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Eliminating the High Voltage Precharge with Existing Hardware in BEV (24AE-0244)

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Agenda

- What is a precharge
- Why is it important
- Challenges precharging from a high-voltage source
- Regulation is required
- Comparisons of precharges
- Power flow
- Advantages of using a precharge from a low voltage source

Precharge prevents damage to parts and equipment

In-rush current is high

Small resistance μΩ

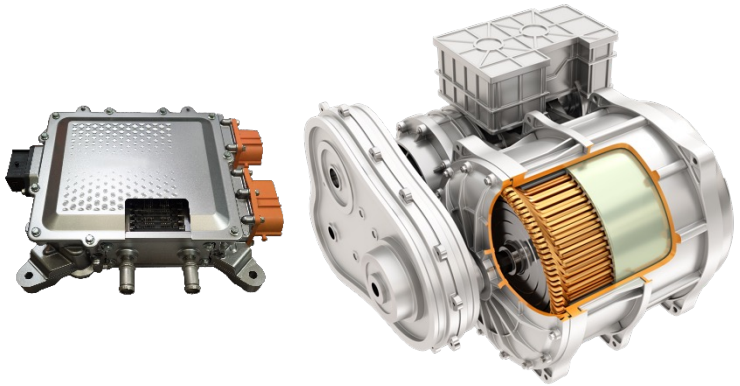
I = {800V – 0V} / μΩ

Starts at zero volts

8,000μF

800V Traction Battery

HUGE CURRENT



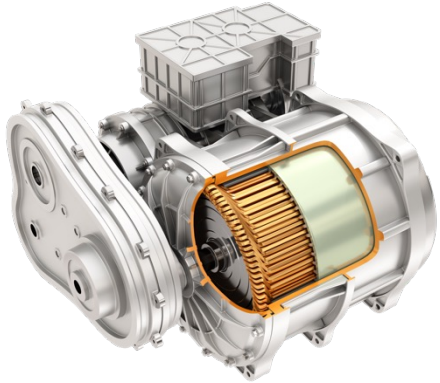
800V Loads

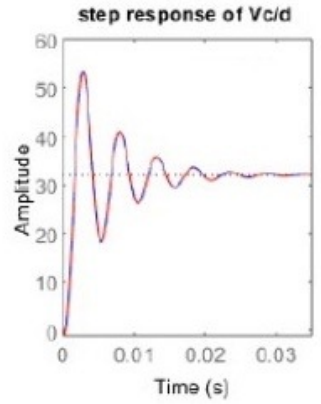
Ringing from dV/dt with loads C and L

800V Traction Battery

HIGH dV/dt

Results in ringing





The Challenge – Why Precharging from the HV bus may not be the best option

Extra components

- Weight
- Cost
- Lifecycle
- Wasted Power
- Mechanical

Why precharge fails

- Heat
- Repeated cycling in a short period causes the precharge resistor to overheat
- Accidentally having a load on, then the precharge never completes and burns up the precharge resistor
- If not used correctly designed, it easily destroys the HV circuits due to in-rush currents

Capacitance	Battery Voltage	Resistor Value	Precharge time	Avg Power
4mF	800V	50 Ohm	1.0 sec	1280W
4mF	800V	100 Ohm	2.0 sec	640W
6mF	800V	50 Ohm	1.5 sec	1280W
6mF	800V	100 Ohm	3.0 sec	640W

