SiC In Traction APUs

Why Microchips CCS Helps Clients

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About Transportation APUs

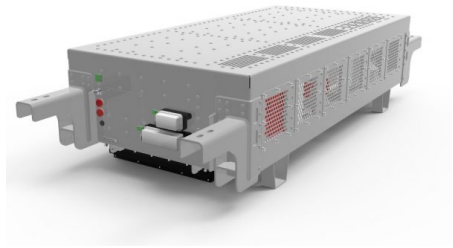
Auxiliary power units (APUs)

are used on trains to support loads other than the traction/propulsion motor

HIGH VOLTAGE

1500 VDC
3000 VDC

Auxiliary Power Unit



HVAC, cooling systems

HVAC

Battery charging

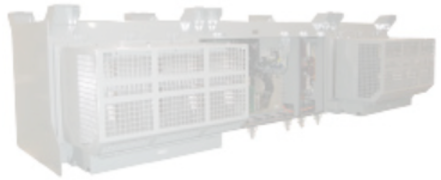
Lighting, Doors, Outlets

Lighting

Doors

Outlets

Traction Propulsion Unit



Propulsion

EFFICIENCY

NOISY

POWER DENSITY

ROBUSTNESS

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About Transportation APUs

Converts 1500/3000 VDC to 700 VDC, which is then turned into 3-phase 440 VAC for further distribution

HIGH VOLTAGE

Must operate continuously and often under light loads, unlike a traction power unit

EFFICIENCY

Need to downsize since these are installed in smaller trams where space is a premium

POWER DENSITY

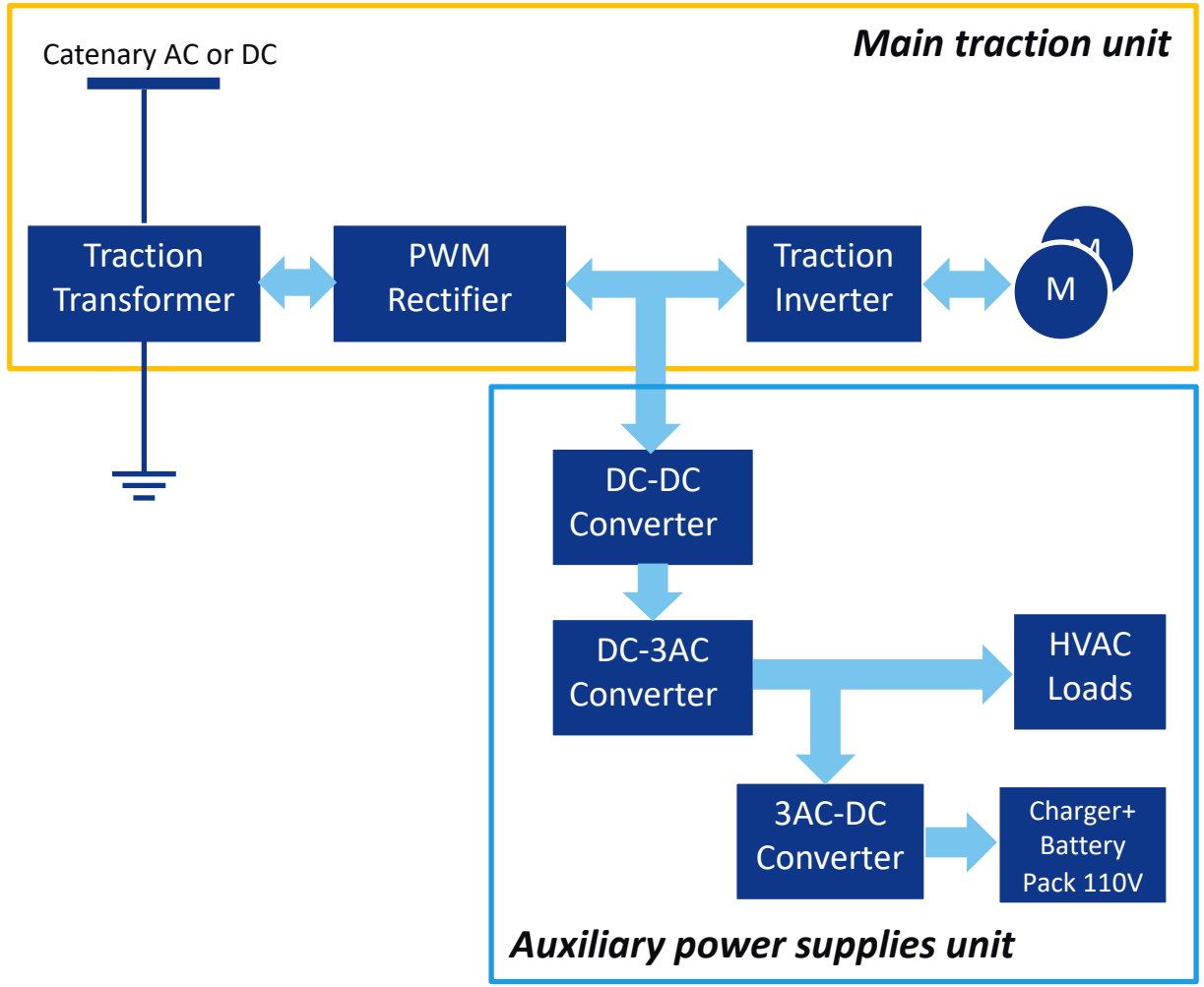
IGBTs limit APU switching frequency to the audible range

