Powering the Future with Wolfspeed SiC Technology

-- Wolfspeed SiC power solutions and Practical Implementation of SiC MOSFET

Agenda

- Wolfspeed SiC power solutions
- Practical Implementation of SiC MOSFET

Wolfspeed SiC power solutions

- Wolfspeed advantage for SiC power systems
- Wolfspeed SiC power solutions on key applications

Wolfspeed SiC power solutions

- Wolfspeed advantage for SiC power systems
- Wolfspeed SiC power solutions on key applications

THE SiC ADVANTAGE

SiC | The Basics

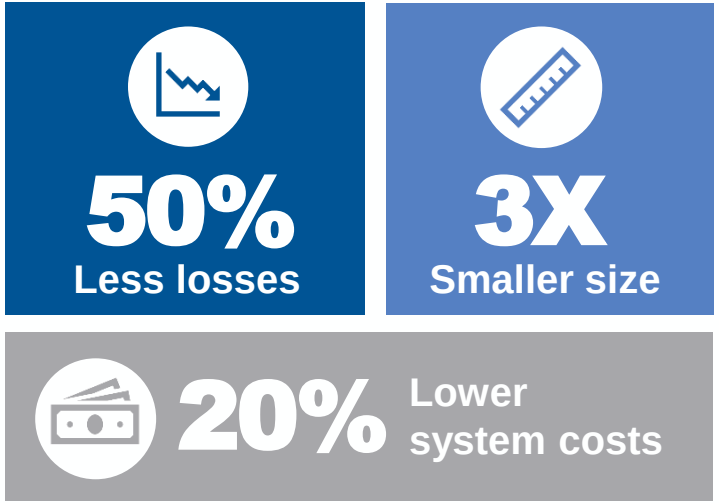
Types of SiC Power Products:

- Schottky Diodes
- MOSFETs
- Standard packaged discrete, bare die and power modules

Silicon Carbide vs. Silicon in Similar Devices:

- Higher power conversion for given die size
- Faster switching speeds
- Better body diode
- Higher potential operating temperature

SiC ENABLES SYSTEMS THAT DELIVER UP TO:



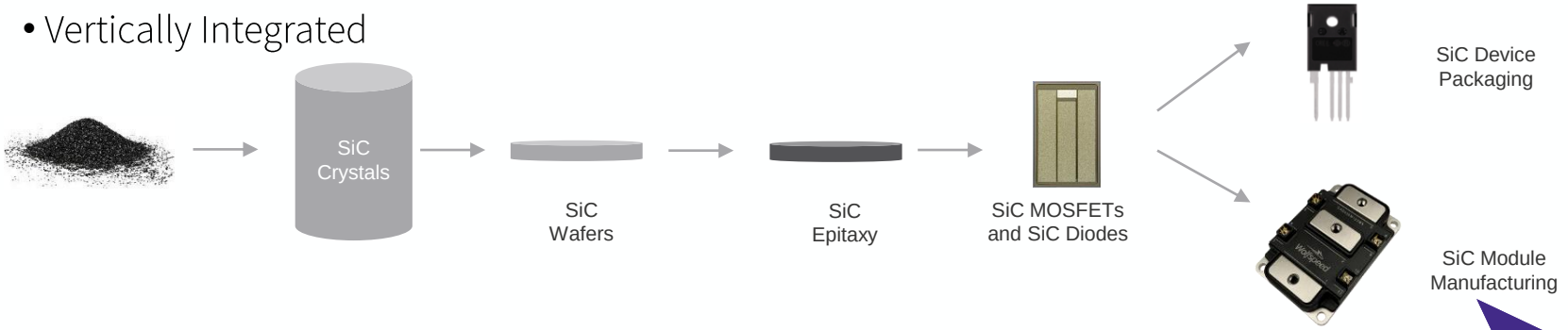
WHEN COMPARED TO Si

THE WOLFSPEED ADVANTAGE

Wolfspeed – The Leader in Silicon Carbide (SiC)

- Three decades of global leadership in wide bandgap materials (SiC, GaN)
- ~3700 SiC and GaN patents issued
- 17+ Years of Diode and MOSFET Production
- #1 SiC materials supplier – SiC wafers, SiC and GaN epi wafers

