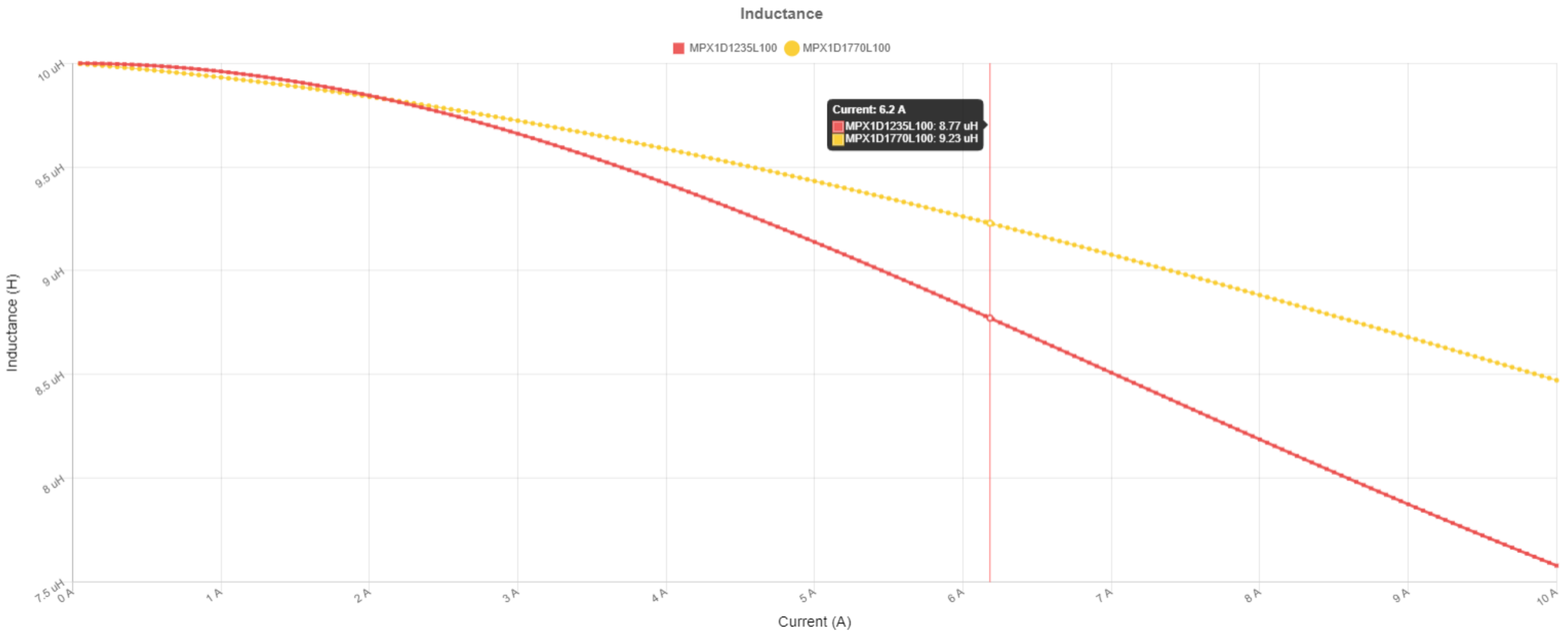
Table 1 – Ratings & Part Number Reference

Part Number	Inductance (µH) at 100 kHz, 1 mA	Inductance Tolerance	DC Resistance (mΩ) Typical	DC Resistance (mΩ) Maximum	Rated Current (A)		
					Irms[1] (Reference)	Isat[2] (Reference)	Isat[3] (Reference)
MPX1D0618LR10	0.10	±20%	2.4	2.8	18.9	22.5	40.0
MPX1D0618LR15	0.15	±20%	3.2	3.8	16.2	20.0	30.0
Part Number	Inductance (µH) at 100 kHz, 1 mA	Inductance Tolerance	DC Resistance (mΩ) Typical	DC Resistance (mΩ) Maximum	Irms[1]	Isat[2]	Isat[3]
					Rated Current (A)		

[1] T = 40 K rise at rated current
[2] Inductance drop 20% at rated current
[3] Inductance drop 30% at rated current
All electrical characteristics data is referenced to 25°C.

