Electronic Components
KEMET
CHARGED.®

KC-LINK

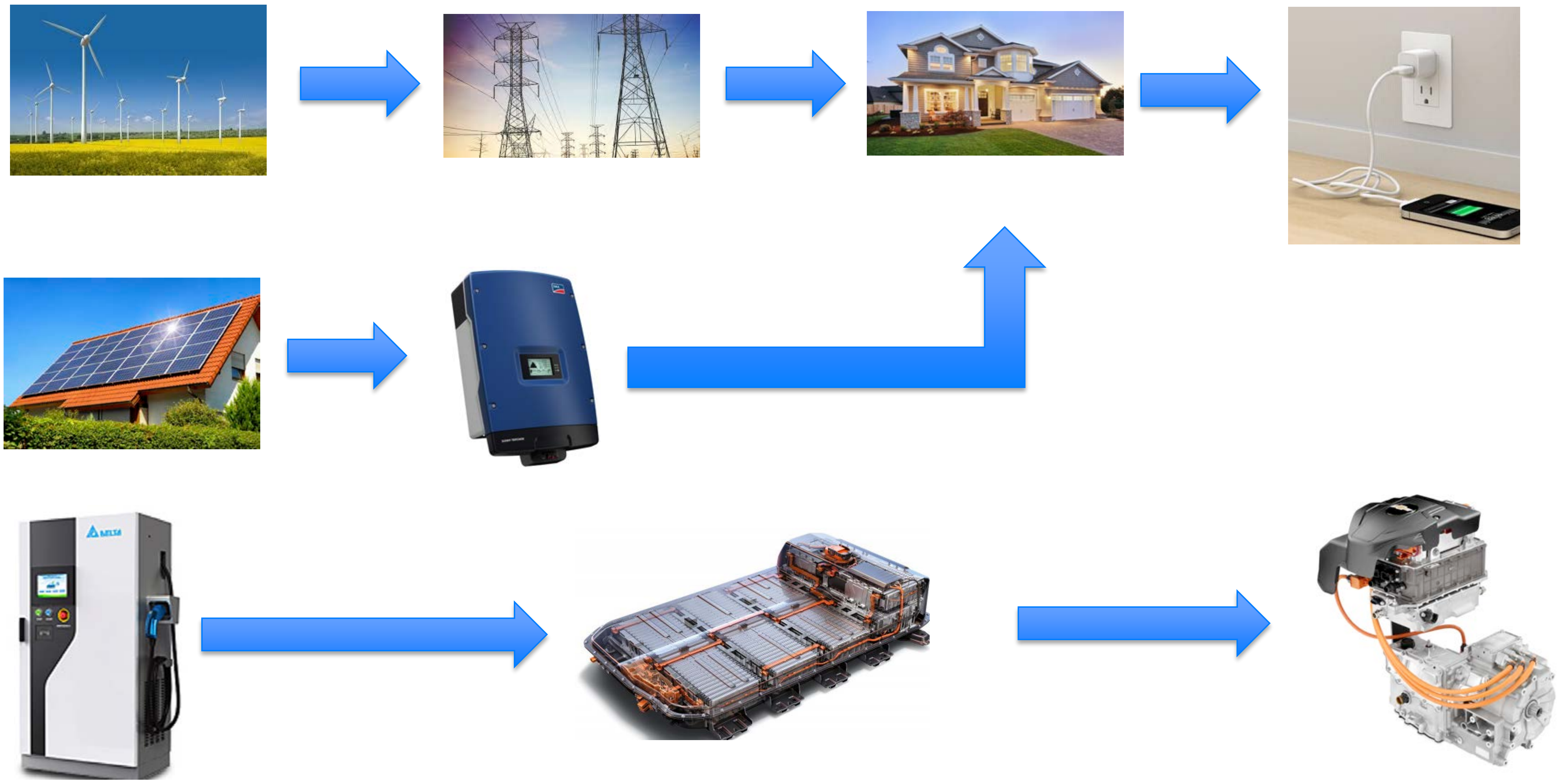
For fast switching semiconductors

KC-LINK
DC LINK CAPACITORS

Outline

- *Power Conversion*
- *Wide Bandgap Semiconductor Technology*
- *KC-LINK*
    - *Overview*
    - *Performance*
    - *Ordering*
- *Future Developments*
- *Summary*