NOISY

APU units supply key elements of the complete system

ROBUSTNESS

Possible solution



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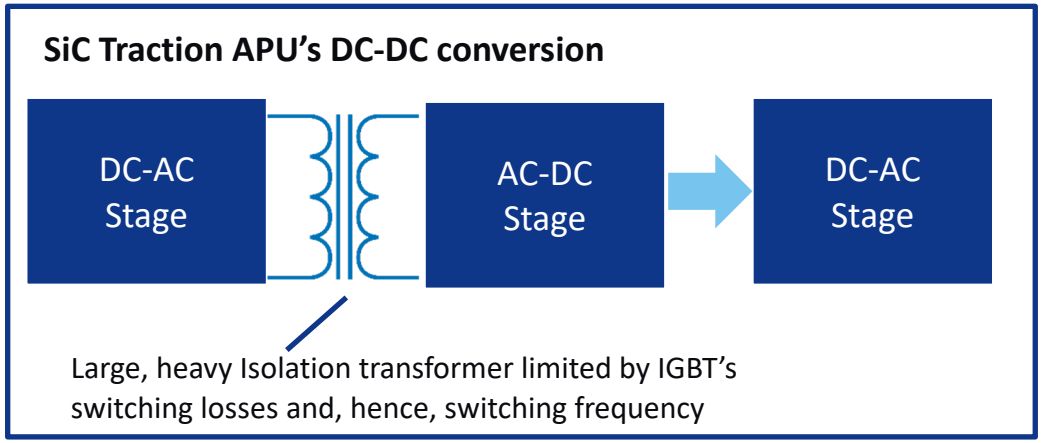
Why SiC For APUs?



Your APU using:	
3.3 kV silicon IGBT	**1.7 kV SiC MOSFET**
• Noisy to passengers and circuits • Higher conduction losses at light loads • Switching losses 4-5x higher; must switch in audible range	• Smaller, lighter, less expensive transformers • Smaller heat sinks • Less noise and greater passenger comfort

3 things are needed first!

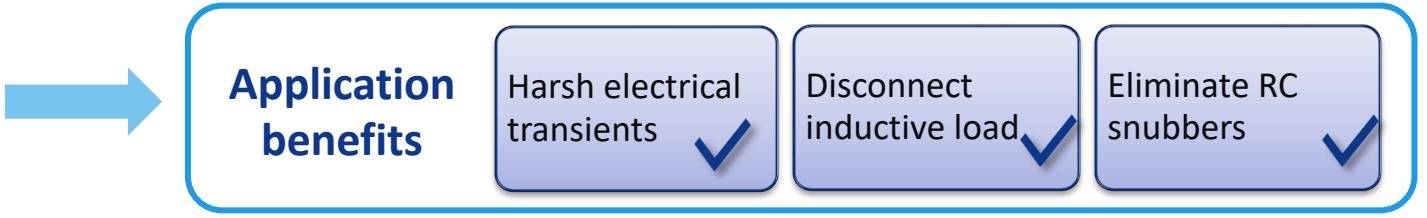
Before we can successfully and confidently deploy SiC in APUs, we need 3 answers:

1. **RELIABILITY & RUGGEDNESS**
2. **LOW INDUCTANCE**
3. **INTELLIGENT GATE DRIVER**

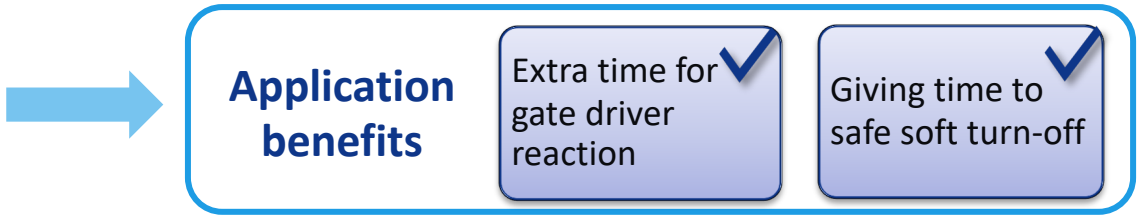
Why Does Ruggedness Matter In APUs/Transportation?

1

Excellent avalanche ruggedness



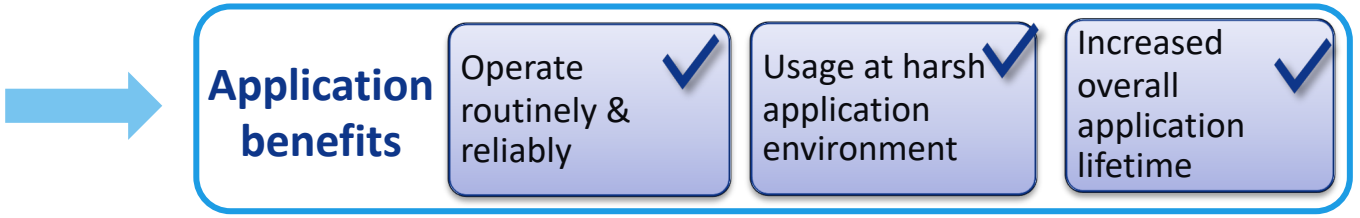
Extra survive short circuit time



No degradation observed in Microchip body diodes

Gate Oxide lifetime predicted to more than 100 years

negligible drifts at V_{th} observed.



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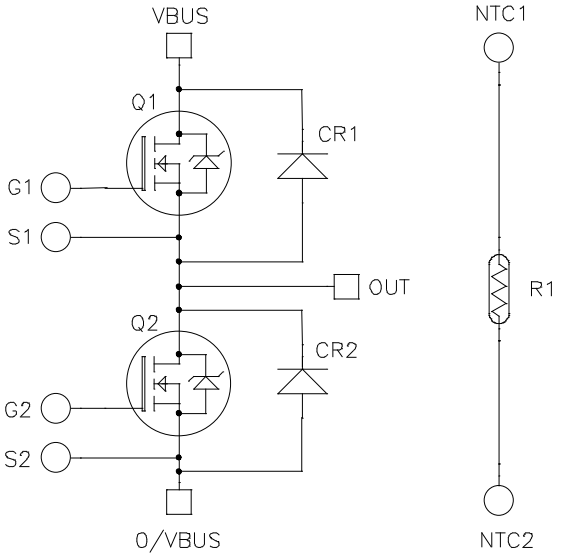
(Very) Low Inductance SP6LI Modules

Microchip SiC
The Inside!