  > 65% Market share
- #1 SiC Power devices supplier
- Vertically Integrated



Adoption of SiC into Various Applications – It's all around

PV Inverters

Shipping in high volume

- MOSFETs
- Diodes
- Modules

EV Battery Charger/DCDC

Shipping in high volume

- MOSFETs
- Diodes
- Modules

Server Power Supply

Shipping in high volume

- MOSFETs in evaluation
- Diodes shipping in high volume

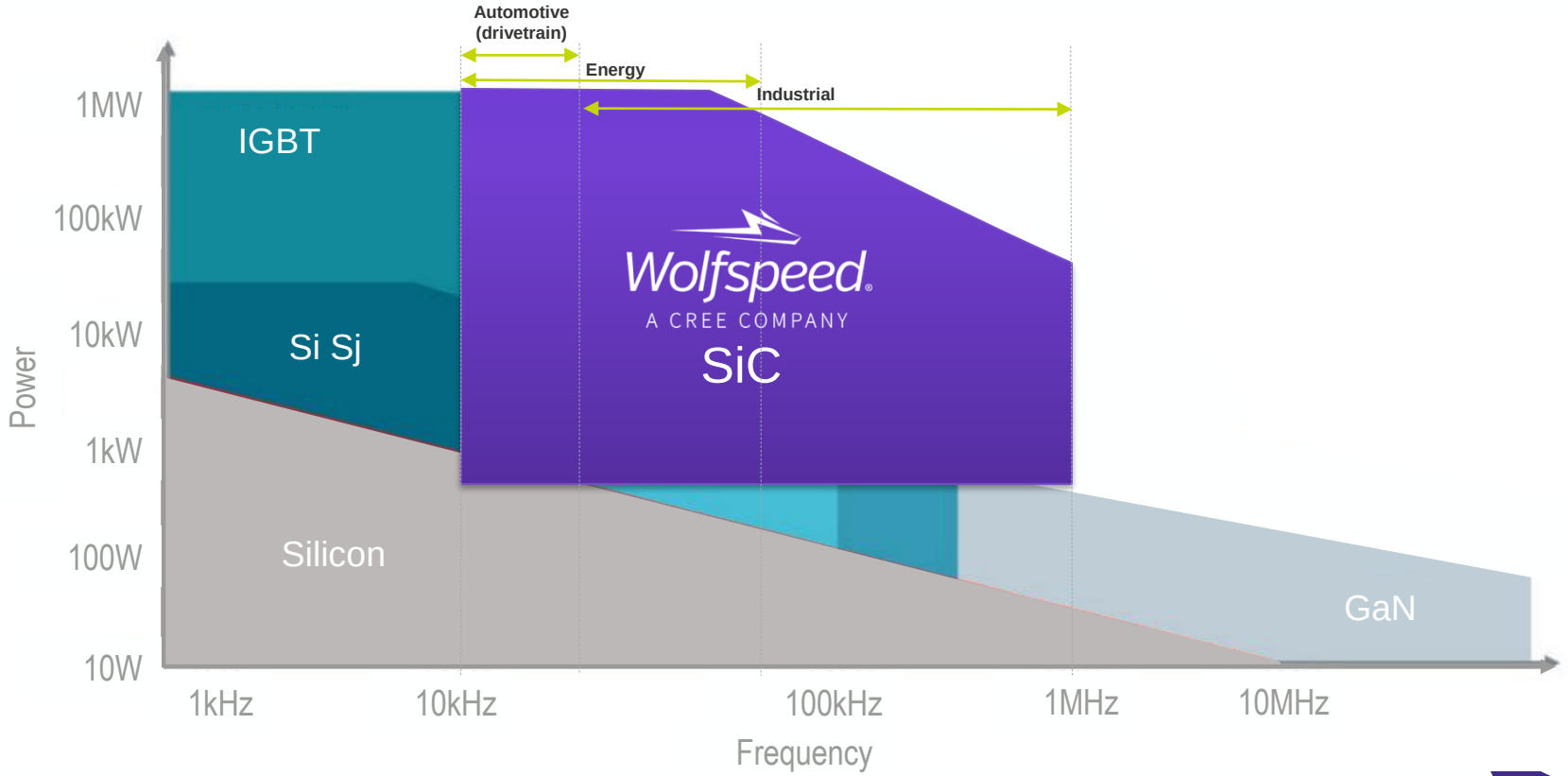
Traction

Shipping in volume

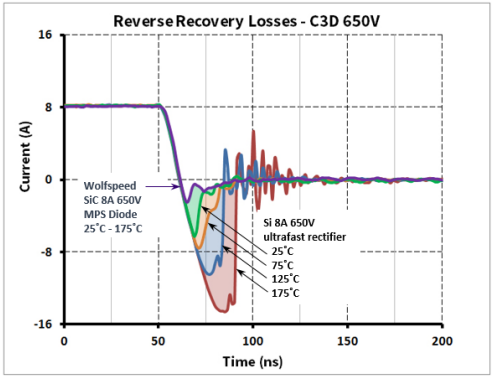
- SiC Modules

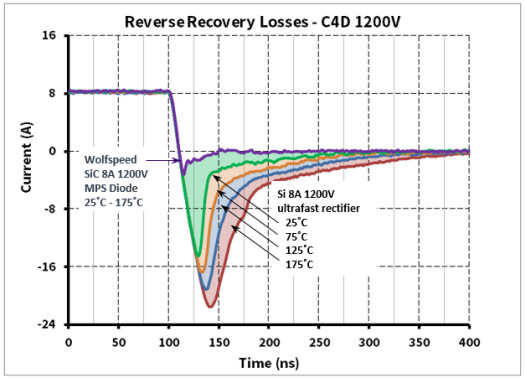
THE SiC ADVANTAGE

Where does SiC fit in the power world?



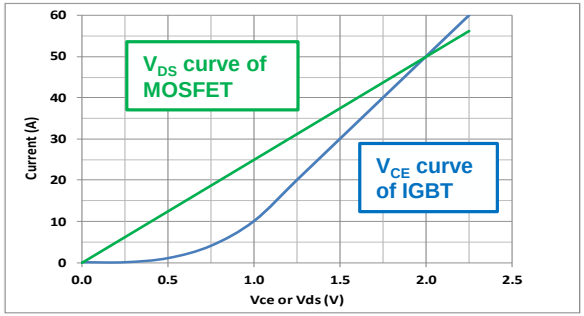
Technology Vs Technology



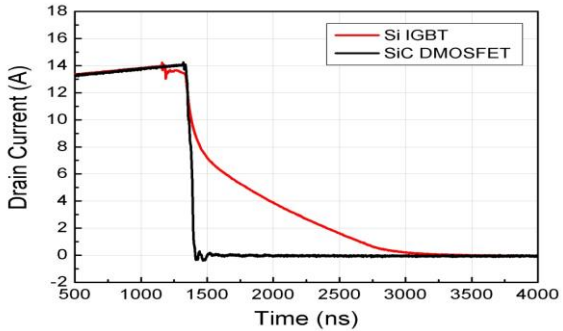


SiC Schottky ~zero reverse recovery charge (Q_{RR}) replace high-loss silicon PIN diodes

Conduction Loss
1200V SiC MOSFET vs. Si IGBT



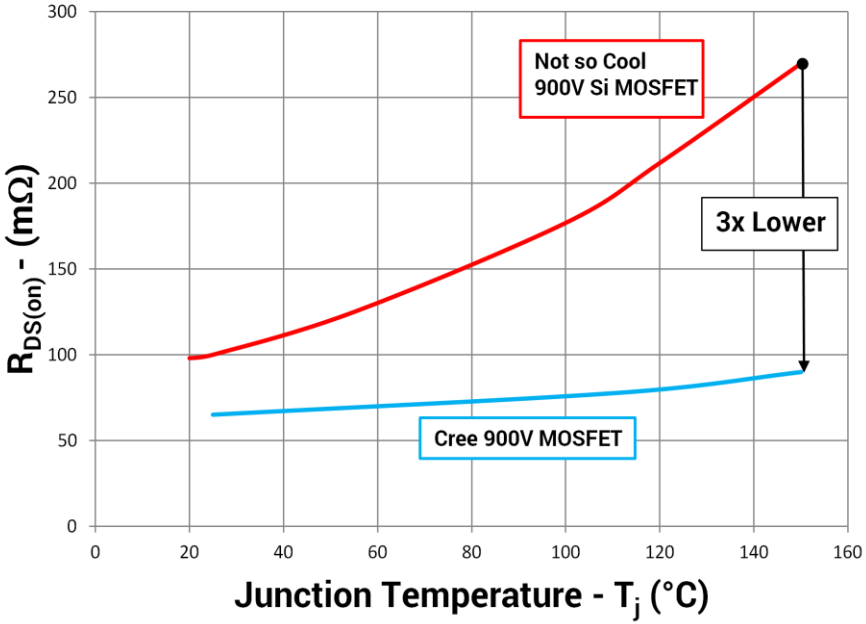
Switch Loss
1200V SiC MOSFET vs. Si IGBT



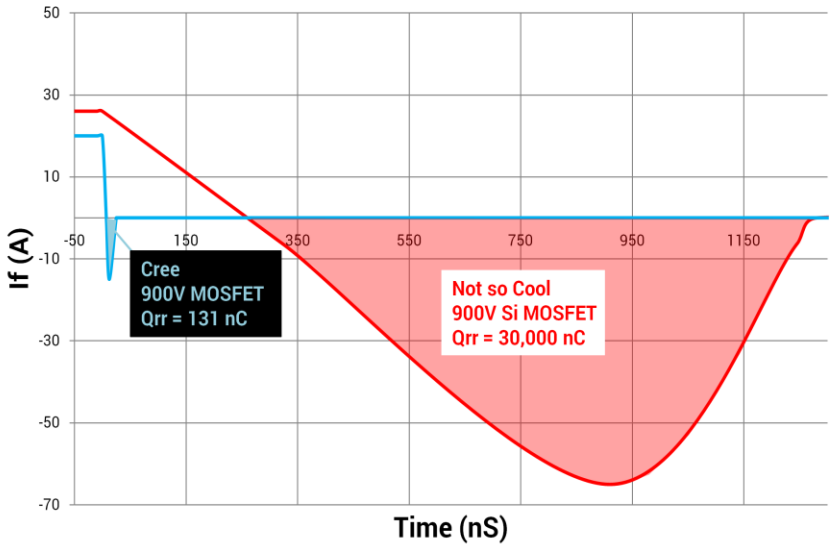
- Under lower loads the SiC MOSFET conduction losses are as much as 1/2 the IGBT
- IGBT tailing current eliminated with SiC
- SiC MOSFET: 400 mJ
- Si IGBT: 4490 mJ

SiC MOSFET vs. Si Superjunction MOSFETs – energy losses

Significantly Lower $R_{DS(ON)}$ Over Operating Temperature



Dramatic Improvement in Body Diode Performance

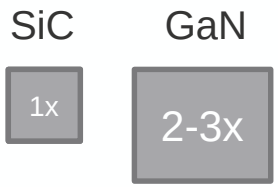


SiC vs. GaN in Power Applications

- SiC is the technology of choice for **high voltage** (>600V), **high power** (>500W), and <1MHz switching frequencies
- GaN on Si *could* be used in the <600V range when fast switching is required, but total cost can become prohibitive
- GaN on SiC is the technology of choice in **RF power** applications that require GHz switching speeds at low voltages

	650V 30A SiC	650V 30A GaN
$R_{DS(on)}$	80mΩ	50mΩ
Price	$7.05	$14.56

Source: Mouser, 250pc price for Rohm and GaN Systems



Relative die size for equivalent current/voltage rating

THE WOLFSPEED ADVANTAGE

Power Product Portfolio

SiC Schottky Diodes and MOSFETS

- Diodes: 600V to 1700V
- MOSFETs: 900V to 1700V (650V is coming)
- Up to 100A current rating (package limited)

