Wolfspeed SiC Power solutions for EV Charging

20kW Off board fast Charger system

A CREE COMPANY

REQUIREMENTS

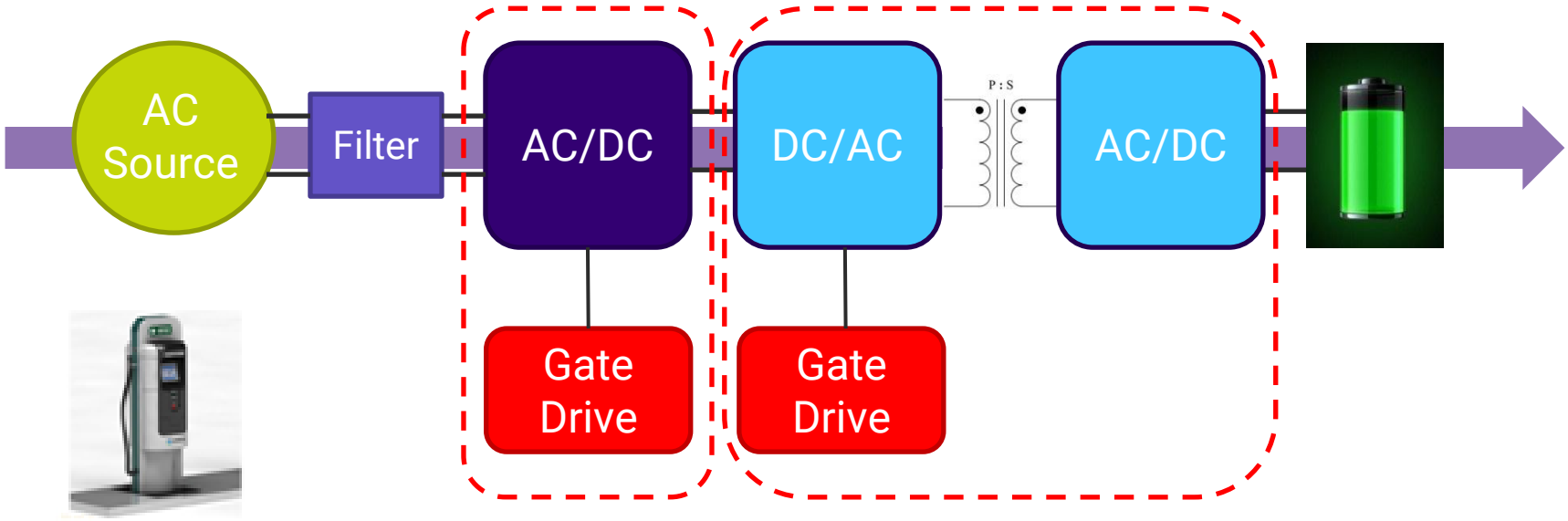
- The traditional way to meet these requirements is with a two-stage topology: AC/DC and DC/DC
- AC/DC focus on input THDi and provide a somewhat constant voltage to the DC/DC stage
- DC/DC provides galvanic isolation and output voltage/current control suitable for a charger application

Parameter	Ref.	Value and description
Input Voltage	Vin	3-ph, 50Hz +/- 6%, 380 Vac l-l rms +/- 10%. 4-wire, 3ph + N + PE
THDi	%	<5%
PF	n/a	>0.9
Output Voltage	Vo	200 – 570 VDC
Max. continuous Output Power	Po.max	20 kW
Max. output current	Io.max	50 Adc
Operating temperature range	T.op	-30C to +50C (typically de-rated at higher temp)
Galvanic isolation	Viso	Yes, 2.5kV isolation.
Efficiency		> 90%
Surge withstand requirements		Not known
Uni-directional or bi-directional		Mostly uni-directional, maybe bi-directional needed in future.