Power Conversion



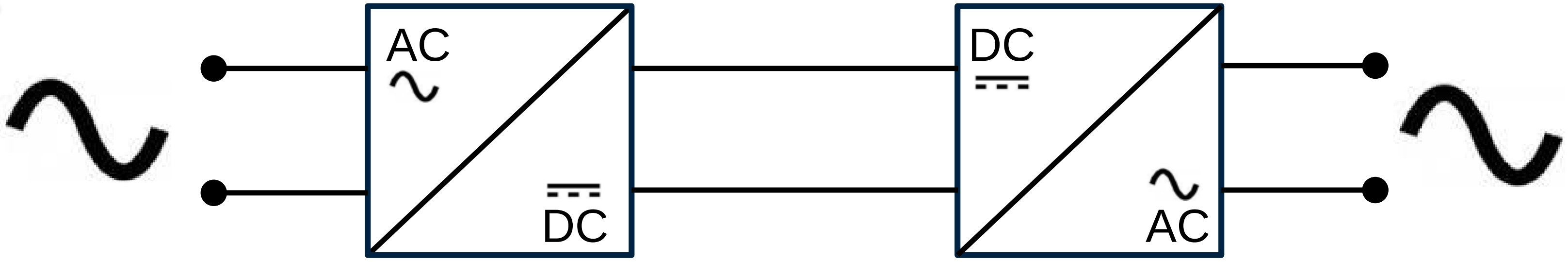
Power Converters

Topology

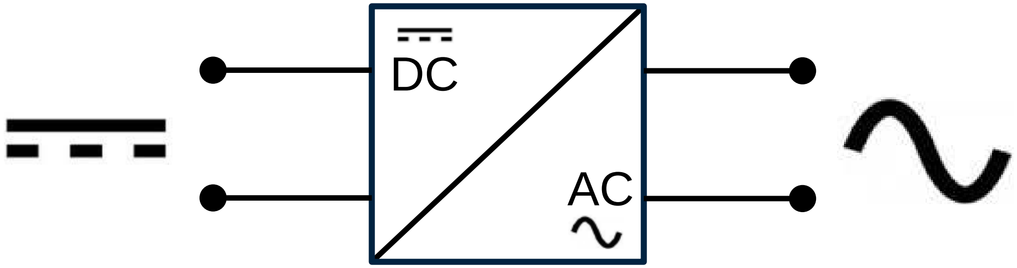
AC-AC

Input Power

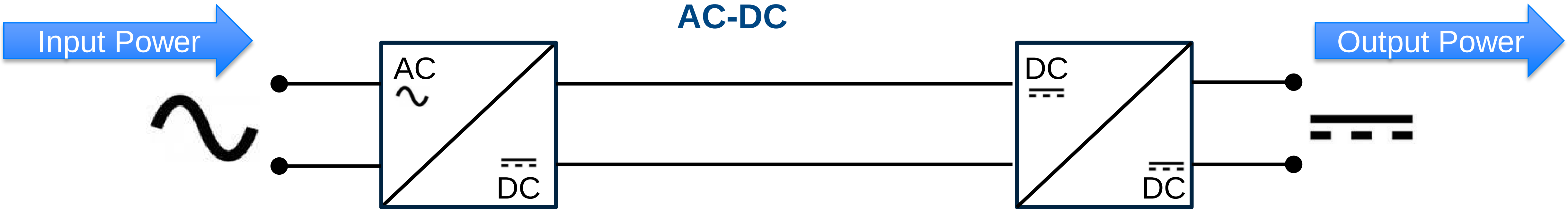
Output Power



DC-AC

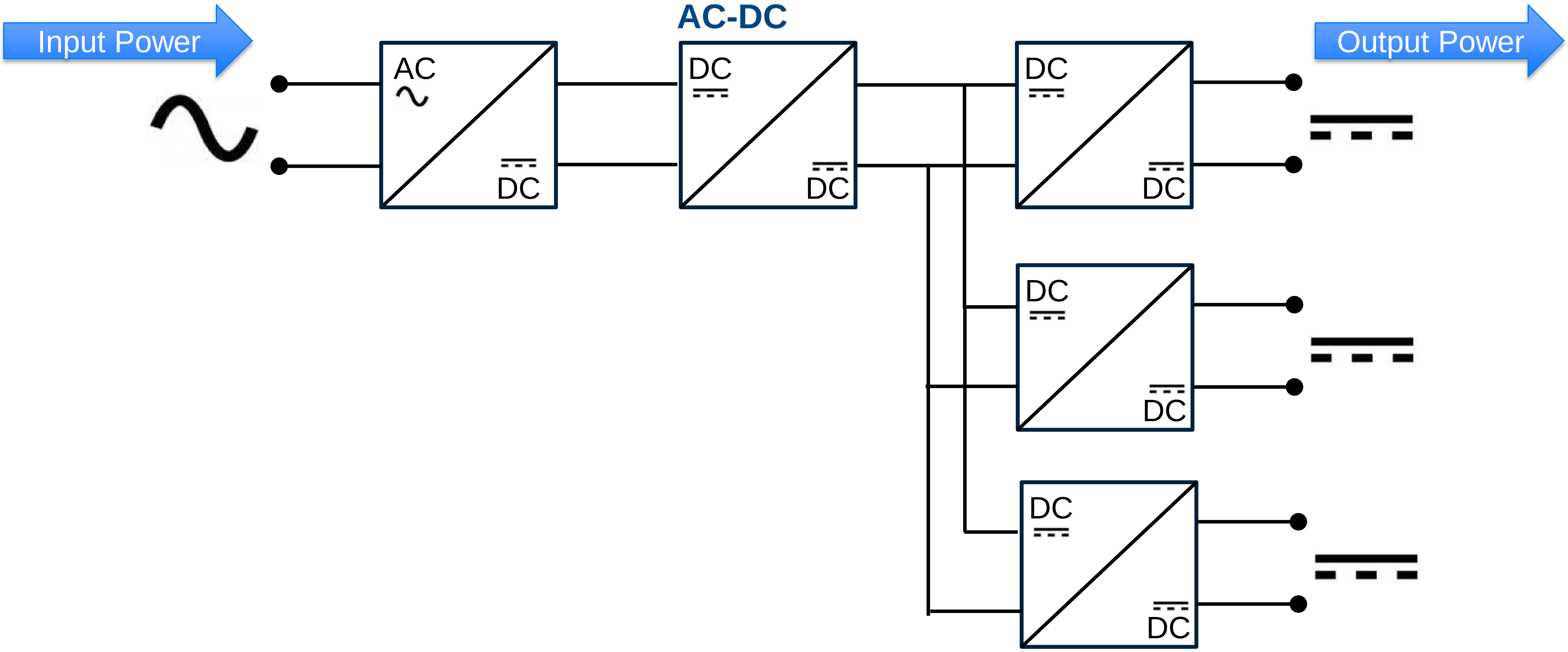


Power Converters
Topology



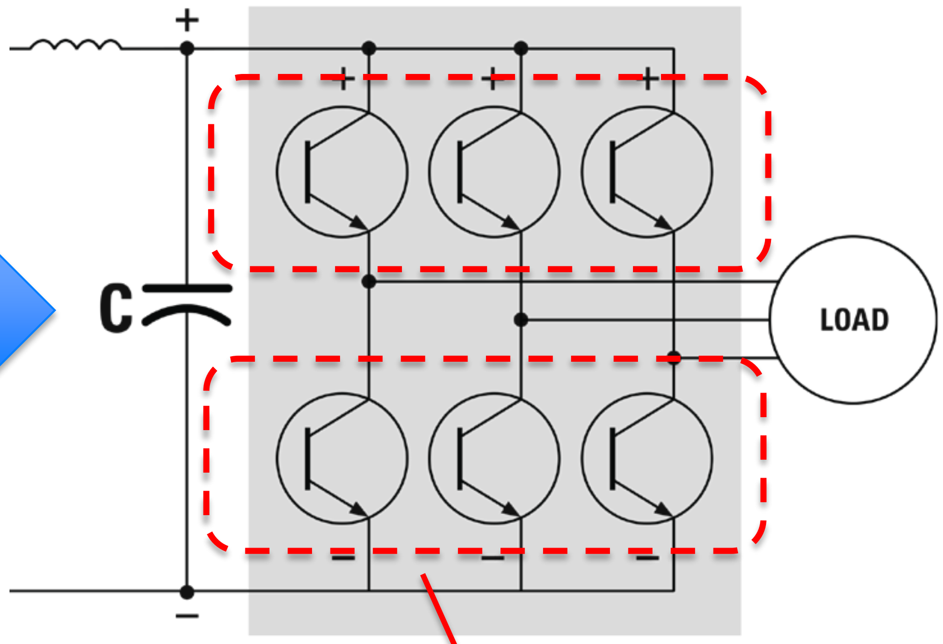
Power Converters

Topology



Power Converters

Transistors Make it Possible!!



Transistors (Electronic Switch)

Traditionally Silicon Based (Si)