The Option – Charge from the Low Voltage Bus

12V Battery / Supercapacitor

48V Battery / Supercapacitor

48V Battery

Precharge from 48V

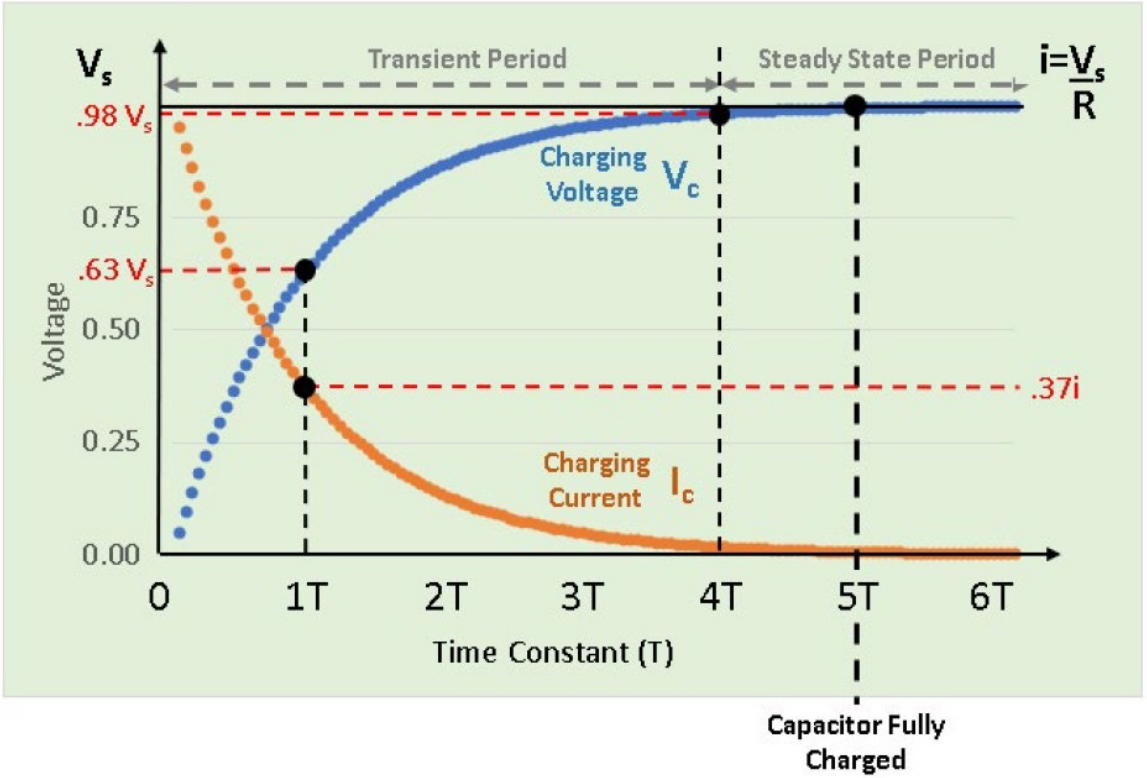
800V Traction Battery

Regulation required

Regulator required in the series powertrain

Regulated Option	Advantage / Disadvantage
12V to 48V Conversion	High current levels with high losses
48V to 48V Conversion	Lowest current and highest efficiency
48V to 800V Conversion	Most difficult and expensive

