



Unprecedented levels of miniaturization in automotive electronics

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Introduction

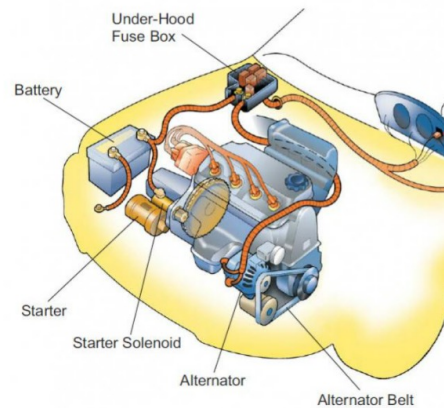
Migration to xEV has increased the electrical power used in the vehicle

Heavy-duty ICE vehicle

14.5V alternator

2.5 – 4.5kW for accessory power

Direct supply at 12V

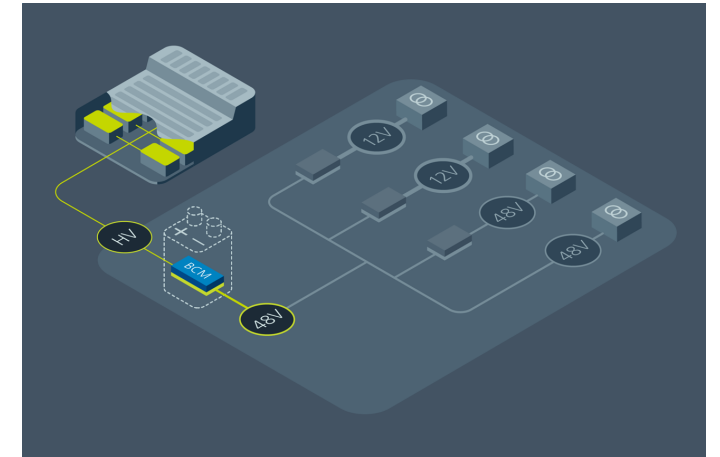


BEV vehicle

800V/400V battery

100kW power req't
(4kW for accessory power)

DC-DC Conversion to 12V

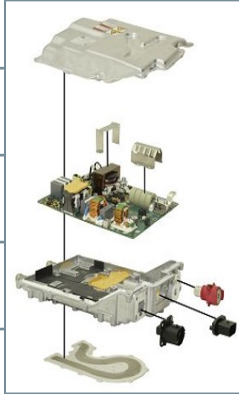
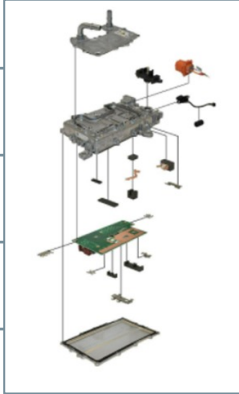


DC-DC conversion systems are heavy and large, improvement in power density is desired

