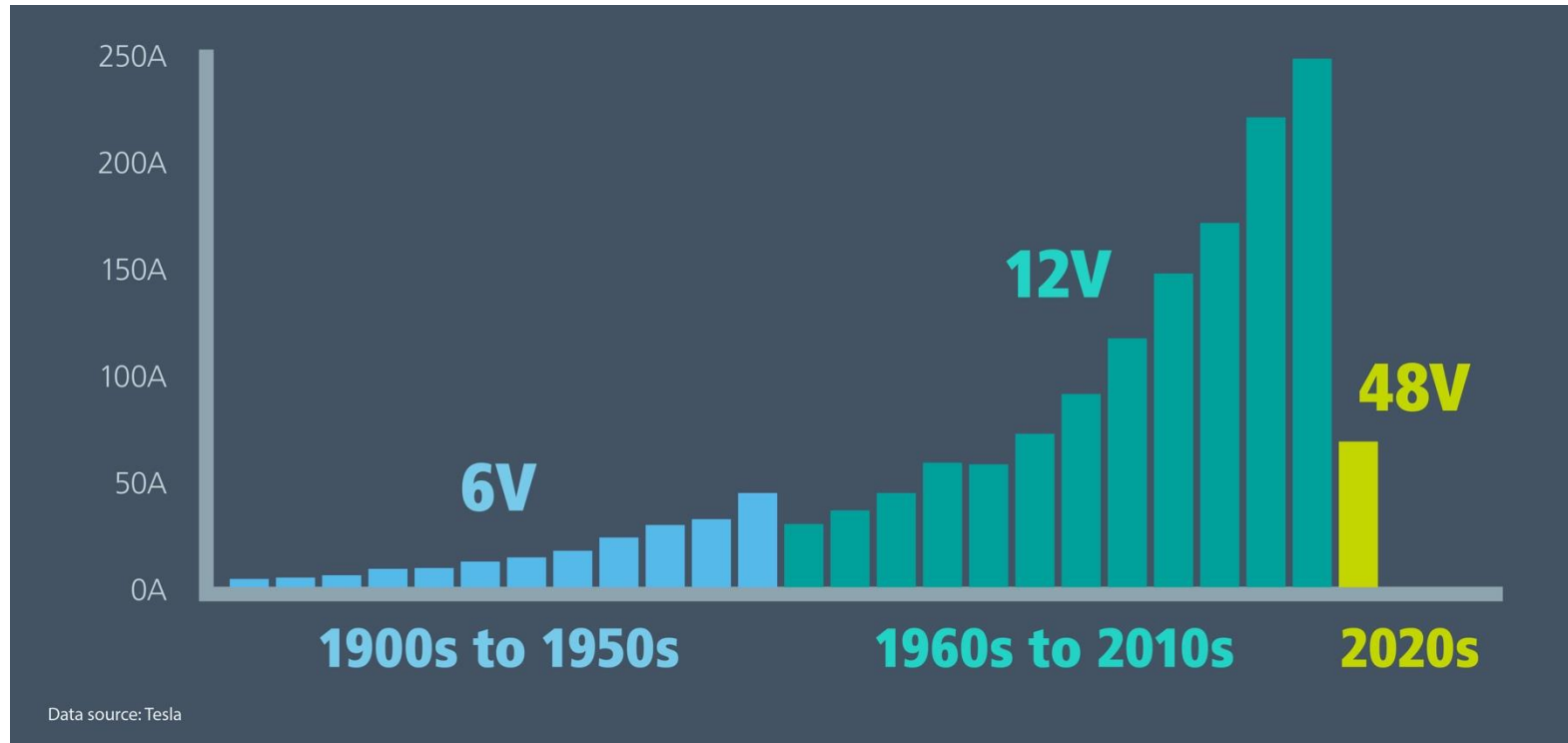




Future-Proof Automotive High-Voltage-to-SELV Conversion Using Sine Amplitude Control (SAC™) Technology

Greg Green, Director of Automotive Marketing

Low Voltage Current draw is achieving all time highs:

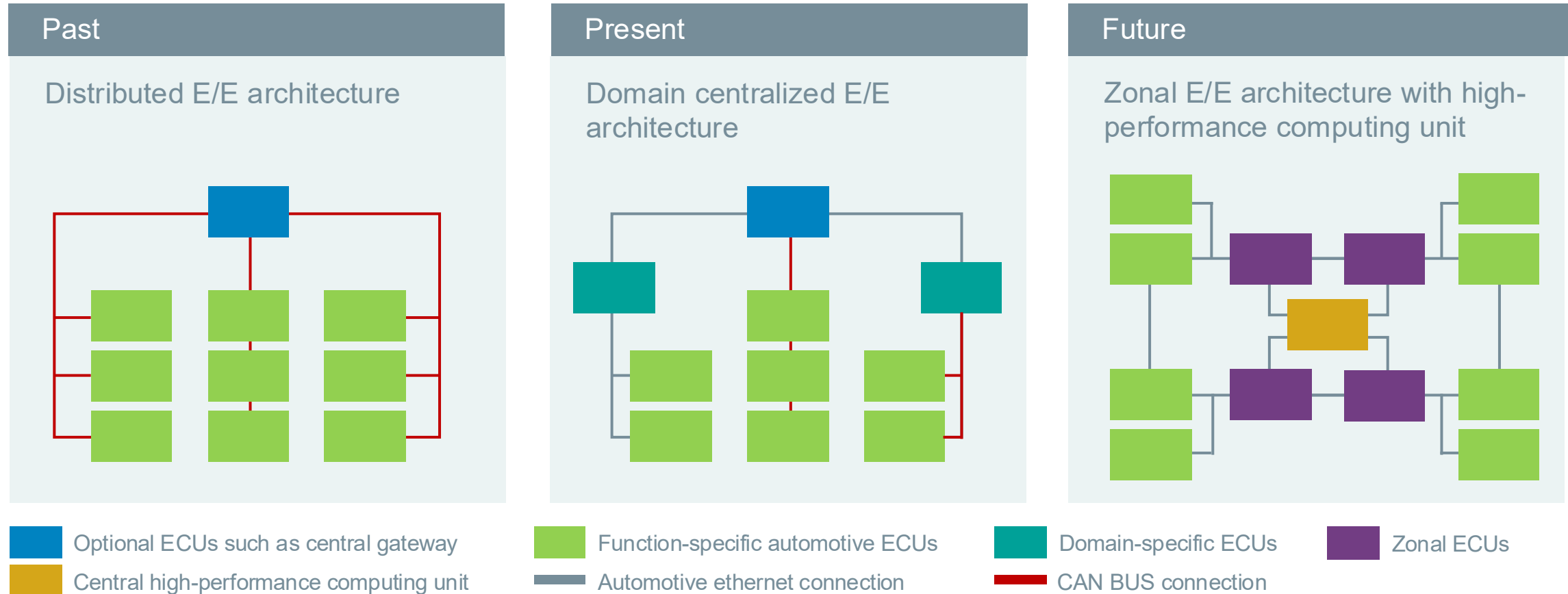


ADAS
EPAS
Active Suspension
IR Heating
Infotainment

The type of power source is not converging, but it is electrifying

- ICE base becomes hybridized
- EREV grows to heavy power users
- BEV remains a growing market segment