Saturation Current: I_{sat}

- Full Product comparison by simulation or measuremet graph:

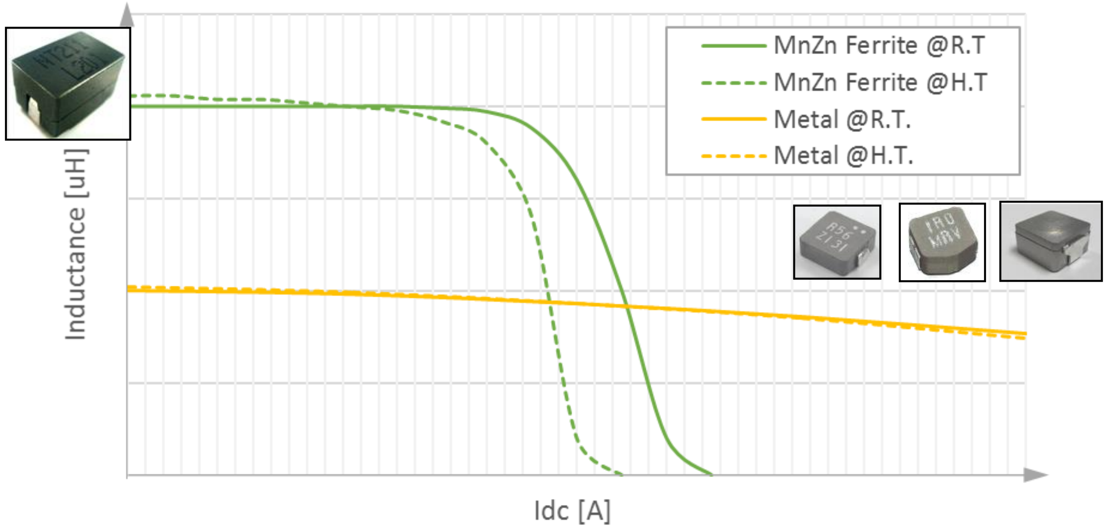


Info	Legend	Size	Ind.	Part Number	Freq. (kHz)	V_{in}	V_{out}	I_{out}	Amb. (°C)	Duplicate	Remove
›	■	**12.5mm**	**10 uH**	**MPX1D1235L100**	100	12	5	10	25	+	×
›	●	17.1mm	10 uH	MPX1D1770L100	100	12	5	10	25	+	×