PN	Voltage	Current Tc=80°C	RDSon Typ Tj=25°C	RDSon max. Tj=25°C	SiC parallel diode ratings	
MSCSM70AM025CT6LIAG	700 V	538 A	2.5 mΩ	3.2 mΩ	300 A	
MSCSM120AM02CT6LIAG	1200 V	754 A	2.1 mΩ	2.58 mΩ	300 A	
MSCSM120AM03CT6LIAG	1200 V	641 A	2.5 mΩ	3.1 mΩ	250 A	
MSCSM120AM042CT6LIAG	1200 V	394 A	4.2 mΩ	5.2 mΩ	180 A	
MSCSM170AM029CT6LIAG	1700V	530 A	2.9 mΩ	3.75 mΩ	300 A	*NEW!*
MSCSM170AM058CT6LIAG	1700 V	277 A	5.8 mΩ	7.5 mΩ	180 A	*NEW!*

SP6LI



- Excellent coupling between VBUS and 0/VBUS bus bars
- Parasitic loop inductance measured at very low **2.9nH**
- Full screw terminals inter-connection for signal and power
- SP6 package Industrial standard 62 mm x 108 mm footprint
- Phase leg configuration
- AlN or Si3N4 substrate with copper or AlSiC baseplate and NTC monitoring
- Module phase legs are easy to parallel and connection to DC bus is achieved without parasitic inductance
- Possibility to interconnect 3 modules together in vertical or horizontal position

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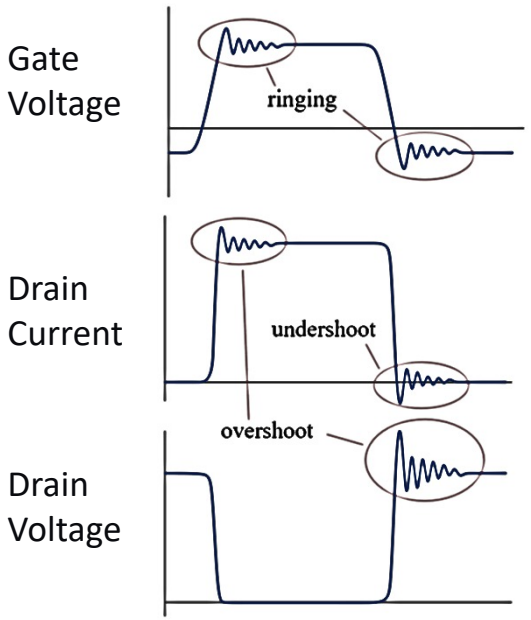
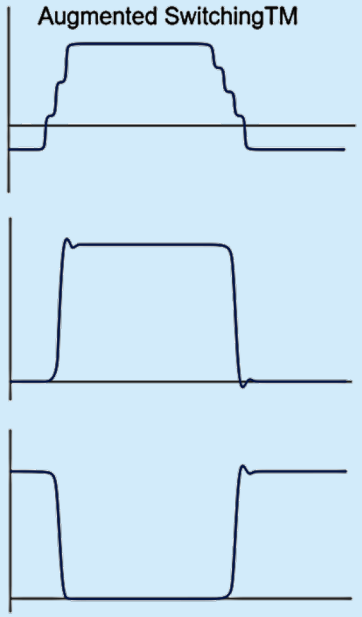
Intelligent Gate Driver | *Digital And Programmable*

Conventional switching



Augmented switching



- ✓ No false faults
- ✓ Mitigates ringing
- ✓ Lowers EMI

✓ Reduces overshoot

✓ Reduces undershoot

- Up to 80% lower V_{DS} overshoot
- Up to 50% lower switching losses
- Robust and fast short circuit protection
- Save countless hours of design tweaking