Evolution from centralized to zonal, responding to increased loads



New solution: Sine Amplitude Conversion

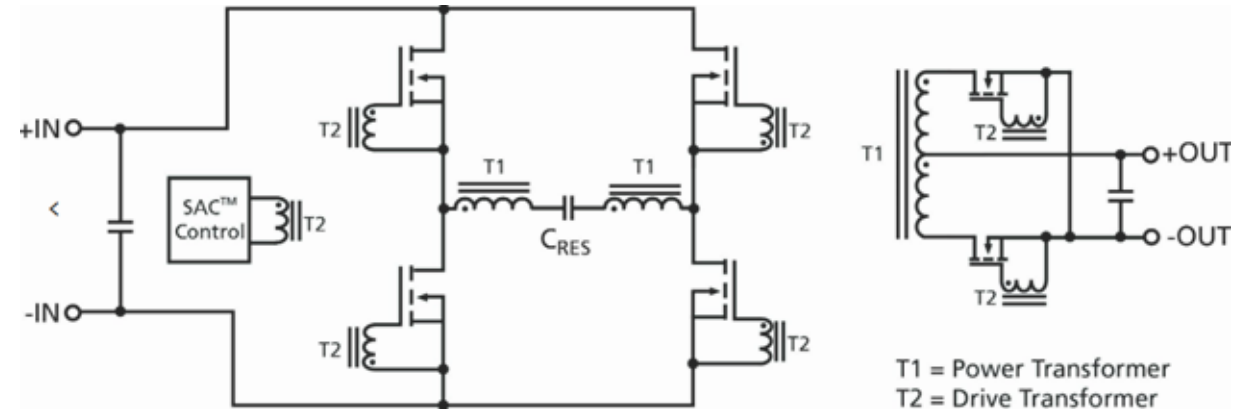
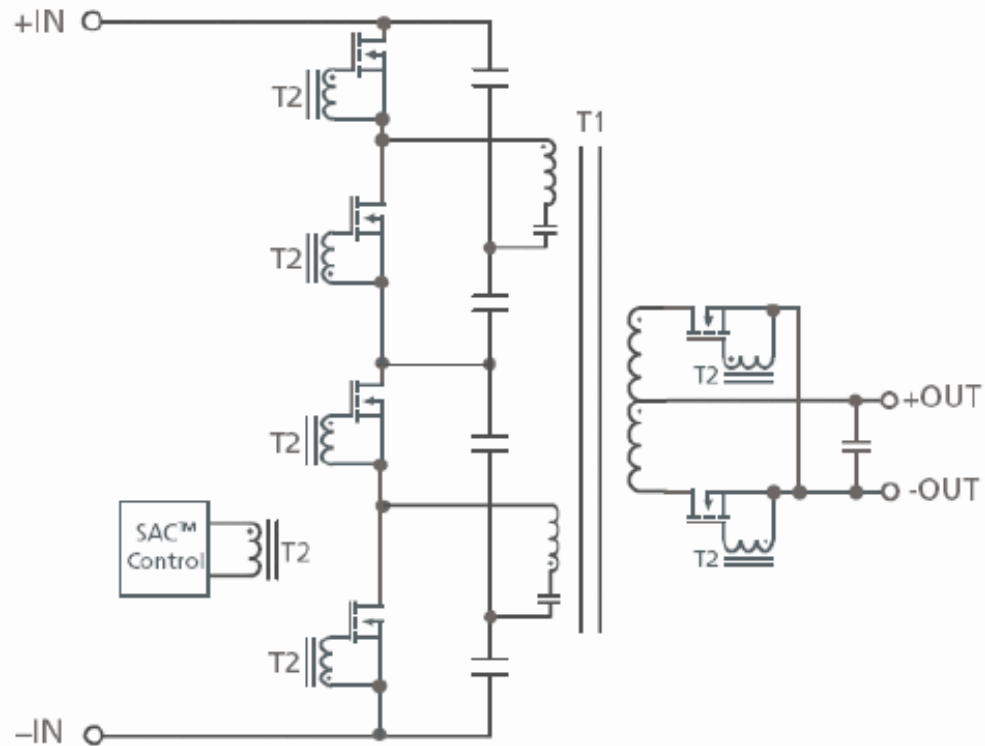
- Resonant topology
 - Operates at high resonant frequency, fixed gain
- Soft switching, constant frequency/duty
 - Low EMI profile
 - Switching losses minimized
- Enables higher switching frequencies and lower volume/weight

DC-DC



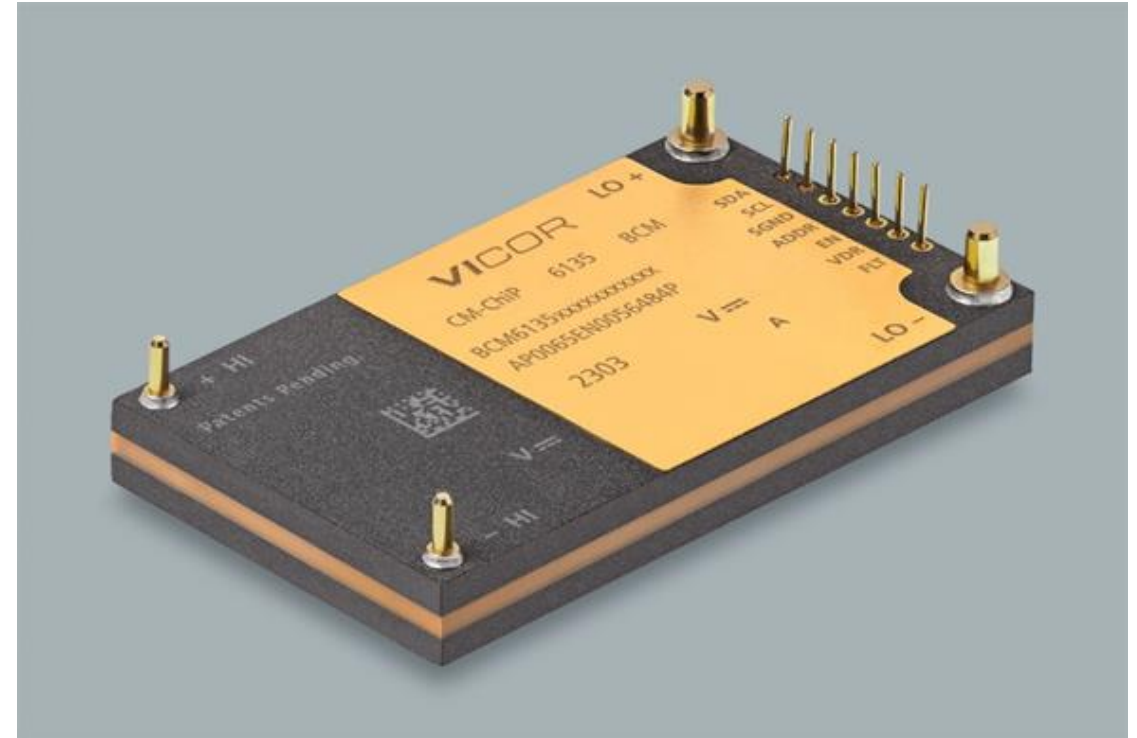
Sine
amplitude
converter

Topology example of SAC implementation – BCM

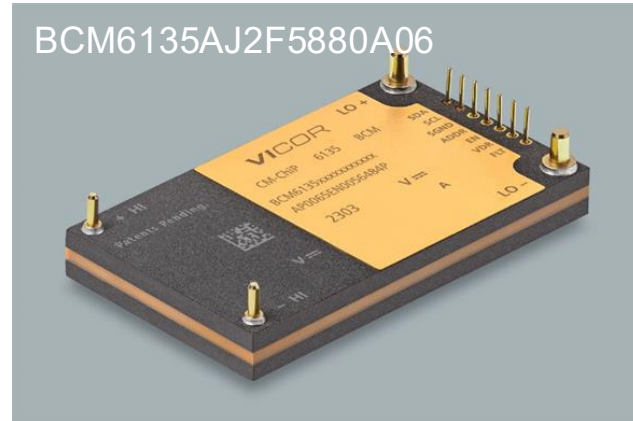


Example of SAC implementation – BCM

- Up to 5 kW peak power, or 100A peak current
- Losses and package performance
 - Peak efficiency 98.3%
 - Full power 97.8%
- Thermal resistance 0.7K/W
- Symmetrical power flow capability
- How is it possible?
 - In house development for controller, transformer, switches and packaging
 - All parameters optimized under the same function



BCM6135 for 800V to 48V with isolation



Creates 4242V input to output isolation internally

Provides 20kW of power when built in an array of 10 modules

Symmetrical performance in buck or boost

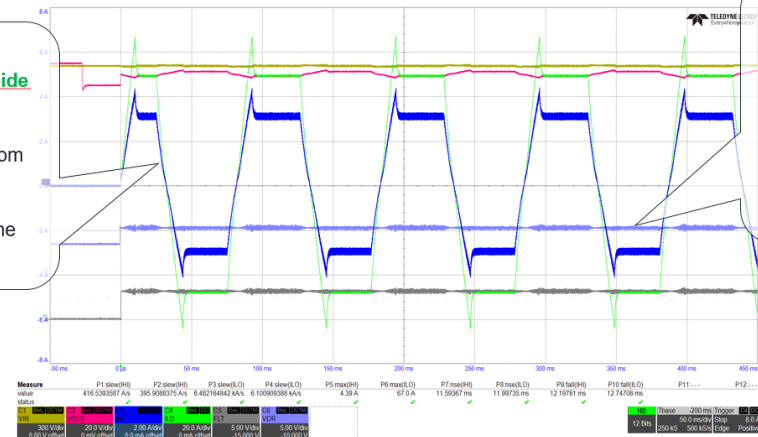
Highest current change (slew) rate of 8 M A/s

Peak Power	2.5 kW
V _{IN} Range	520 – 920V
V _{OUT} Range	32.5 – 57.5V
Peak Current	80 A
Bidirectional	Yes
Start-Up Bias	Internal

System Load Transient

800VHI, 50VLO, 0 to 50A ILO, 0A to 3.125A IHI

- Hiside LoSide Currents
- Linear transition from forward to reverse
- No dead time



