How to Design Multi-kW Converters for Electric Vehicles

Part 1:	Electric Vehicle power systems
Part 2:	Introduction to Battery Charging
Part 3:	Power Factor and Harmonic Currents
Part 4:	Power Factor Correction
Part 5:	The Phase Shifted Full Bridge
Part 6:	How the PSFB works
Part 7:	A High Power On Board Charger Design
Part 8:	MOSFET gate driver considerations and References

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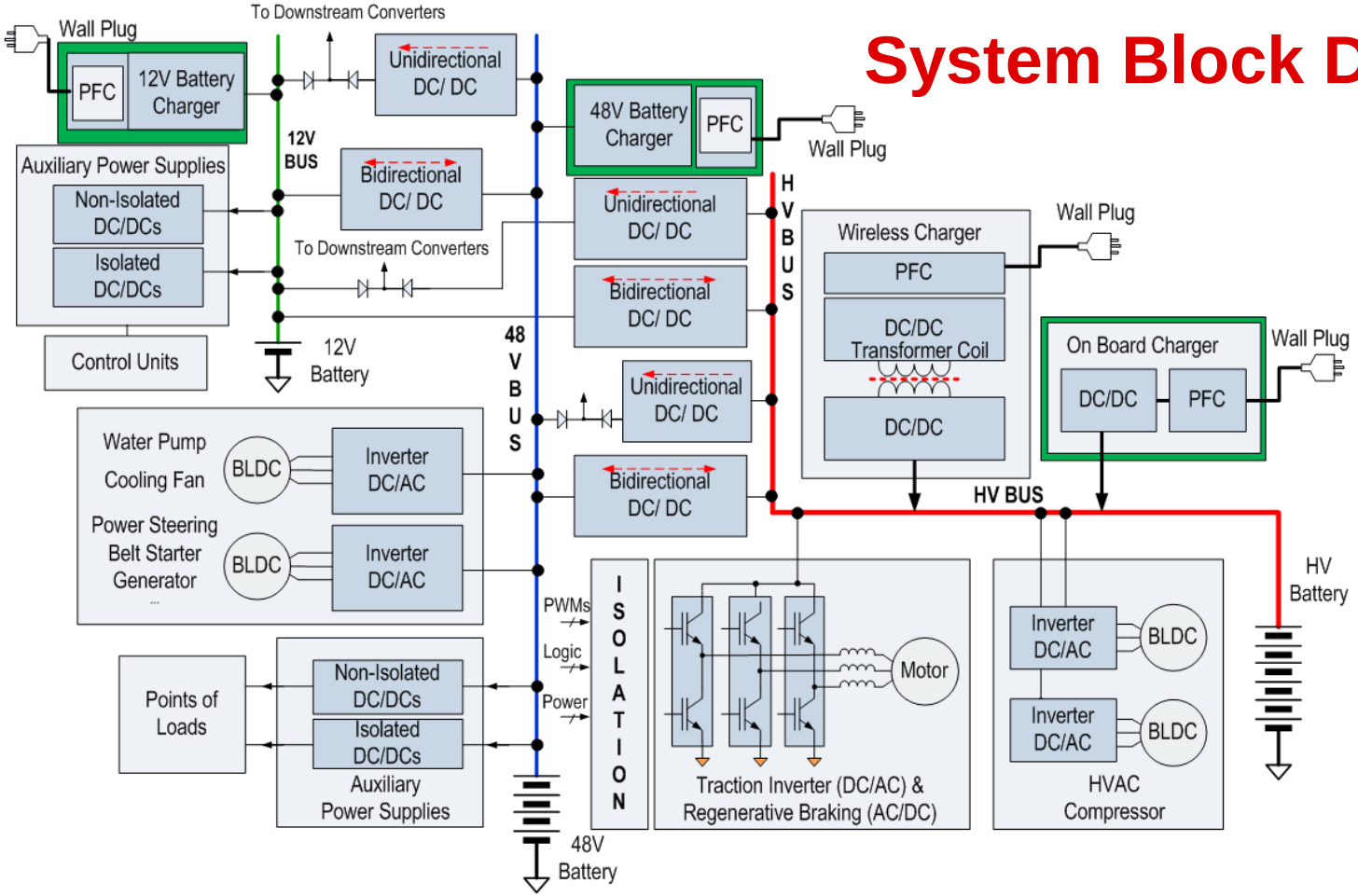
System Block Diagram



Potential OBC Applications (green)

