



KUNDENSEMINAR POWER SUPPLIES – MAKE OR BUY?

Die richtige Auswahl passiver Bauelemente

1. AC/DC

2. DC/DC

Mittwoch, 17. April 2024



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.

- 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



ARCOTRONICS GROUP



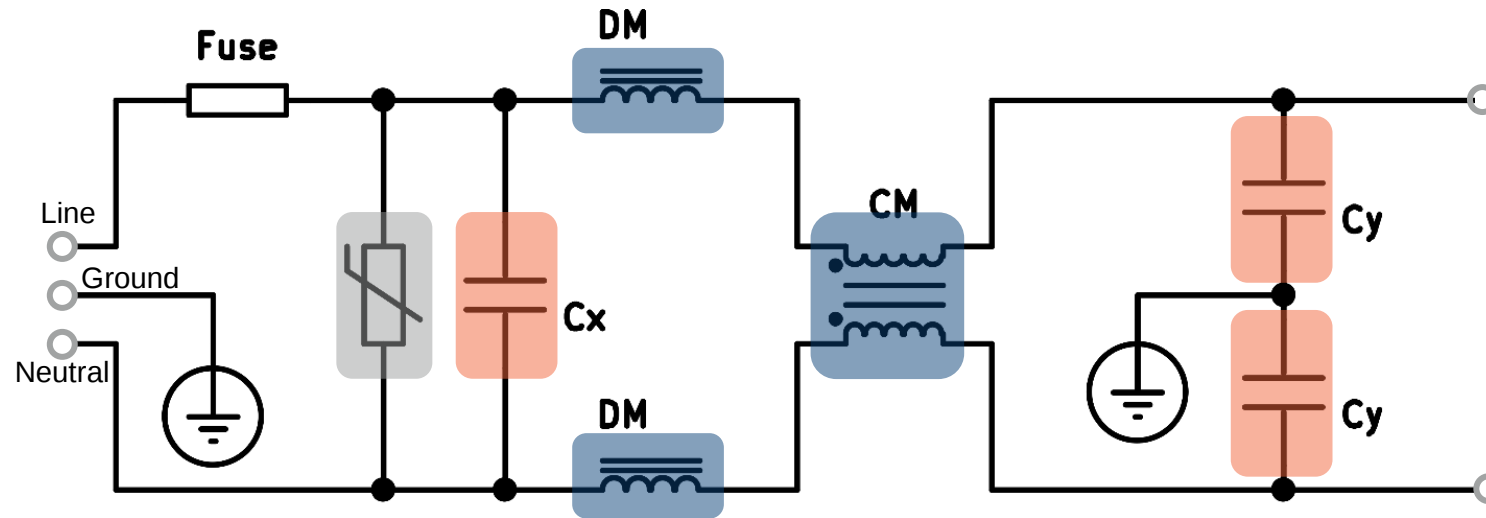
Pulse



1. ACDC

AC Filtering

- AC Line Filter to reduce EMI

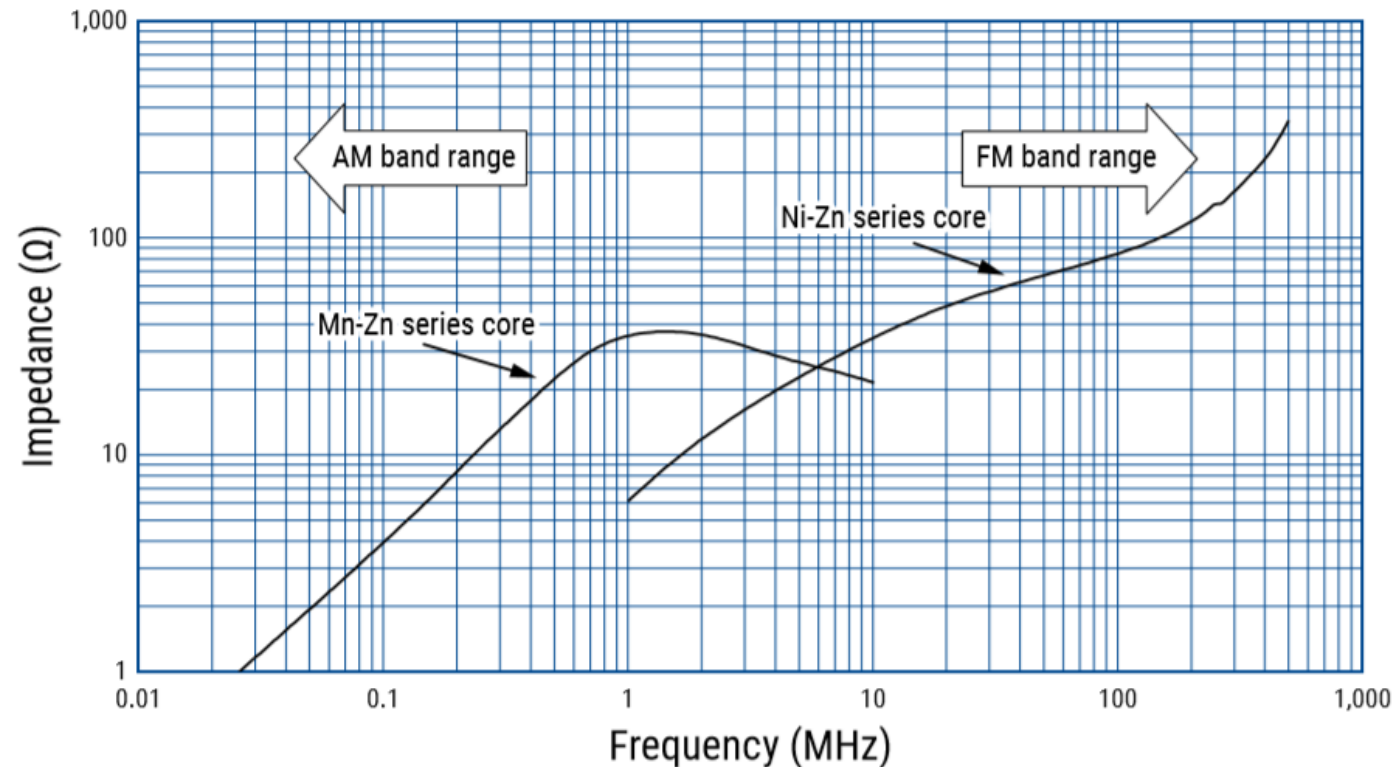


- Frequency Range

Frequency Range of different material

- Different Core Materials

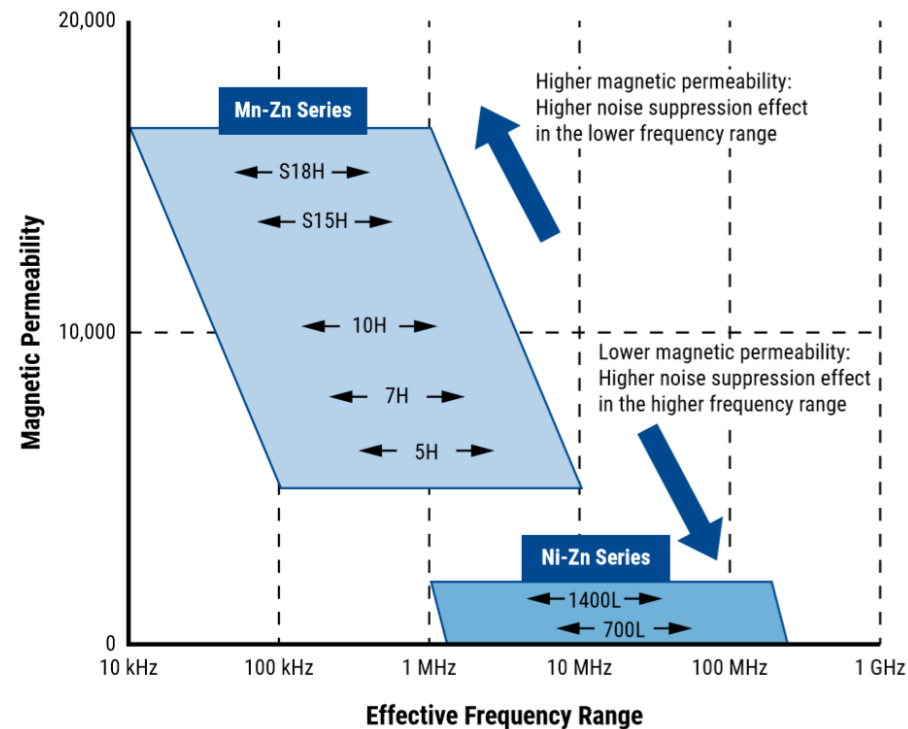
- MnZn → lower frequency range
- NiZn → higher frequency range



Core material and permeability

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

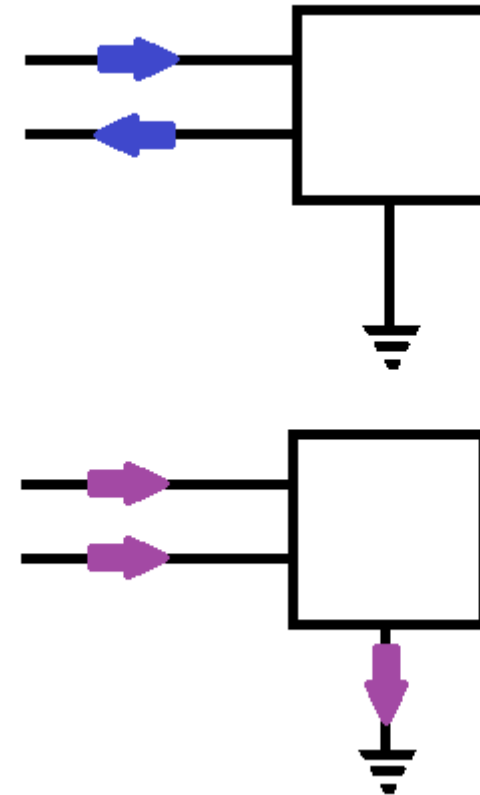
$$L = \frac{\mu_0 \mu_r A n^2}{l_{eff}}$$