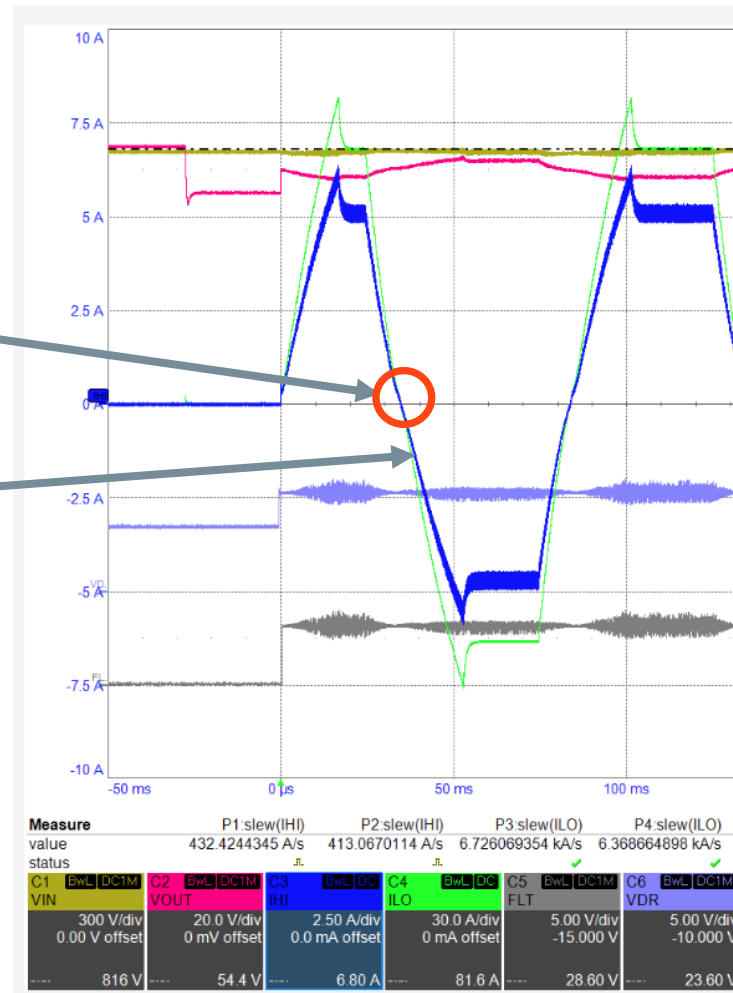
- VDR Power is constant highlighting how the powertrain behaves no different forward or reverse

Bidirectional current flow and bandwidth

No dead zone in Transition

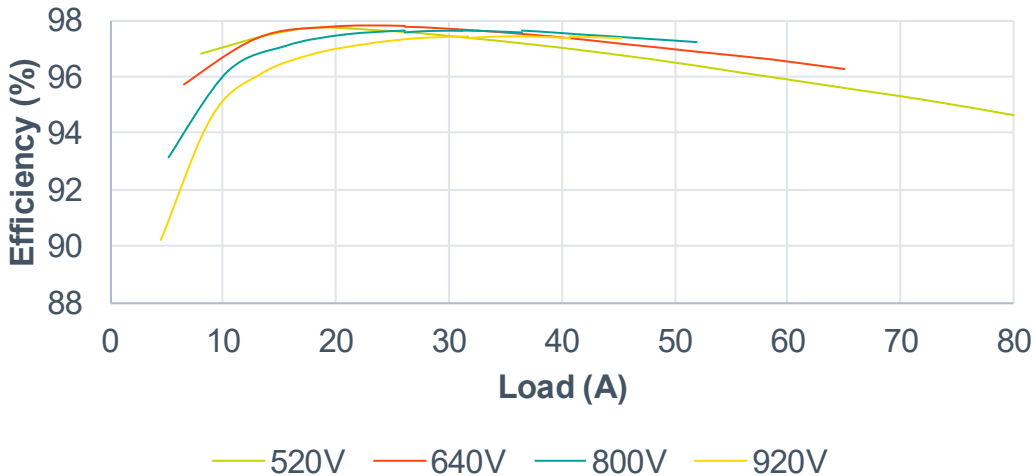
Linear Transition between forward and reverse

VDR 在电流方向变化时保持恒定

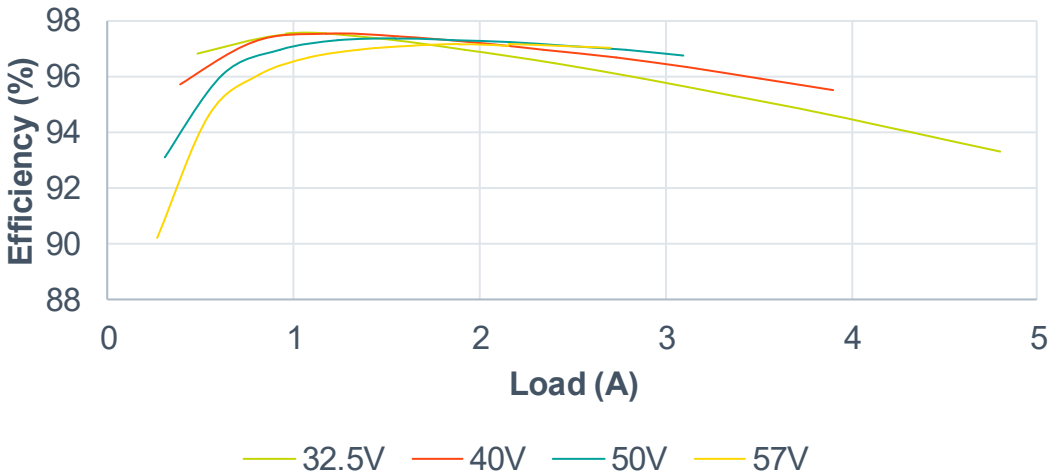


Symmetrical power processing

BCM6135 Step-Down Efficiency vs Load



BCM6135 Step-Up Efficiency vs Load



Product Ratings				
Step-Down Operation	K = 1/16	V _{HI} = 800V (520 – 920V)	V _{LO} = 50V (32.5 – 57.5V) No Load	I _{LO} = 80A Max
Step-Up Operation		V _{LO} = 50V (32.5 – 57.5V)	V _{HI} = 800V (520 – 920V) No Load	I _{HI} = 5A Max

48V to 12V SAC modules



DCM3735M-AN1

Peak power: 2.0 kW

V_{IN} range: 17 – 58V

V_{OUT} range: 8 – 16V

Peak current: 160 A

Bidirectional: no

Regulated



NBM2317-A0R

Peak power: 1.0 kW

V_{IN} range: 40 – 60V

V_{OUT} range: 10 – 15V

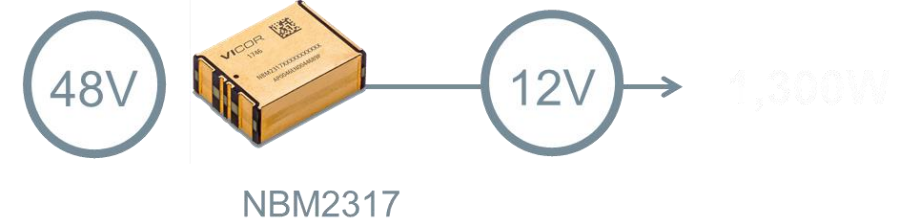
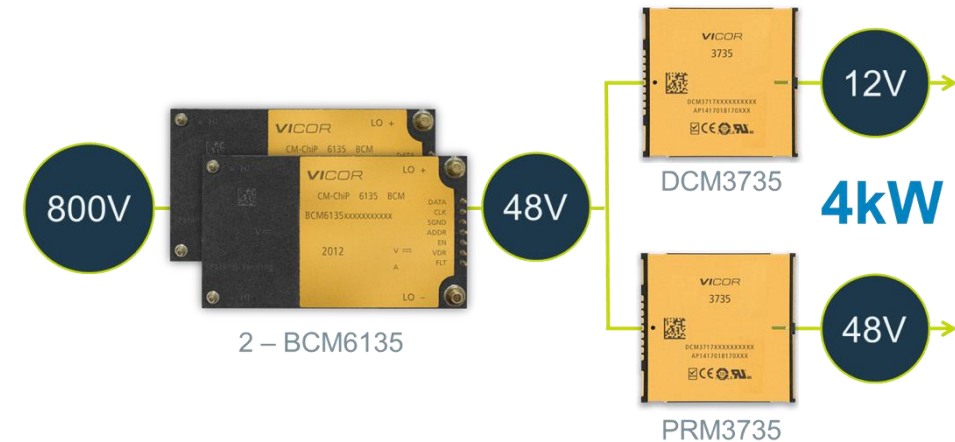
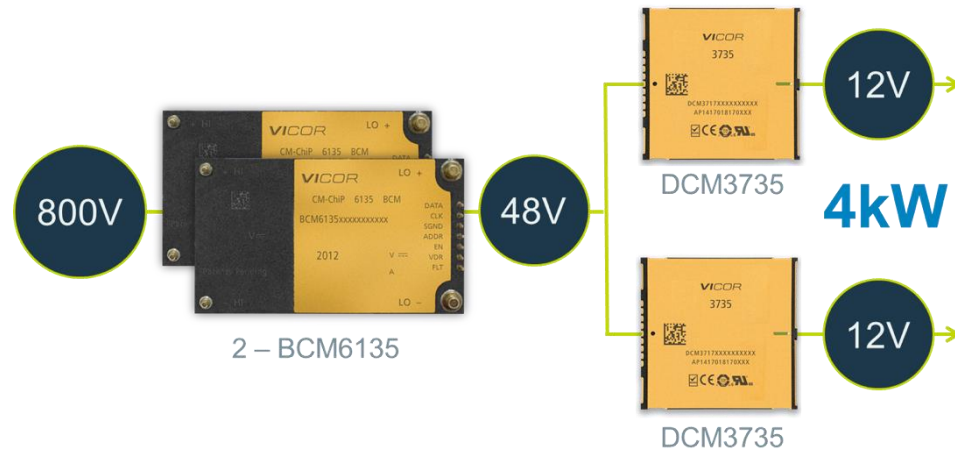
Peak current: 80 A