Benchmarking DC-DC converters

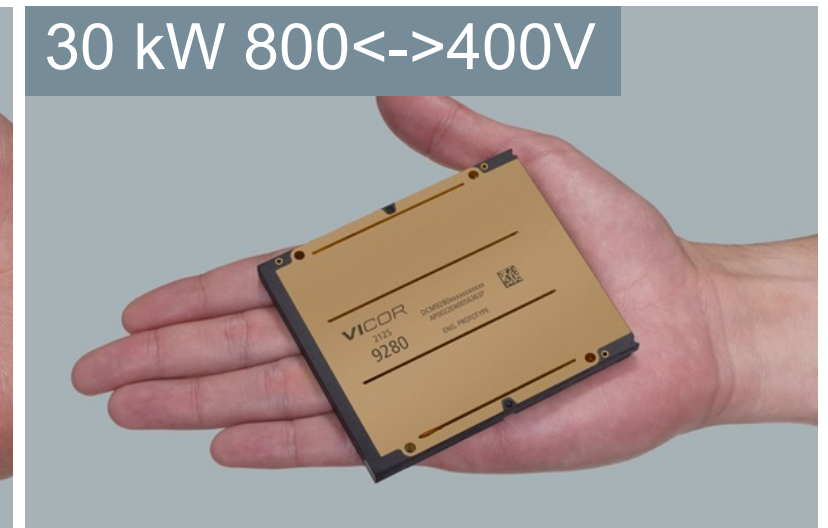
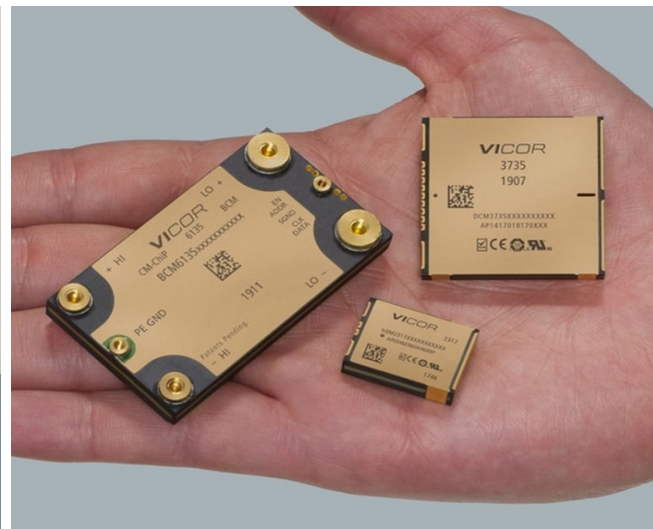
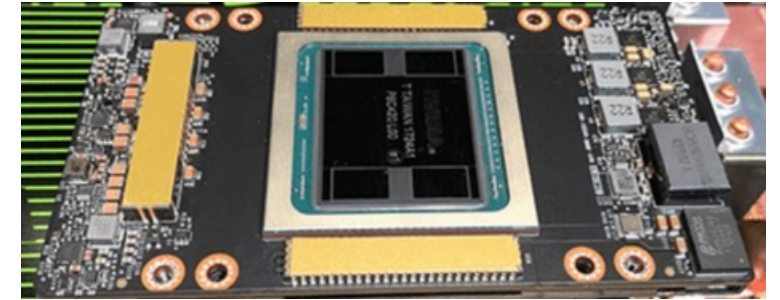
400V to 12V



	Tesla model X		Ford Mach-e	
DC-DC power rating	2300W		3400W	
DC-DC converter mass	2.1kg		2.301kg	
DC-DC volume L	1.8L		4.03L	
Power density – volume	1.3kW/L		0.84 kW/L	
Power density – mass	1.1kW/kg		1.5 kW/kg	

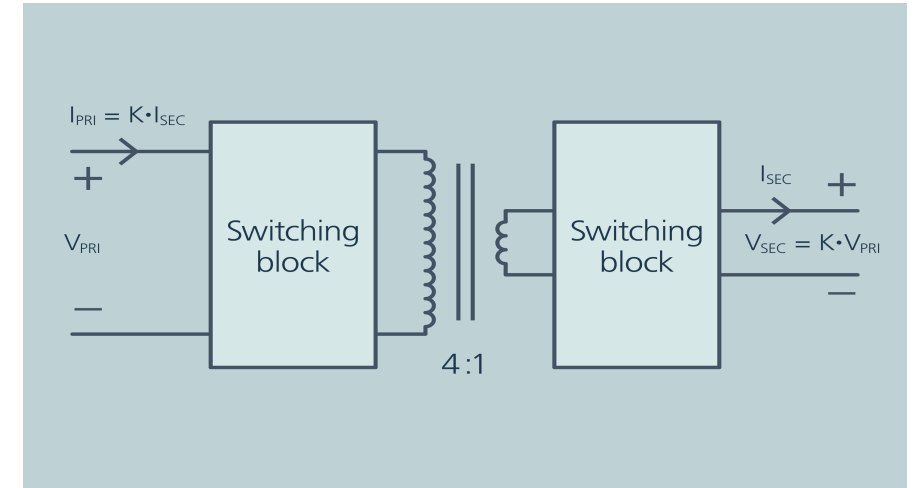
Miniature power conversion devices

- Benefits of Sine Amplification Conversion
- BCM6135 transient and efficiency data
- NBM6123 current sharing data