- Differential or Common Mode

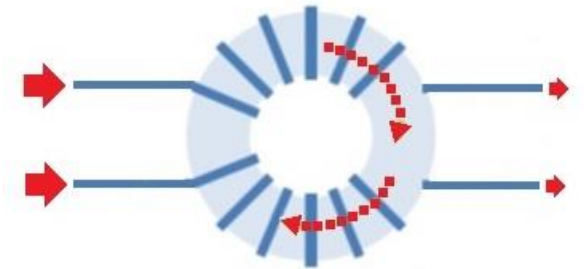
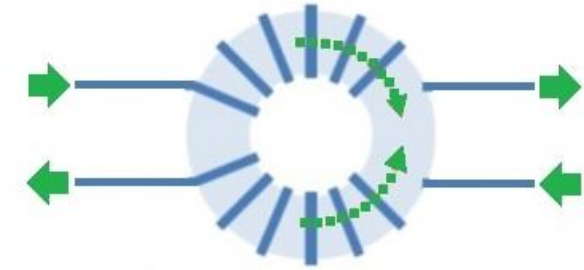
Common Mode or Differential Mode

- 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

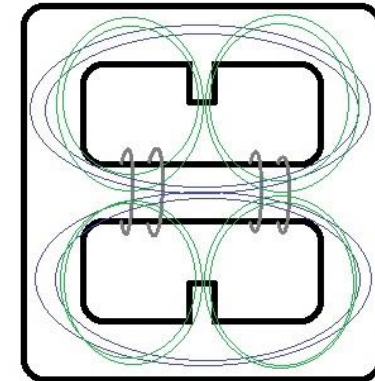
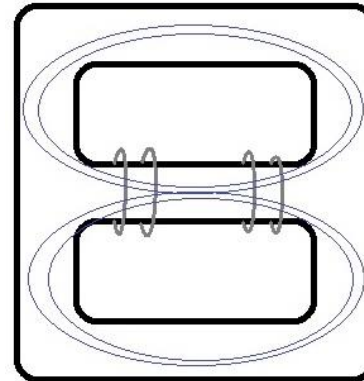
- Differential Mode signal is identical on both lines
 - This creates no magnetic field in the core
 - No losses for Differential Mode Signal
-
- Common Mode Interference creates magnetic field
 - Magnetic Field creates heat in the core
 - Common Mode Inteference is reduced



- Core Style

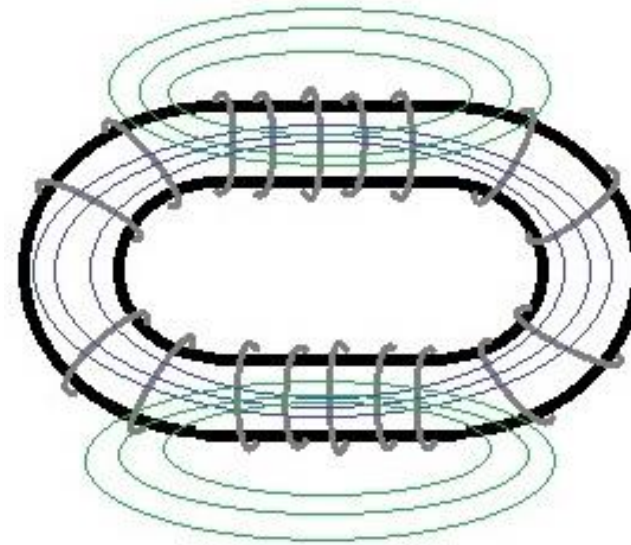
Common Mode Choke types

- 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



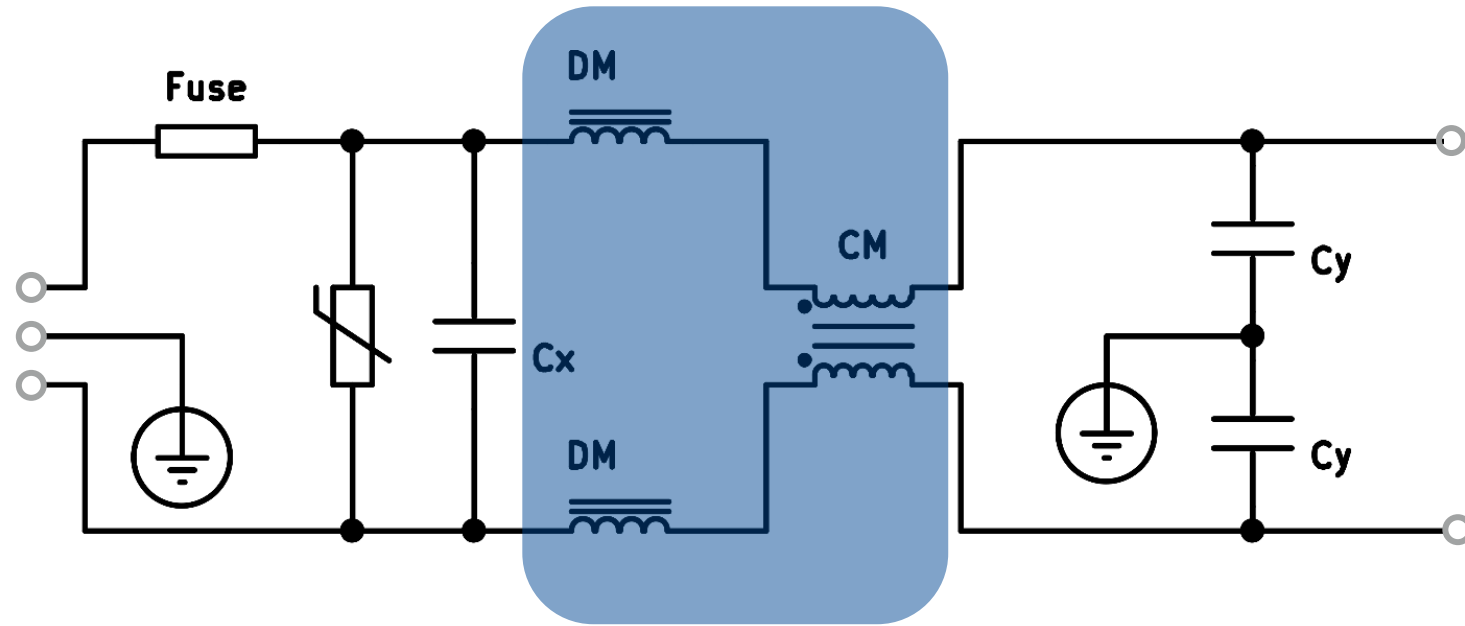
Common Mode Choke types

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



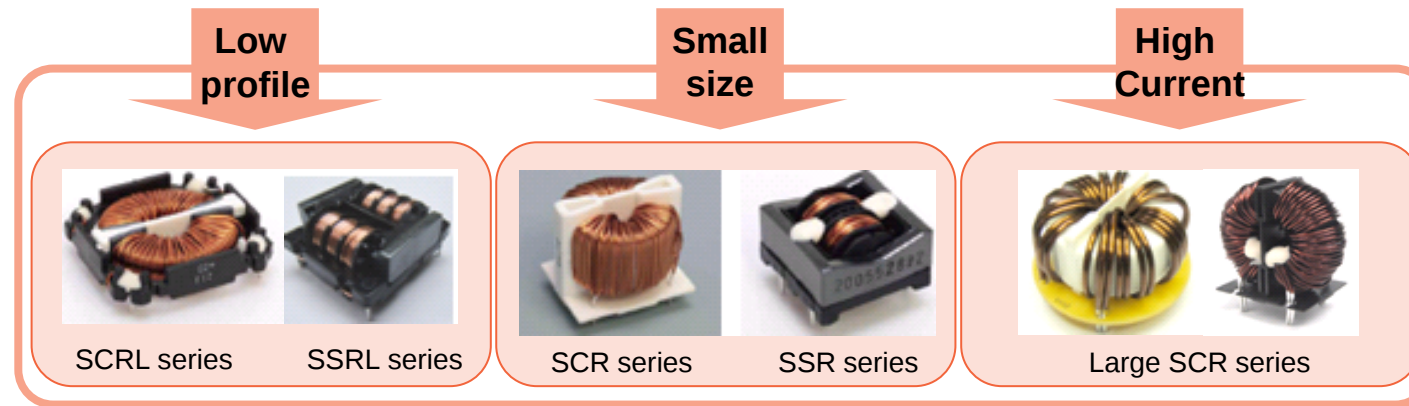
Common Mode Choke types

- Dual Mode and Hybrid Mode Chokes



Choice of the right Choke

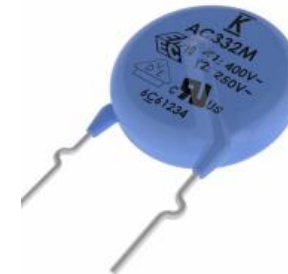
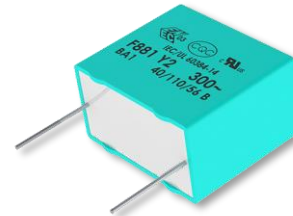
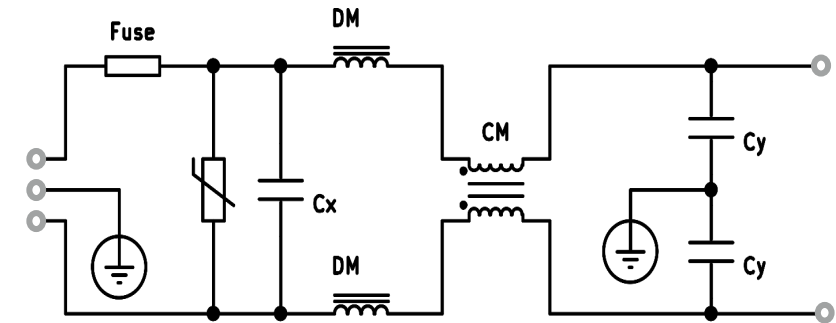
- What is important to find the choke:
 - Frequency Range to filter → Core Material
 - Attenuation → to calculate Impedance / Inductance
 - Maximum Current → Size and Style of the Choke (Wire cross section)
 - Maximum Size recommendations → Type or style of the Choke (horizontal / vertical ...)