OFF BOARD EV CHARGING IMPLEMENTATION

- **Background**
  - Most existing silicon designs target 12-15KW
    - Modified Vienna PFC + Interleave 3L LLC DC/DC + Full Bridge output rectifier
    - Common 650V silicon MOSFET parts with reasonable efficiency :
    - Silicon dc-dc stage is 97.5% max at 50% load / 550V.
    - Si Vienna is 98% so total efficiency of best silicon solution is 95.5%, typical silicon solution is 94-95%
    - Trend is moving towards 700V DC output.
- **Where Wolfspeed Silicon Carbide makes the difference**
  - Increase power density – 20KW in same form factor + higher efficiency and lower system cost $/kW
    - Existing silicon15KW challenged to achieve 20KW with similar topologies and device cost
    - 20kW gives better system $/W
    - Maximum higher power density per footprint for modularization to 80kW-120kW
    - Drive for higher efficiency (Now 94% is the silicon entry level, we target SiC achieve >96%)
- **Wolfspeed Solution : All SiC 20KW Turnkey design for off board**
  - 3 phase 6-switch PFC to replace the Vienna PFC (in design)
    - Higher frequency with comparable system cost to give better power density
    - Easy design with 2 level topology
    - Highest efficiency
    - Bi- directionality
  - DC/DC Stage
    - 2 level Full Bridge LLC for 200-550V O/P (complete) , 2 level Phase shift Full Bridge for 200-700V O/P (complete)
    - Highest efficiency available
  - Full working hardware solution complete and evaluated by Mid June
    - Design files, performance data suite, Gerber files, BOM & reference hardware will be made available

Wolfspeed SiC enables smaller, cooler and lower $/kW in Off Board EV Chargers



- Use SiC devices to achieve ***increased performance, improved efficiency, and reduced size and weight***.
  - Minimize weight and volume with ***high-frequency switching***
  - Reduce required thermal management by less device loss