Sine amplitude fixed ratio conversion

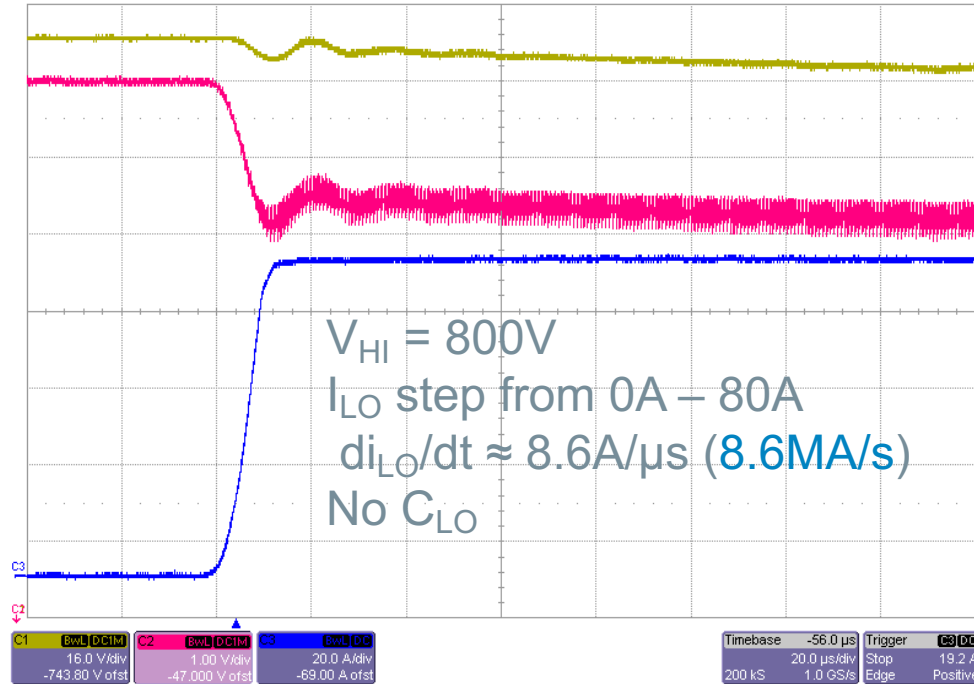
- Sine Amplitude Converter topology :
 - Zero-voltage switching
 - Zero-current switching
- Fixed-ratio conversion:
 - Divide/multiply the voltage/current
- Up to 8.6 MA/s transient current capability
- Ideal transformer behavior
- No inductor usage
- Not dependent on internal energy storage



K factor	1/16	1/4	1/1	4/1
V_{PRI}	800	48	48	12
V_{SEC}	48	12	48	48
I_{PRI}	1	1	1	4
I_{SEC}	16	4	1	1

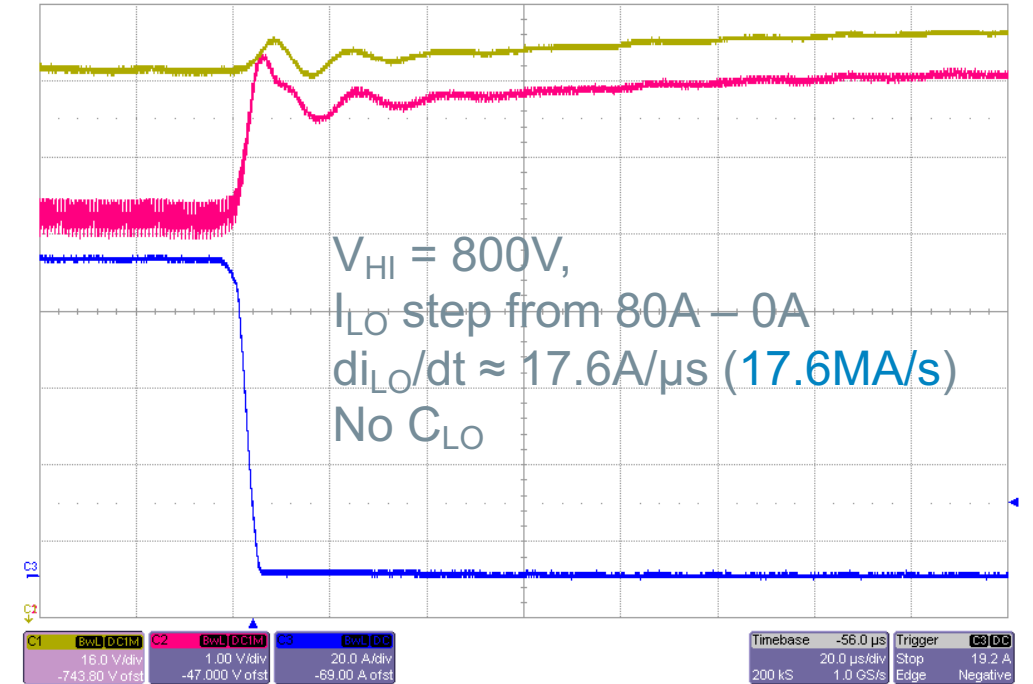
BCM6135 load step transient is extremely fast