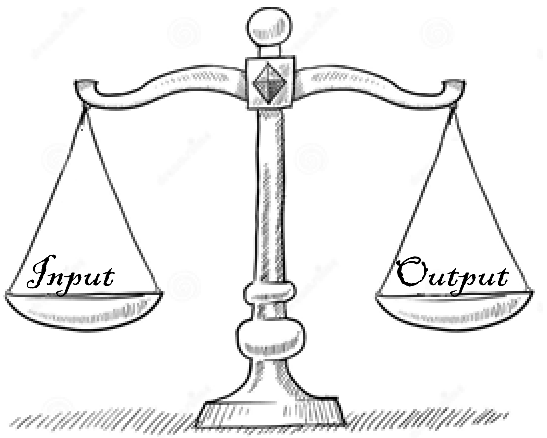
Power Converters

Design Goals

Size

Weight

Efficiency



Power Converters

Efficiency Explained

Electronic Components KEMET CHARGED®

Ideal Power Converter

Input Power

100kW

Output Power

100kW

Efficiency=100%

$$Efficiency = \frac{Output\ Power}{Input\ Power} \text{ x } 100\%$$

Actual Power Converter

Input Power

100kW

Output Power

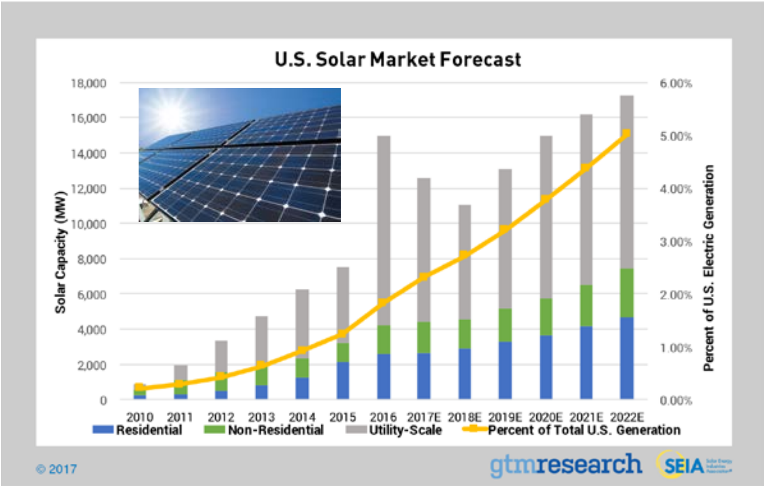
90kW

Efficiency=90%

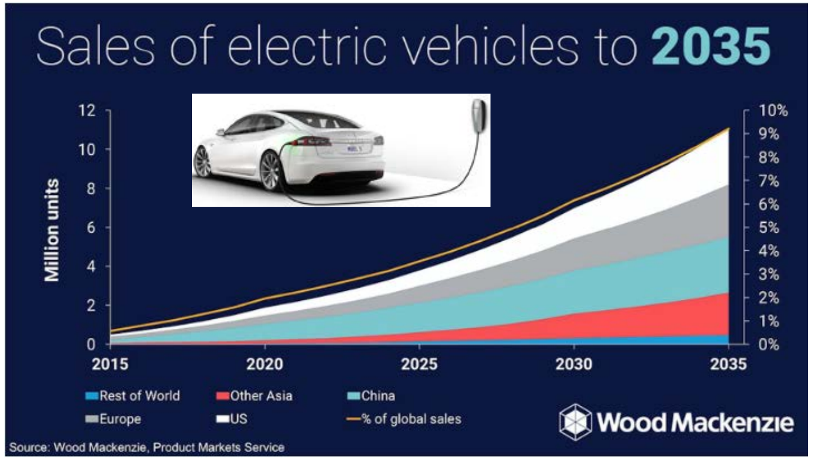
Power Converters

Electronic Components KEMET CHARGED®

Solar Energy



Electric Vehicles



Data Centers

90% to 90.5% (+0.5%) = BIG SAVINGS

Every 0.5% Matters

Power Converters

Improving Size, Weight, and Efficiency

Increase Allowable Transistor Temperature

No bulky cooling

Increase Frequency

-Smaller passive components
-Lower losses

Increase Voltage

-Lower losses

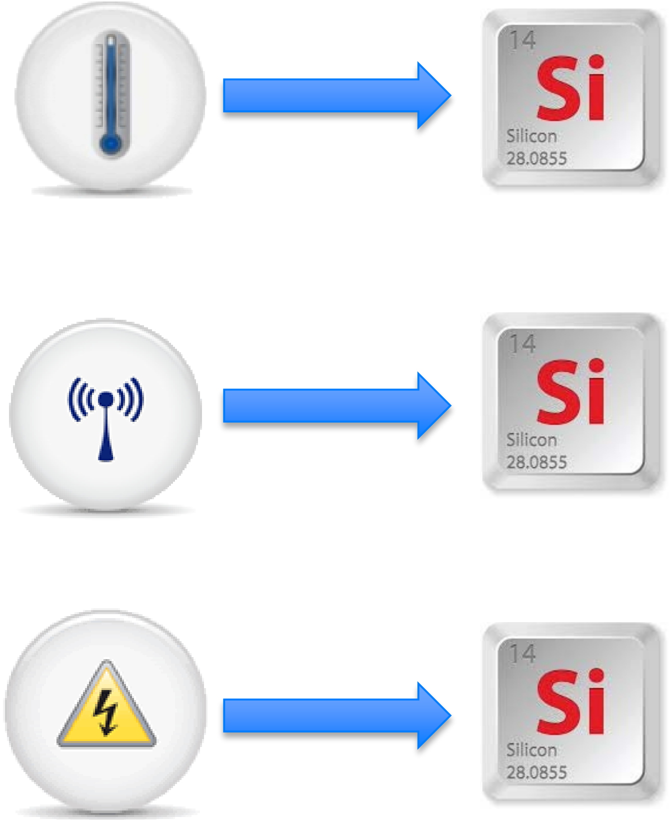
Smaller Size

Reduced Weight

Improved Efficiency

Power Converters

Limitations with Si Based Power Converters



Limitation

- Limited to lower temperatures
- Limited to lower frequencies
- Limited to lower voltages

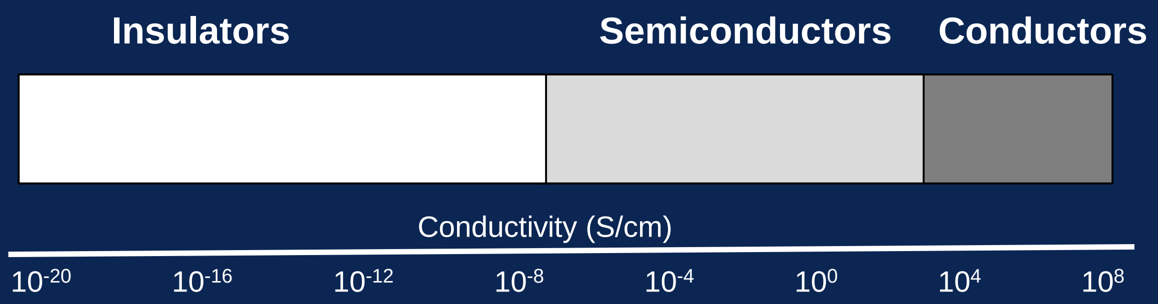
Design Impact

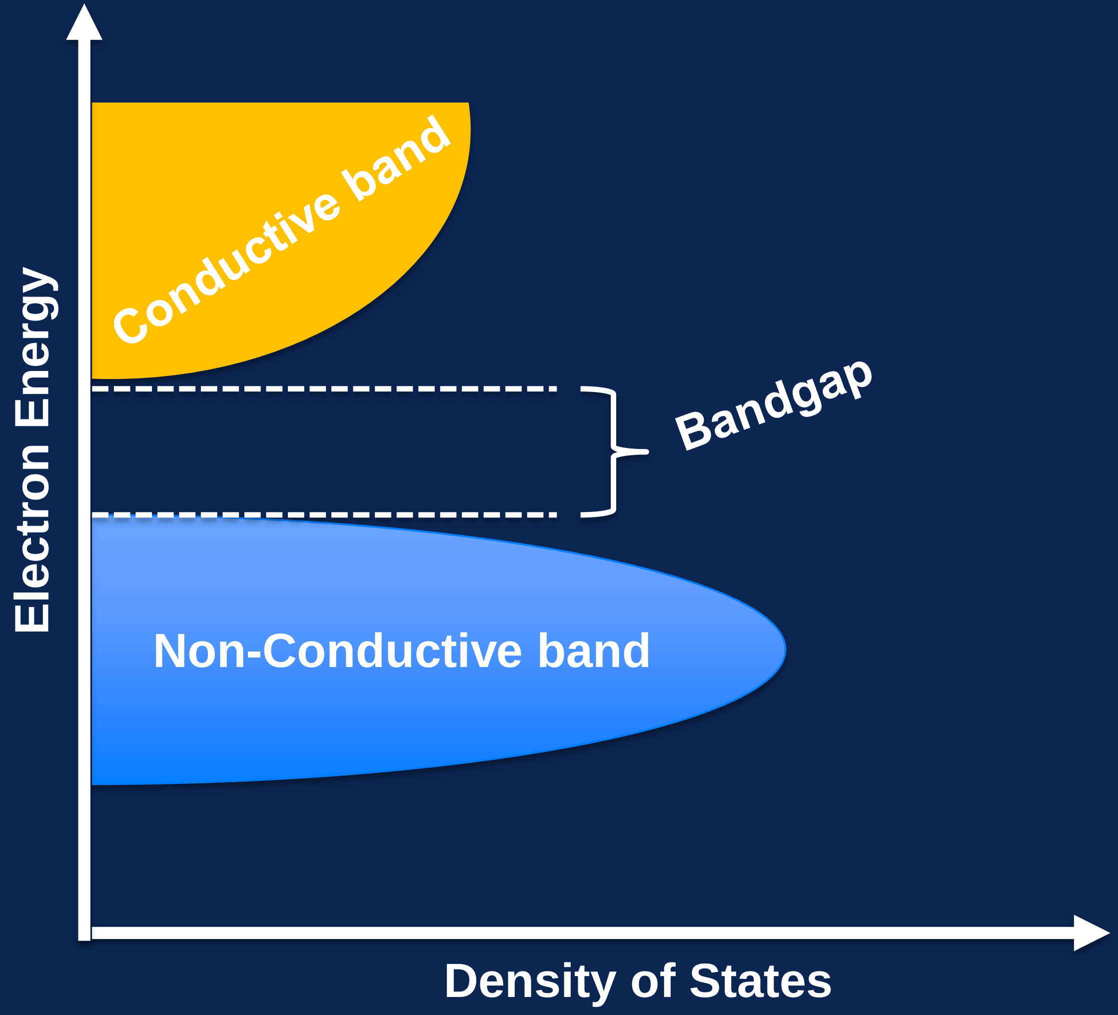
- Bulky cooling
- Bulky passive components
- Increased losses, Larger Transistors