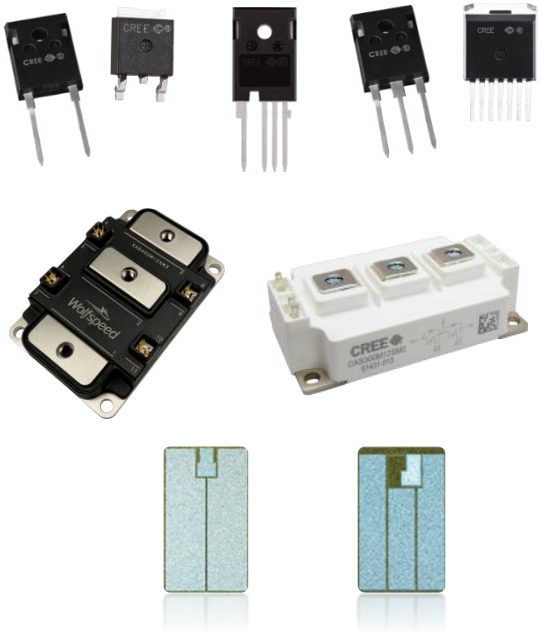
SiC Power Modules

- Up to 1700V rating
- Up to 450A current rating
- Half-bridge and three-phase configurations

SiC Bare Die

- Up to 1700V rating
- Up to 196A current rating

Package Options



New product releases

3rd Generation 1200V SiC MOSFETs

Part Number	VBR	Rdson	I_D	Package options
C3M0016120D/K	1200V	16mΩ	100A	TO-247-3L, TO-247-4L
C3M0021120D/K	1200V	21mΩ	75A	TO-247-3L, TO-247-4L
C3M0032120D/K	1200V	32mΩ	50A	TO-247-3L, TO-247-4L
C3M0032120J1	1200V	32mΩ	50A	TO-263-7L XL
C3M0075120K/J	1200V	75mΩ	30A	TO-247-4L, TO-263-7L
C3M0075120D	1200V	75mΩ	30A	TO-247-3L
C3M0160120D/J	1200V	160mΩ	20A	TO-247-3L, TO-263-7L
C3M0350120D/J	1200V	350mΩ	10A	TO-247-3L, TO-263-7L

XM3 Half-Bridge SiC Module

- New industry standard optimized for SiC
- Ultra-low loss, low inductance for fast switching operation
- Maximum junction temperature of 175 °C
- Designed to simplify external bussing for easy paralleling of modules in stacks or higher-current applications
- Cost effective design and manufacture

Configuration (part #)	BV_{DSS} (V)	I_{DS} (A)	T_{Jmax} (°C)
½ Bridge (CAB450M12XM3)	1200	450	175
½ Bridge (CAB400M12XM3)	1200	400	175

Wolfspeed SiC power solutions

- Wolfspeed advantage for SiC power systems
- Wolfspeed SiC power solutions on key applications

WOLFSPEED IMPACT ON KEY APPLICATIONS

Target markets

Automotive

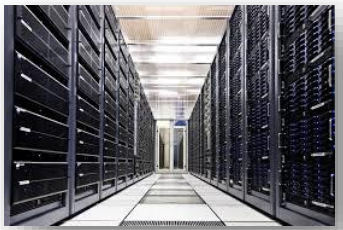
- On Board Charging
- On Board Dc-Dc
- Drivetrain
- Fast/super Charging

Energy

- Solar Inverters
- Energy Storage
- Smart Grid
- Wind

Light Industrial

- Server SMPS
- Netcom SMPS
- Aux Power
- Medical



Heavy Industrial

- Traction
- Welding
- Induction Heating
- Industrial Robots

WOLFSPEED IMPACT ON KEY APPLICATIONS

On-board charger (OBC)

What: Silicon Carbide MOSFETs and Diodes

Where:

- Uni/Bi-directional on-board charger
- Converts AC power from grid into DC power for the battery all within the vehicle
- Typically ranging from 3.3kW – 22kW

Why: Minimize the size, weight, and cost of the OBC while maximizing power delivered to the battery

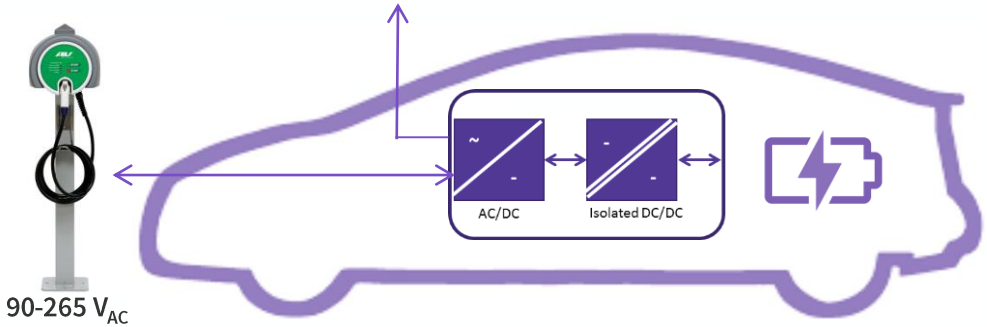
SiC Advantage:

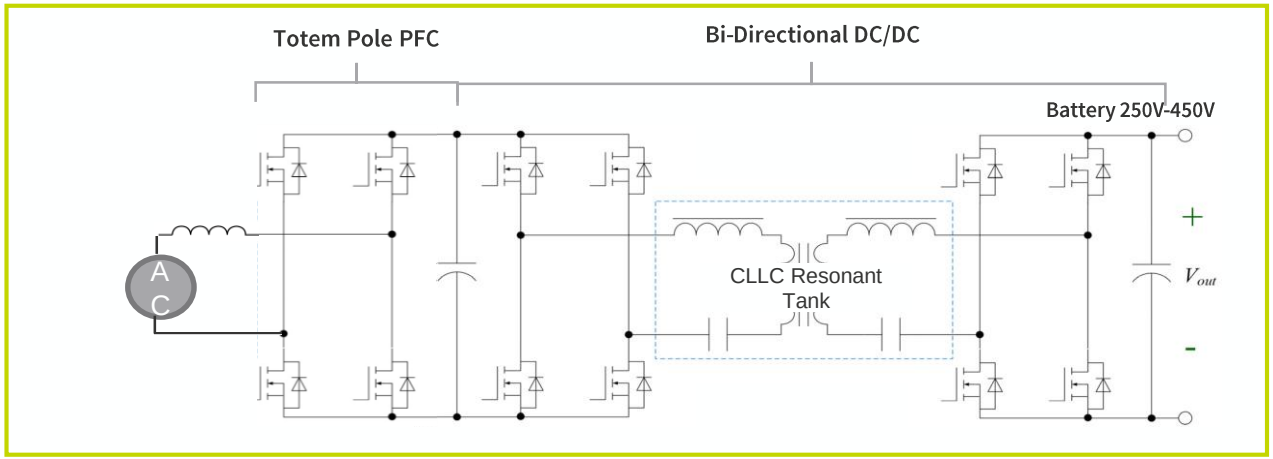
- Up to 30% lower losses
- Deliver 2x increase in power density
- 30% fewer components

Wolfspeed in 6.6kW OBC | Bi-directional

Overall trends:

- High power density
- High Efficiency
- V2X requires a bi-directional OBC. Bi-directional charging pushed by EV initiatives worldwide