Bidirectional: yes

Non-regulated



Power system designers need powerful, scalable flexible options



3 modules support many applications

Active
Suspension

Zonal
Architectures

Fast
Charging

Glass De-ice
and De-fog

High Power
Auxiliary
systems

Power
Delivery
System

Central
DC-DC

IR
Passenger
Heating

Glass De-ice and De-Fogging

- In xEV vehicles clearing the glass is a major concern
 - Less waste heat from hybrid engine requires too much time
 - Heating air is least efficient process for BEV's
- Vicor modules facilitate safe and efficient electrical heating of the glass



System Application Benefits

Vicor Paladin Demonstration Unit - 4kW 800V to LV DC-DC

Paladin demonstrates Vicor's power density advantage

- Developed to allow customers to see at a system level the benefits of Vicor automotive modules in power density
 - Delivering 3.6 kW /L of power density
 - Lightweighting DC-DC to only 1.7 kg
- Showcase flexibility of the Vicor approach
 - Mix and match 12V and 48V power load requirements
 - Common package layout for up to 3 vehicle power configurations

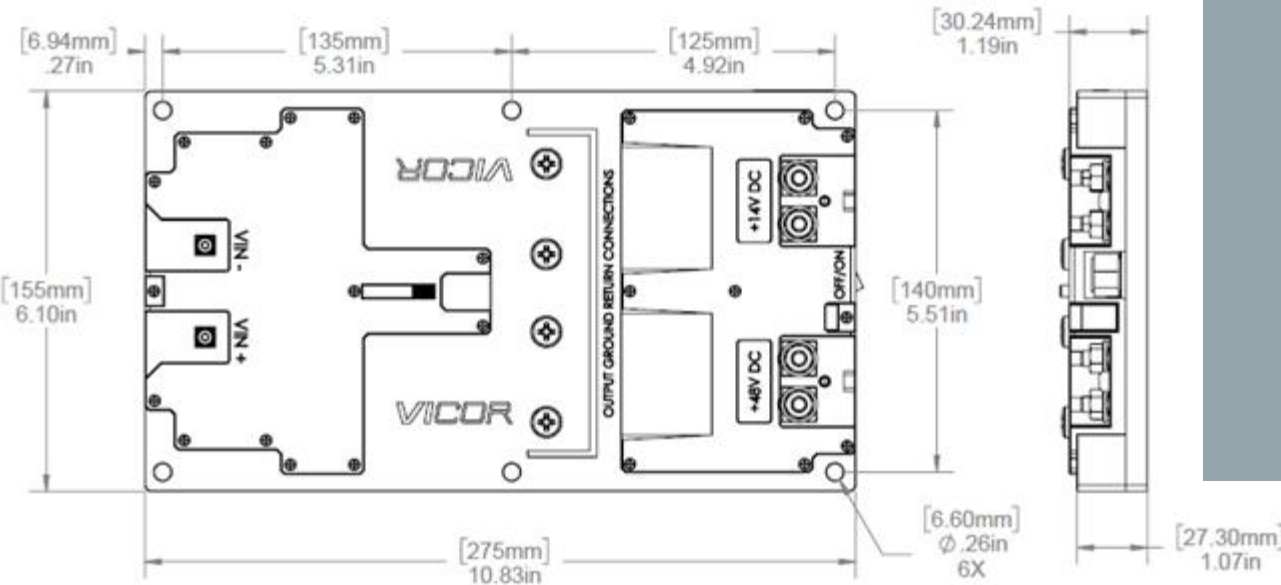
Vicor 800V to LV 4kW DC-DC – Target specifications

Input Voltage range	520 – 920 V	Limited operation for 520–560V
Output Voltage range LV48 LV12	36 – 54V 8 – 16V	Regulated at 48V setpoint Regulated at 12V setpoint
Output Power LV48 LV12	2.4 kW (50A at 48Vout) 1.4kW (100A at 14Vout)	Power derating for < 46Vout Power derating for < 9Vout
Output Current LV48 LV12	50A max continuous 100A max continuous	Current derating for > 48Vout
Output Voltage regulation	+/-1.0V for LV48 +/-0.2V for LV12	
Efficiency	94 %	800Vin, 48 / 14Vout, Full load
Operating temperature	-40 to 125 degC of Modules Tint *1	Power derating for Modules Tcase > 65 degC *2
EMI	Integrated filtering	Input side and output side filtering

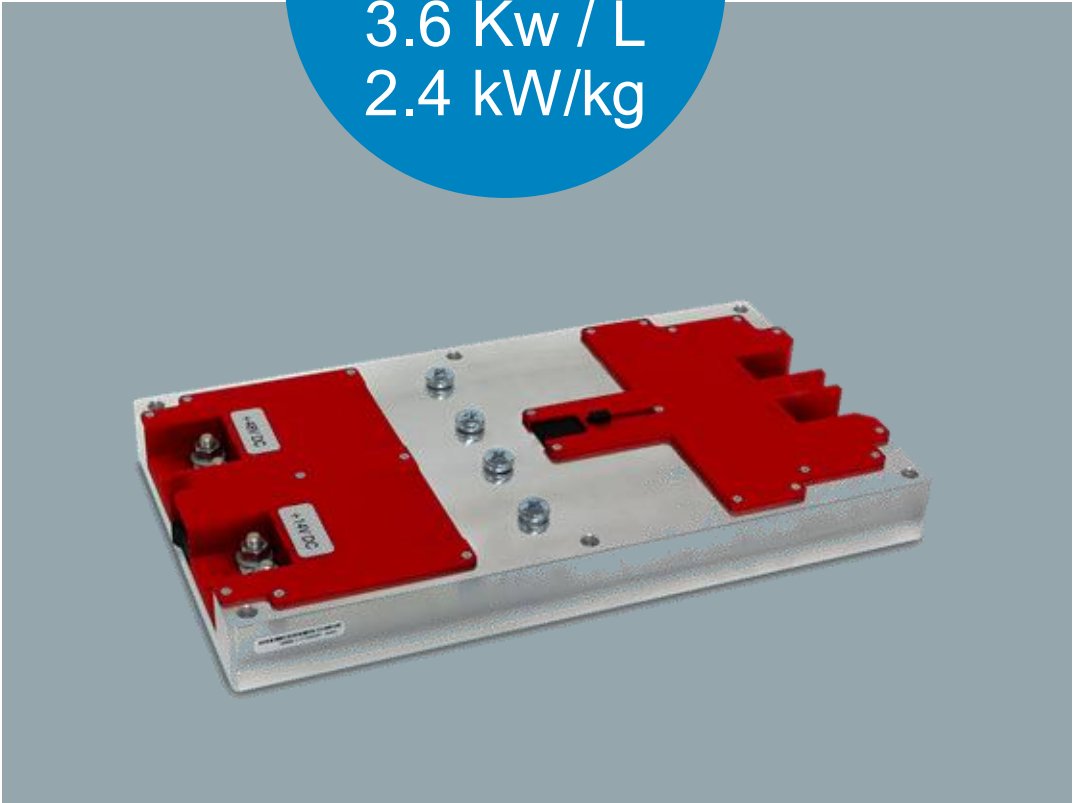
*1: Tint = Module internal temperature. Can vary depending on cooling plate performance *2: Tcase = Module top and bottom surface temperature. Operational condition: 800Vin, 48Vout, 14Vout