Inductors

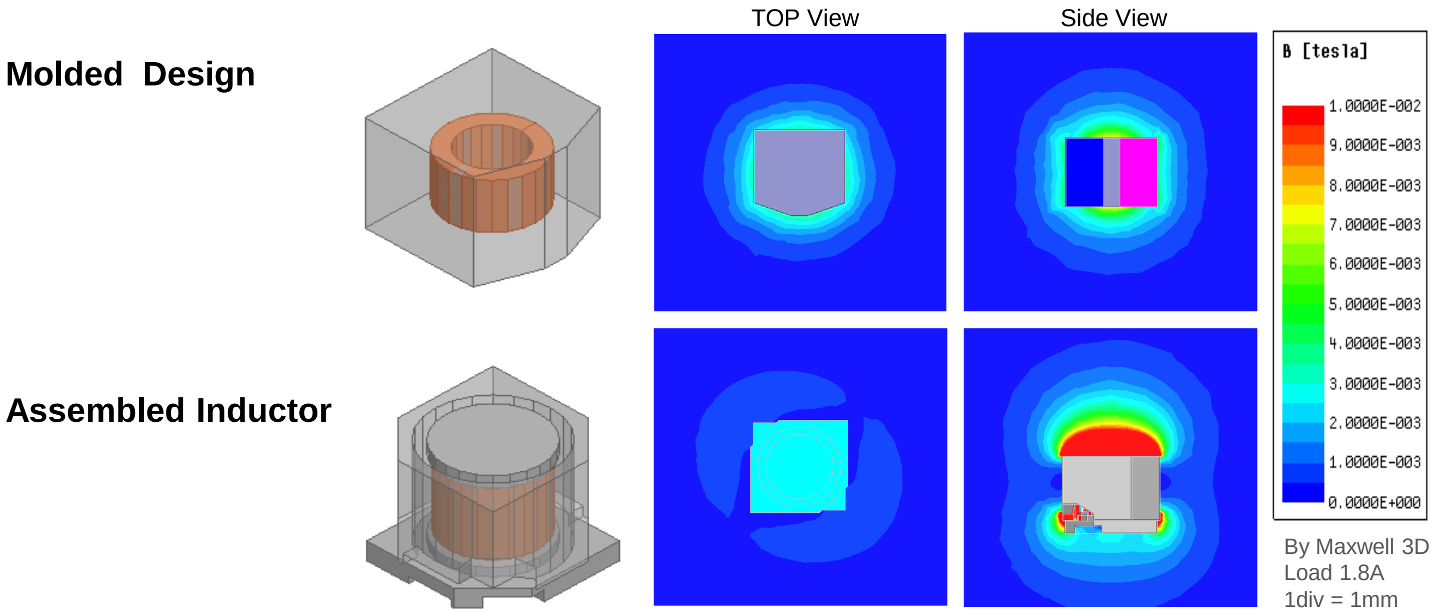
MnZn and Metal Composite Comparison

- Advantages of the MnZn Ferrite Core
  - Higher Inductance with higher permeability → less turns / smaller size / higher current
  - Stable inductance in lower Current range
- Advantages of Metal Composite Core
  - Very slow saturation
  - Very stable saturation over a wider range



Molded vs. Assembled Inductor

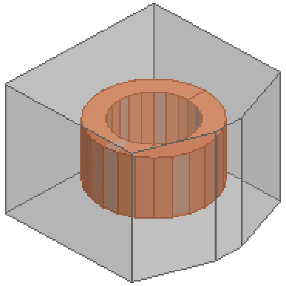
- Advantages of Metal Composite molded Design
  - No open area, no visible air gap, material is fully surrounding the coil
  - Reduced Magnetic Flux / Magnetic Field → improved EMC

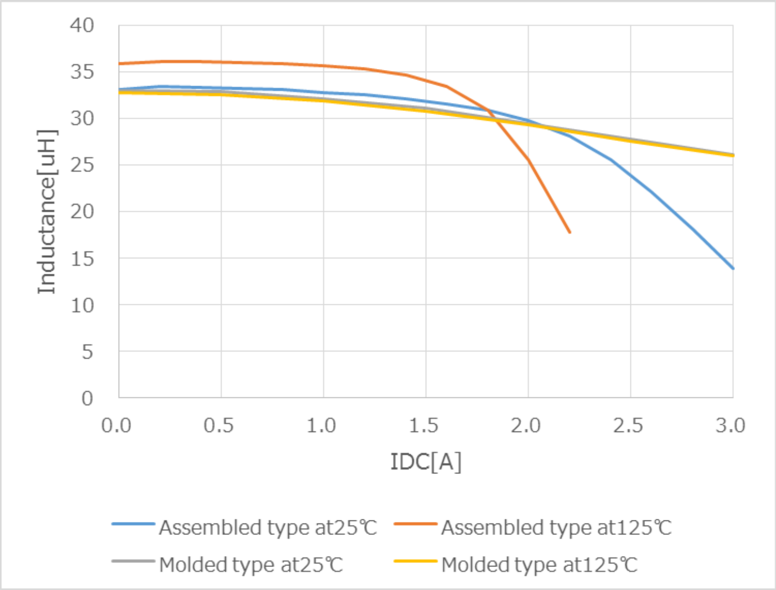


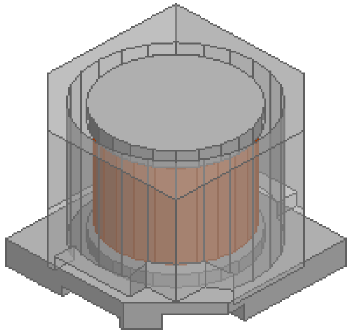
By Maxwell 3D
Load 1.8A
1div = 1mm

Molded vs. Assembled Inductor

- Advantages of Metal Composite molded Design
  - Very soft saturation
  - No hard drop
  - Stable over temperature
  - Higher Ripple Current Capabilities