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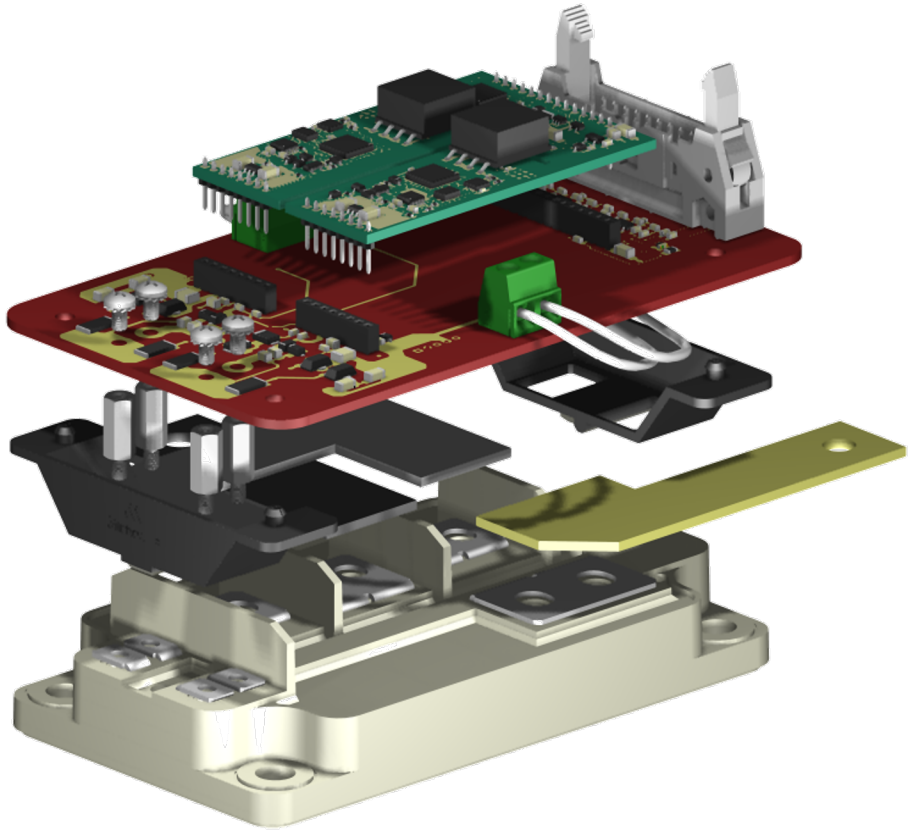
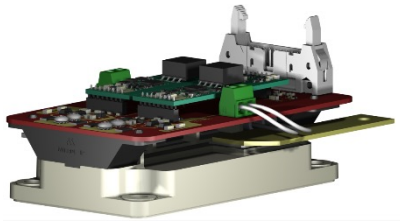
Total SiC Solution For APUs | *Power Density*





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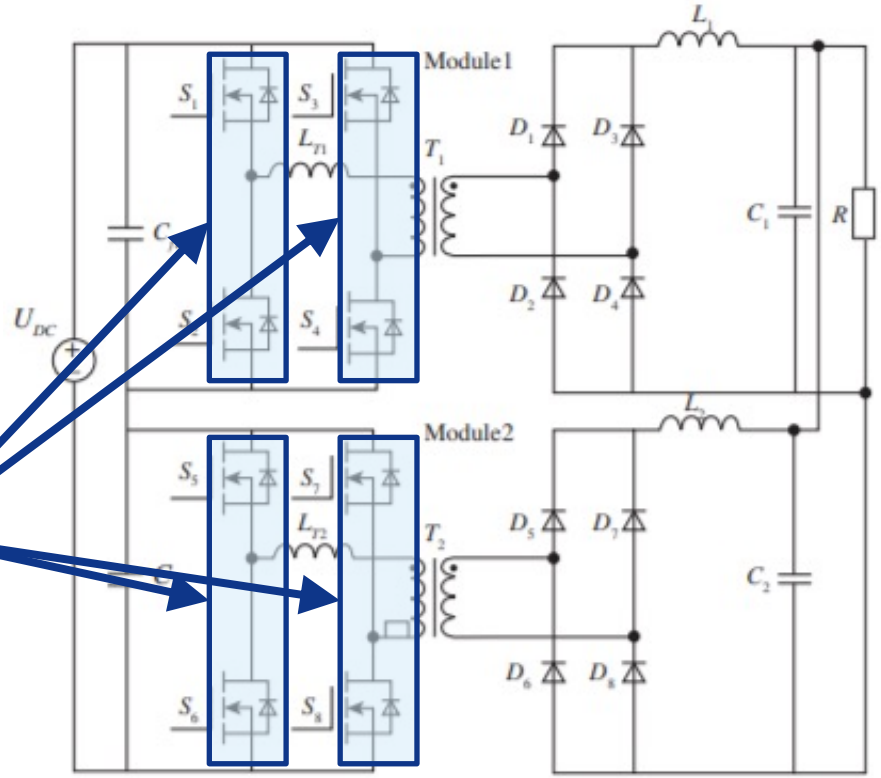

APU DC-DC converter using 1700 V SiC MOSFETs in phase-shifted full bridge topology

Huang et al., IEEJ J. Industrial Applications Vol. 8 (4), 2018

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