- Film Capacitors

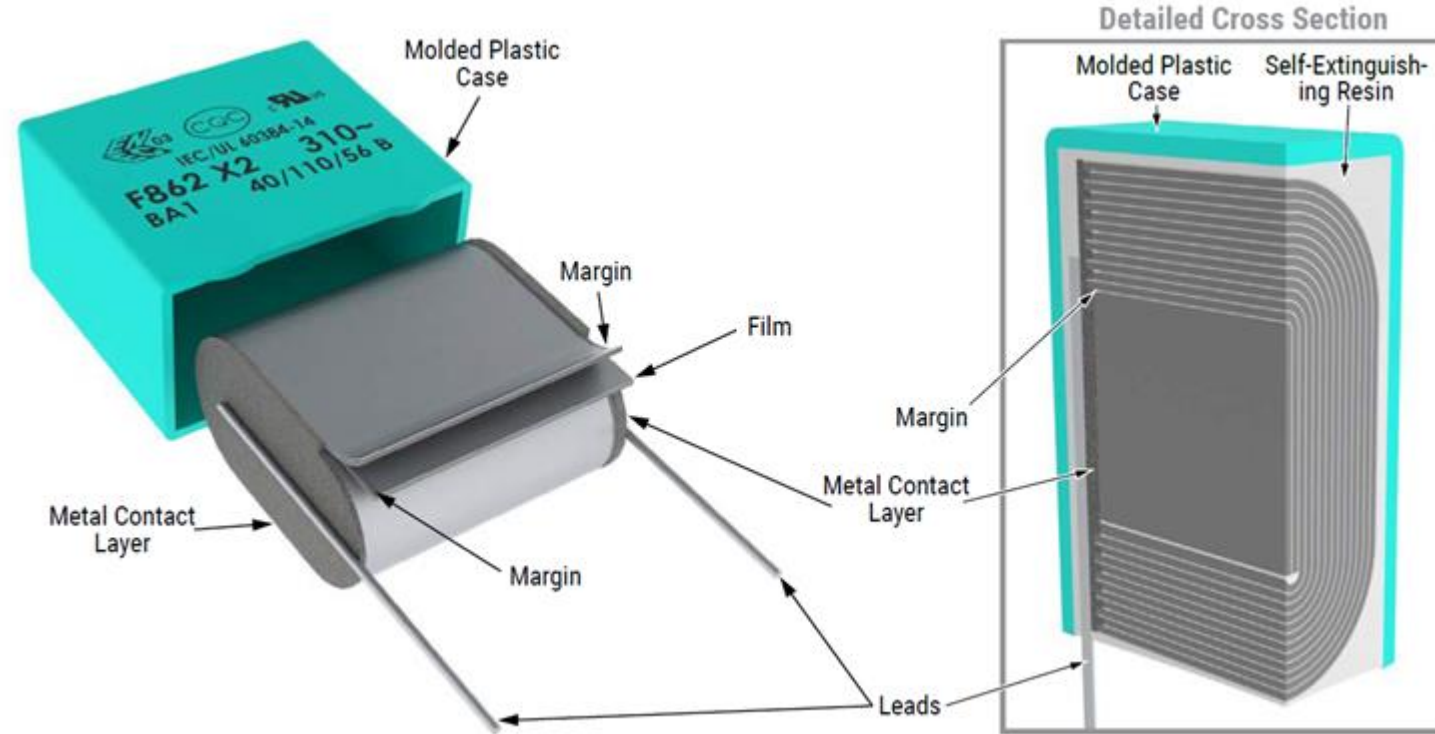
Safety Capacitors

- 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

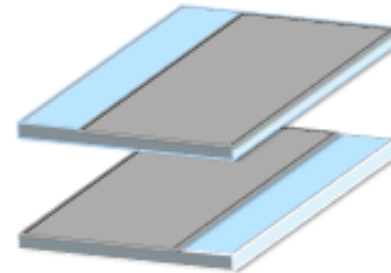


Film Capacitor Basics

- Wound Capacitor Construction



- 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



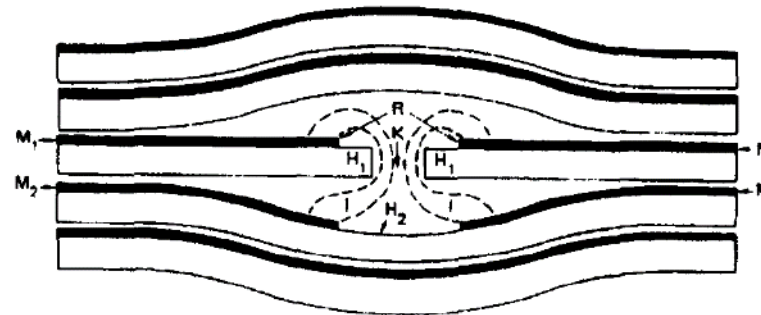
Self Healing

- Process

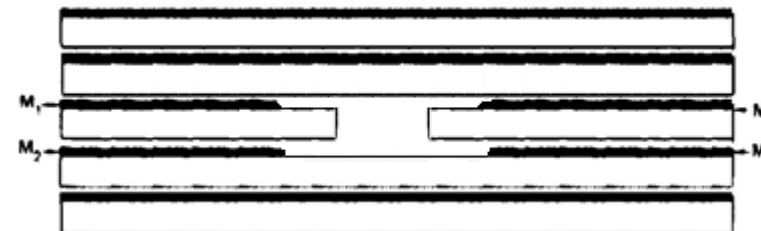
1. Defect Density



2. Evaporization

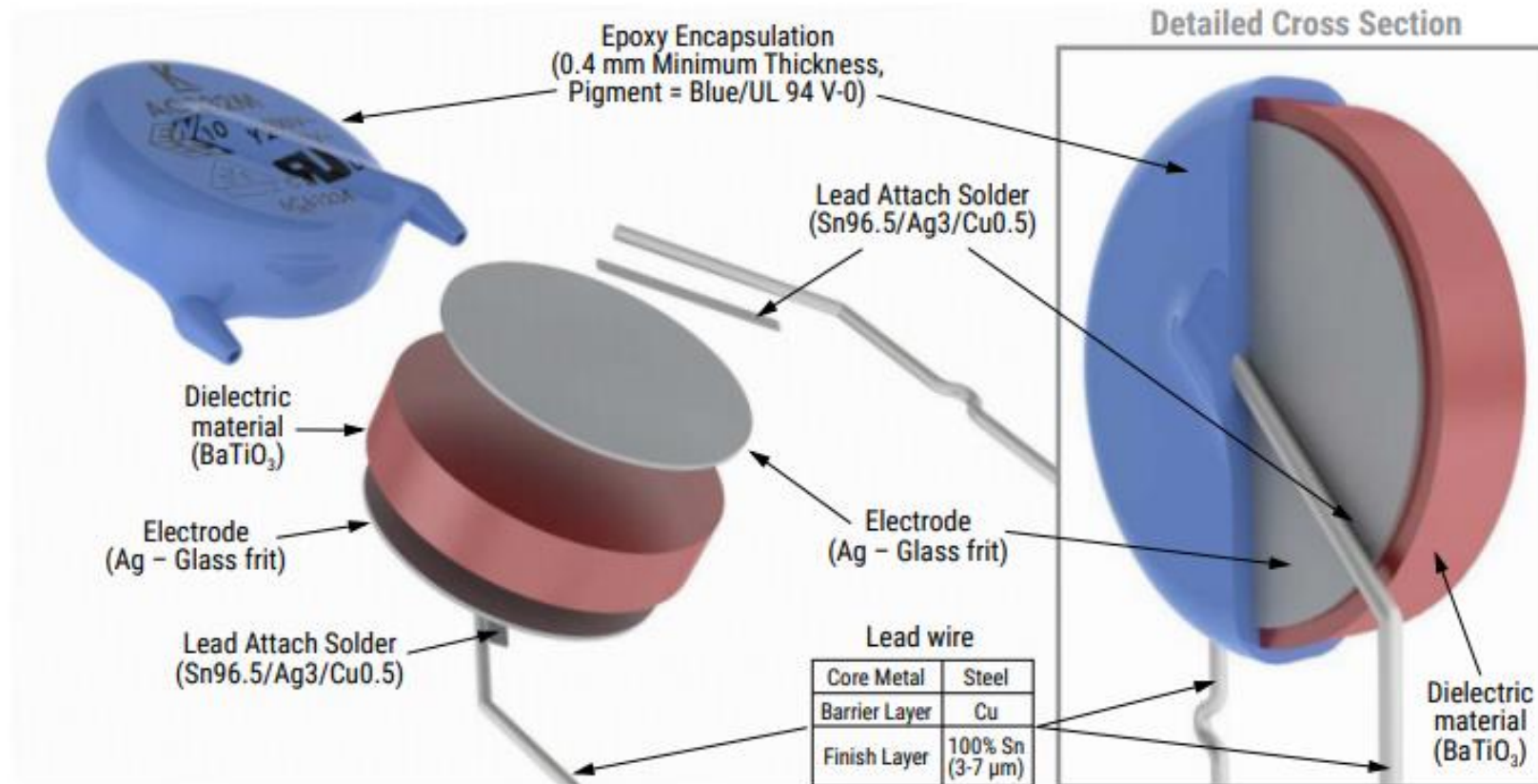


3. Isolated Area



Safety Capacitors

- THT Construction



SMD Safety Certified Capacitors

CAS Series

Safety Standard Recognized

X1/Y2 and X2 Classifications

High Reliability / BME Technology

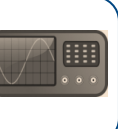
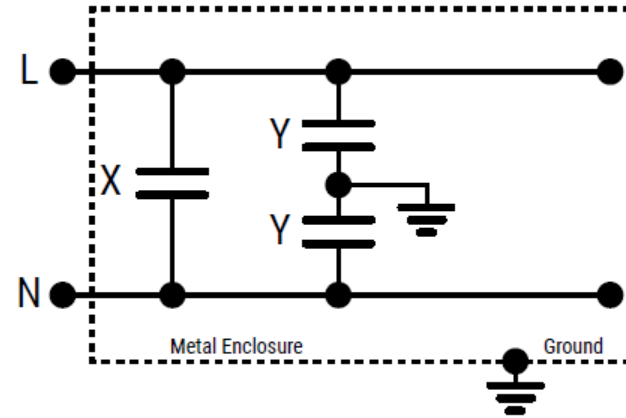
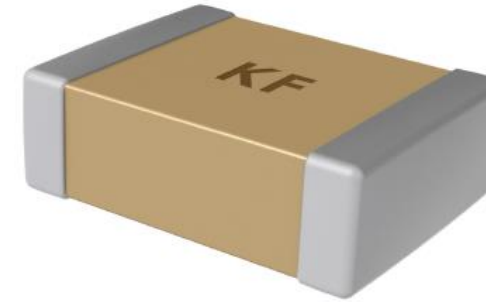
250 VAC Rated Voltage