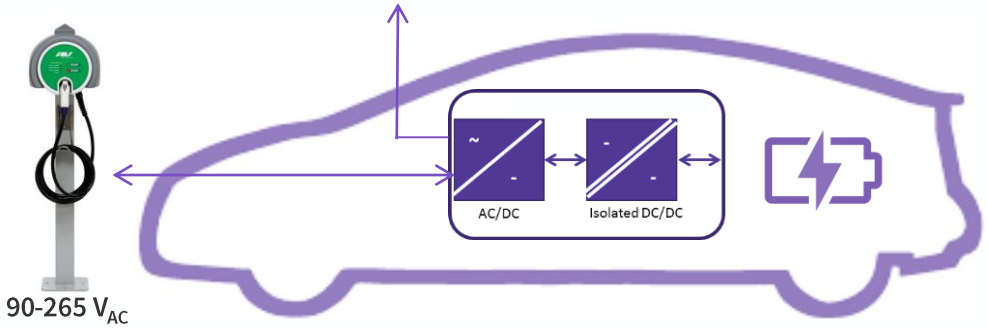


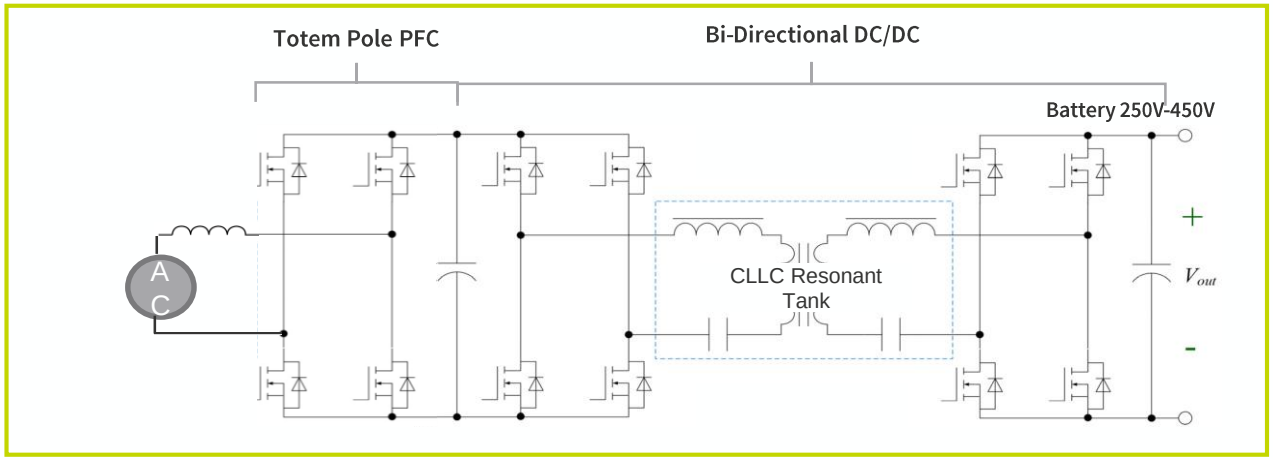
900V/1000V
SiC MOSFET

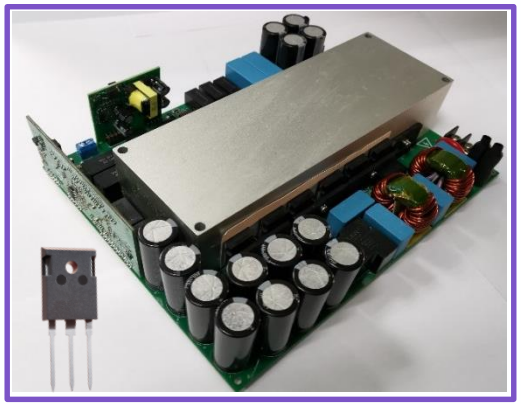
Wolfspeed in 6.6kW OBC | Bi-directional

Overall trends:

- High power density
- High Efficiency
- V2X requires a bi-directional OBC. Bi-directional charging pushed by EV initiatives worldwide







650V
SiC MOSFET

BI-DIRECTIONAL HIGH POWER CONVERSION

Thanks to the low power loss of C3M 650V SiC MOSFET and the advantage of integrated heatsink solution, all the design targets are achieved.

- ✓ High Power Density 3.3kW/L PCBA
- ✓ High Efficiency > 96.5% in charging and discharging mode
- ✓ Bi-directional Operation

The low power loss of **SiC MOSFET and Integrated Heatsink Solution** delivers

HIGH EFFICIENCY

+

HIGH POWER DENSITY

WOLFSPEED IMPACT ON KEY APPLICATIONS

DC Fast Charger

What: Silicon Carbide MOSFETs and Diodes

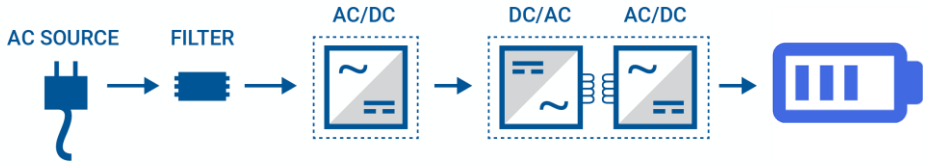
Where:

- EV off-board battery charging 80kW – 300kW
- DC charge from station to car
- Typically constructed from multiple 15-50kW blocks

Why: Minimize charger size and weight while maintaining a <30 minute charge time.

SiC Advantage:

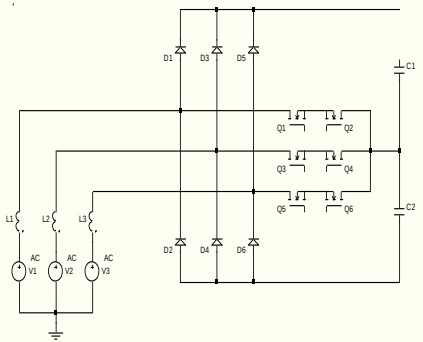
- Up to 30% lower losses
- 2-3X faster switching speed
- Deliver 65% increase in power density
- 30% fewer components.



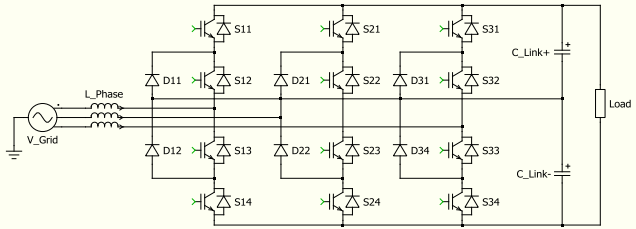
SiC AC/DC Converter Improves Performance and Cost Vs Silicon

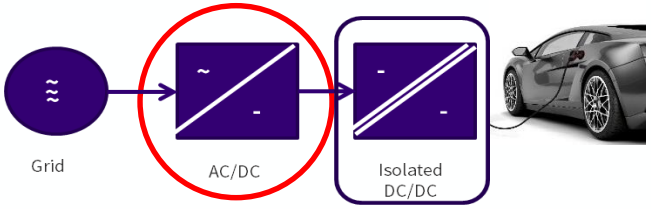
Today's Silicon Design Options

Design Using Si MOSFET



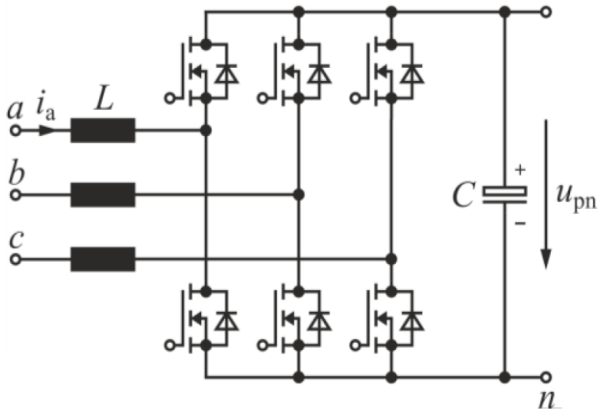
Design Using Si IGBT





Simplify with SiC

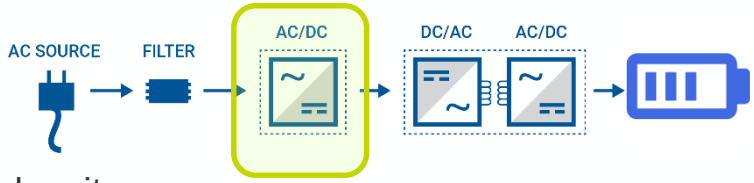
- Fewer components
- Lower system cost
- Higher efficiency
- Smaller size
- Enables Bi-directional power transfer



1000V/1200V SiC MOSFET
TO-247-4 Package

WOLFSPEED IMPACT ON KEY APPLICATIONS: DC FAST CHARGER

Off Board Charging AC-DC Reference Design



Features:

- 20kW, 3-phase AC/DC converter – high efficiency and power density
- Simple 2-level topology replaces complicated multi-level Si MOSFET (12 devices) or Si IGBT (18 devices) solution
- High operating frequency significantly reduces magnetics size and weight
- Higher efficiency and higher power density than Si solution

Included with the reference design:

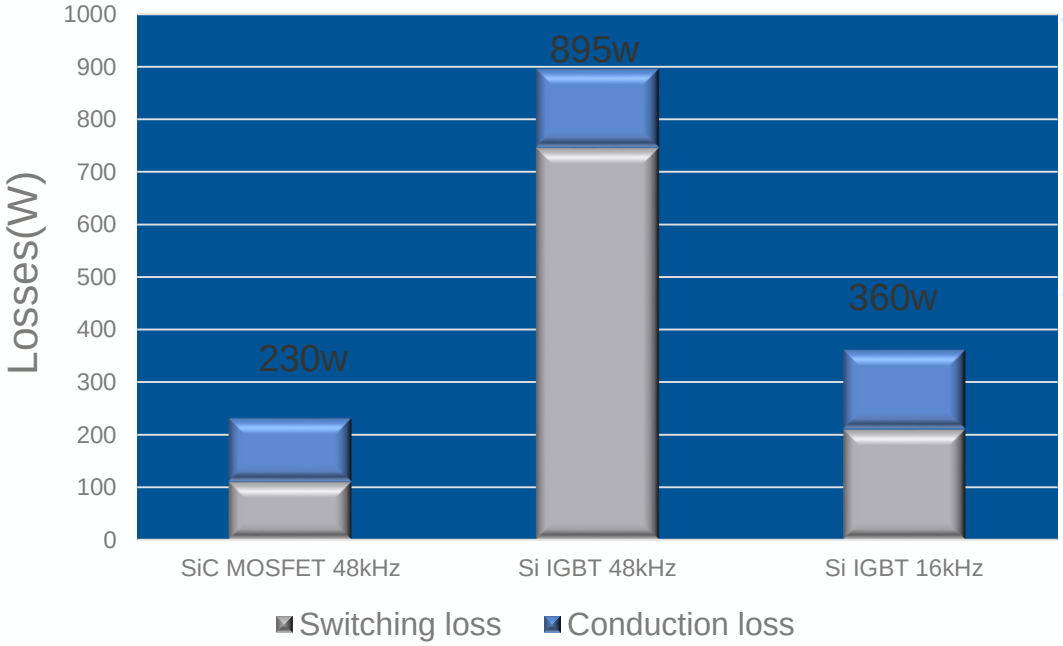
- Schematic
- Board layout
- Bill-of-materials
- Connection and user guide
- Waveforms and efficiency charts

Technical Specifications:

Input Voltage Range	380V-480V AC
Output Voltage	800V DC
Output Power	20kW
Efficiency	> 98%
MOSFET Package	TO-247-4L

Comparison with Si IGBT

Estimated semiconductor losses (V_{GRID} = 380V, V_{LINK} = 800V, P_{OUT} = 20 kW, constant T_j = 110 °C)



AMCC-50
Weight: 590g
Volume: 199cm³

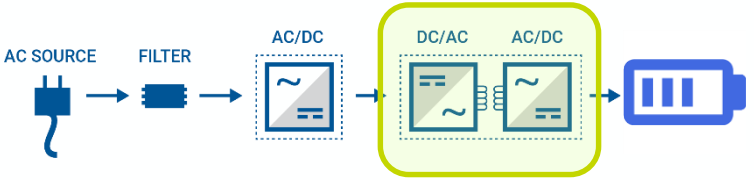
AMCC-200
Weight: 1670g
Volume: 572cm³

- **48Khz AMCC-50**
- **16Khz AMCC-200**

To use Si IGBT, the switching frequency has to be reduced to 16kHz

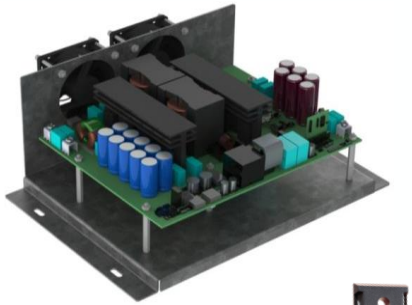
WOLFSPEED IMPACT ON KEY APPLICATIONS: DC FAST CHARGER

Off Board Charging DC-DC Reference Design

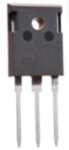


Features:

- 20kW LLC DC-DC converter: high efficiency/power density
- Simple 2-level topology using SiC to replace complicated multi-level Si topology
- High operating frequency significantly reduce the magnetics size and weight
- Higher efficiency and higher power density than Si solution



1000V/1200V
SiC MOSFET
TO-247-4 Package



SiC Schottky Diode
C3D20065D
TO-247-3 Package

Included with the reference design:

- Schematic
- Board layout
- Bill-of-materials
- Connection and user guide
- Waveforms and efficiency charts

Technical Specifications:

Input Voltage Range	650-750V DC
Output Voltage	300-570V DC
Output Power	20kW
Switching Frequency	110-350 kHz
Efficiency	> 98%
MOSFET Package	TO-247-4L

WOLFSPEED IMPACT ON KEY APPLICATIONS: DC FAST CHARGER

Off Board Charging DC-DC Reference Design

- 33% more power, 25% smaller size

Technical Specifications:

	SiC
Input Voltage Range	650-750V DC
Output Voltage	300-570V DC
Output Power	20kW
Switching Frequency	110-350 kHz
Efficiency	> 98%
Power Density	65% higher Than Si

15KW Silicon based solution
- 4.1 Kg
- More components

20KW SiC based solution
- 3.2 Kg
- 20% fewer parts

WOLFSPEED IMPACT ON KEY APPLICATIONS

Drivetrain Inverter

What: Silicon Carbide MOSFETs

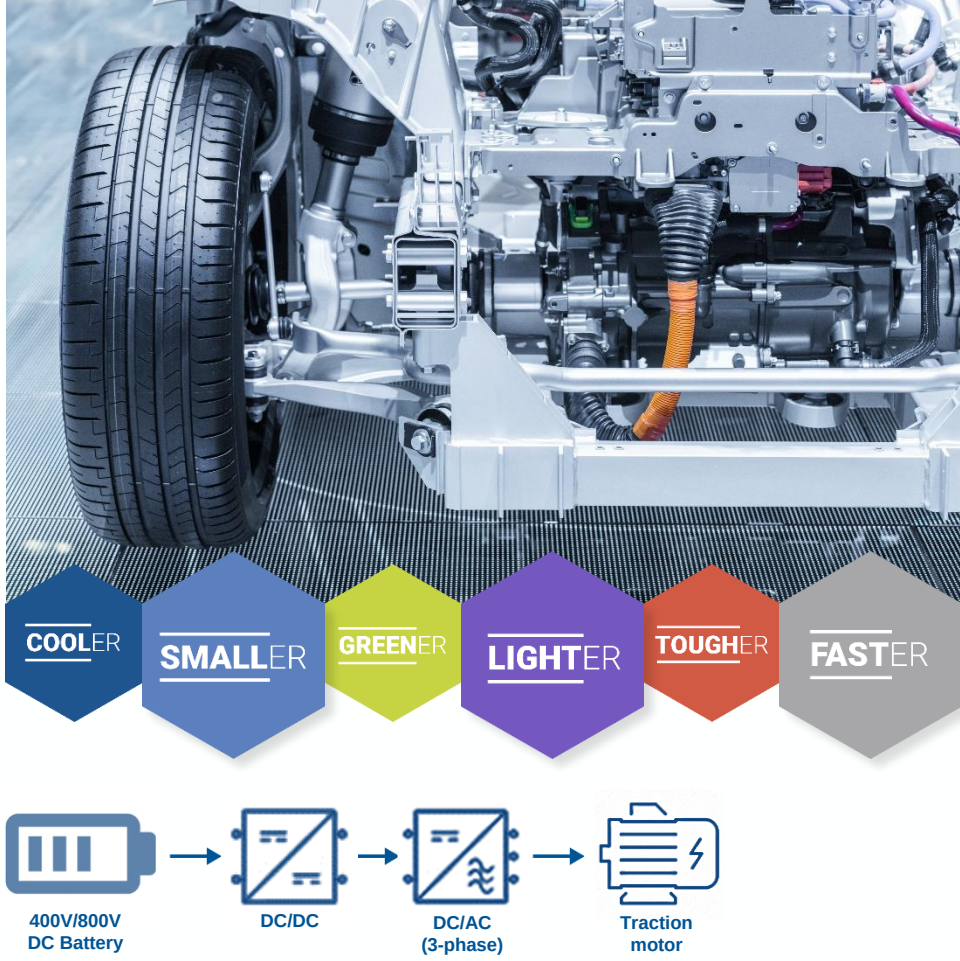
Where:

- 90 – 350kW+ EV drivetrain inverter
- Single, dual, or in hub drives

Why: Maximize EV range while minimizing overall system and battery cost. Bi-directionality also enables regenerative braking.