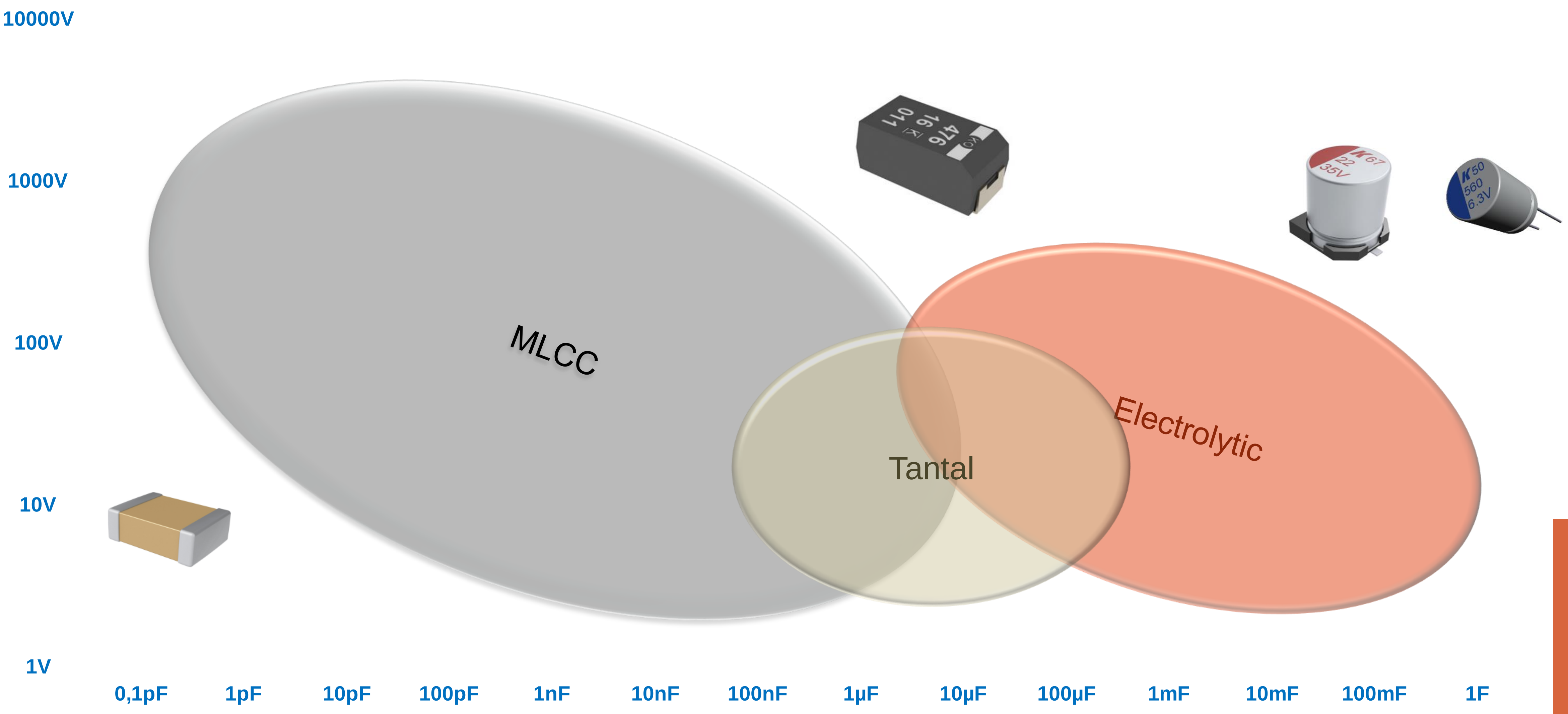






Capacitors

Capacitor Series Overview



Capacitor Comparison

- SMD Solution

Technology	Ceramic	Tantal Polymer	Aluminium Electrolytic (SMD)	Aluminium Polymer (SMD)
Capacitance Range	max. 22µF	max. 470µF	max. 2700µF	max. 2700µF
Voltage Range	max. 3kV_{DC}	max. 50V_{DC}	max. 100V_{DC}	max. 100V_{DC}
Size Range (EIA)	**0402 - 2220**			
Size Range (mm)	1005 - 5750	**2012 - 7743**	**∅4 – ∅16**	**∅4 – ∅16**
Lifetime	Good	Perfect	Limited	Good