Peak Impulse Voltage Capable up to 5KV

C0G and X7R Dielectrics

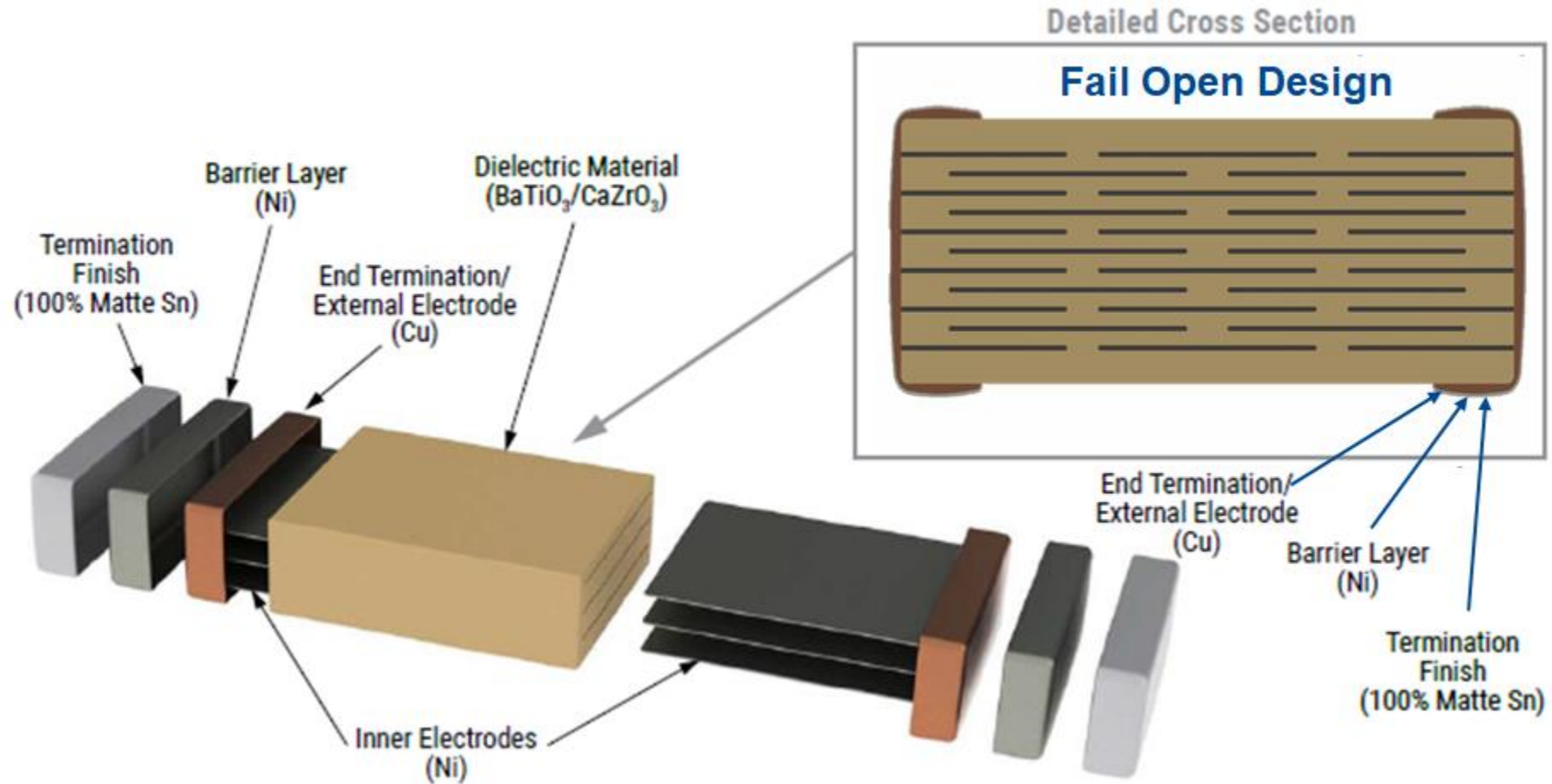
1808 – 2225 Case Sizes

c **UL**® US



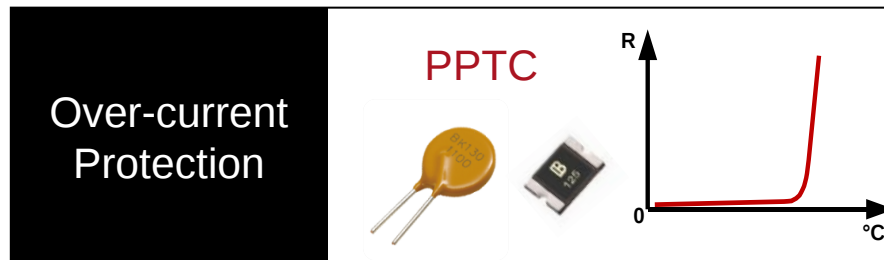
Safety Capacitors

- MLCC Construction



Circuit Protection Products

- Electrical Characteristics



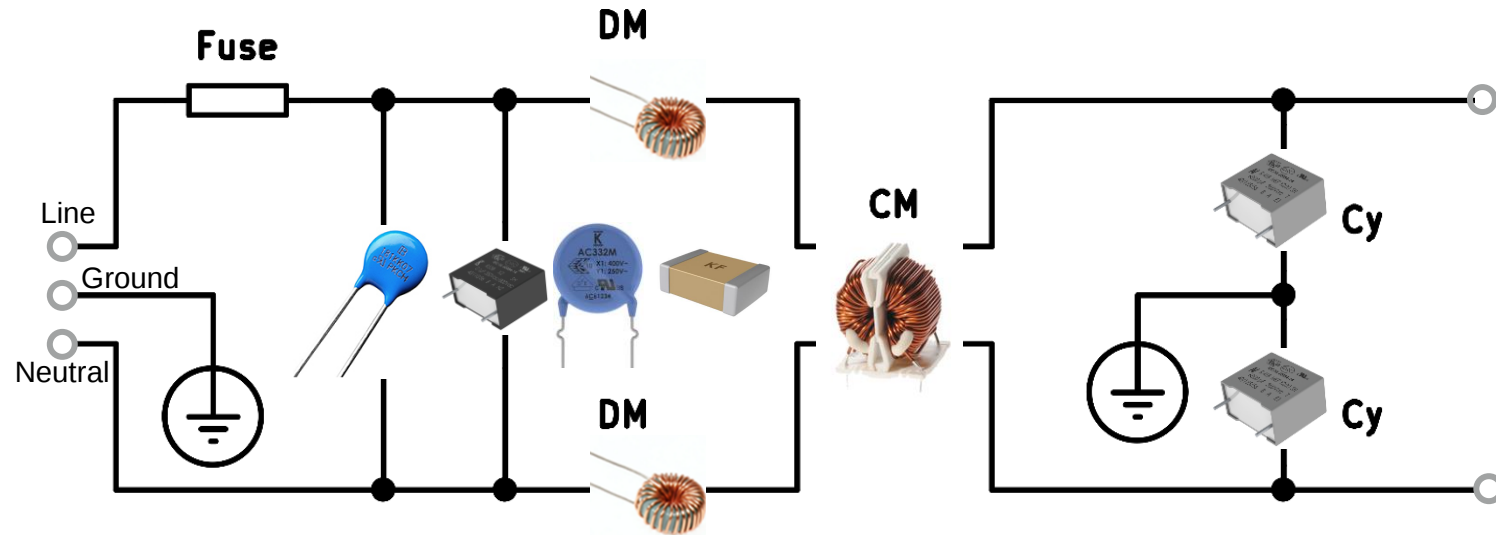
MOV (Metal Oxide Varistors)