Charge time inversely proportional to power level

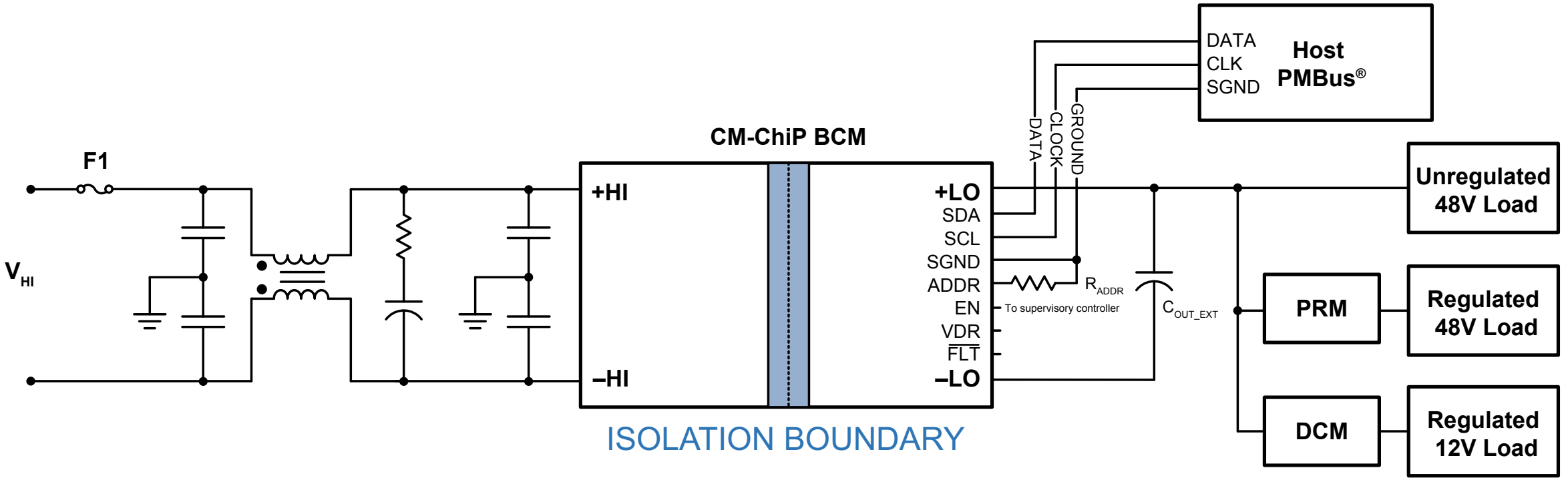


BCM6135 with K = 1/16

- Isolated
- Controllable V_{OUT} on the low side
- Has PMBus® to monitor the voltage
  - Readout from PMBus
  - HV is on the other side of the contactor → very useful

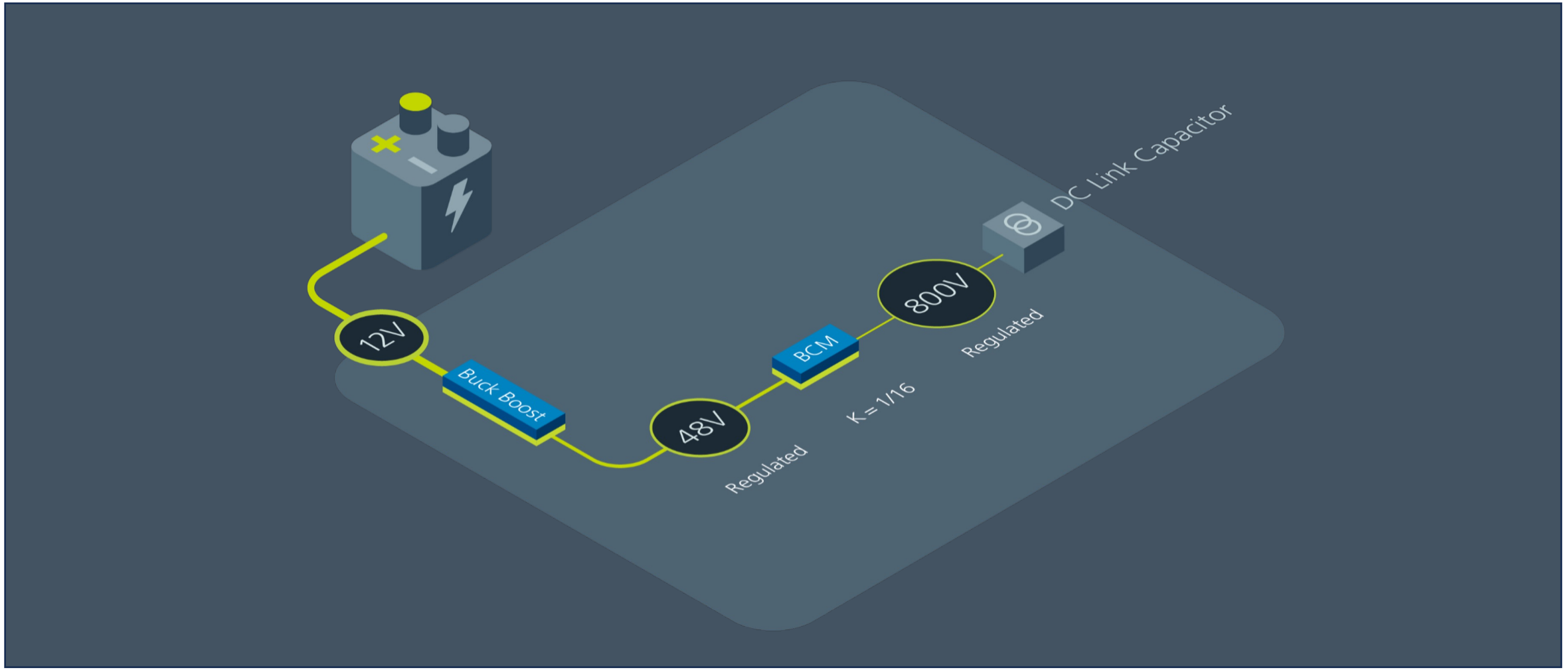
61.33 x 35.35 x 7.42mm	80A
68g	97.3% peak Efficiency