Mechanical overview

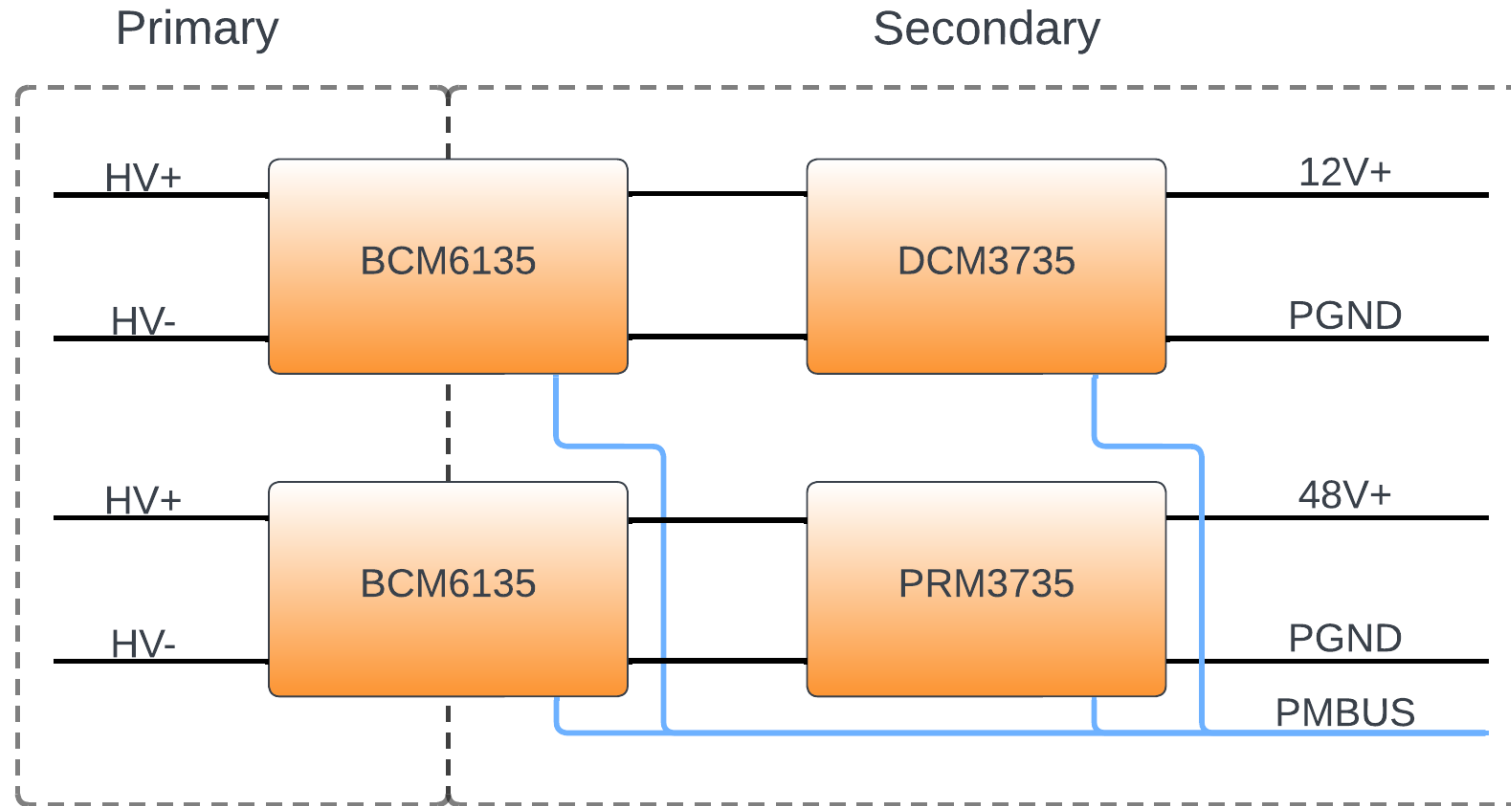
Dimensions	275 x 155 x 27.3mm	1.1L package volume
Mounting	Clearance holes	M6 clearance holes
Cooling Method	Cold plate	
Weight	1.7kg	



Power
Density
3.6 Kw / L
2.4 kW/kg

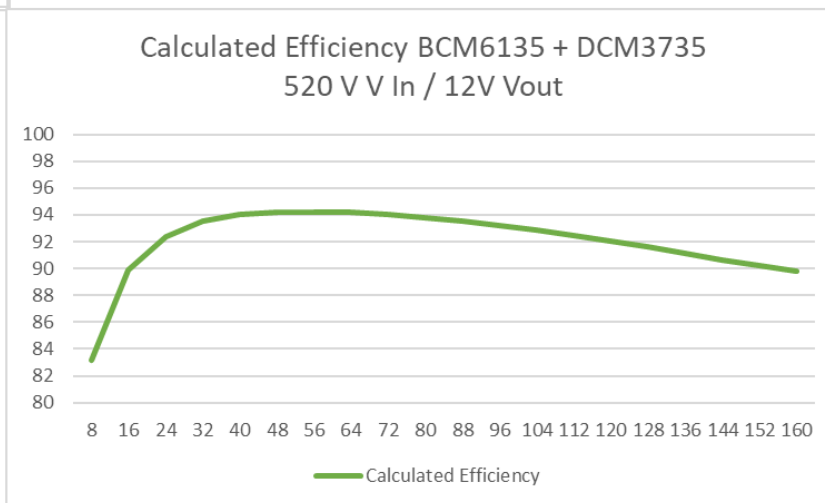
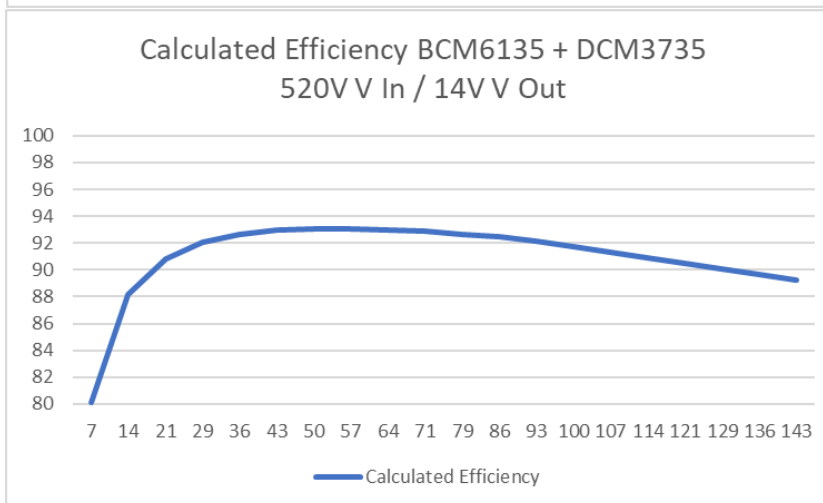
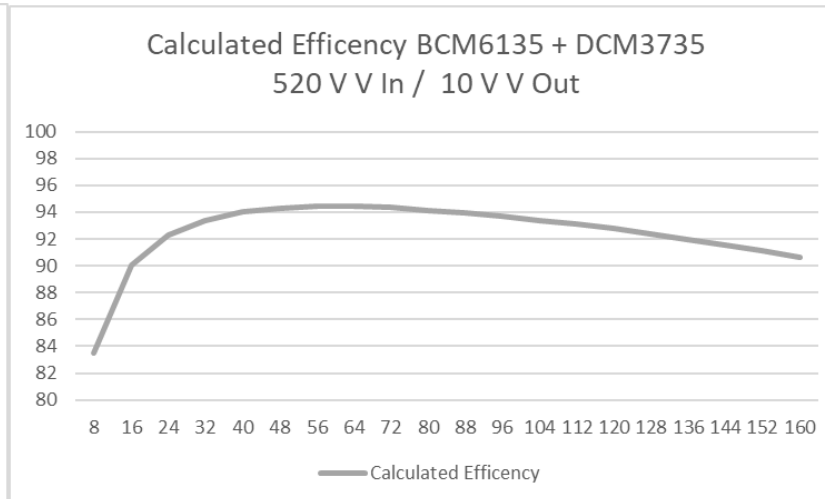
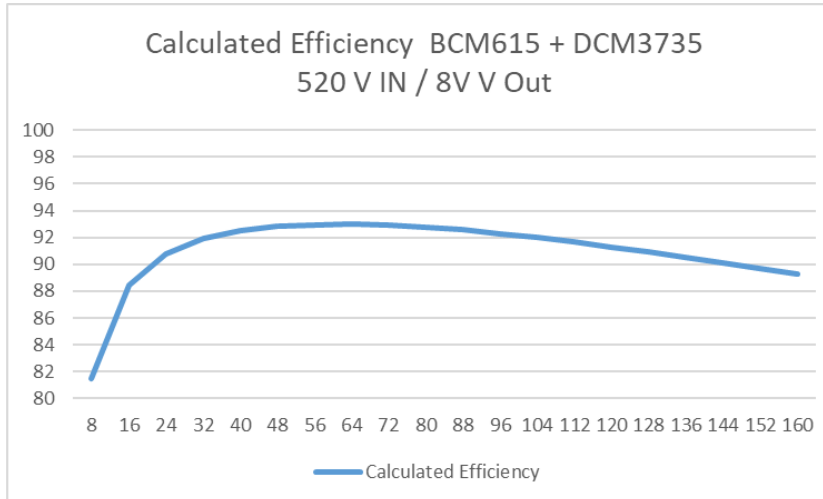