- 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

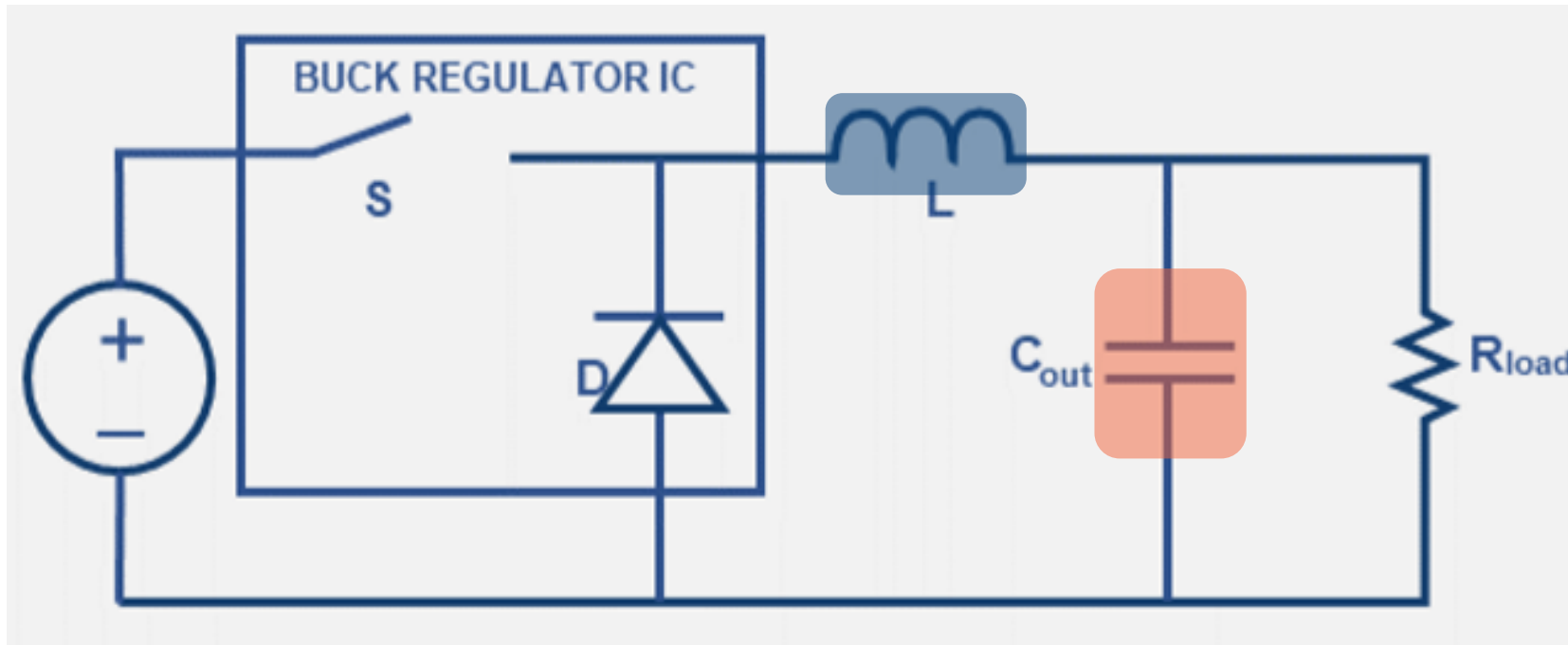
- YAGEO Product Solutions



2. DCDC

DC-DC Converter

- Buck Converter



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

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

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

- Inductor Calculation

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

- 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!*“

- 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 preferred!
- Why 25% lower Inductance is not 25% higher ripple current???
- Because: 25% lower L is 75% = 0.75 = $\frac{3}{4} \rightarrow \frac{4}{3} i_{ripple} = 1.33 i_{ripple}$

Inductor Current

Inductor Selection

- 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

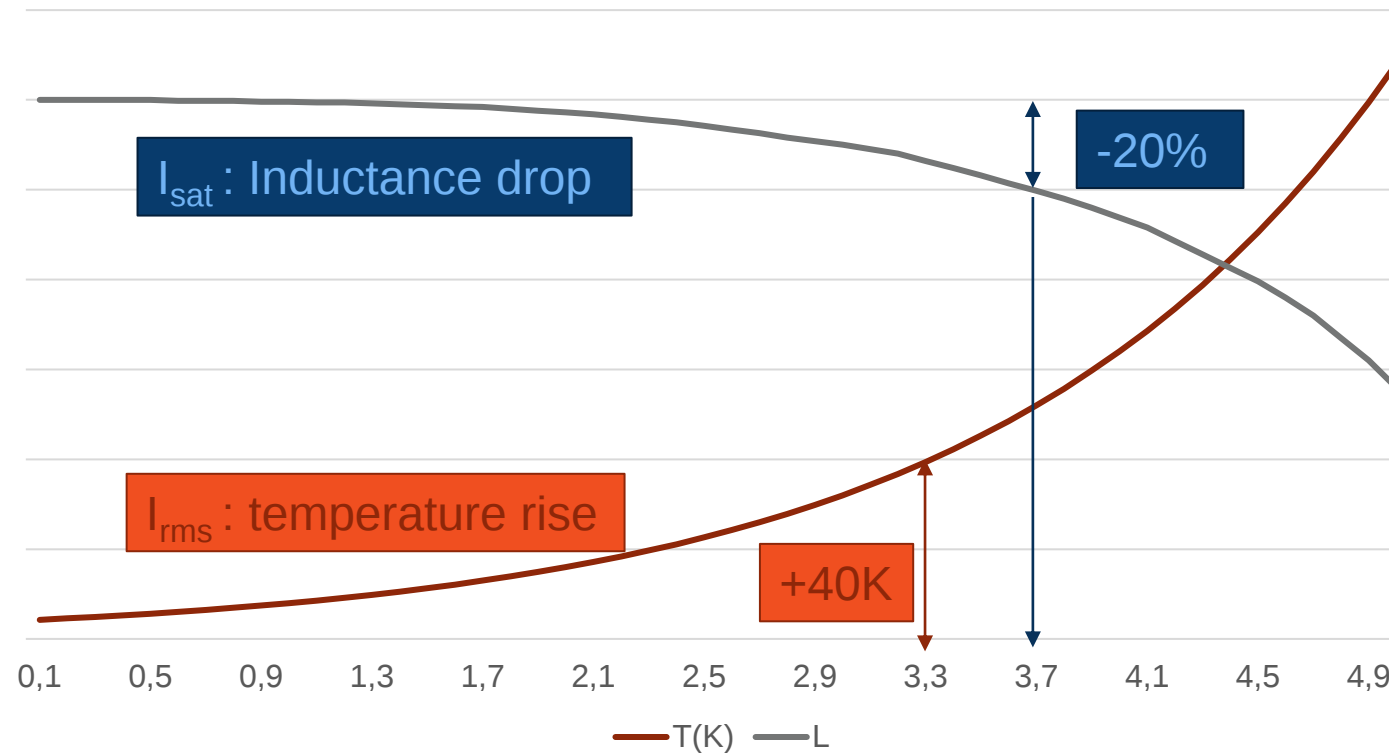
² Inductance drop 20% at rated current

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 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