Wide Bandgap (WBG) Semiconductors

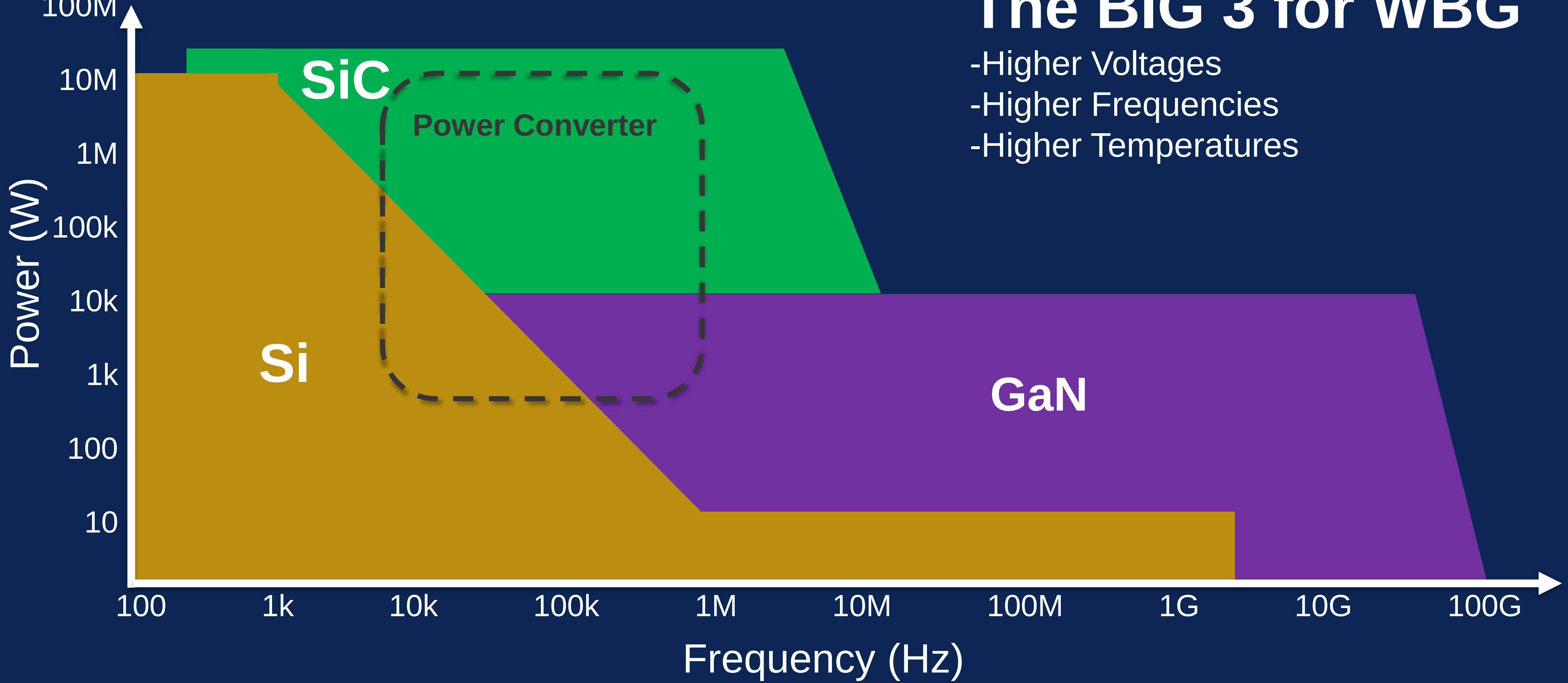
Semiconductor Material	Bandgap Energy (eV)
Germanium (Ge)	0.7
Silicon (Si)	1.1
Silicon Carbide (SiC)	3.3
Gallium Nitride (GaN)	3.4

WBG





Wide Bandgap (WBG) Semiconductors



The BIG 3 for WBG

-Higher Voltages
-Higher Frequencies
-Higher Temperatures

Wide Bandgap Based Power Converters

Power Conversion	Si Based	WBG Based on GaN or SiC
DC to DC	85%	95%
AC to DC	85%	90%
DC to AC	96%	99%

Source: Mouser Electronics, L. Culberson, 2016

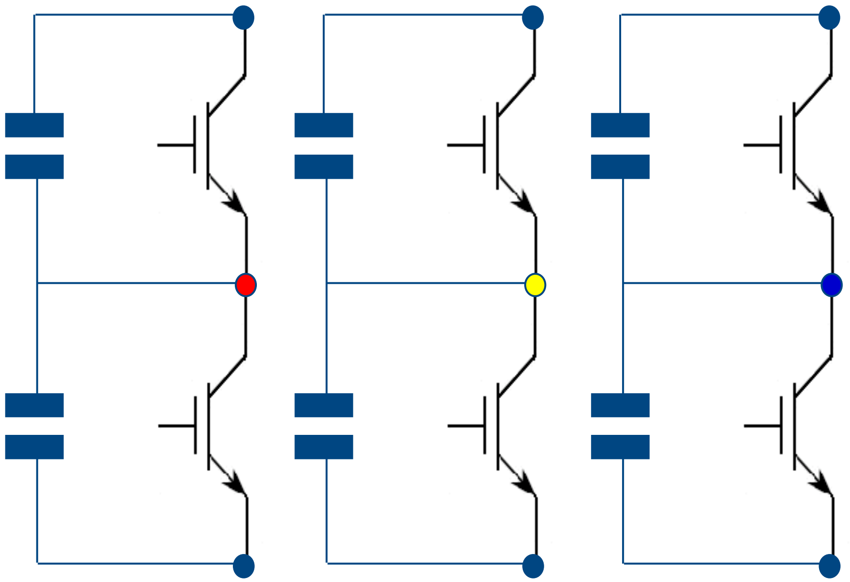
- Smaller (Higher Power Densities)
- Less Cooling
- More Efficient