Block diagram



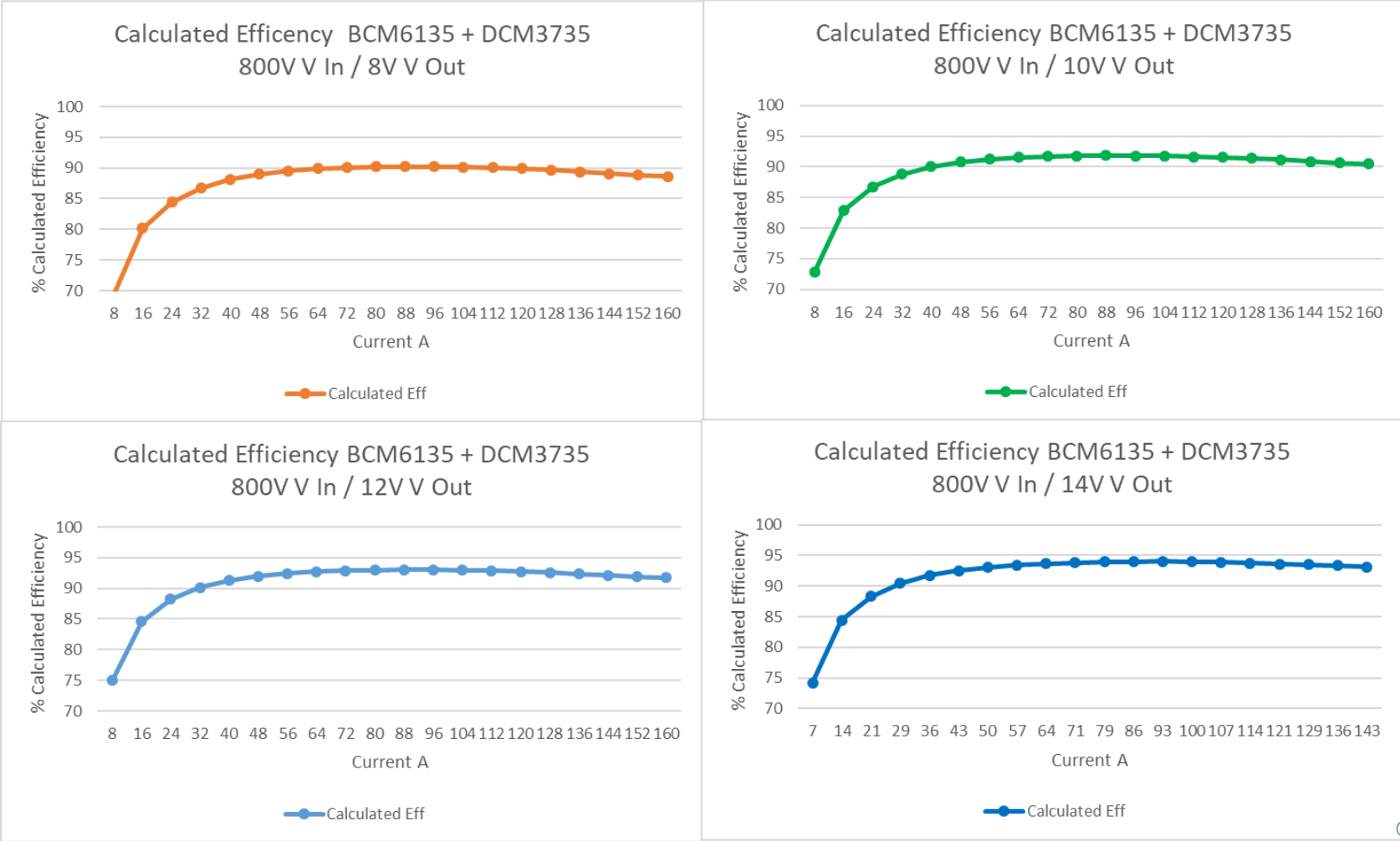
Paladin DC-DC Converter Testing Results

540V to 12V BCM6135 + DCM3735 calculated efficiency

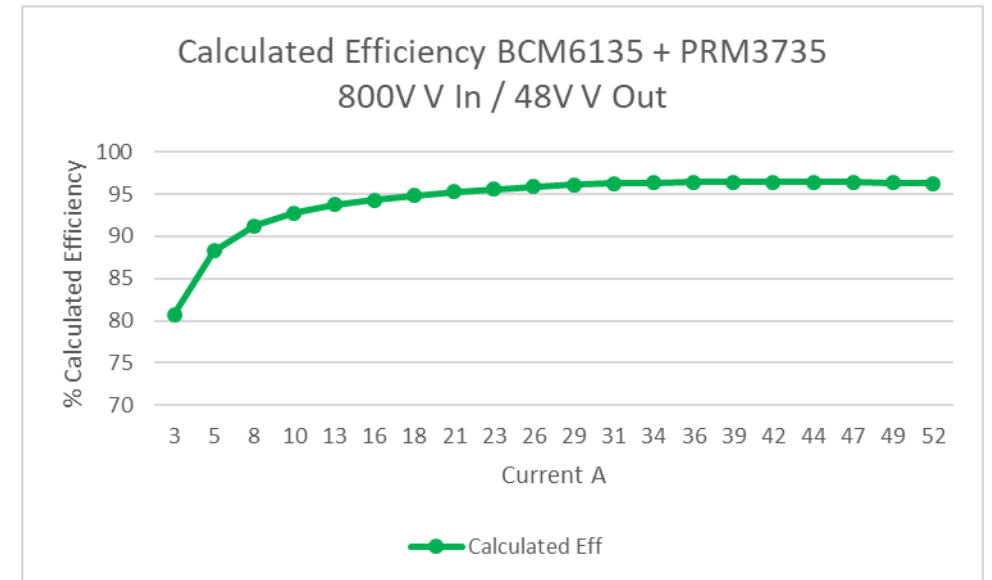
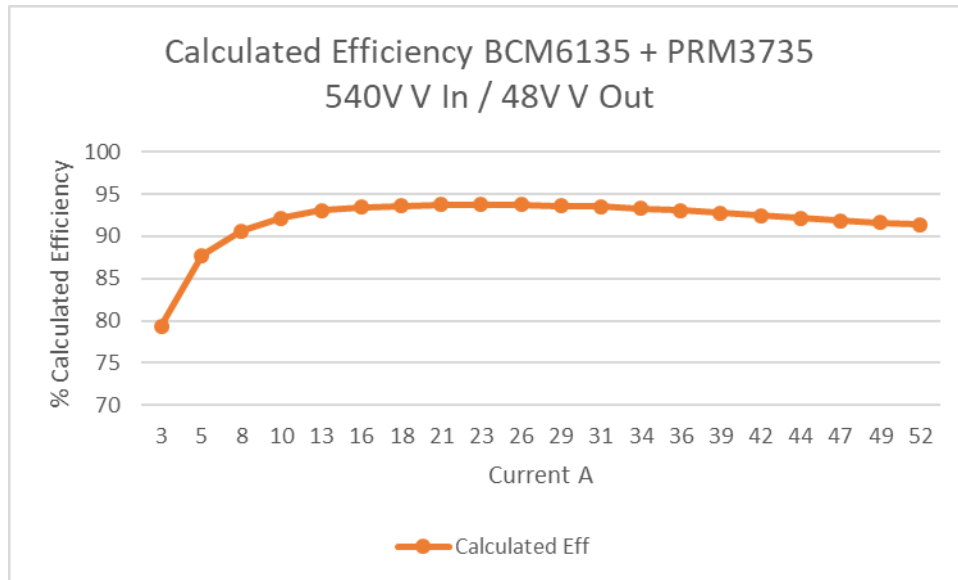