$$\Delta\vartheta = 125^{\circ}C - 85^{\circ}C = 40^{\circ}C$$

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

$$\Delta\vartheta = 155^{\circ}C - 85^{\circ}C = 70^{\circ}C$$

SMD Inductors

Large-Current Power Inductors MPCH



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



SMD Inductors

Metal Composite Power Inductors MPX



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

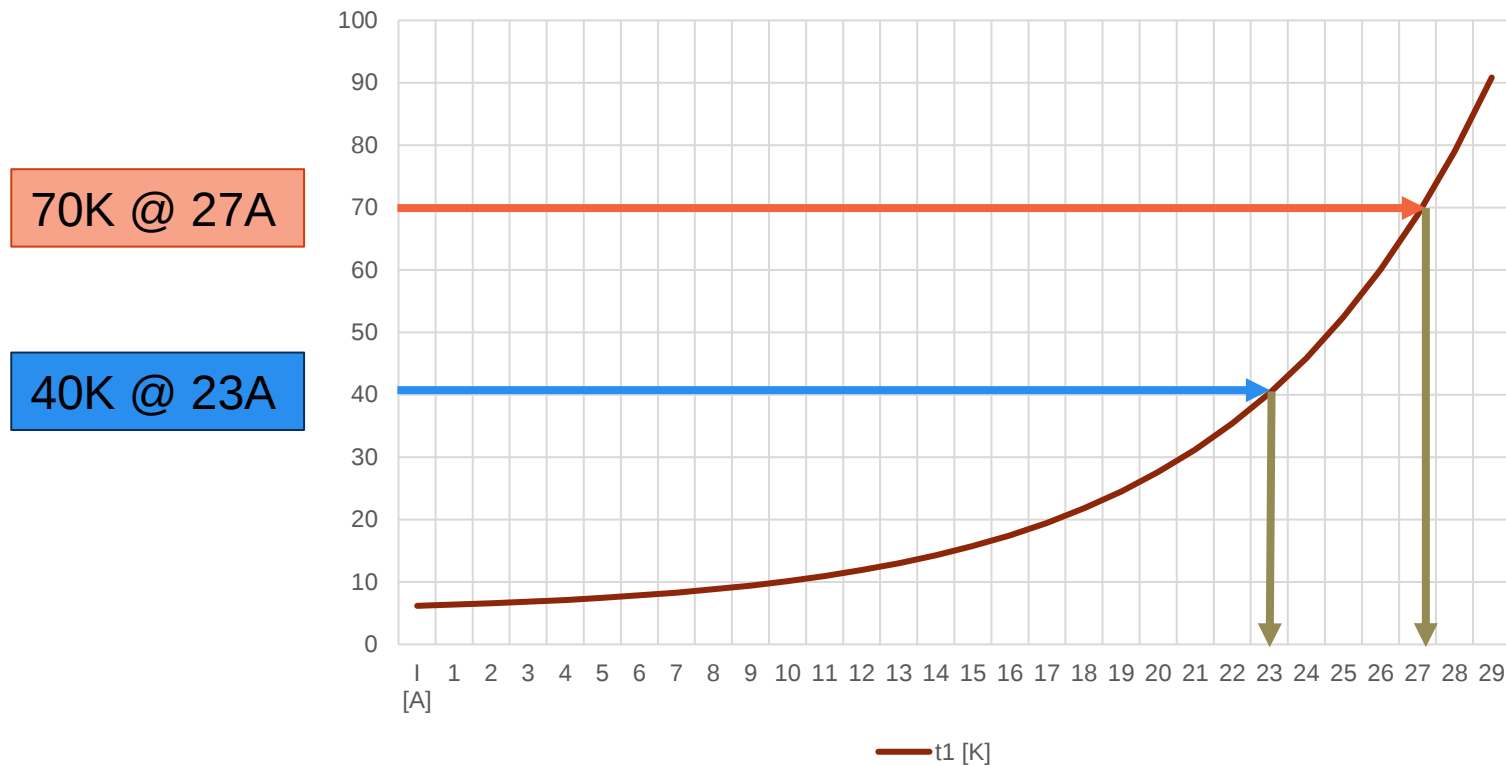
Benefits

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



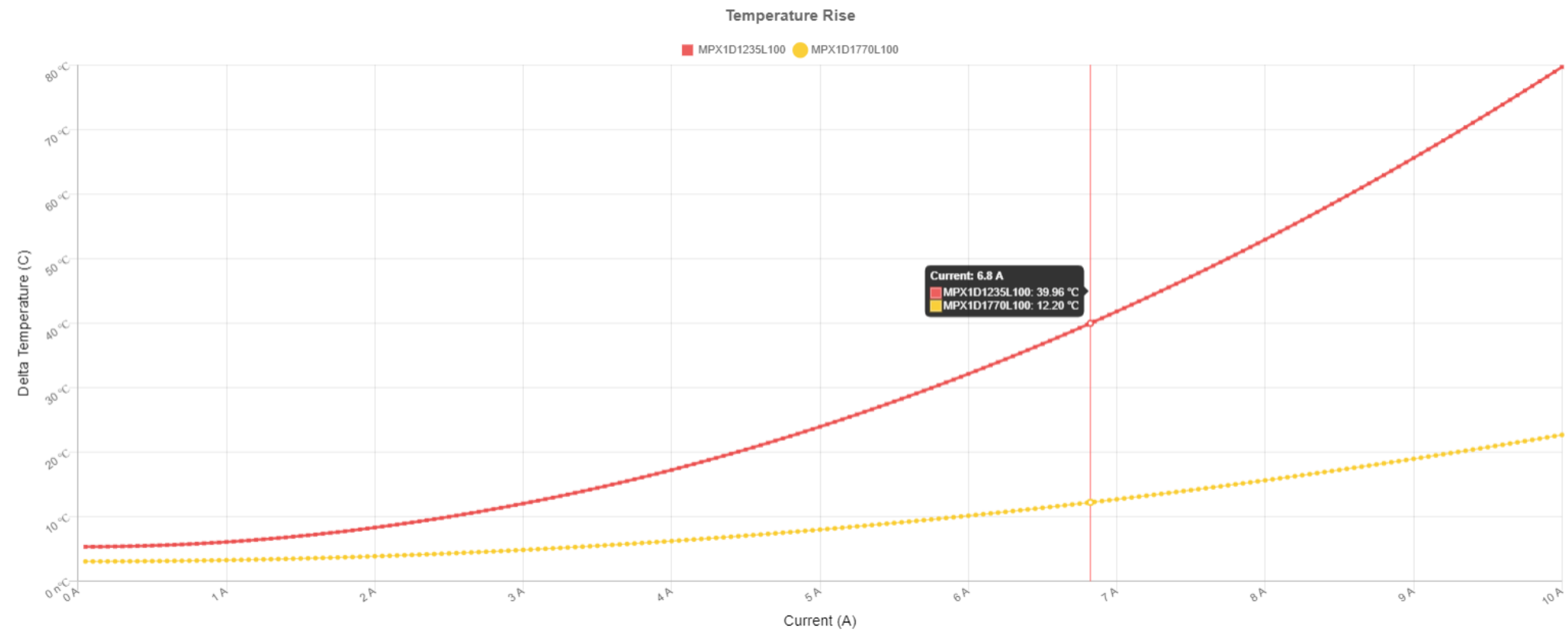
Rated Current: I_{rms}

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



Rated Current: I_{rms}

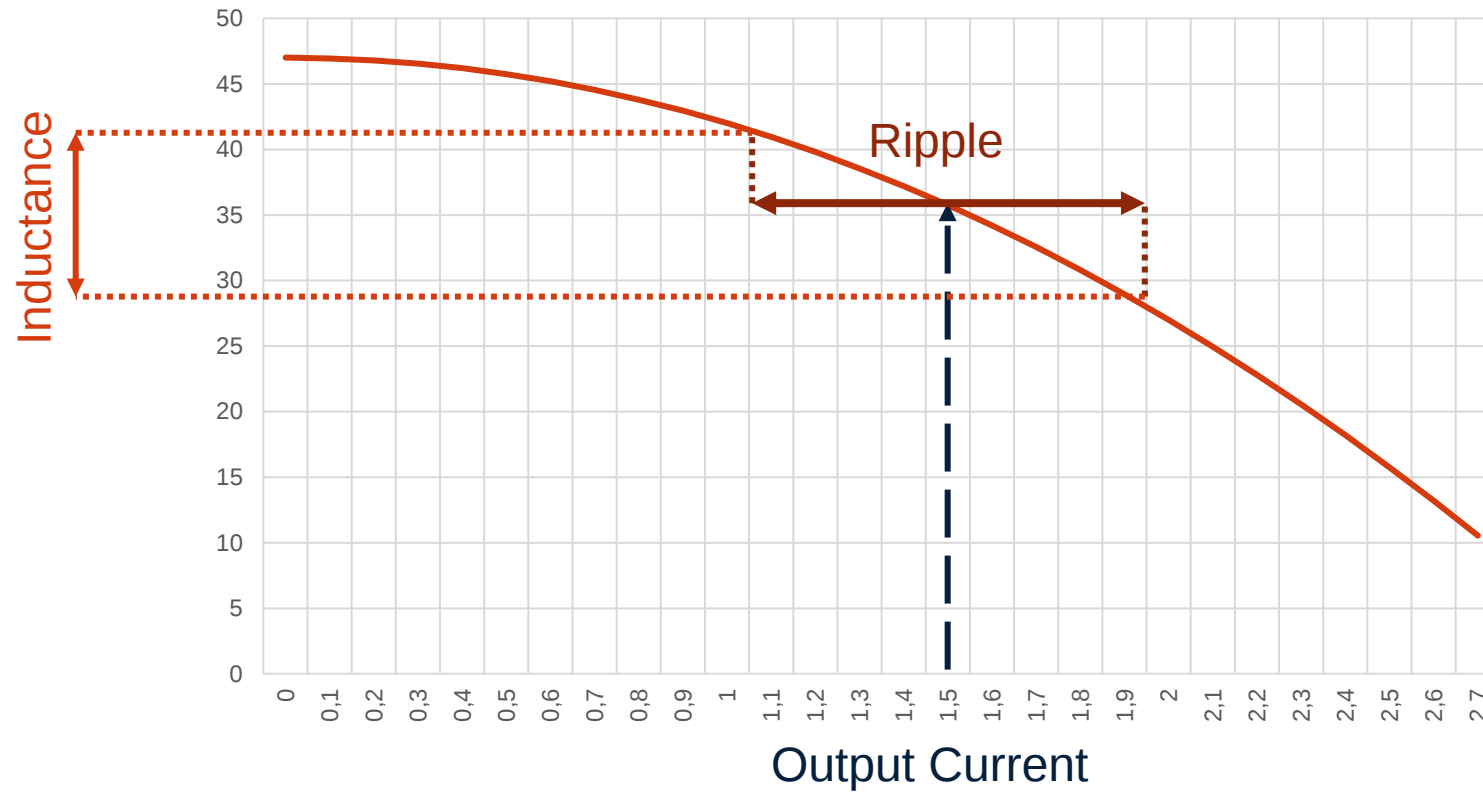
- Full Product comparison by simulation or measuremet graph:



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	+	×

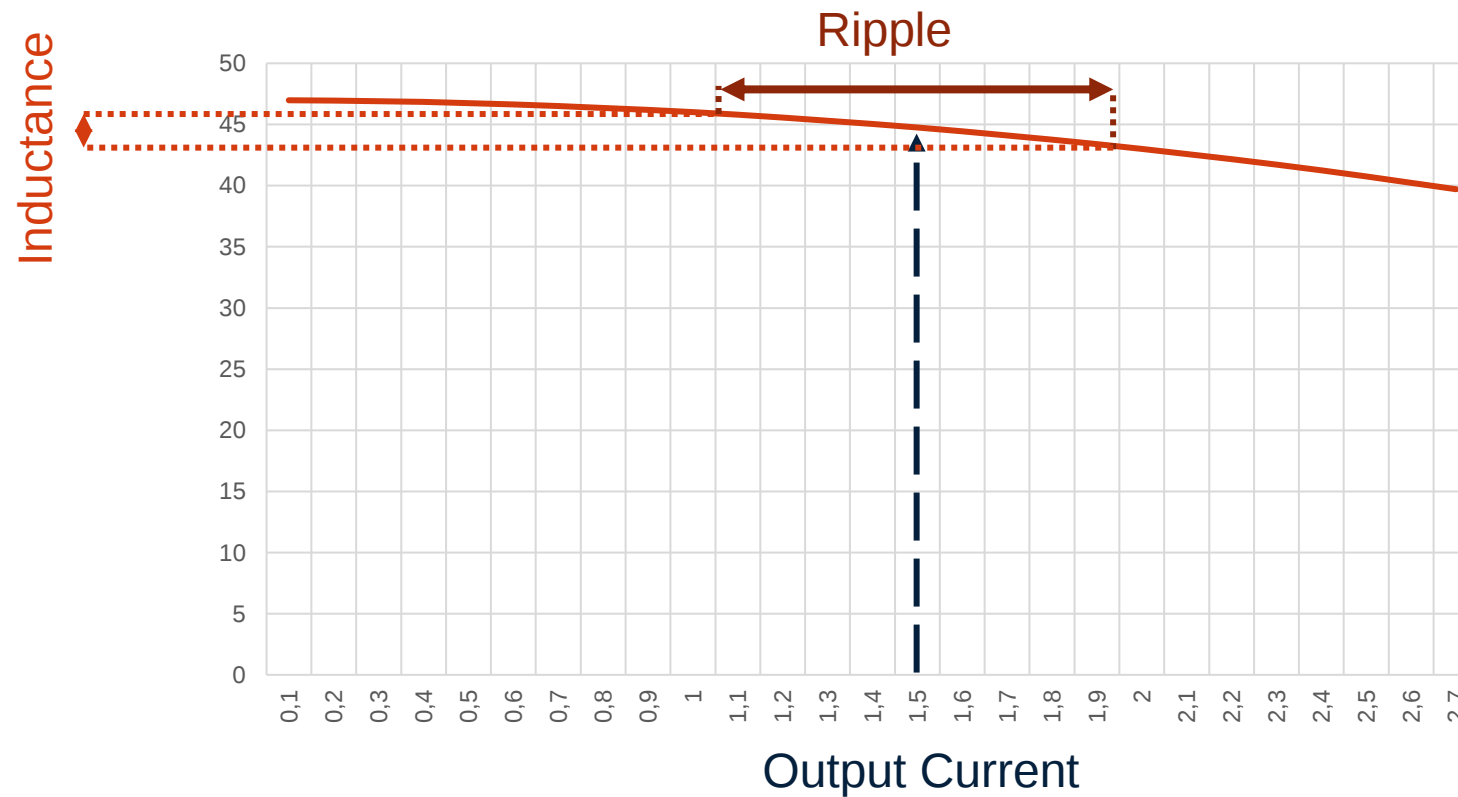
Rated Current: I_{sat}

- 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

Table 1 – Ratings & Part Number Reference

Part Number	Inductance (µH) at 100 kHz, 1 mA	Inductance Tolerance	DC Resistance (mΩ) ±10%	Rated Current (A)	
				I_{rms}^1 (Ref.)	I_{sat}^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.