Wide Bandgap Trend

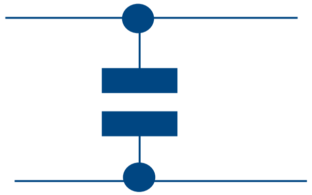
Impact on Capacitors

Key Capacitor Applications

Snubber



DC Link



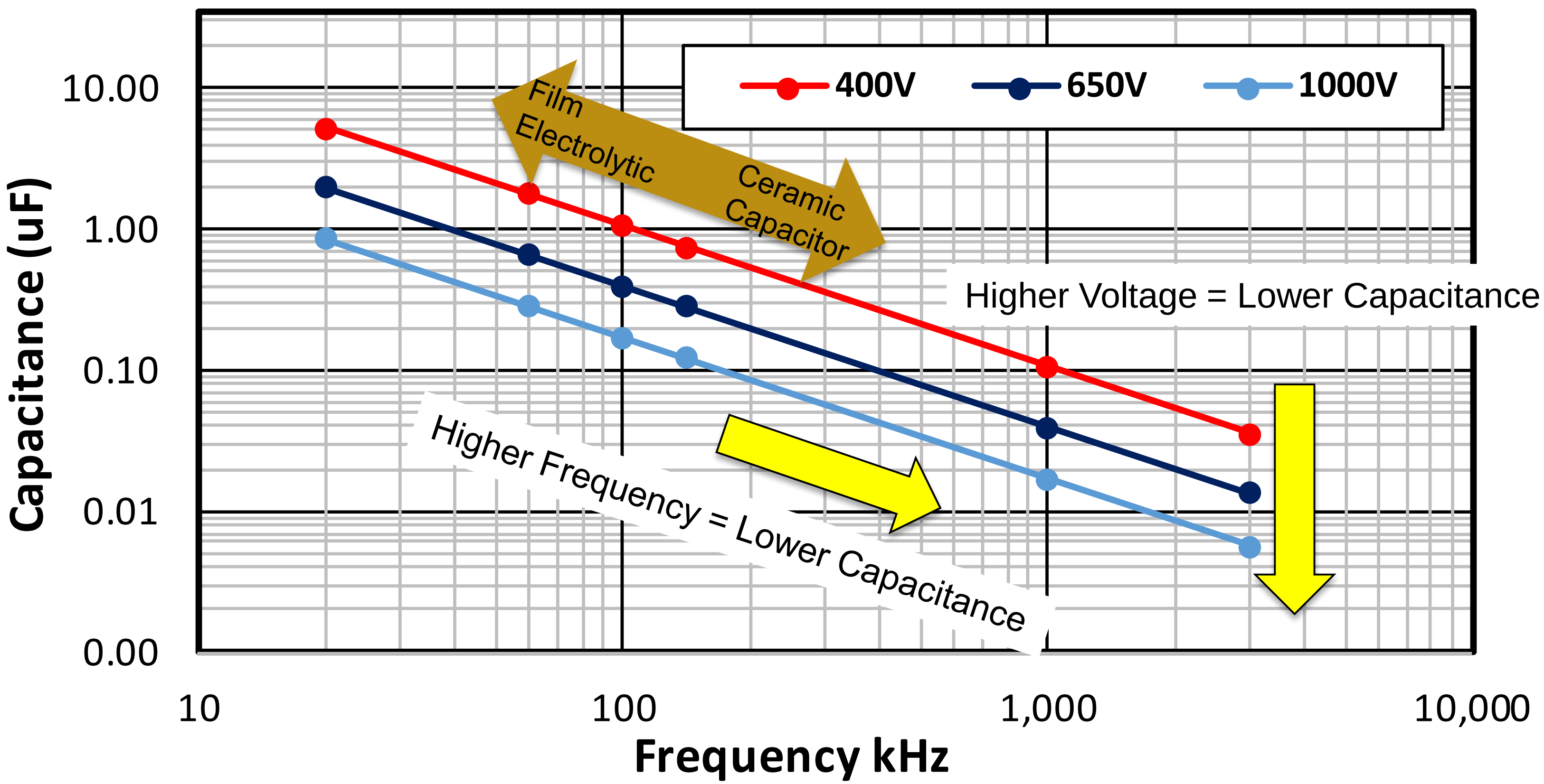
Resonant

Wide Bandgap Trend

Impact on Capacitors

$$C = \frac{P_{load}}{U_{ripple}\left(U_{max} - \frac{U_{ripple}}{2}\right) 2 * \pi * frequency}$$

DC-LINK Capacitance vs Switching Frequency and Voltage
10kW Power Converter

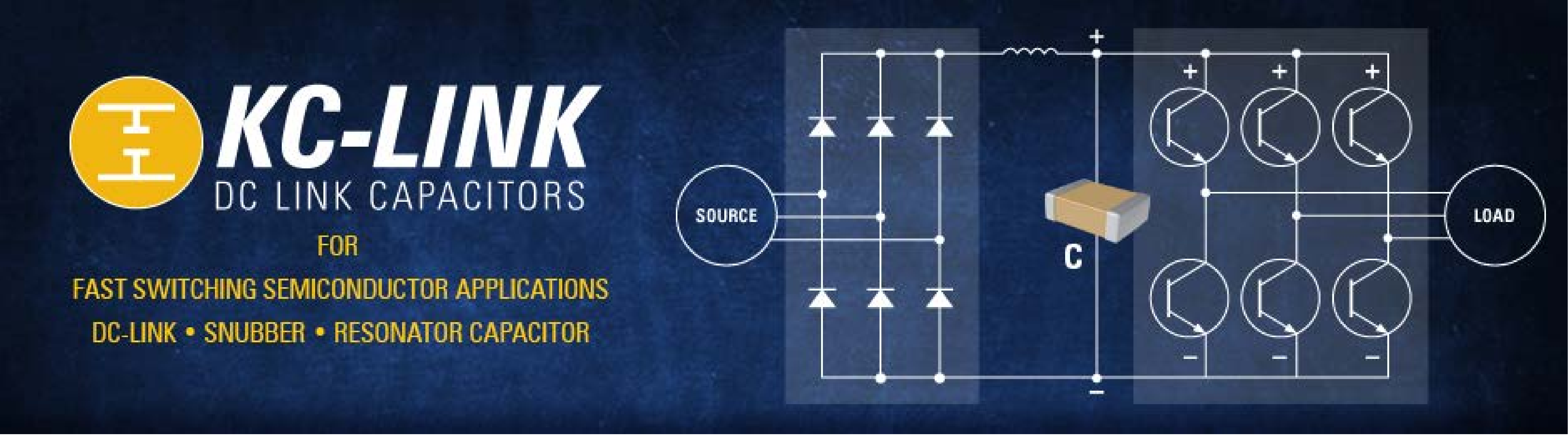


*** Source: Prof. R. Kennel, Technical University Munich, Germany***

Wide Bandgap Trend

Impact on Capacitors

The BIG 3 for WBG	Capacitor Requirement
Higher Operation Voltages 400V → 900V →1200V→1700V	Reliable performance at higher voltages
High Junction Temperatures 105^{o}C → 125^{o}C → 200^{o}C+	Reliable performance at elevated temperatures ≥ 125^{o}C with robust mechanical performance Packaging close to the hot semiconductor to: • Lower ESL • Minimize cooling costs
Higher Switching Frequencies 20kHz → 100kHz → 100's MHz	Smaller, low ESR, low ESL low loss capacitors with high current handling capability



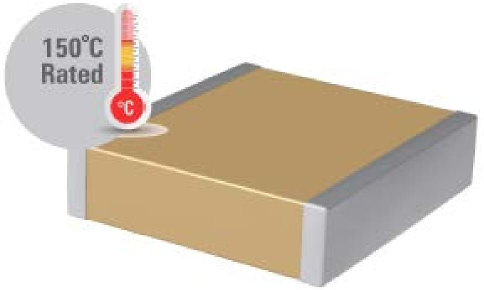
Features and Benefits

- AEC-Q200 automotive qualified
- Very high ripple current capability
- Extremely low equivalent series resistance (ESR)
- Extremely low equivalent series inductance (ESL)
- Operating temperature range of −55°C to +150°C
- High frequency operation (>10 MHz)
- No capacitance shift with voltage
- No piezoelectric noise
- High thermal stability
- RoHS Pb-free