This can be used as a virtual battery due to the transient speed



CH1 - V_{HI} : 16V/div. (DC)
CH2 - V_{LO} : 1V/div. (DC)

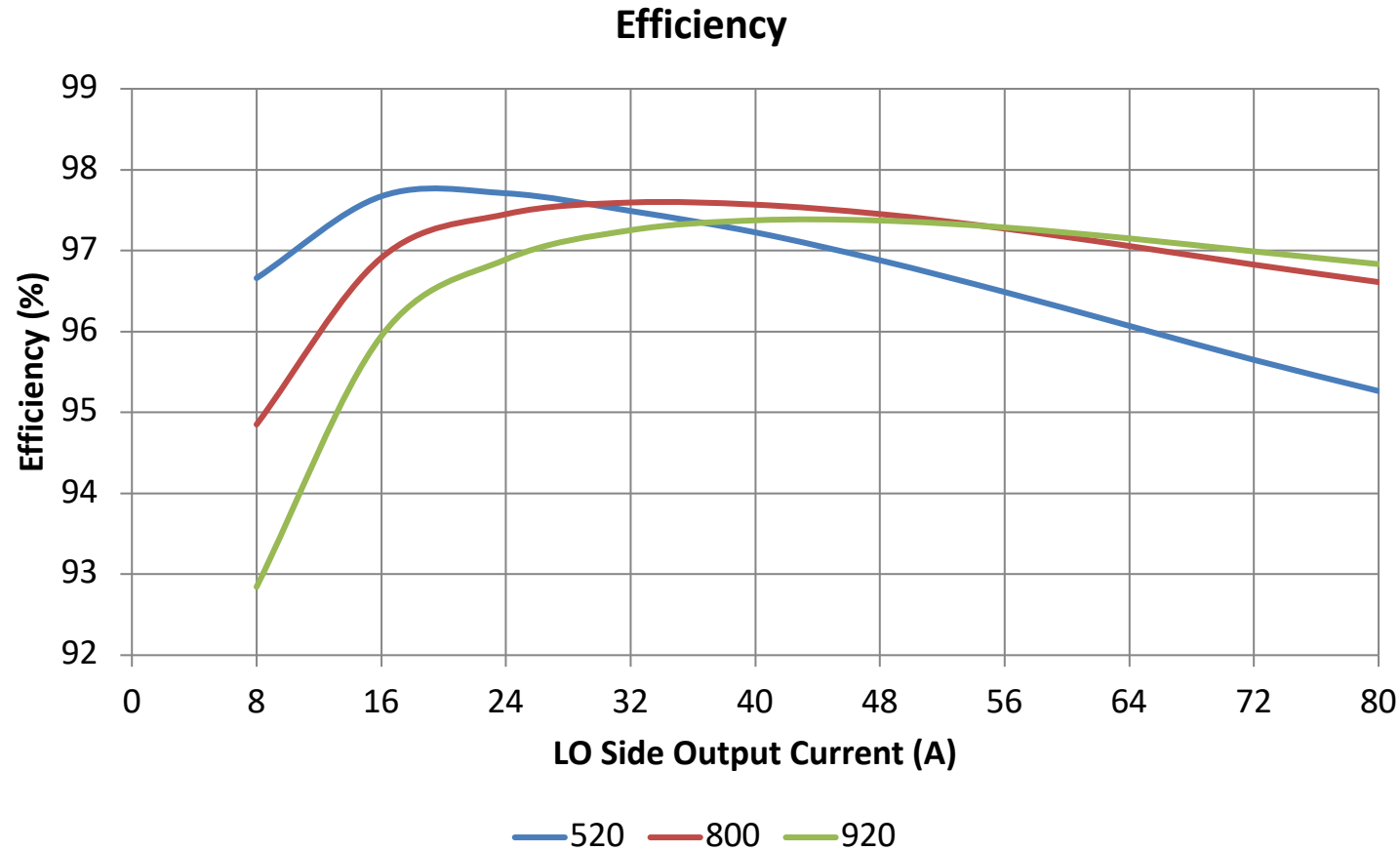
CH3 - I_{LO} : 20A/div (DC)
Timebase - 20 μs /div