- 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) Typical	DC Resistance (mΩ) Maximum	Rated Current (A)		
					I_{rms}^1 (Reference)	I_{sat}^2 (Reference)	I_{sat}^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	I_{rms}^1	I_{sat}^2	I_{sat}^3
Rated Current (A)							

¹ T = 40 K rise at rated current

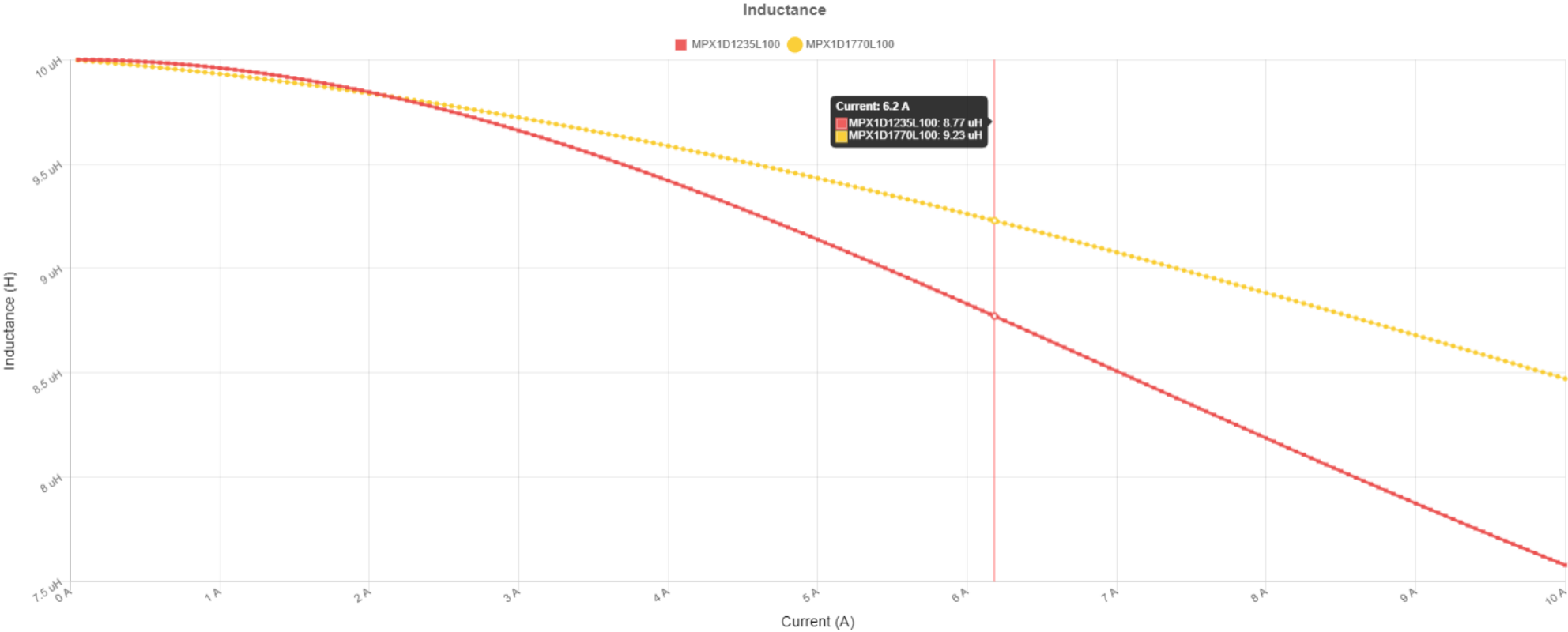
² Inductance drop 20% at rated current

³ Inductance drop 30% at rated current

All electrical characteristics data is referenced to 25°C.

Saturation Current: I_{sat}

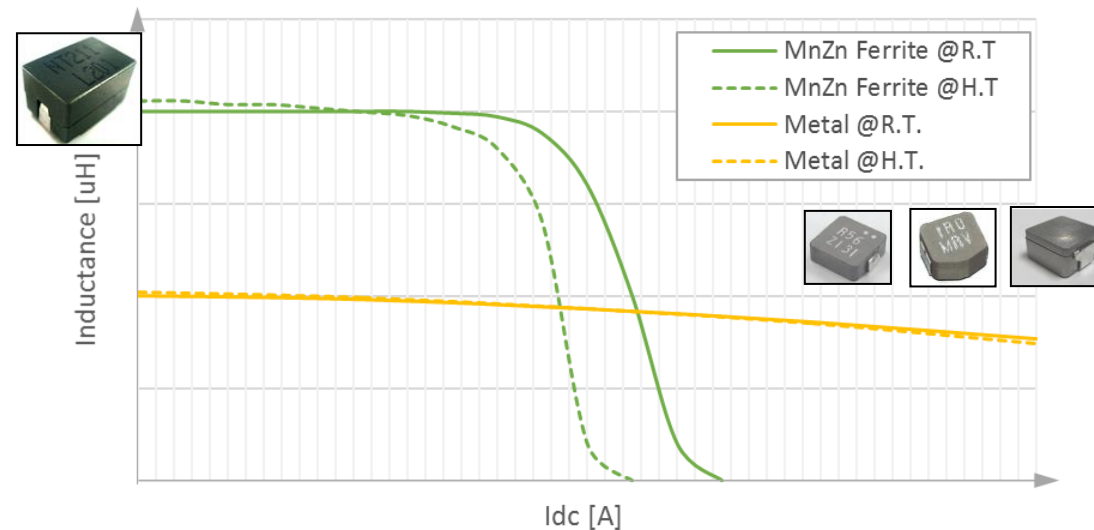
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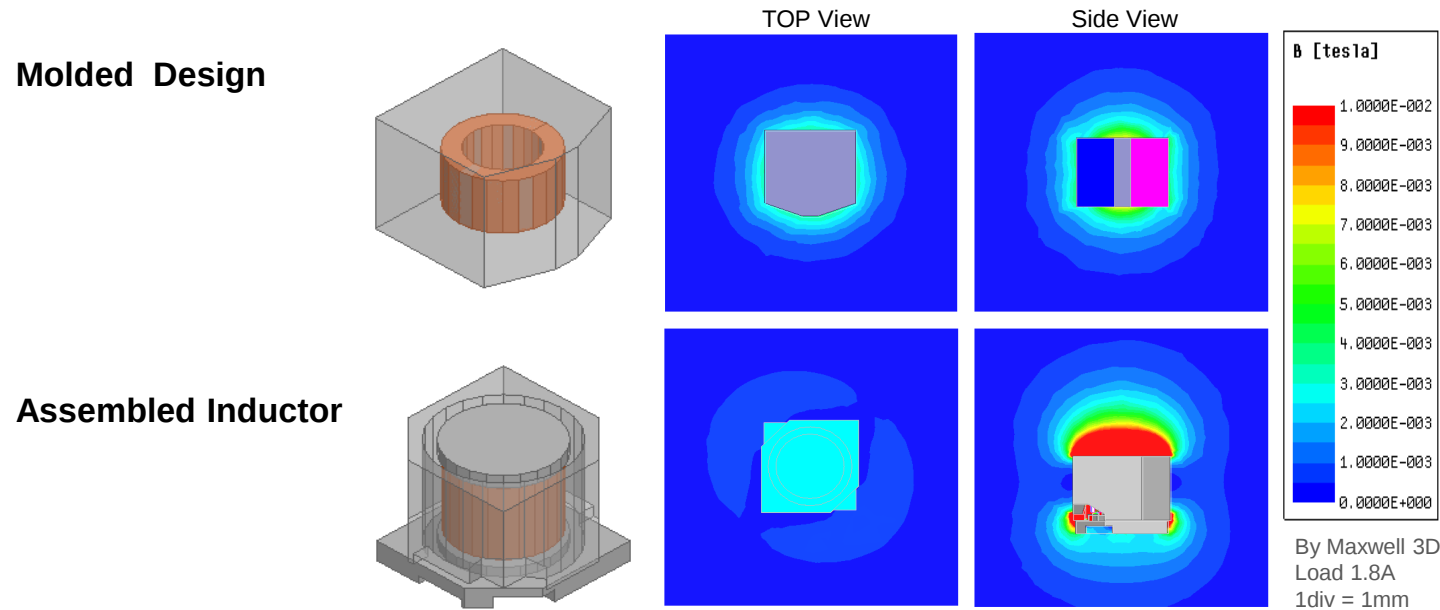
MnZn and Metal Composite Comparison