BCM6135 with K = 1/16

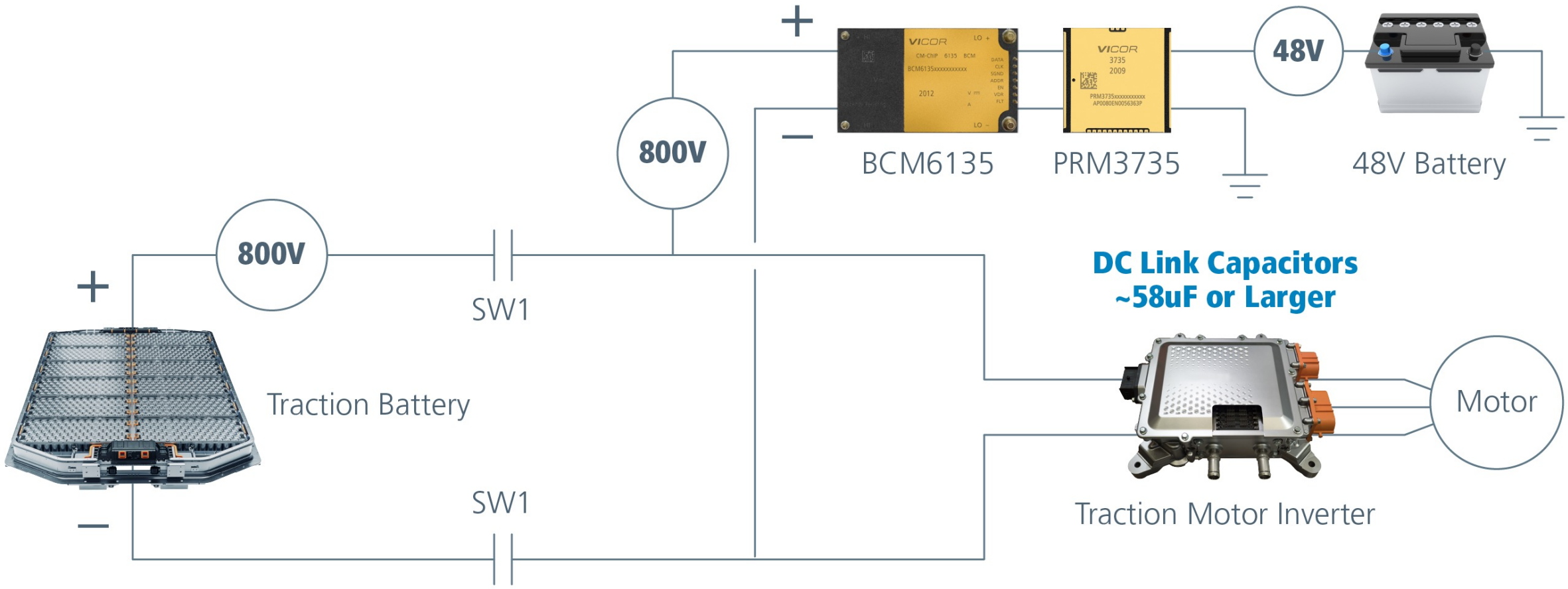


Need to control the ramp as C_{OUT} HI is limited to 0.39µF and the DC link cap is ~58µF and any input capacitance from loads