PFC

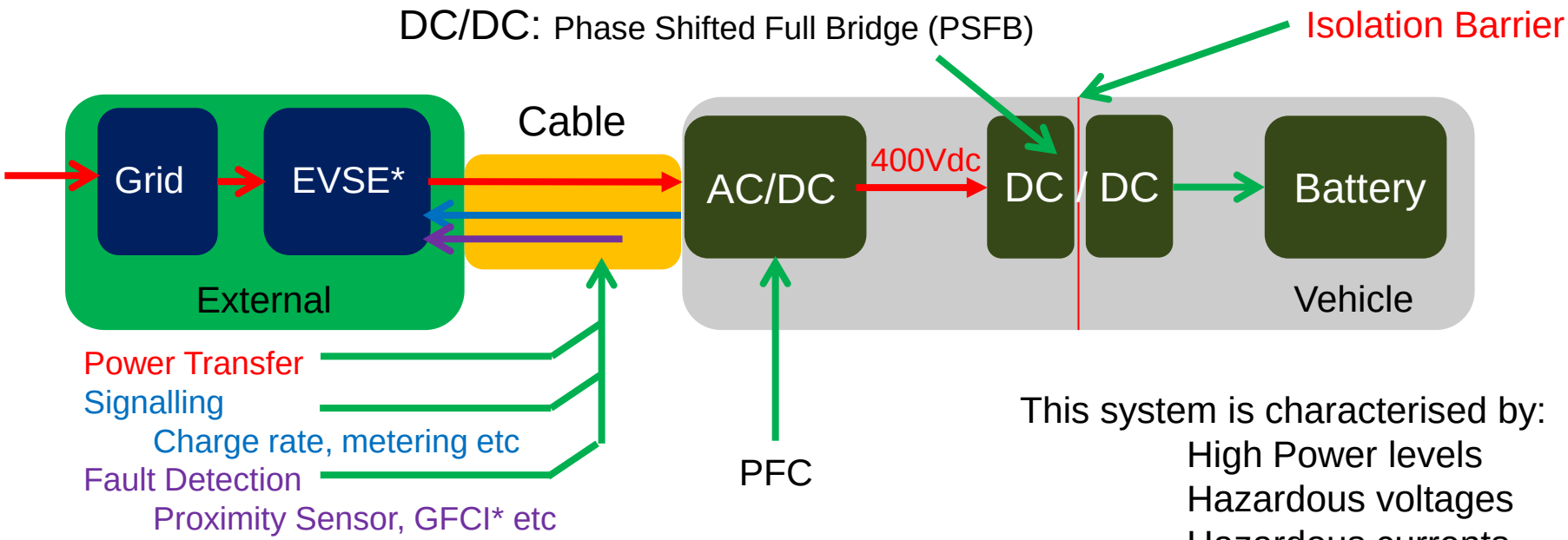
Unidirectional

High Power

ZVS for low loss on HV inputs

Interleaved PFC reduces stress and EMI

Typical high power system: EV charger



Charger power levels (SAE)
Level 1: Single phase: AC power, 1.92kW
Level 2: Split phase: AC power, 19.2 kW
Level 3: DC power, 240kW

This system is characterised by:
- High Power levels
- Hazardous voltages
- Hazardous currents
- Harsh environment

*EVSE – Electric Vehicle Service Equipment
*GFCI – Ground Fault Current Interruptor
(EVSE) Reference Design, tidub87

On-Board Charger (OBC)

What is the On-board Charger?

- An On Board Charger is used in an electric vehicle (EV) or hybrid electric vehicle (HEV) to charge the traction battery (48V or HV usually ~400V)
- This includes:
  - Converts the grid 50/60Hz into DC
  - Adjusts the DC level to the levels required by the battery and provides the galvanic isolation
  - Includes a Power Factor corrector (PFC)

What does this EE consist of?

- **PFC Controller and Rectification**
  - High Efficiency rectification with lowest harmonic impact to the grid
- **Controller**
  - Analog or Digital Control (<2kW to >100kW)
  - Adjusts the DC level to the levels required by the battery
- **Galvanic Isolation**
  - Galvanic Isolation Grid to Battery
  - Bias Supply
- **Diagnostics**
  - Temperature Sensing
  - Current & Voltage Sensing
  - Iso Barrier

A brief word about efficiency

Is 99% efficiency really so much better than 98% efficiency ?

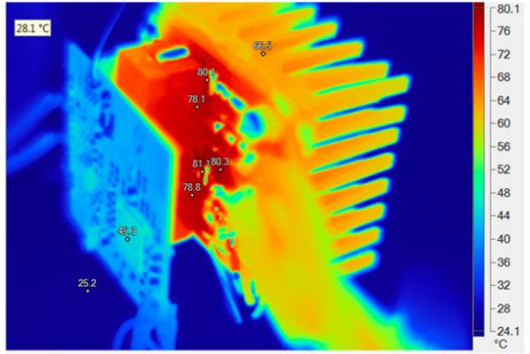


Figure 28. Thermal Image Captured After 30 Minutes When Delivering 310 W at 16.4-V Battery

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A brief word about efficiency

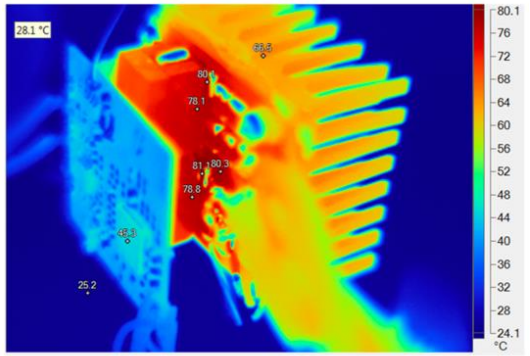

Figure 28. Thermal Image Captured After 30 Minutes When Delivering 310 W at 16.4-V Battery

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Is 99% efficiency really so much better than 98% efficiency ?

YES – of course it is

Better to think in terms of power loss

- 2kW at 99% efficiency => 20W of loss
- 2kW at 98% efficiency => 40W of loss – twice as much heat to shed

At constant power, as product gets smaller:

– surface area reduces & temperature rises

Best solution to reducing temperature rise is to reduce losses –

- This eases thermal design
- Allowing replacement of expensive liquid cooling with lower cost air cooling !

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Thank You

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