SiC Advantage:

- ~80% lower losses
- ~30% smaller size
- Lower system cost



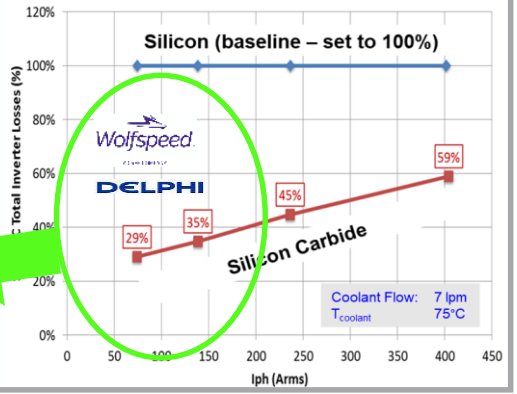
Wolfspeed SiC EV drivetrain savings

Battery Electric Vehicle

Light Load Saving

In Partial Load
Up to 6-10% savings
Even on 400V

SiC cuts 400V Inverter Losses 40->70%



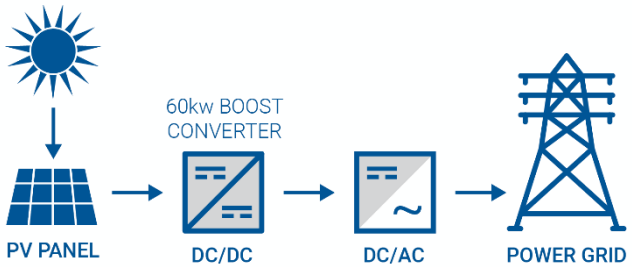
Overall Cost of EV	**$15,000-$100,000**
Incremental Cost of Using SiC	**$75-$150**
~3.0% SiC Battery Savings	**$600-$1000**
Space Savings	**$- Significant**
Cooling Requirements Savings	**$- Significant**
SUMMARY	**Savings $525 to $850**

Costs savings from reduced space, cooling, provide additional savings (will vary by vehicle model)

WOLFSPEED IMPACT ON KEY APPLICATIONS

Inverters for Solar Power and Energy Storage

- **What**: SiC MOSFETs and Diodes
- **Where:** Panel array boost converter to provide input voltage for battery charger and/or power grid inverter
- **Why**: Minimize size and weight while increasing ruggedness for lower installation and maintenance costs
- **SiC Advantage**: 99.5% efficiency enables:
  - Up to 3X smaller size
  - 10X lighter weight

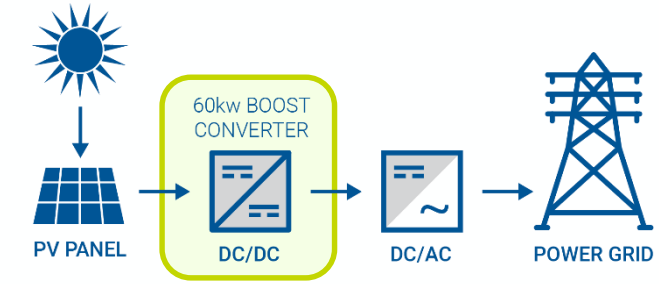


WOLFSPEED IMPACT ON KEY APPLICATIONS: SOLAR POWER

60kW Boost Converter Reference Design

Parameters	Values
Input voltage range	470VDC-800VDC
Output voltage	850VDC
Output Power	60kW (Vin ≥ 600V) 50kW (Vin < 600V)
Switching frequency	78kHz
Efficiency	99.5%
Power Density	127W/in^3
Topology	Interleaved DC/DC Boost
Power device package	TO-247-4

- Featuring Wolfspeed 3rd Gen C3M 1200V MOSFETs
- Featuring Wolfspeed 4th Gen C4D 1200V Schottky diodes

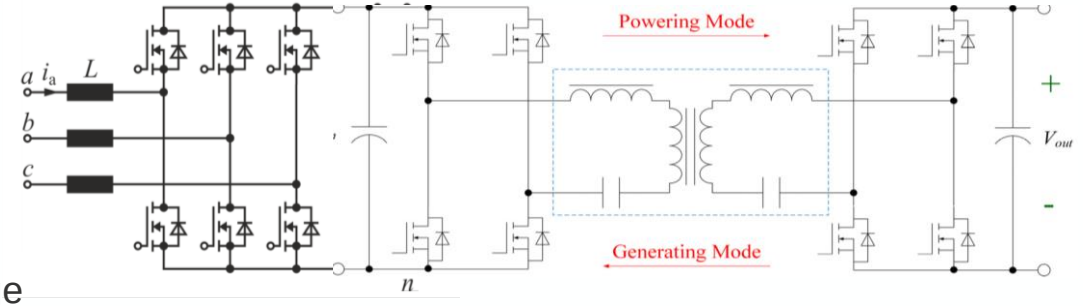


SiC Schottky Diode
C4D101120D
TO-247-3 Package

SiC MOSFET
C3M0075120K
TO-247-4 Package

WOLFSPEED IMPACT ON KEY APPLICATIONS

Energy Storage

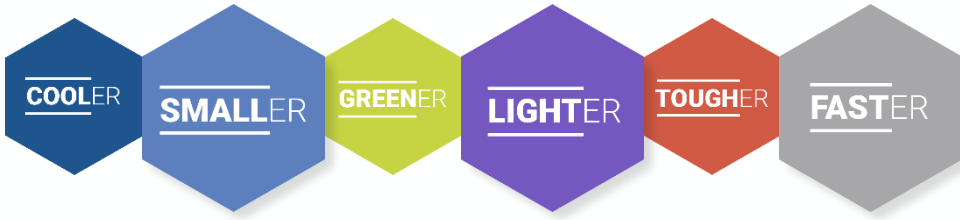


What: Silicon Carbide MOSFETs

Where:

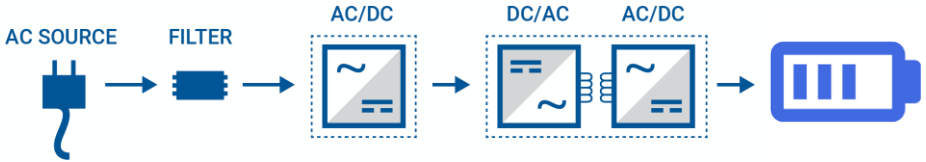
- Bidirectional 5kW – 200kW energy storage system
- Converts AC power from grid into DC power for the battery and also deliver the energy back to grid

Why: Bidirectional operation, Minimize the size, weight, and cost while maximizing power delivered to the battery



SiC Advantage:

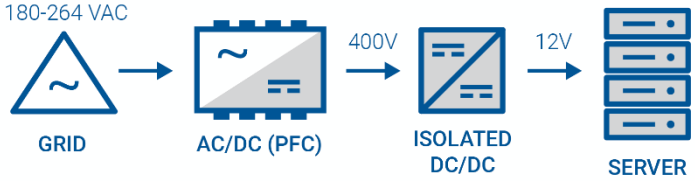
- Up to 30% lower losses
- Deliver 65% increase in power density
- 30% fewer components.



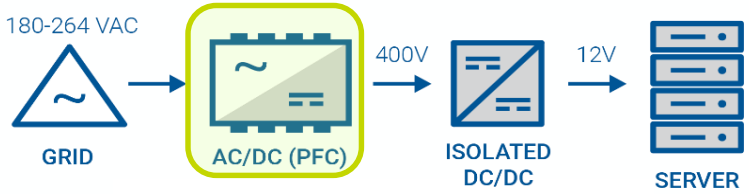
WOLFSPEED IMPACT ON KEY APPLICATIONS

High Efficiency Power for Data Centers

- **What**: Silicon Carbide MOSFETs and Diodes
- **Where:** Data centers for cloud computing
- **Why:** Minimizing electricity consumption — cooling system can be up to 40% of the electricity cost
- **SiC Advantage**:
  - Achieves 80+ Titanium standards
  - Lower E-BOM cost
  - Contributes to 620 billion kWh in energy savings from 2010 to 2020



Bridgeless Totem-Pole PFC Reference Design



- 2.2kW high efficiency bridgeless totem-pole PFC
- Featuring Wolfspeed 650V MOSFETs
- Meets 80+ titanium efficiency rating
- Board dimensions: 213 x 112.5 mm

Parameters	Values	Note
Input voltage range, 47-63Hz	180-264V (rms)	
Output voltage	400V nominal	+/- 2%
Output power	2,200 W	At 230V AC
Output power	1,500 W	At 180V AC
Input power factor	>.98	
Input THD at full load	<5%	
Switching frequency	64 KHz	Fixed frequency
Efficiency	**>98.5%**	Including Aux
Cooling	Forced air, 15x40mm Fan	1.5W power
Topology	Totem pole	Diode as LF switch
Power devices package	TO-263-7 TO-247 TO-247-4	

PROBLEM STATEMENT

How to Improve a 200KW UPS System?