800V to 12V BCM6135 + DCM3735

calculated efficiency

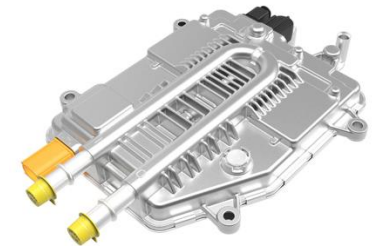


BCM6135 + PRM3735 calculated efficiency



3 to 4x improvement in power density

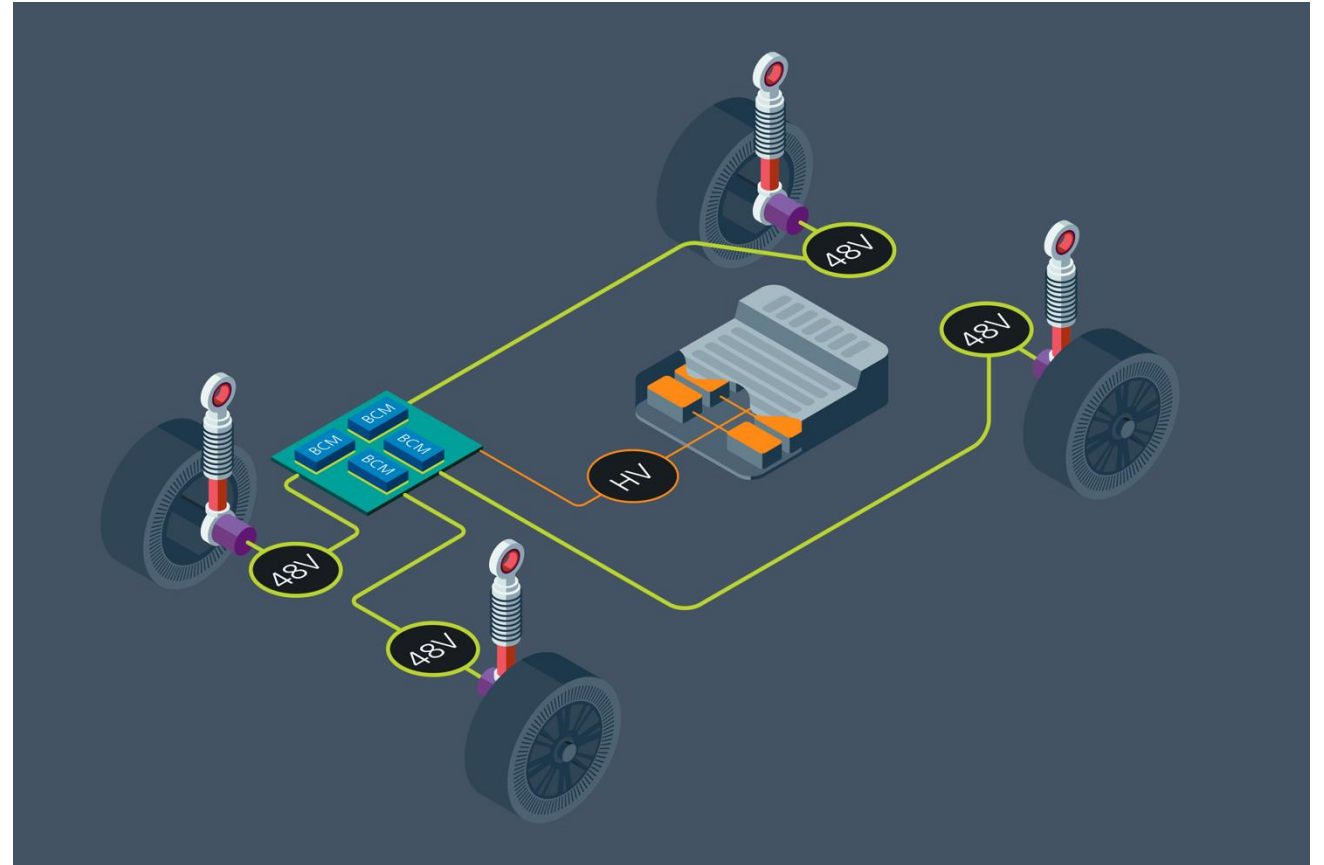
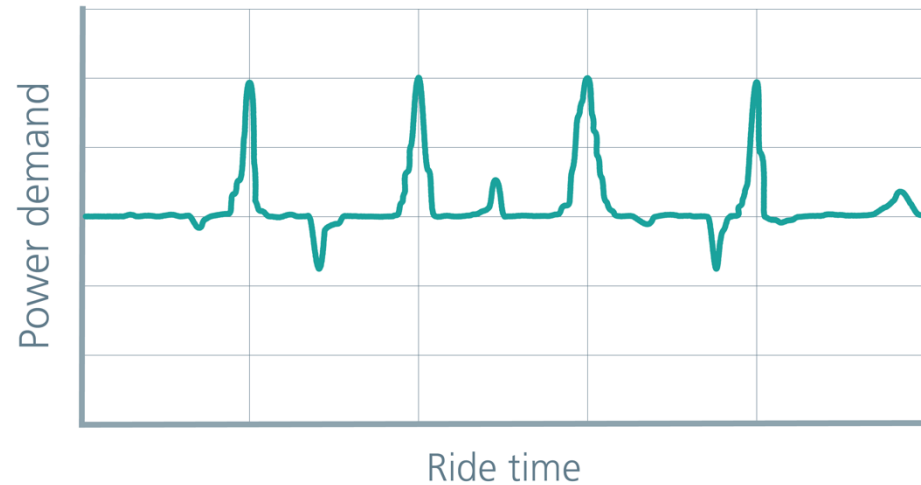
	Vicor Solution	Tesla Model X	Vitesco 4 th Generation
Pout W (Output Power)	4000 @ 13.8V	2300 @ 12 V	3500 @ 14.5V
Weight kg	1.7	2.1	2.6
Footprint mm ²	24500	30520	50000
Volume L (w/o connectors)	1.7L (275 x 155 x 42)	1.8L (140 x 218 x 60)	2.5 L (250 x 200 x 50)
Efficiency	95%	93% Estimate	96% Estimate
Power Density kW/liter	2.35	1.3	1.34
Gravimetric Power Density kW/kg	2.35	1.1	1.5



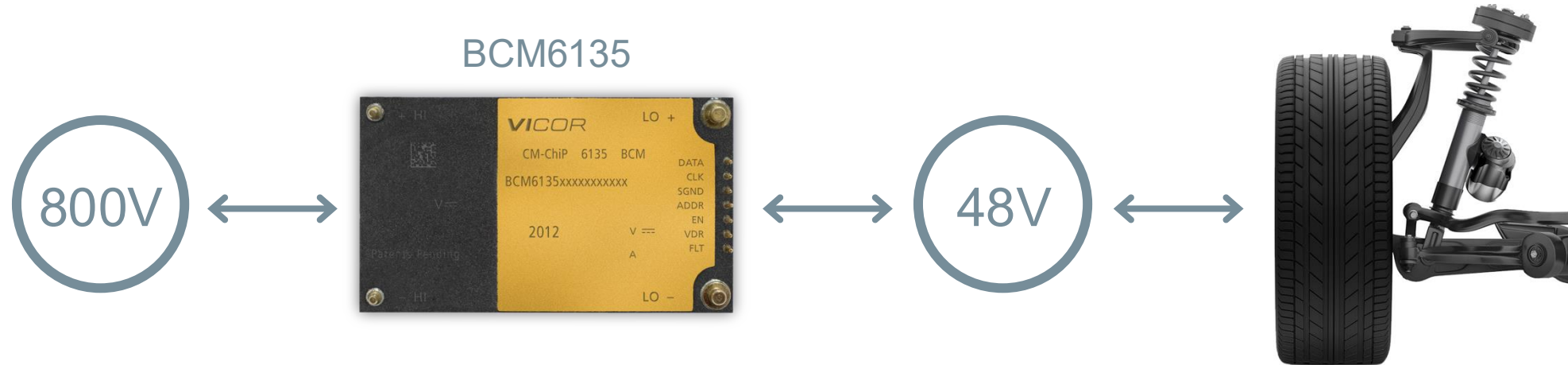
Active Suspension Case Study

Active suspension systems have demanding power requirements

- Highly dynamic profiles
- Extreme peak currents
- Energy recuperation



SAC based BCM6135 meets and exceeds active suspension power requirements



800V to 48V

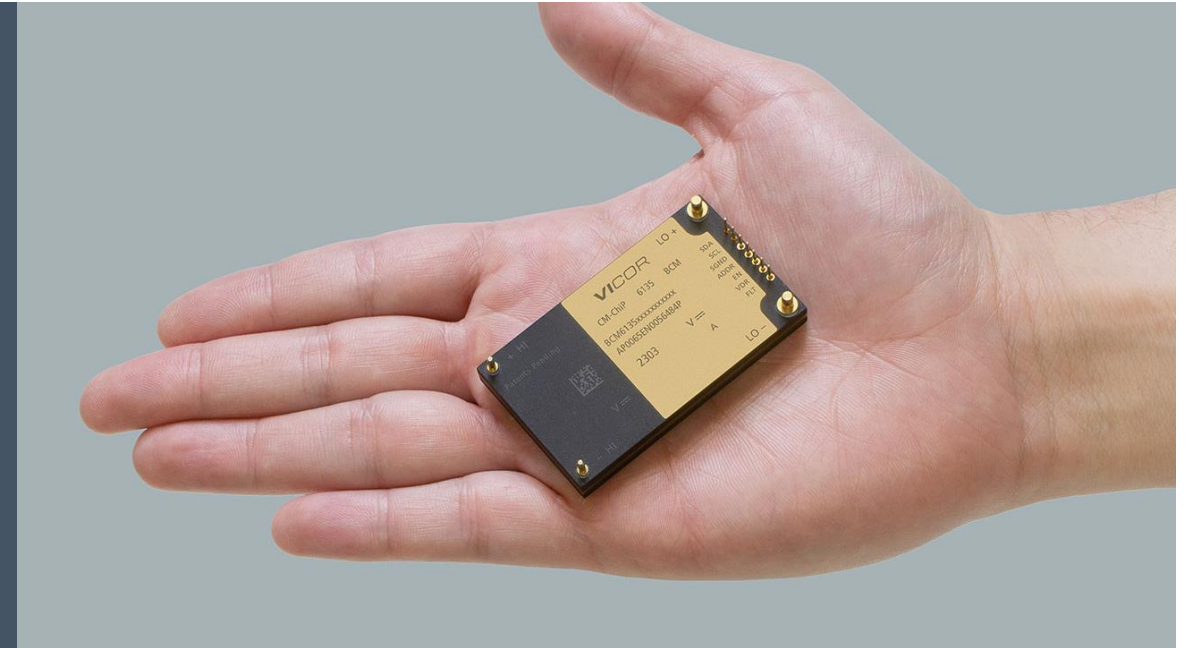
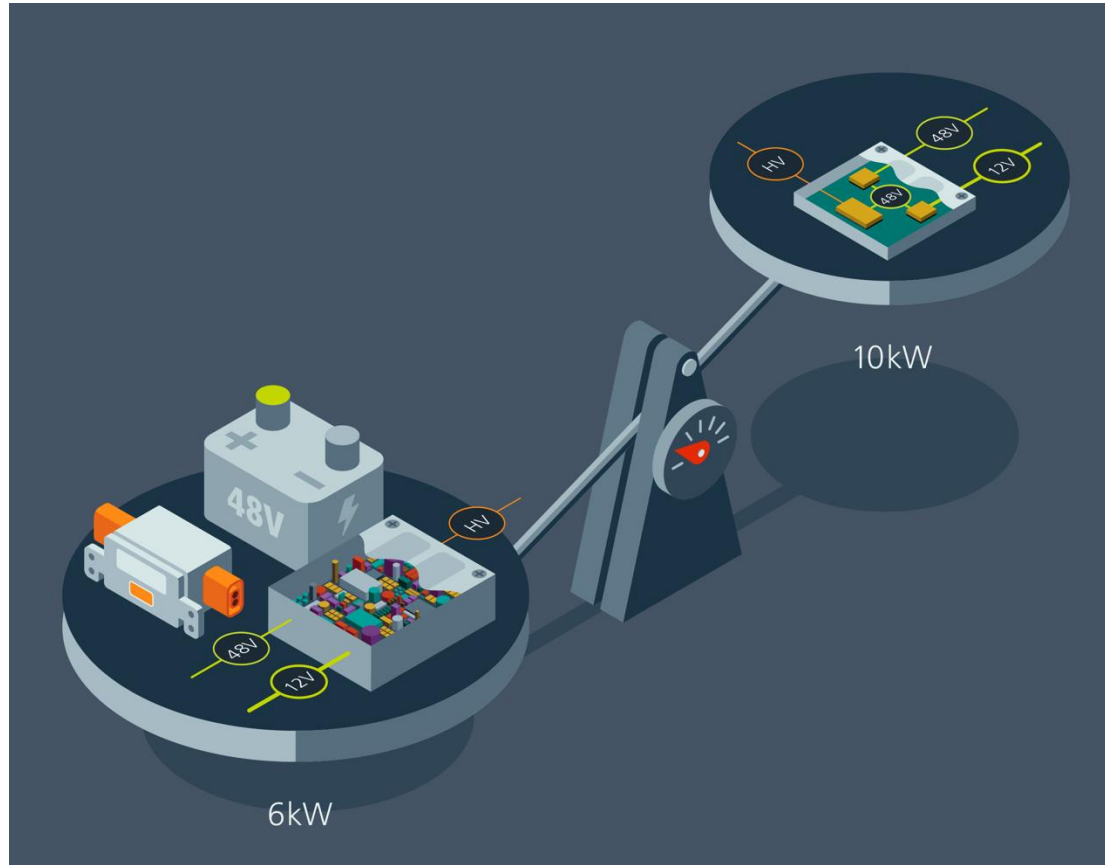
Isolation for user safety contained inside the module's 61 x 35 mm footprint