Capacitor Comparison

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Lifetime	Good	Perfect	Limited	Good
Price per piece [1)]	Low	High	Low	Mid

[1]: 1µF

Capacitor Comparison

- SMD Solution

Technology	Ceramic	Tantal Polymer	Aluminium Electrolytic (SMD)	Aluminium Polymer (SMD)
Capacitance Range	max. 22µF	max. 470µF	max. 2700µF	max. 2700µF
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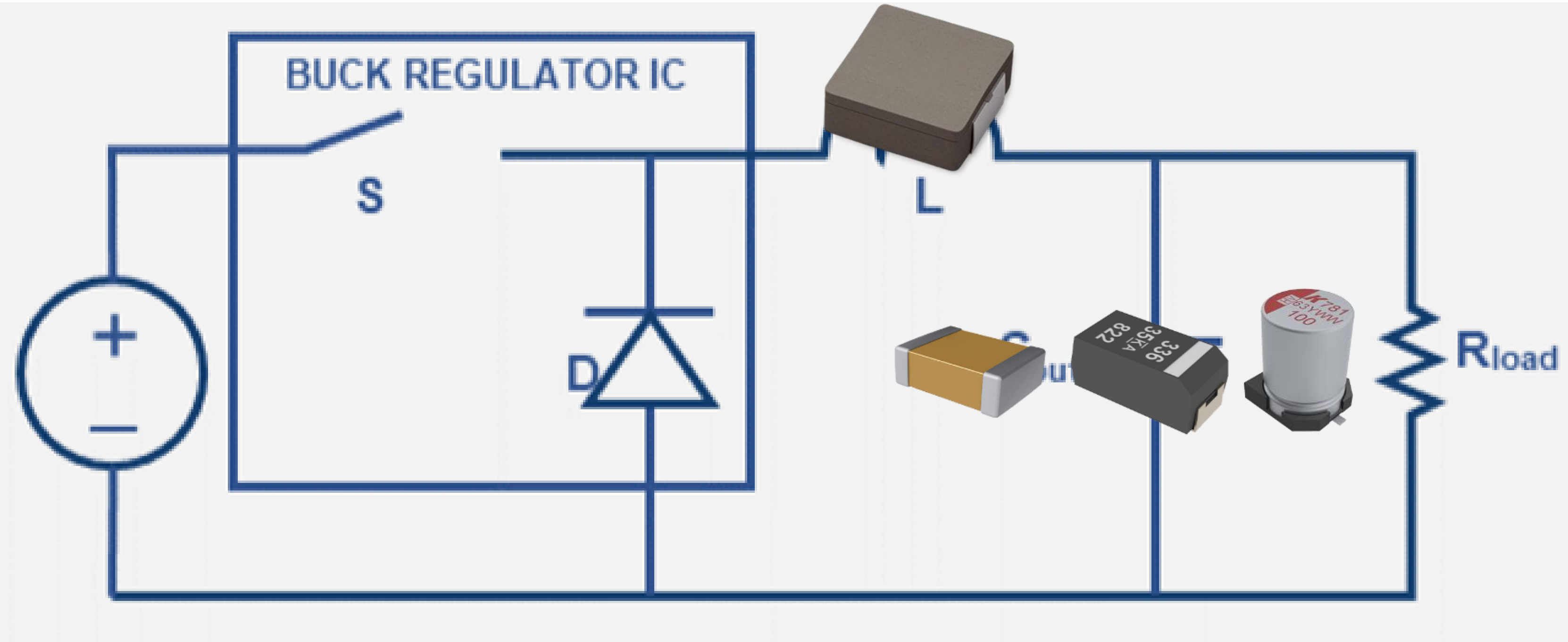
Size Range (EIA)	**0402 - 2220**			
Size Range (mm)	1005 - 5750	**2012 - 7743**	**∅4 – ∅16**	**∅4 – ∅16**
Lifetime	Good	Perfect	Limited	Good
Price per piece 1)	Low	High	Low	Mid
Price per µF 2)	High	Low	Low	Mid
Price per Volume 3)	Low	Mid	Low	High

1: 1µF
2: 100µF / 100V
3: 10µF / $100mm^3$

Summary

- YAGEO Product Solutions



YAGEO Group

Thank you.

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