UPS are large

- Silicon-based UPS designs are extremely large in size
- UPS using silicon create sizeable heat loads

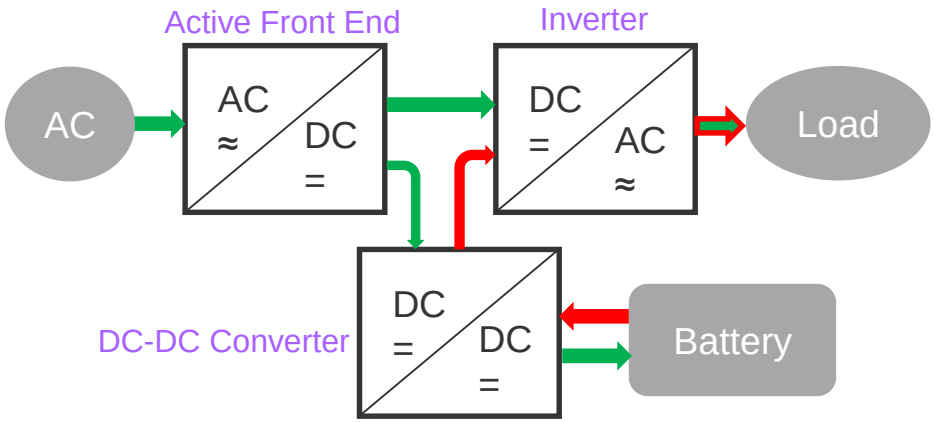
UPS can be inefficient

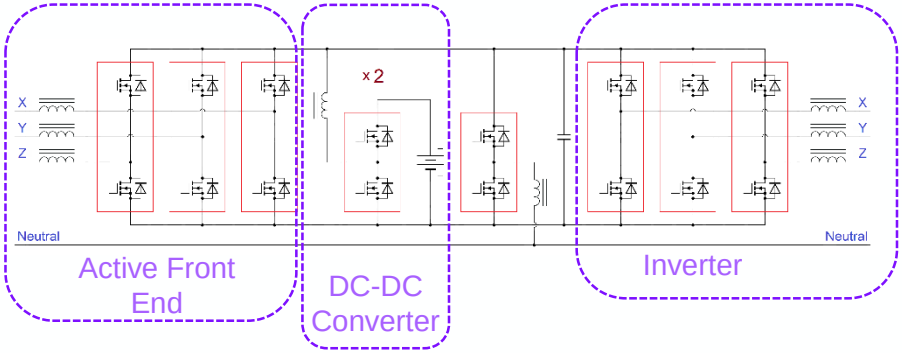
- Silicon based switching losses add-up in high power applications

What Can SiC Enable?

- 38% reduction in system losses
- 42% reduction in passive component volume
- 35% reduction in passive BOM costs

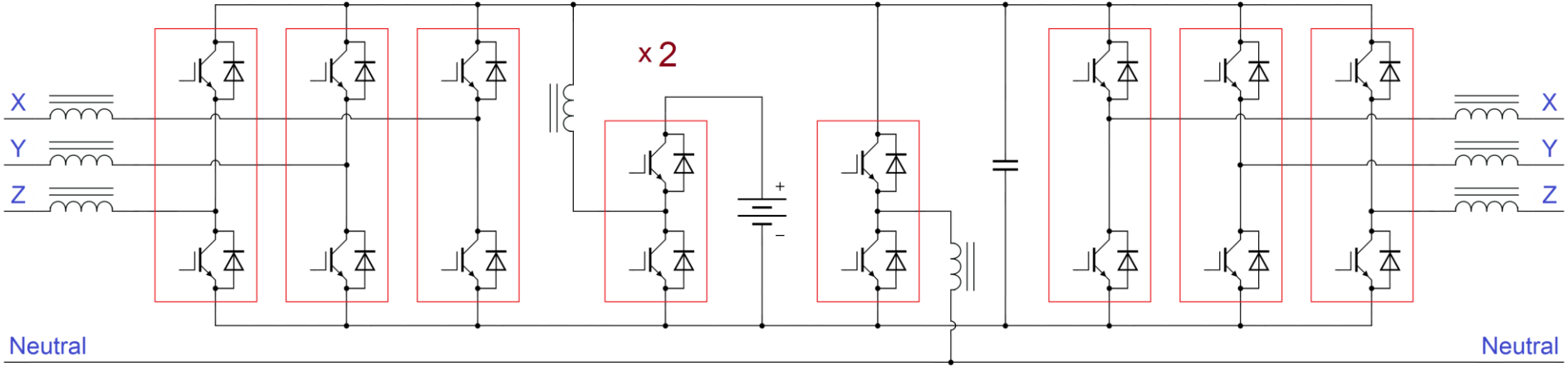
Advantages of Double Conversion UPS Topology





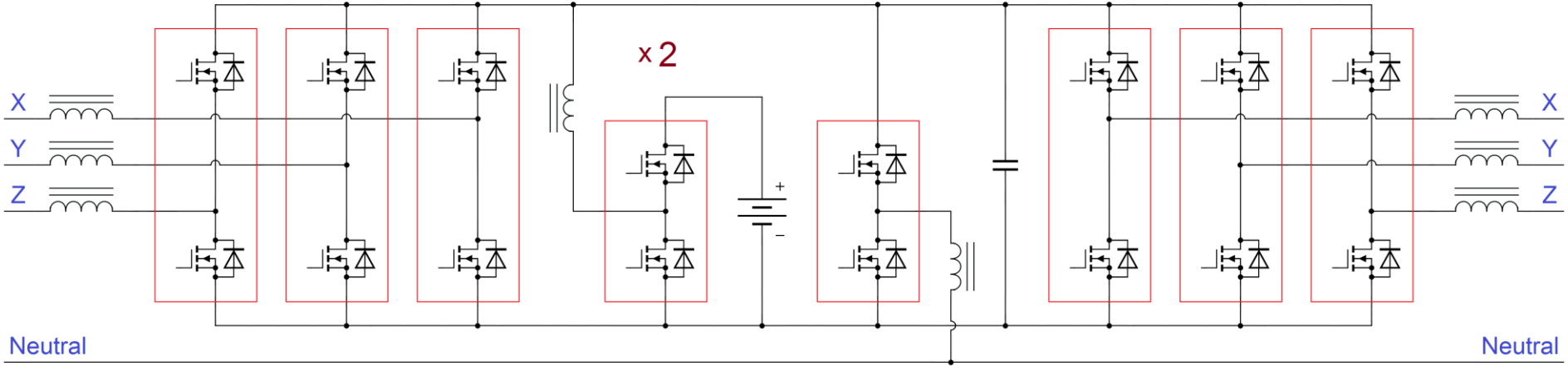
- The DC link with energy storage effectively decouples the load from the grid
- The topology can provide extremely clean power in even with unstable grid power