CH1 - V_{HI} : 16V/div (DC)
CH2 - V_{LO} : 1V/div (DC)

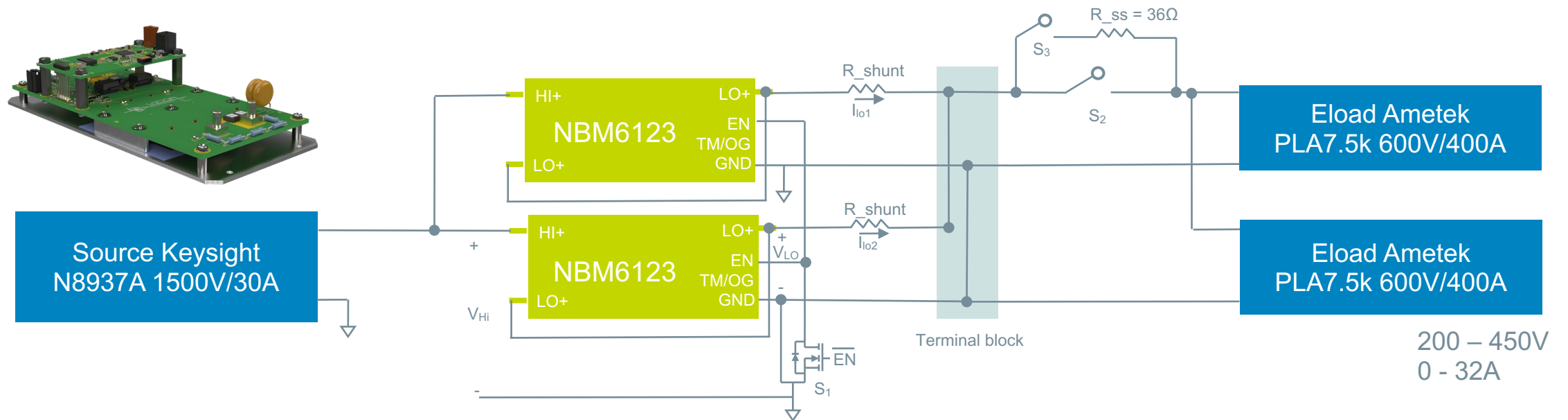
CH3 - I_{LO} : 20A/div (DC)
Timebase - 20 μs /div