Can surge up to 30% for power events < 30 ms

Symmetrical buck/boost capability to directly supply regenerated power back to the HV battery

Power switching speeds that will exceed the control system processing times by over 100x

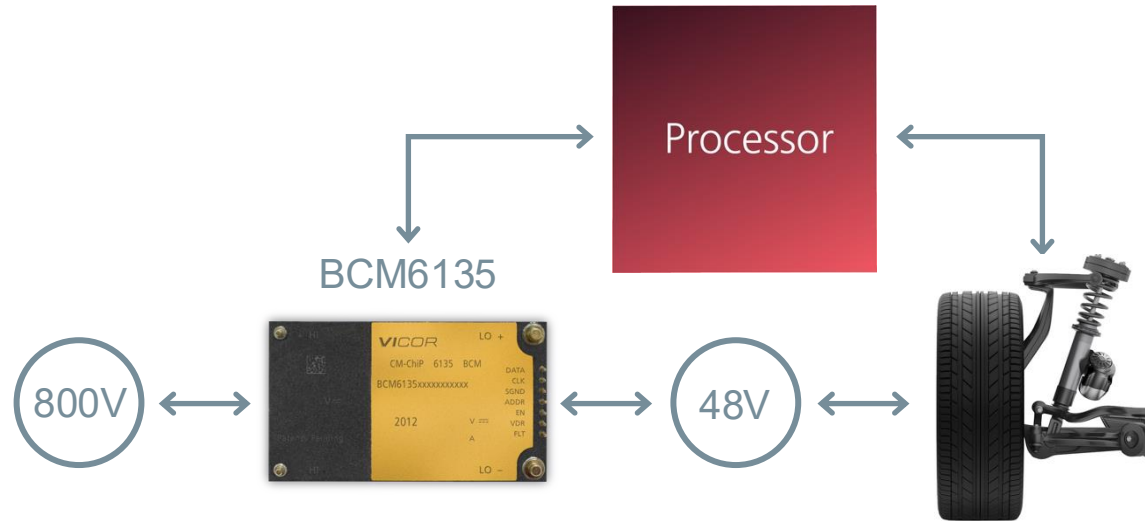
Sine Amplitude Converter systems provide more power from less space and weigh less



218 kW/L for 800V to 48V

500 kW/L for 48V to 12V

DC-DC conversion happens faster than ECU cycles with the BCM6135



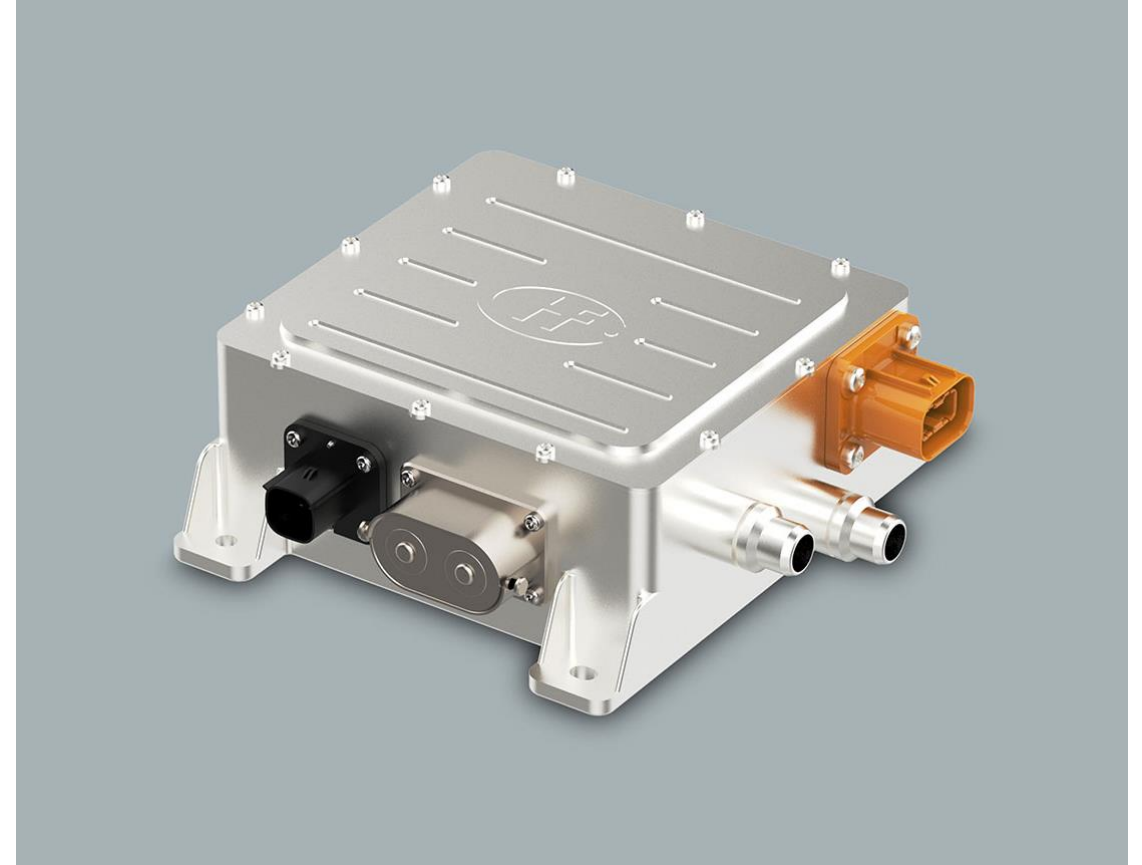
- ECU cycles average around 10 ms
- The BCM6135 reacts in under 10 μ s
- No lag in power conversion from 800V to 48V



The BCM6135 allows for the creation of a DC-DC converter with **best-in-class power density**

- Hongfa has used the BCM6135 in its compact 7kW DC-DC to be used with active suspension
- Power density of 2.5 kW/L and 2.7 kW/L
- Peak efficiency of 97.3%
- Up to 94% of the power drawn can be sent back to the HV Battery

HF3661 800V to 48V DC-DC active suspension power system	
Vin range	800V: 600 – 900V (DC)
Vout range	48V: 37.5 – 56V (DC)
Peak Efficiency	97.3%
Dimensions	197 x 201 x 71mm = 2.8L
Weight	2.6kg



Conclusion

- Symmetric performance of BCM6135 reduces the required power level for the DC-DC
- Transient performance eliminates latency in power delivery for suspension events
- The DC-DC converter will be reduced in size and weight, while eliminating super-capacitors or 48V batteries