Applications

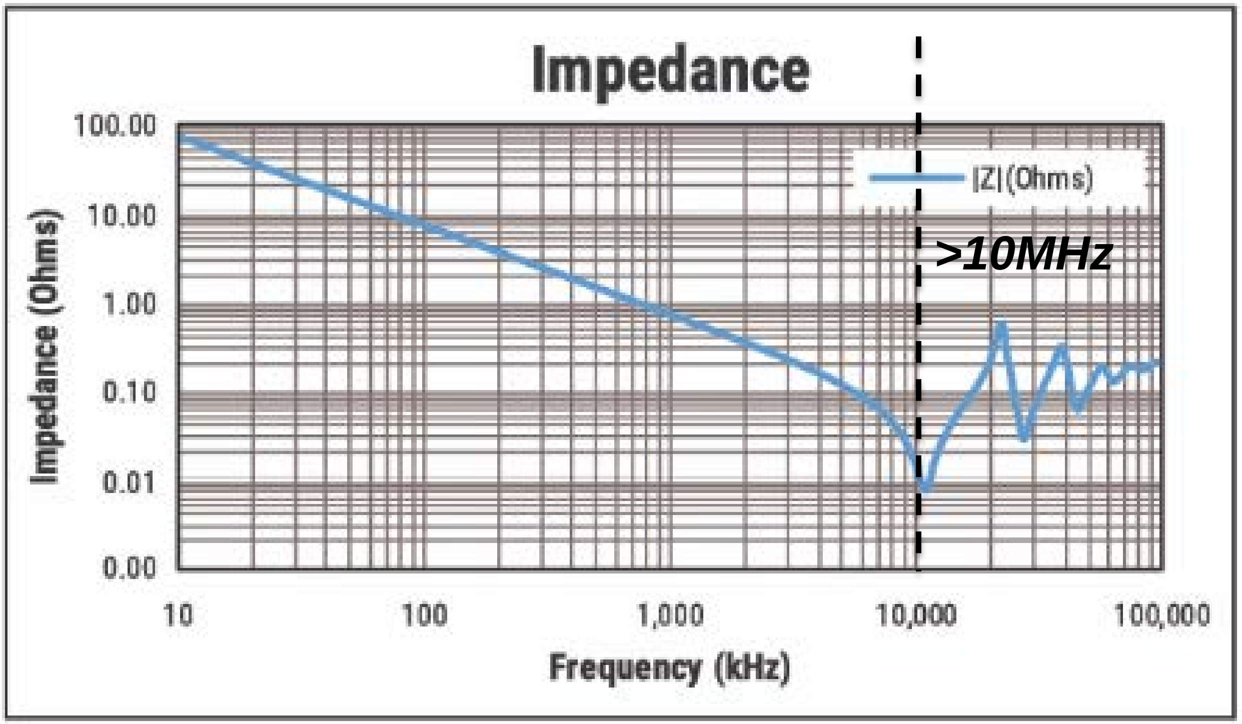
Pb-Free RoHS

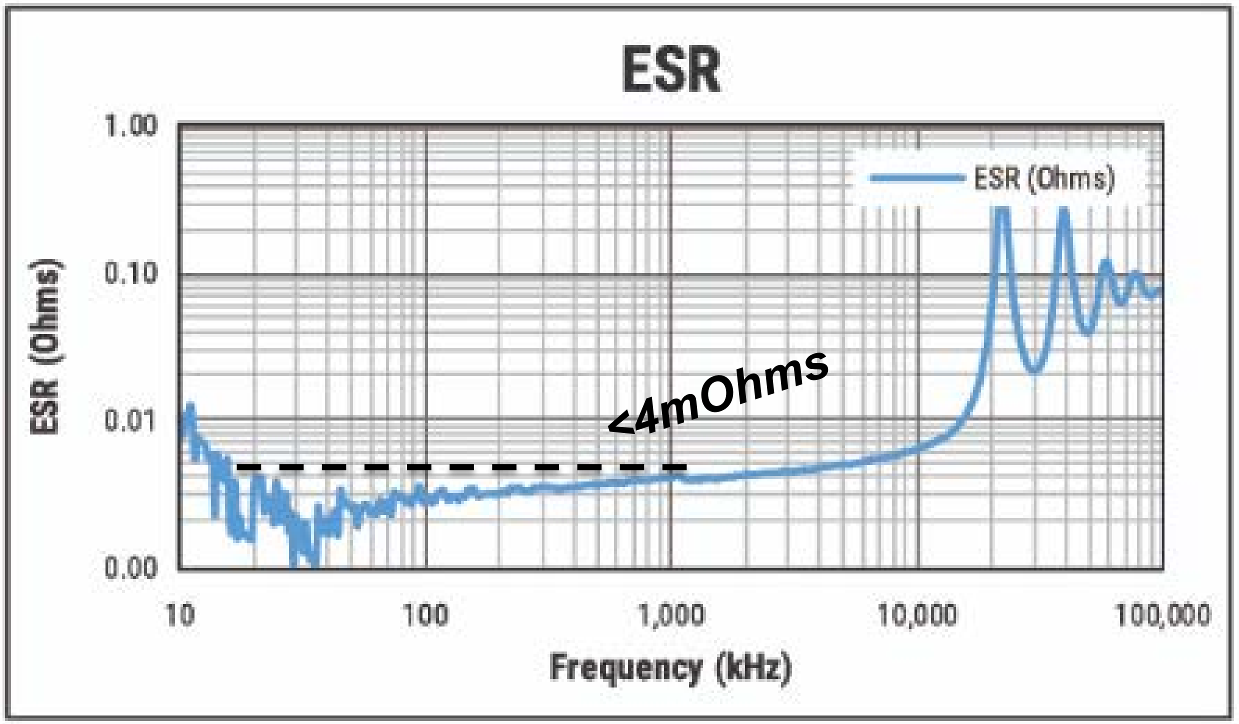
- Wide bandgap (WBG), silicon carbide (SiC) and gallium
- nitride (GaN) systems
- EV/HEV (drive systems, charging)
- Wireless charging
- Photovoltaic systems
- Power converters
- Inverters
- LLC resonant converters
- DC-Link
- Snubber