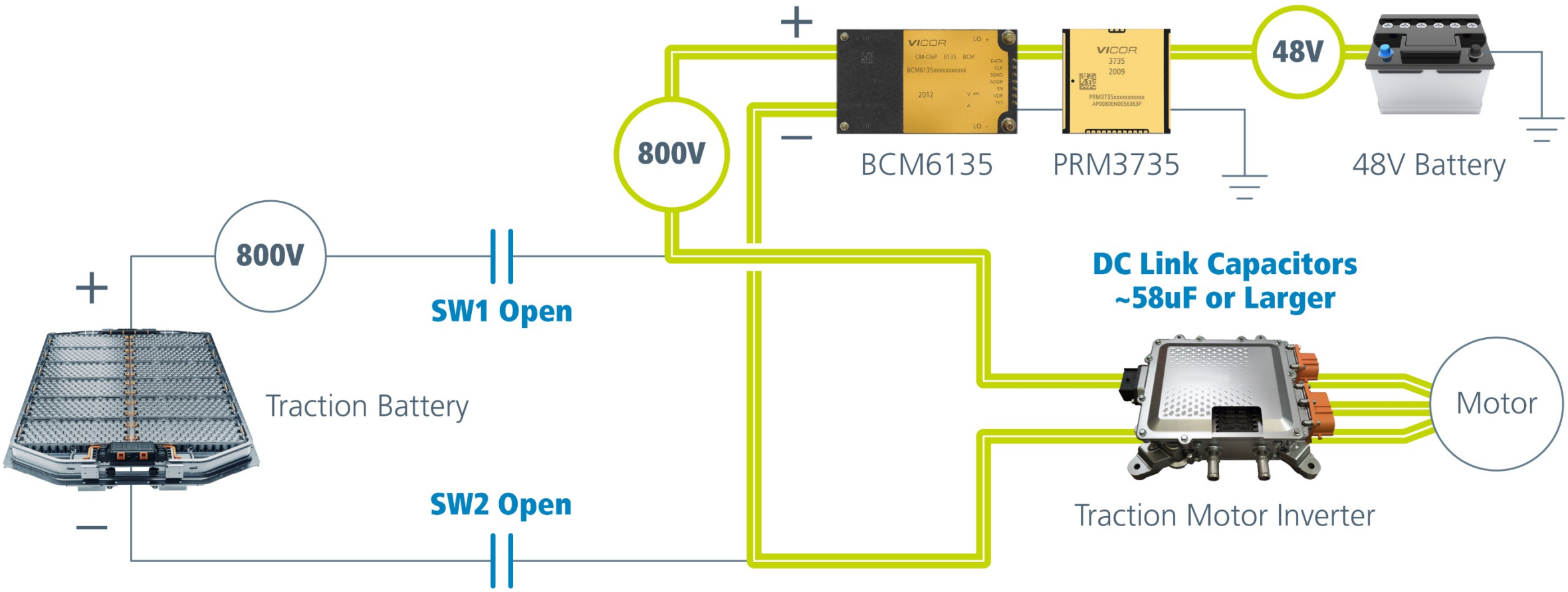
Using a 12V battery enables low-power regulated 48V bus at no cost