Wolfspeed SiC solutions for EV Charging

20kW Phase shift dc-dc module design

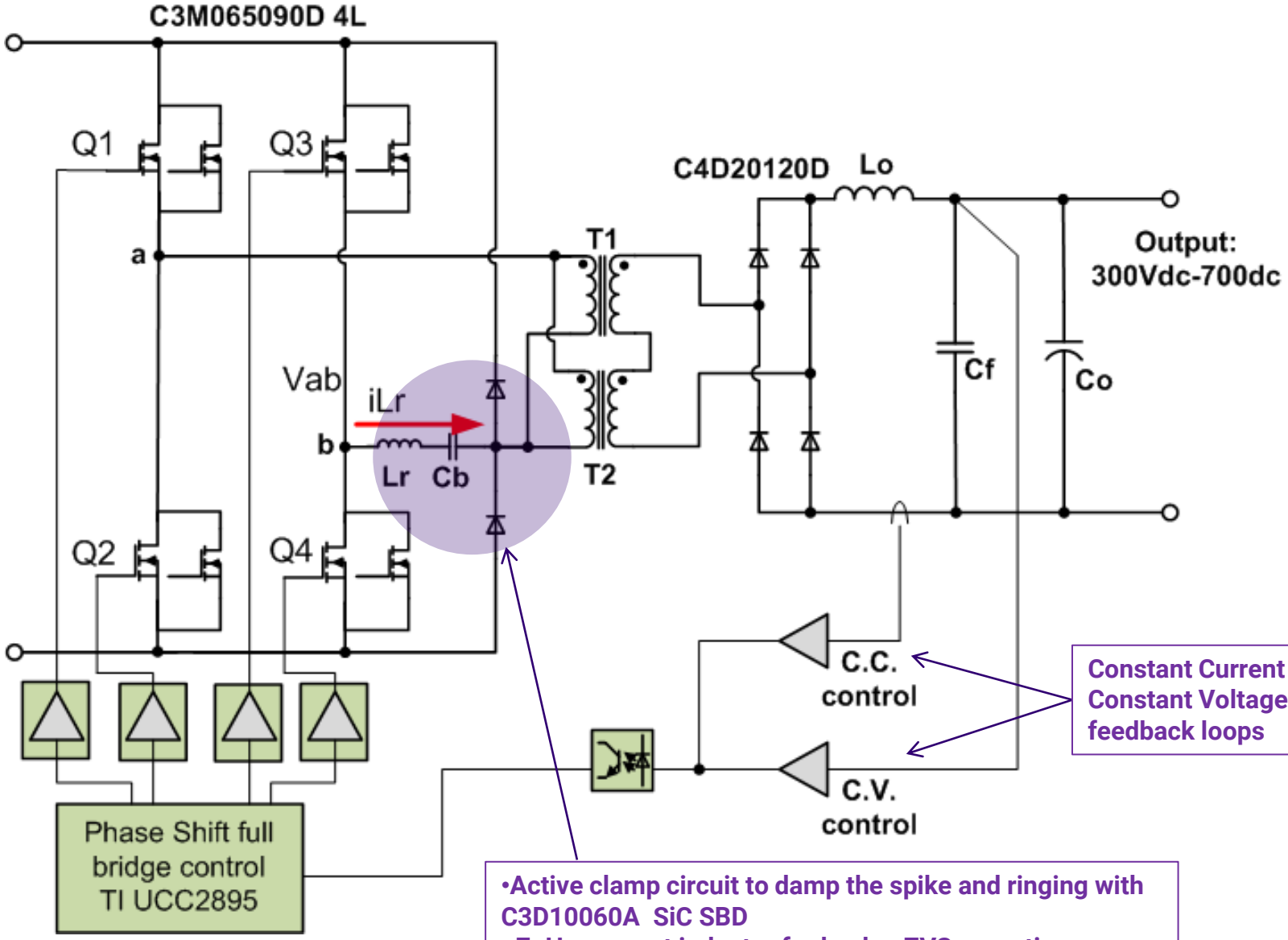
Vo/p 300V to 700V

A CREE COMPANY

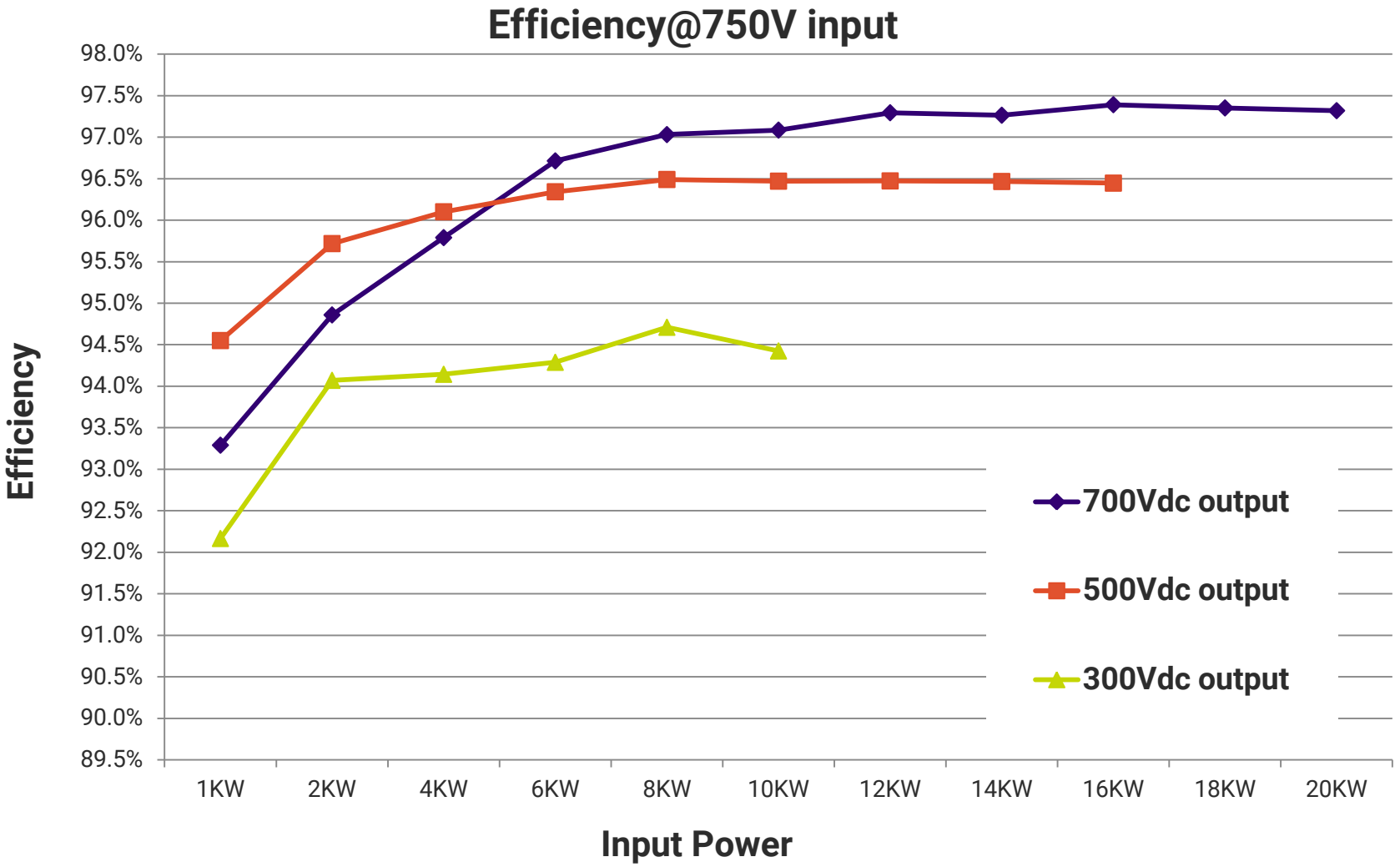
20KW PHASE SHIFT REFERENCE DESIGN SPECIFICATION

- Input voltage: 700Vdc-750Vdc
- Output Voltage: 300Vdc-700Vdc
- Frequency: 200KHZ
- Output power: 20KW
- Output Max Current: 30A
- Power Density: >45W/cube inch
- E-cap free with long life time and high reliability
- Wolfspeed devices: 8pcs C3M0065090D 4L, 4pcs C4D20120D, 2pcs C3D10060A and 1pcs C2M1000170D
- Applications: EV charger, EV DC/DC and HVDC