BCM6135 efficiency



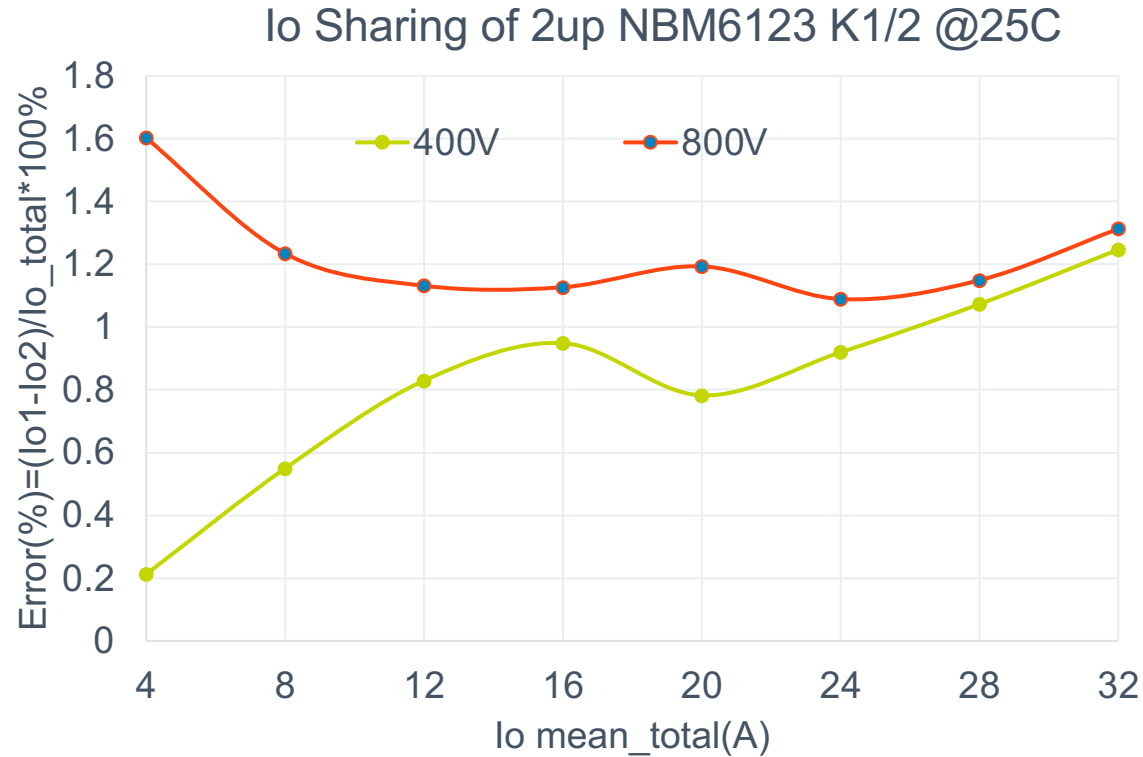
Bench measurement at
25°C ambient

Power test setup – current sharing



- This array combines 2 NBM6123 modules in Buck Mode 800V – 400V
 - Each module provides 7.5kW
 - Array provides 15kW

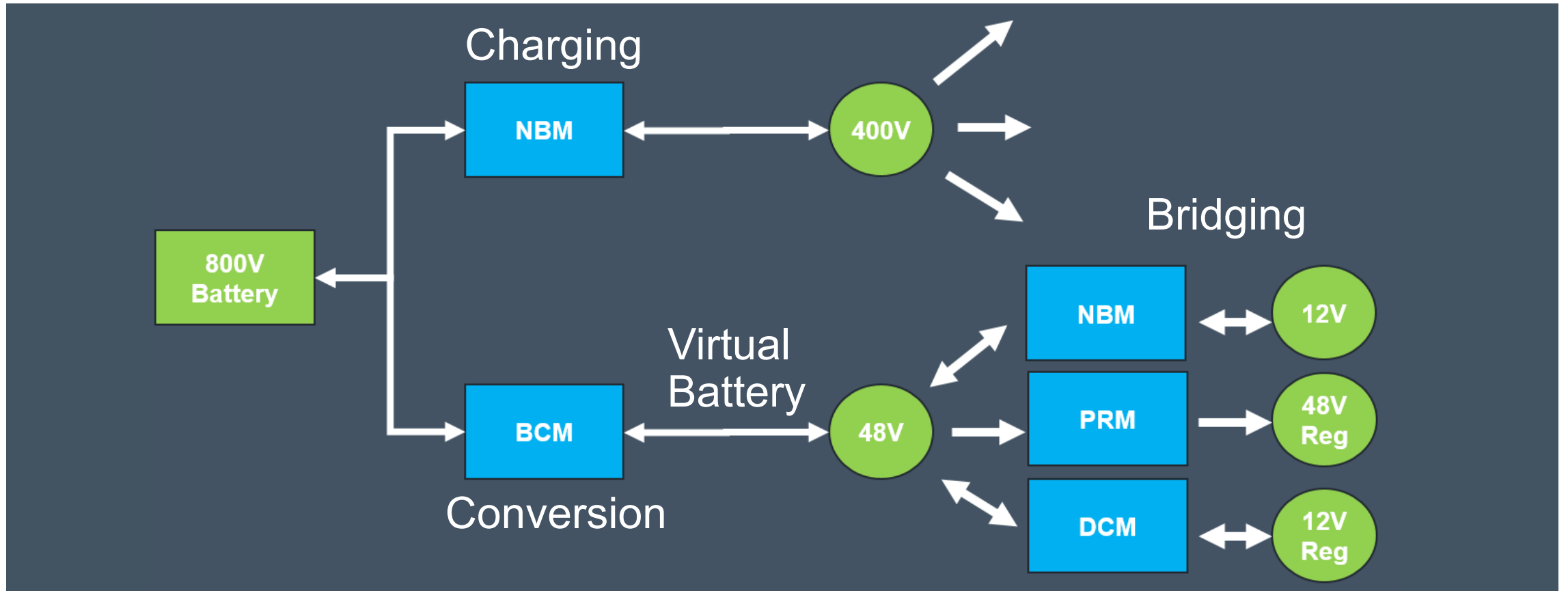
Network to higher power with array of miniature modules