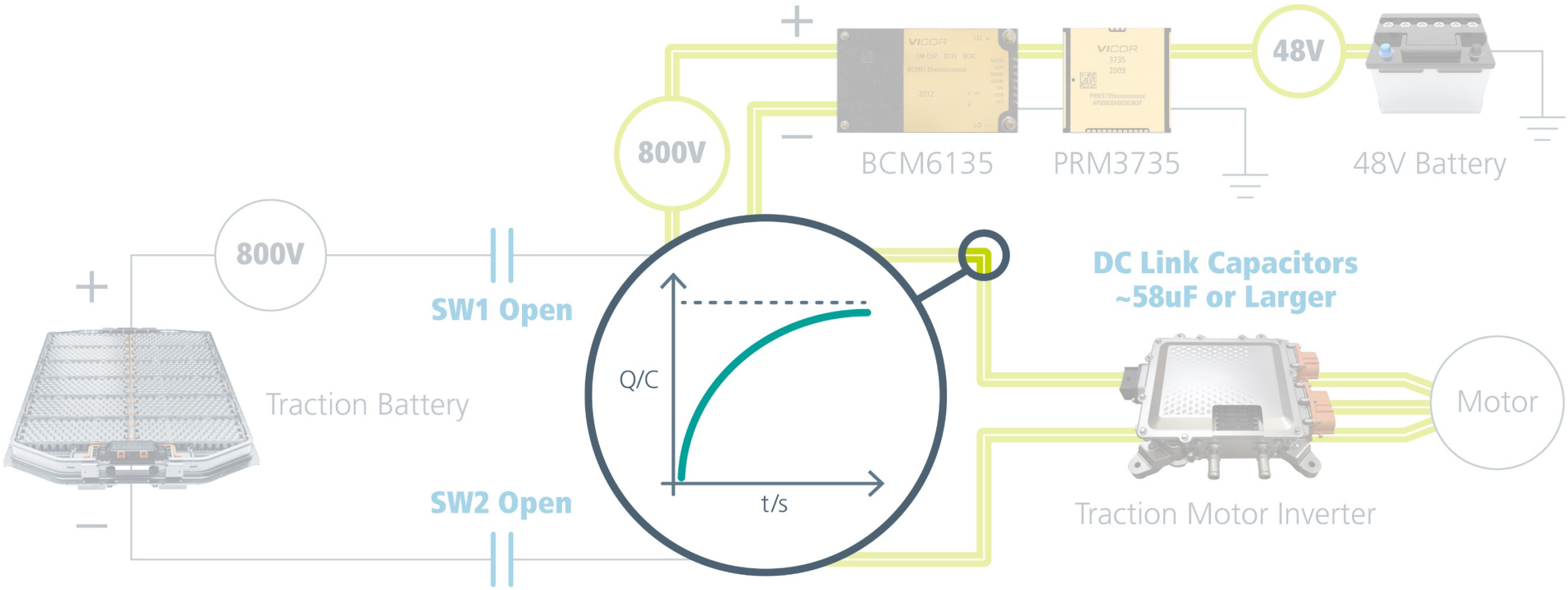
The Vicor Solution



The Vicor Solution



The Vicor Solution



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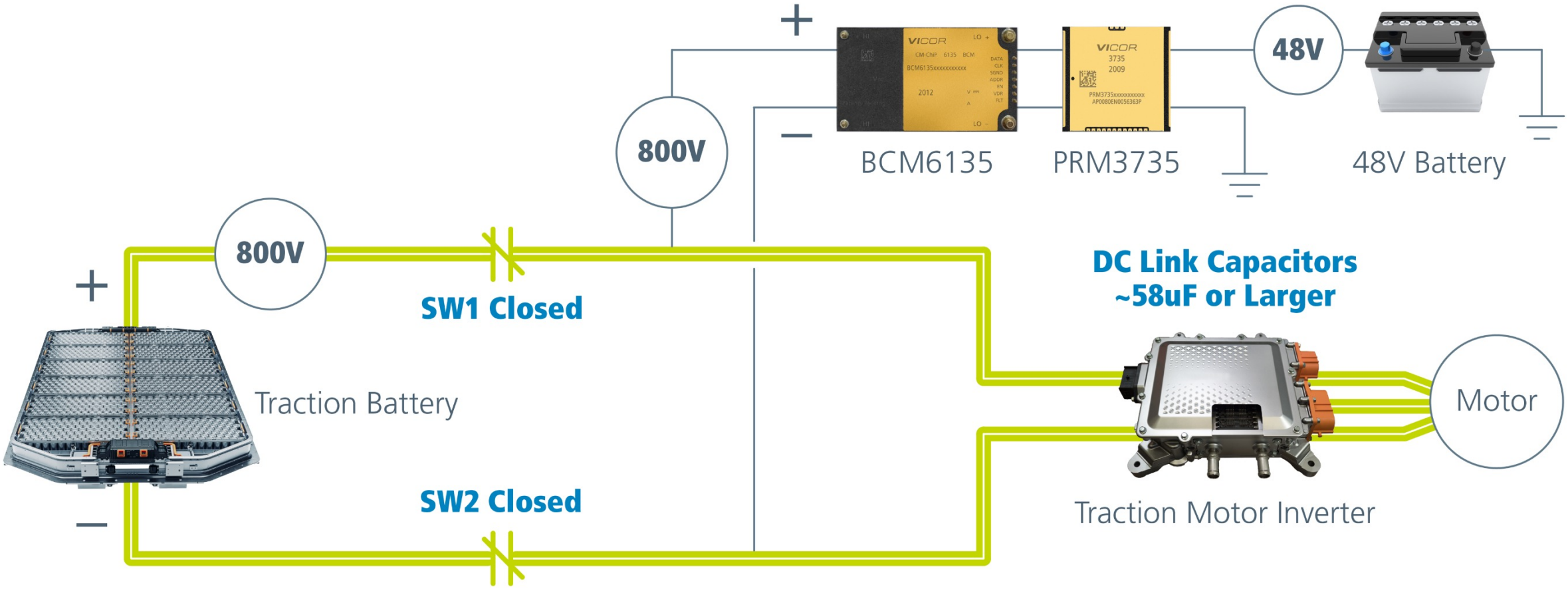


Example from the Lab

- Use a 48V source charging an 800V load with BCM6135 (K = 1/16)