- 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



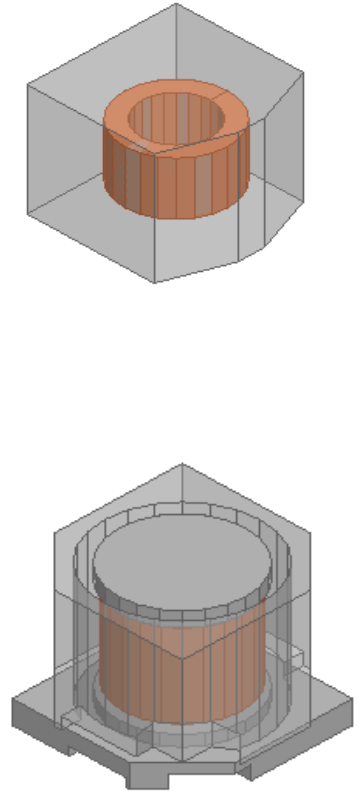
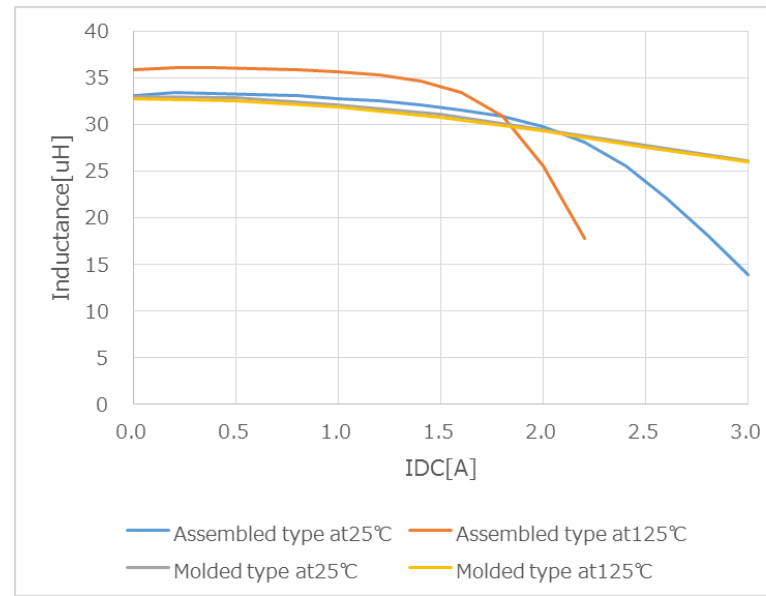
Molded vs. Assembled Inductor

- 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



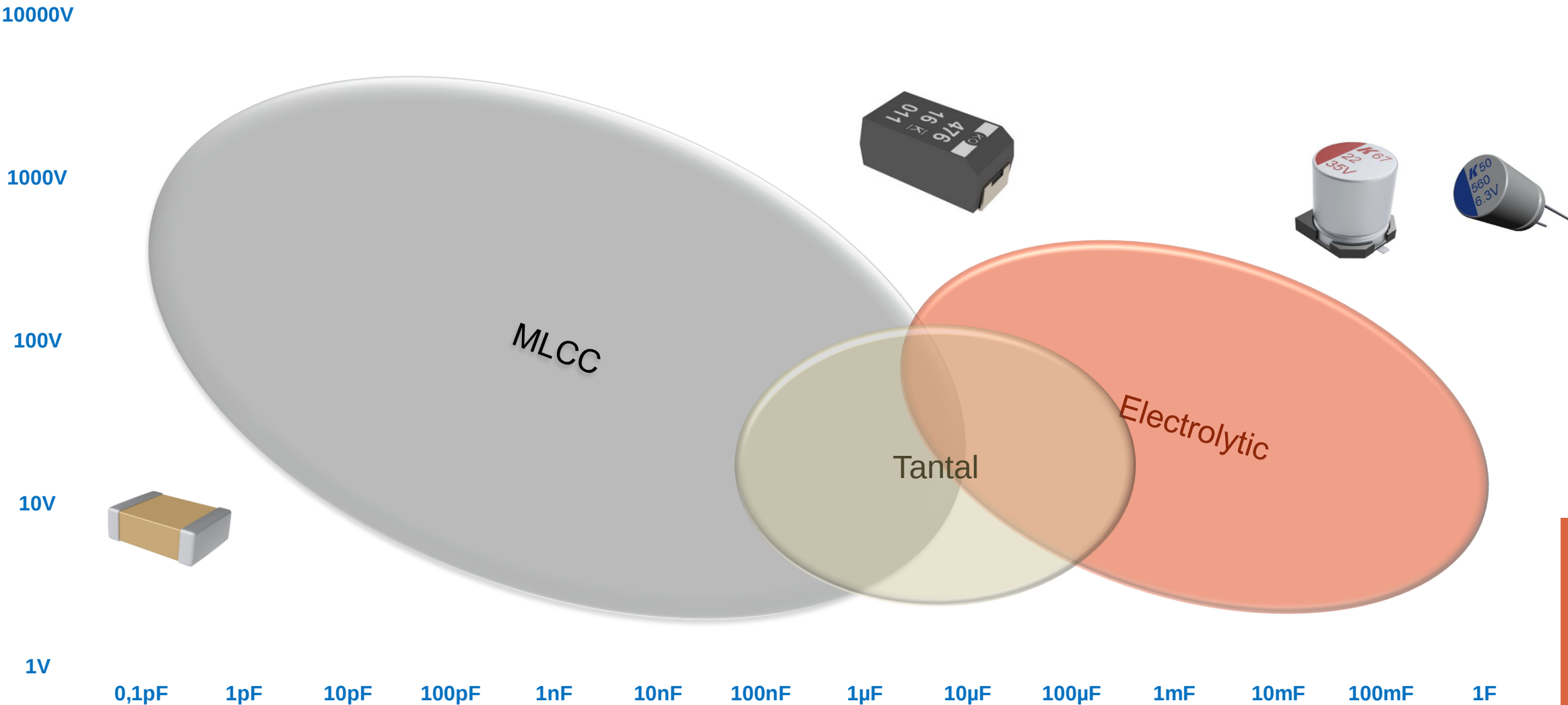
Molded vs. Assembled Inductor

- 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. 22 μ F	max. 470 μ F	max. 2700 μ F	max. 2700 μ F
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	Ø4 – Ø16	Ø4 – Ø16
Lifetime	Good	Perfect	Limited	Good

Capacitor Comparison

- SMD Solution

Technology	Ceramic	Tantal Polymer	Aluminium Electrolytic (SMD)	Aluminium Polymer (SMD)
Capacitance Range	max. 22 μ F	max. 470 μ F	max. 2700 μ F	max. 2700 μ F
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Size Range (mm)	1005 - 5750	2012 - 7743	Ø4 – Ø16	Ø4 – Ø16
Lifetime	Good	Perfect	Limited	Good
Price per piece ¹⁾	Low	High	Low	Mid

¹⁾: 1 μ F

Capacitor Comparison

- SMD Solution

Technology	Ceramic	Tantal Polymer	Aluminium Electrolytic (SMD)	Aluminium Polymer (SMD)
Capacitance Range	max. 22 μ F	max. 470 μ F	max. 2700 μ F	max. 2700 μ F
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	Ø4 – Ø16	Ø4 – Ø16
Lifetime	Good	Perfect	Limited	Good
Price per piece ¹⁾	Low	High	Low	Mid
Price per μ F ²⁾	High	Low	Low	Mid
Price per Volume ³⁾	Low	Mid	Low	High

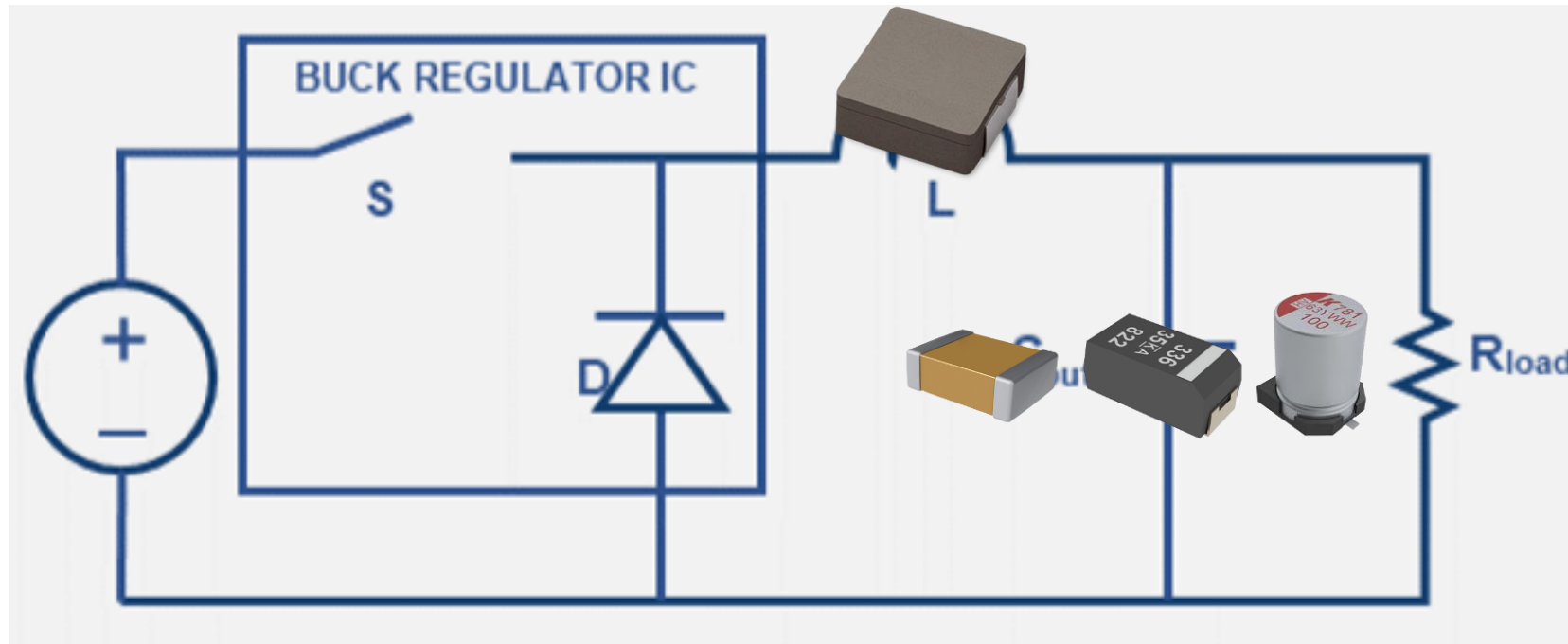
¹⁾: 1 μ F

²⁾: 100 μ F / 100V

³⁾: 10 μ F / 100mm³

Summary

- YAGEO Product Solutions





YAGEO
Group

Thank you.



WWW.YAGEO.COM