20KW PHASE SHIFT REFERENCE DESIGN BLOCK DIAGRAM

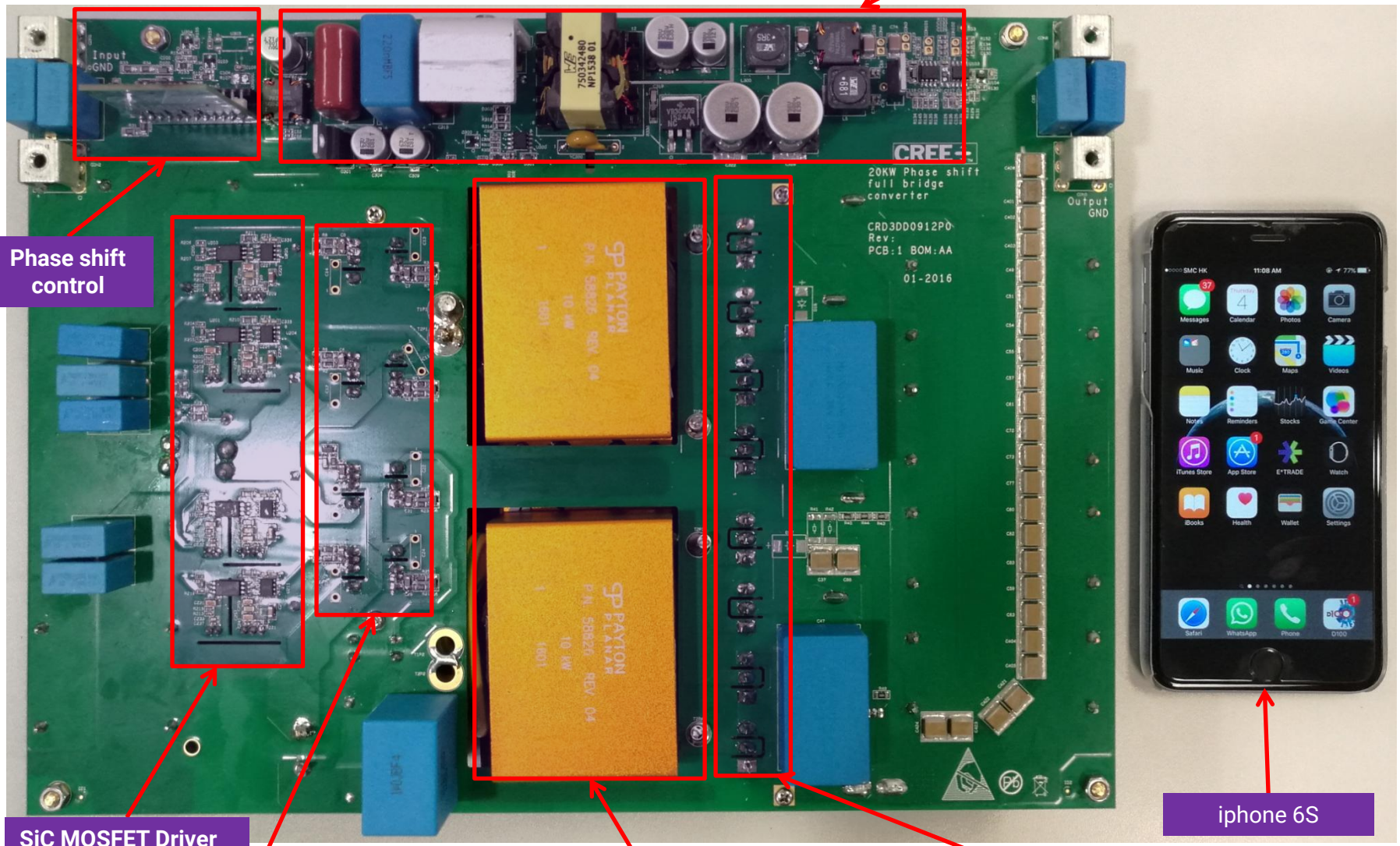


EFFICIENCY AT 750V INPUT

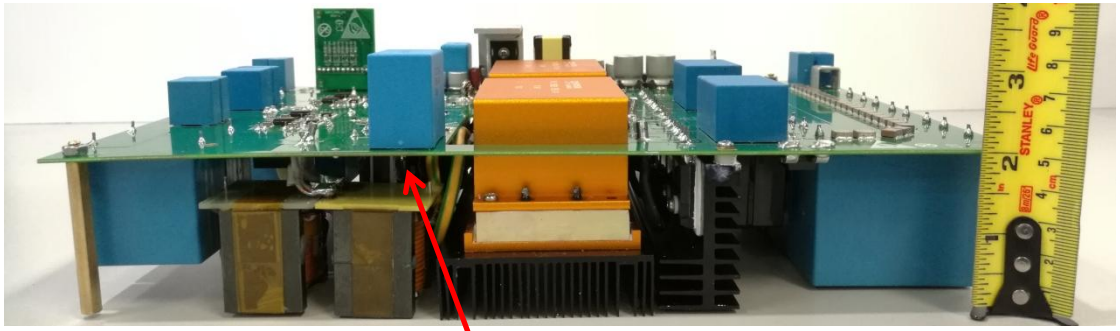


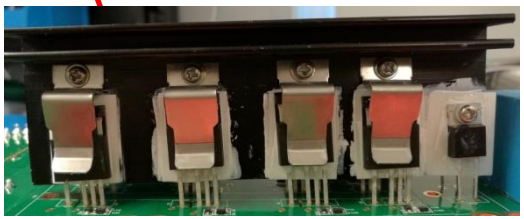
Note: the efficiency includes aux power losses with air-forced fan cooling

20KW PHASE SHIFT DCDC CONVERTER



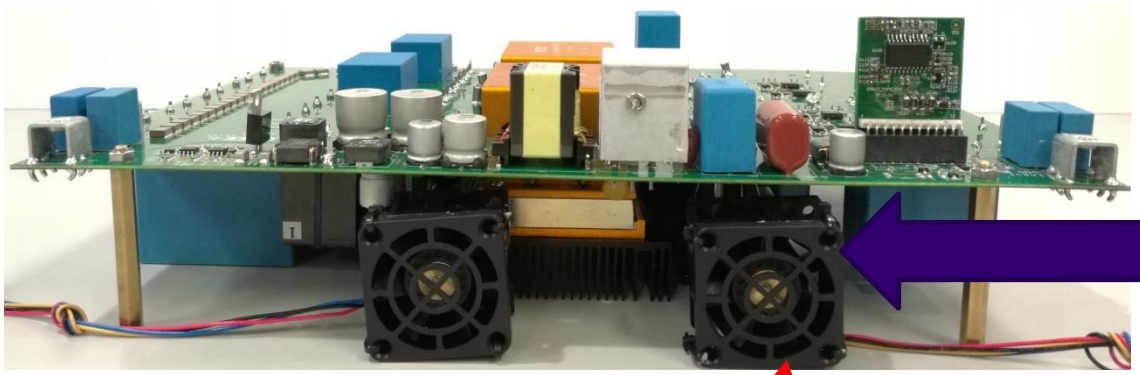
SIDE PICTURE OF 20KW PHASE SHIFT DEMO BOARD

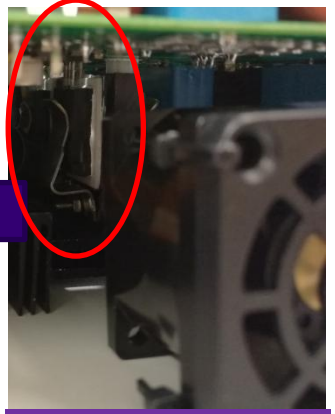




SiC MOS C3M0065090D 4L with heat sink

C3M0065090D 4L





12W air-forced fan cooling

Fan cooling MOSFET

WOLFSPPEED 20KW OFF BOARD EV CHARGING IMPLEMENTATION

- **20kW LLC Dc-Dc Paper design kit (PDK) –**
  - Design & layout files
  - Schematic
  - BOM
  - Component spec sheet
  - User guide

- **20kW Phase shift Dc-Dc Paper design kit (PDK) –**
  - Design & layout files
  - Schematic
  - BOM
  - Component spec sheet
  - User guide

- **20kW Phase shift Dc-Dc & 20kW LLC dc-dc demo boards -** Available to purchase end of June 2016
- **20kW Active front end Ac-Dc**
  - Paper design kit and hardware demo boards available – End August (estimate)

Thank you

A CREE COMPANY