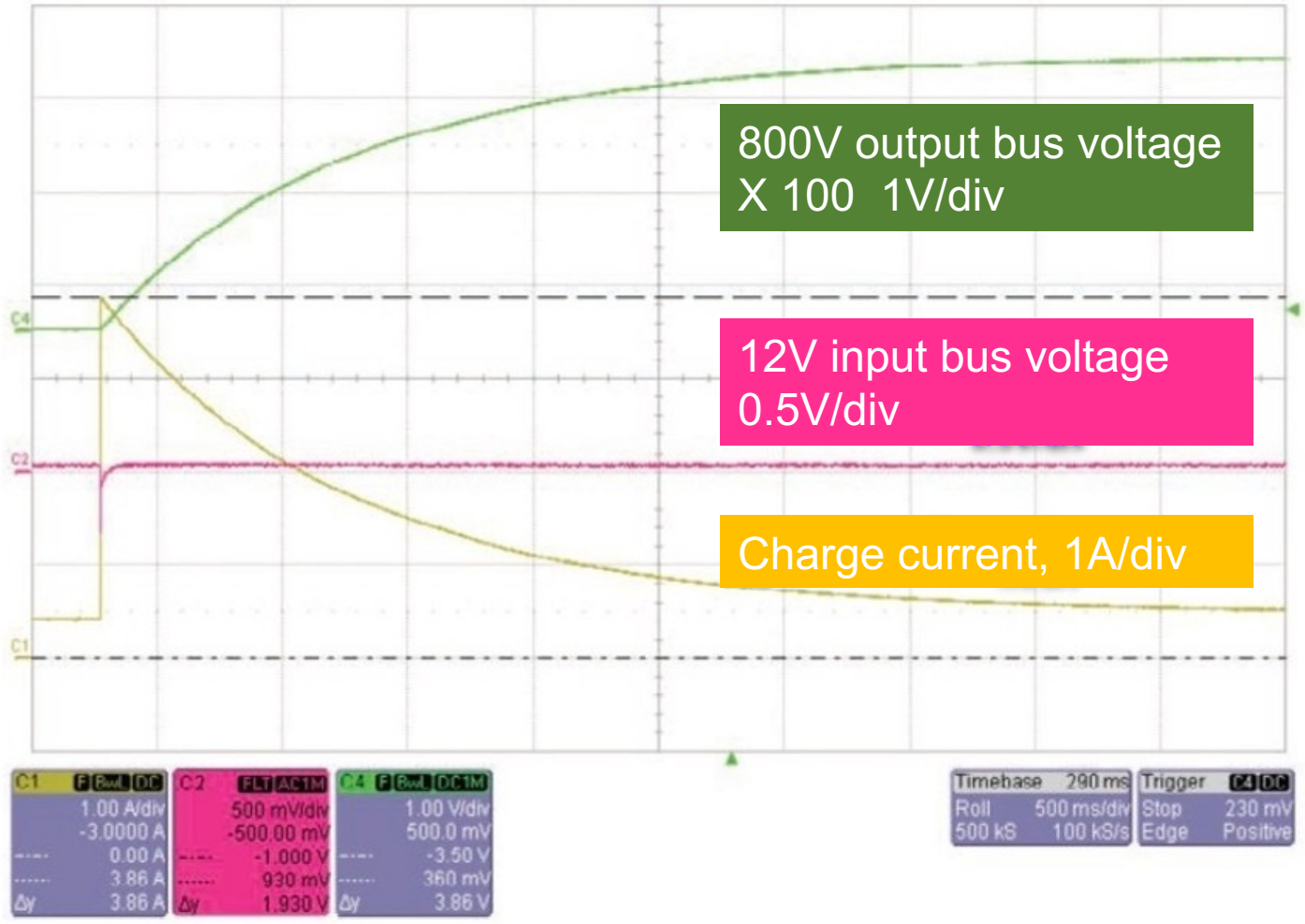
- Use a buck-boost with current control capability
  - Set current to 4.9A
  - Alternative ramp-up voltage on the 48V side slowly
    - Maintain 5A or lower on high side

High side (800V)	Low side (400V)
800V	48V
5A	80A

Charging the HV Bus from 48V Source

Transient test outcome

- Boosted output with x100 attenuation
- LV bus voltage
- Controlled secondary-side In-rush current



Conclusion – Benefits

- Reuse existing hardware
- Cost savings
- Safer
- Compact in size

- High efficiency
- No series resistor
- Longer range
- Future proof
- Energy savings
- Safer to prevent overheating or fires
- Weight savings
- Faster
- Get a bonus 48V node

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Thank you

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Questions?

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