Performance

Electrical Performance

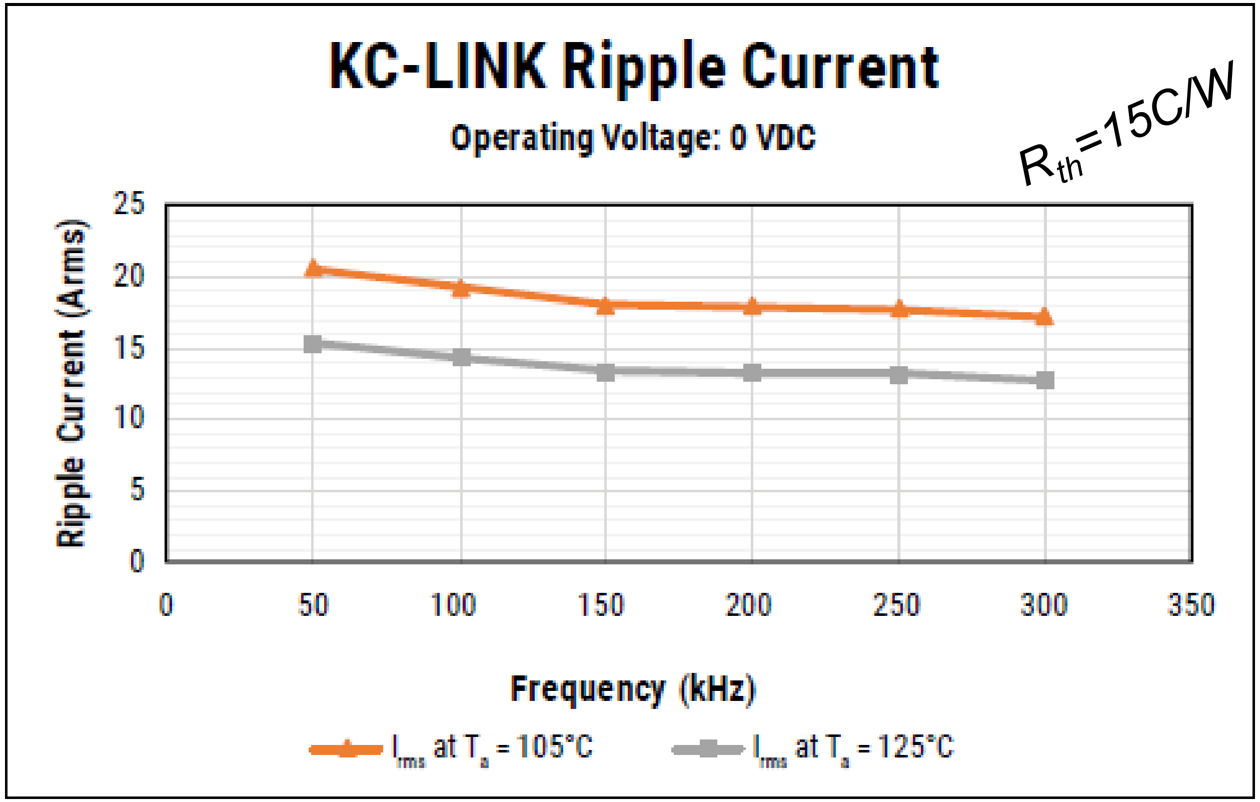


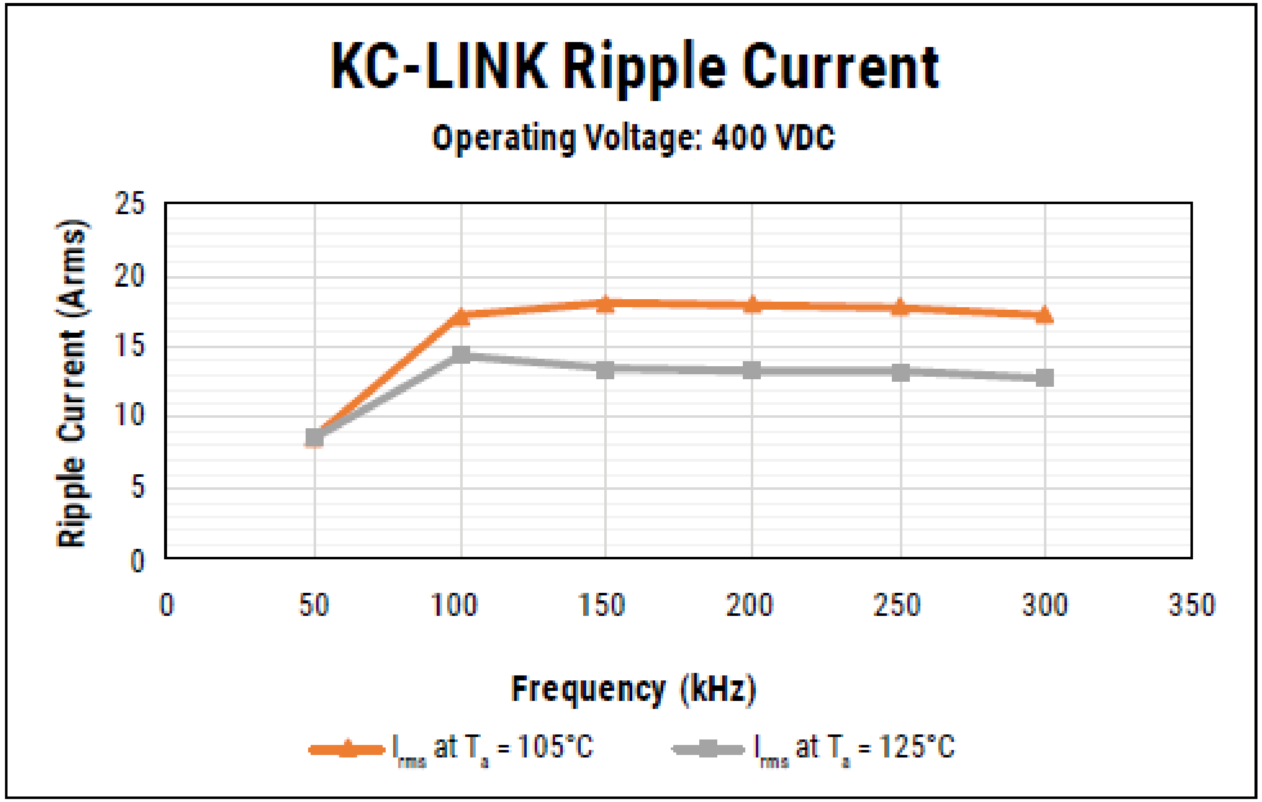


C0G 3640 220nF 500V

Performance

Ripple Current
Continuous

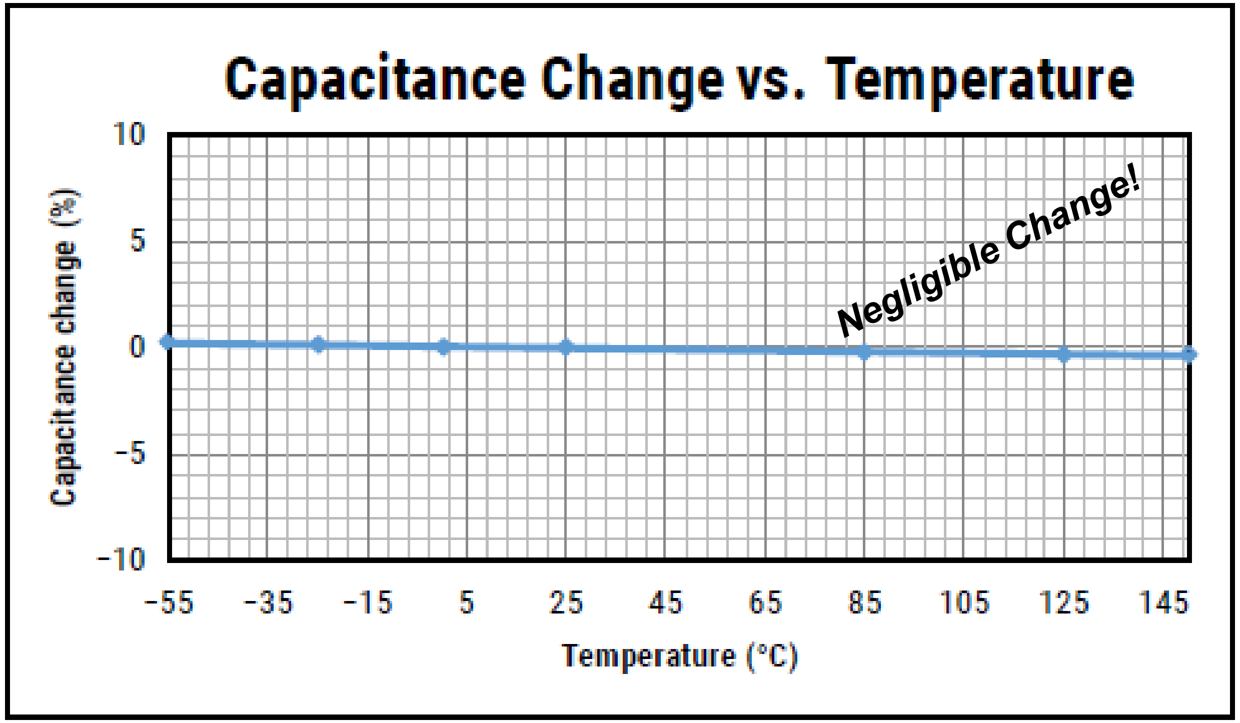


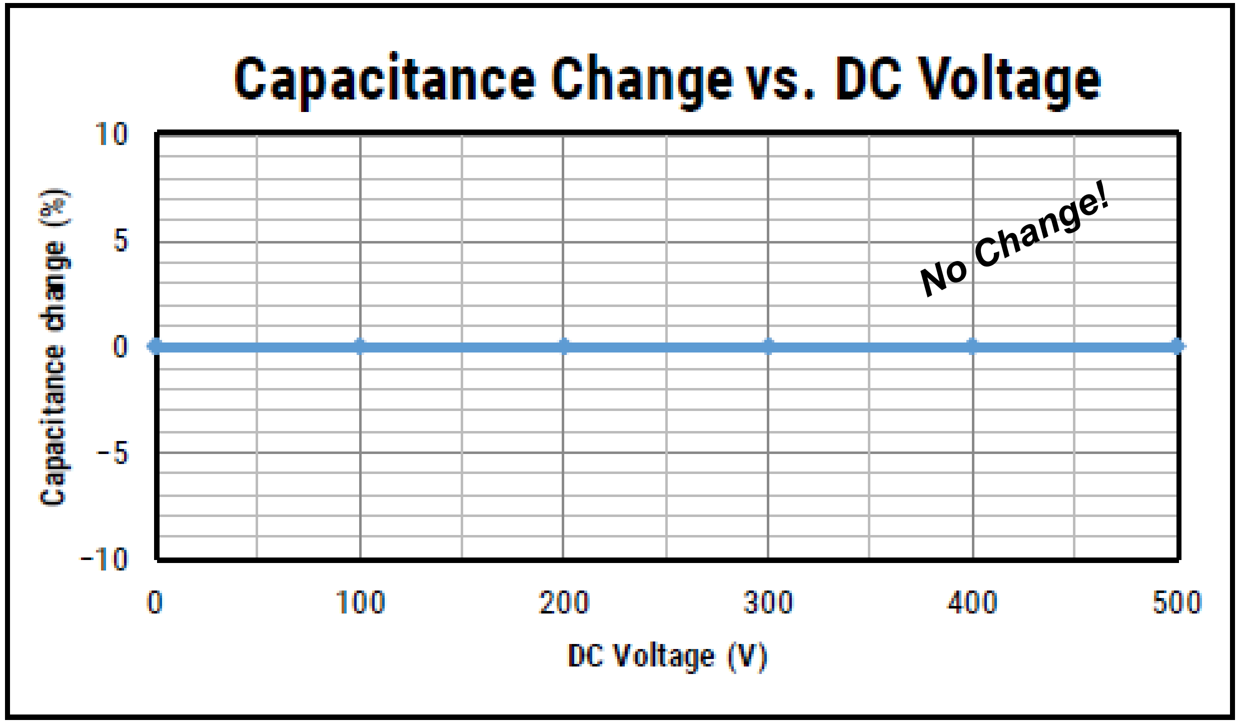


C0G 3640 220nF 500V

Performance

Capacitance Stability





C0G 3640 220nF 500V

How to Order

Electronic Components
KEMET
CHARGED®

Ordering Information

CKC	33	C	224	K	C	G	A	C	TU
Series	Case Size (L"x W")	Specification/ Series	Capacitance Code (pF)	Capacitance Tolerance	Rated Voltage (V)	Dielectric	Subclass Designation	Termination Finish	Packaging (Suffix/C-Spec)
CKC = KC-LINK	33 = 3640	C = Standard	Two single digits and number of zeros. Use 9 for 1.0 – 9.9 pF e.g., 2.2 pF = 229	F = ±1% G = ±2% J = ±5% K = ±10%	C = 500 V	G = C0G	A = N/A	C = 100% matte Sn	See "Packaging C-Spec Ordering Options Table" below