Minimal Current Sharing error which enables arrays of up to 10 modules

Current Sharing Error is under 1.5% for 400V and 800V

Power network possibilities

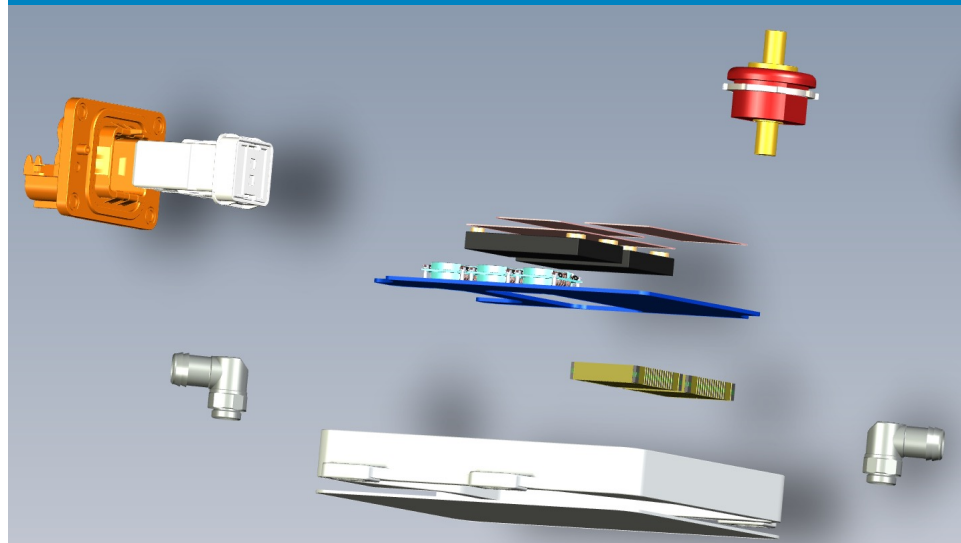


Miniaturized 400V – 12V DC-DC

The contents of this system:

- 2 BCM6135 to convert 400V to 48V
- 2 DCM3735 to convert 48V to regulated 12V
- System PCB board with circuits for:
 - Reverse Polarity
 - VCC
 - Pre-charge
 - EMI Filters
 - Isolator

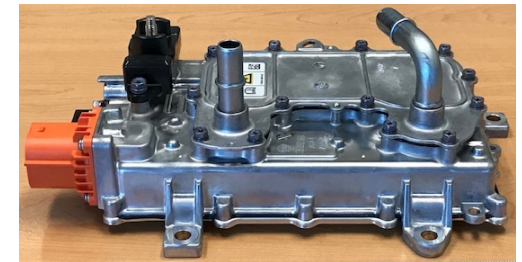
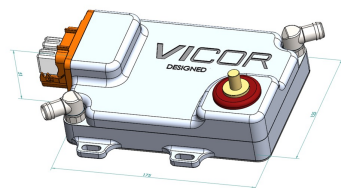
Vicor Chipset for 4 kW
Volume 0.046L = 87 kW / L
Mass 266 g = 15 kW / kg



- HV Connector
- LV Post Connector
- CAN Connector
- Cooling Plate
- Housing

Miniaturization achieves up to 4x improvement in power density

	Vicor concept	Tesla model X	TDK production Mach-E
P_{OUT} W (Output Power)	4000 @ 13.8V	2300 @ 12V	3410 @ 15.5V
Output current A	290	193	220
Weight kg	1.4	2.1	2.7
Size mm (w/o connectors)	0.76 L (175 x 125 x 35)	1.8L (140 x 218 x 60)	4.0 L (288 x 200 x 70)
Efficiency	95% estimate	93% estimate	93% peak
Power density kW/liter	5.22 (4x Improvement)	1.3	0.84
Gravimetric power density kW/kg	2.50 (1.6x Improvement)	1.1	1.5



Benefits of miniaturized power modules

1. Higher Efficiency provides for less cooling loads at high power conversion
2. Higher power density for lower weight and smaller package size
3. Ability to create a virtual battery

Acknowledgements

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Scan and download the presentation



VICOR

Thank you