Packaging C-Spec Ordering Options Table

Packaging Type	Packaging/Grade Ordering Code (C-Spec)
Commercial Grade	
7" Reel/Unmarked	TU
13" Reel (Embossed Plastic Tape)/ Unmarked	7210
Automotive Grade[1]	
7" Reel	AUTO
13" Reel (Embossed Plastic Tape)/ Unmarked	AUTO7210

KC-LINK Offering

Under Development

Electronic Components
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		1812					2220					3640				
		Voltage Rating					Voltage Rating					Voltage Rating				
Cap, uF	Cap Code	500	650	1000	1200	1700	500	650	1000	1200	1700	500	650	1000	1200	1700
0.0047	472															
0.0056	562															
0.0062	622															
0.0068	682															
0.01	103															
0.012	123															
0.015	153															
0.018	183															
0.022	223															
0.033	333															
0.039	393															
0.047	473															
0.056	563															
0.068	683															
0.082	823															
0.1	104															
0.15	154															
0.18	184															
0.22	224															
0.47	474															

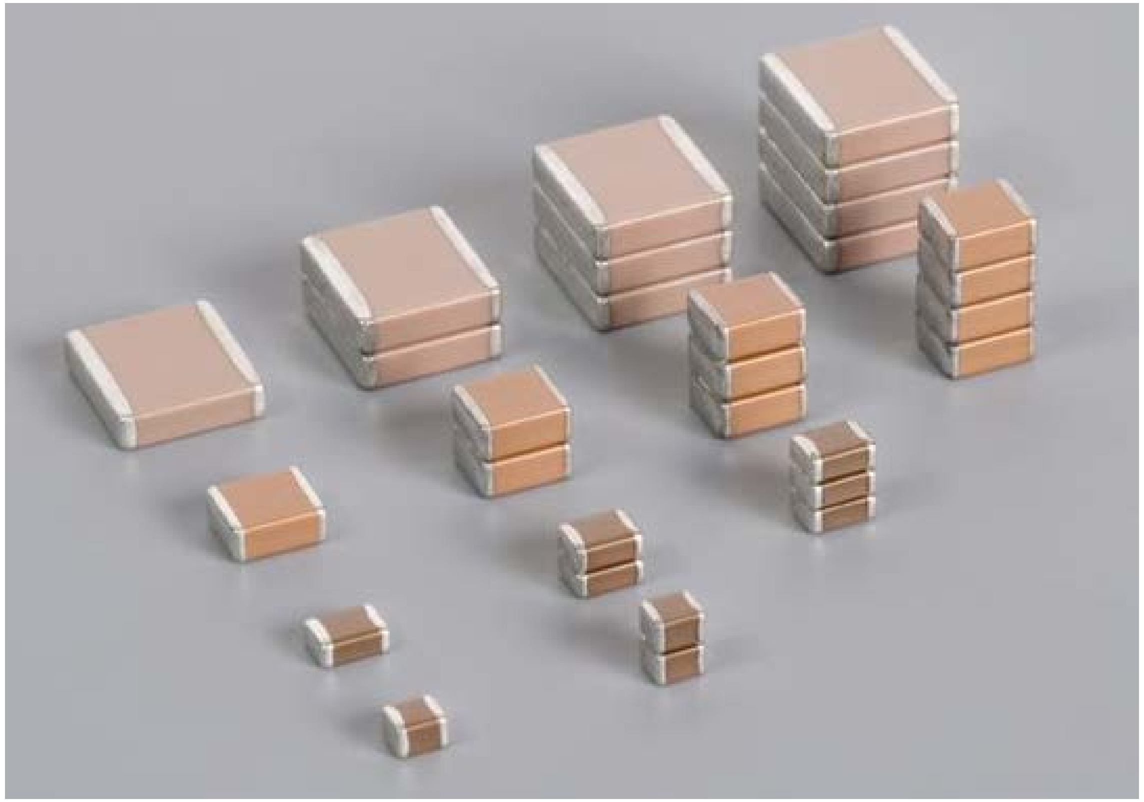
Available Now

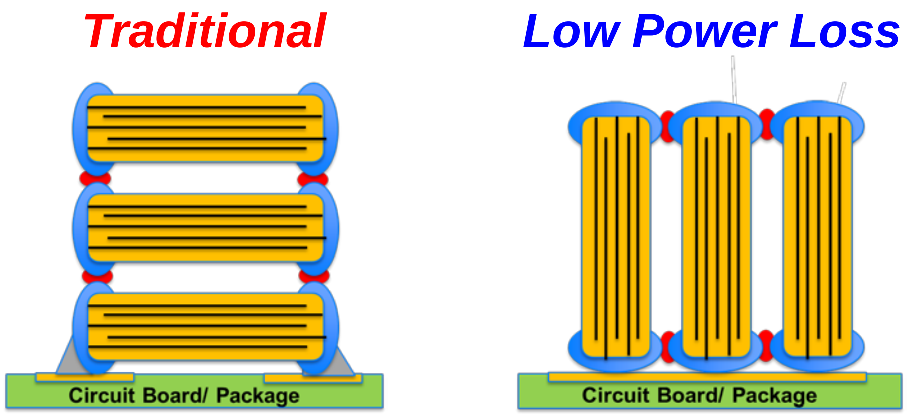
UNDER DEVELOPMENT
KEMET

MOUSER ELECTRONICS
Digi-Key CORPORATION
Farnell

KC-LINK with KONNEKT Technology

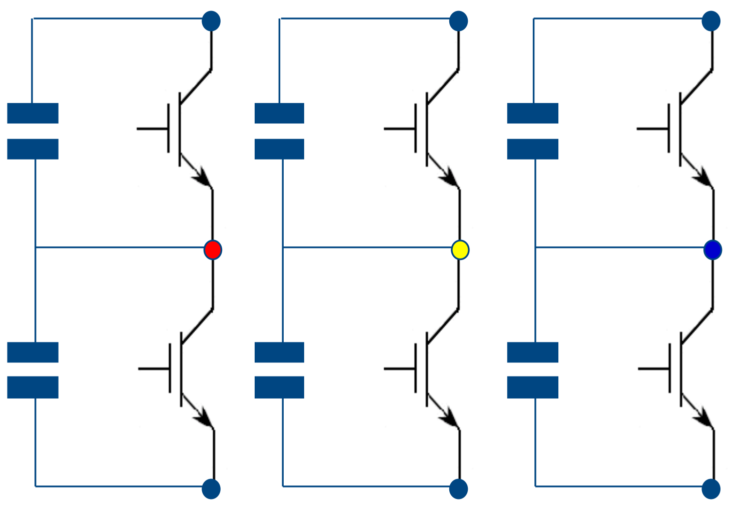
Under Development



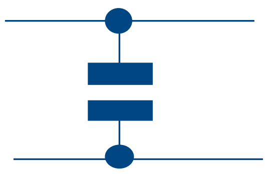


- Wide Band Gap – Remember the BIG 3!!!
  - Higher Voltages
  - Higher Frequencies
  - Higher Temperatures
- KC-LINK
  - Extremely low equivalent series resistance (ESR)
  - Extremely low equivalent series inductance (ESL)
  - Very high ripple current capability
  - Ideal solution for snubber, DC-LINK and resonant applications

Snubber



DC Link



Resonant

Thank You!!!

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