Si IGBT UPS Block Diagram



8 kHz Switching Frequency

Wolfspeed XM3 SiC Module UPS Block Diagram

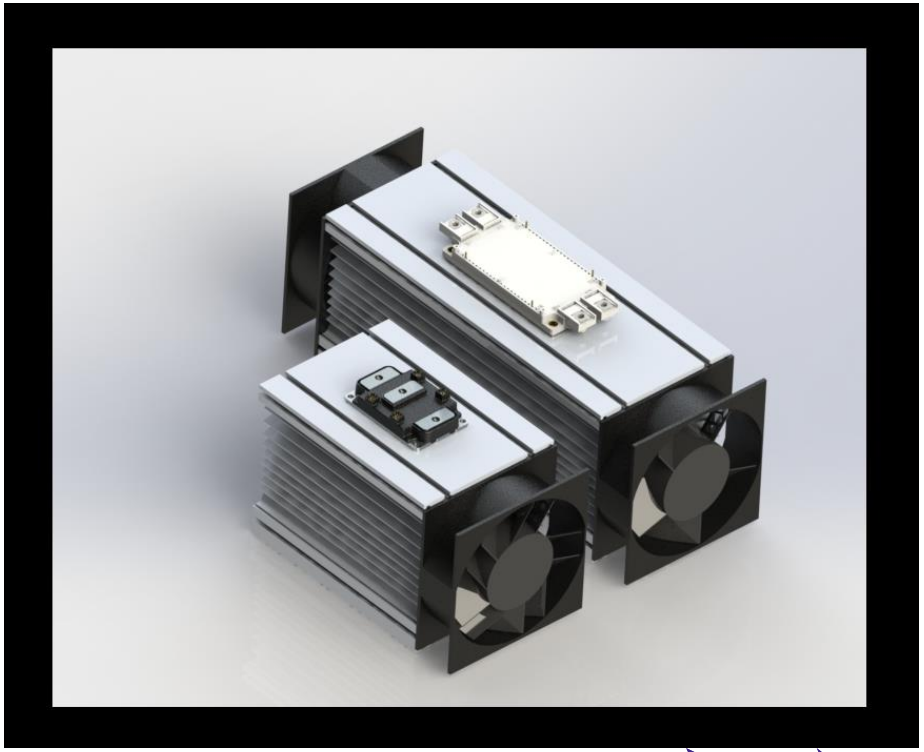


25 kHz Switching Frequency

The Wolfspeed Advantage

Reducing Switching Losses & Cooling Requirements

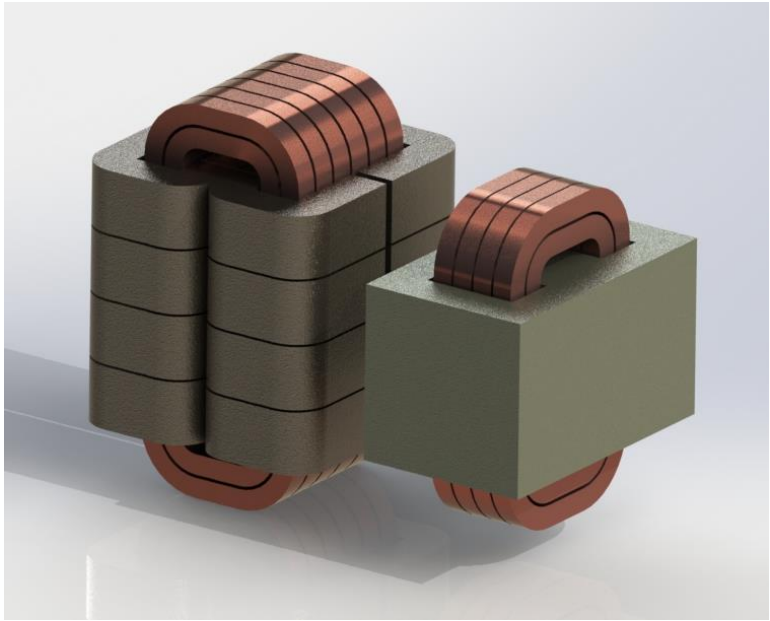
- Wolfspeed's SiC module has 662 W of losses compared to a Si IGBT's 1100 W
- Each SiC module only requires a single cooling fan, due to the high efficiency
- The heatsink + fan volume is reduced from 6.4 L per module to 3.7 L per module
- Using Wolfspeed XM3 SiC Modules yields:
  - **40.4% reduction in switching losses**
  - **42% reduction in cooling volume**
  - **43% reduction in thermal solution cost**



The Wolfspeed Advantage

Reducing Inductor Requirements via Switching Frequency

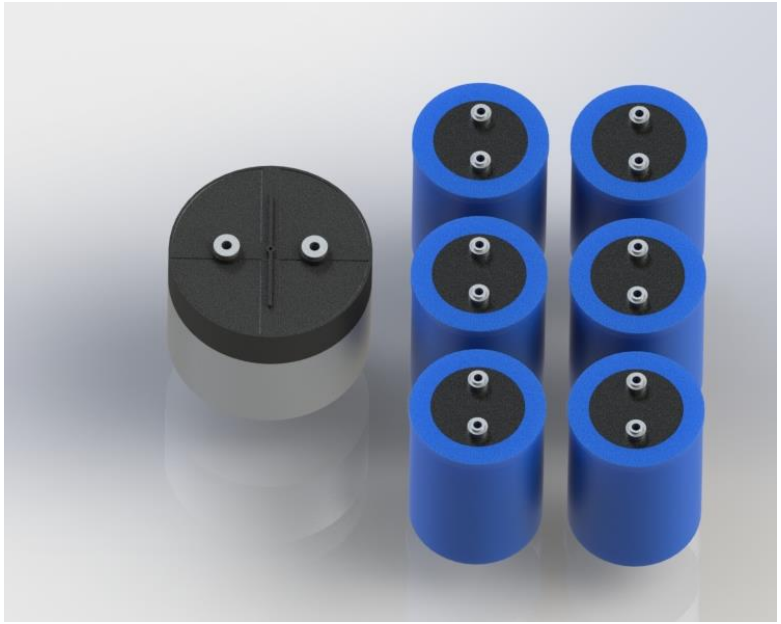
- Wolfspeed XM3 SiC Modules allow the switching frequency to increase from 8 kHz to 25 kHz resulting in the following:
- The required **inductance is reduced from 100μH to 30μH**
- Each inductor can be **reduced in size by 37%**
- **Reduces total losses by 20%**
- A **23% reduction in inductor cost** can be achieved with SiC



The Wolfspeed Advantage

Reducing Capacitance via Switching Frequency

- Wolfspeed XM3 SiC Modules allow the switching frequency to **increase from 8 kHz to 25 kHz** resulting in the following:
- DC link capacitance can be dramatically reduced from **2322μF** to **740μF**
- Capacitor **volume reduction of 67%** is achieved with SiC
- Capacitor **cost is reduced by 66%**



Agenda

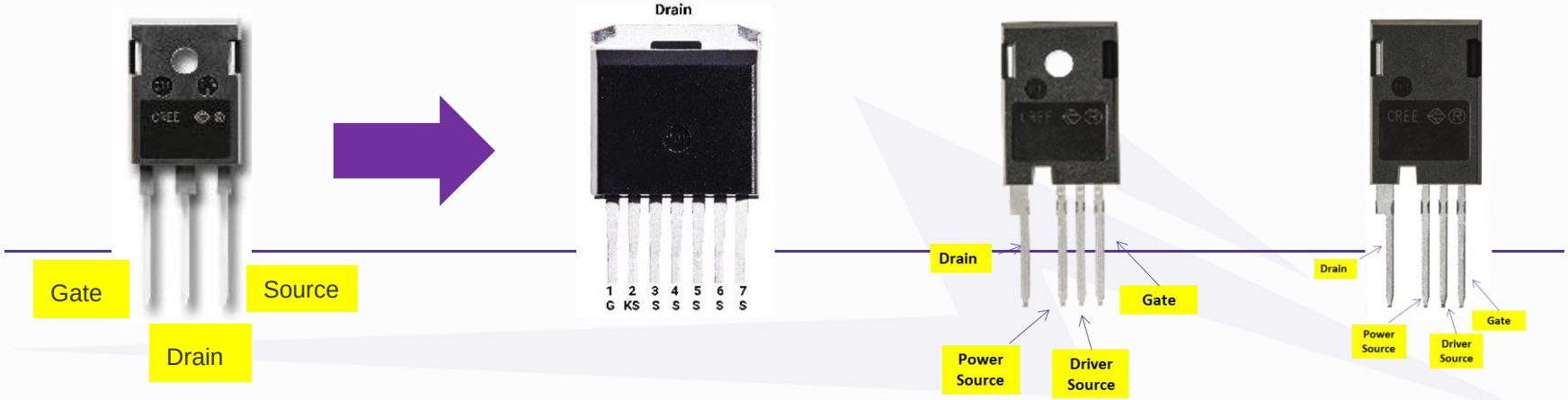
- Wolfspeed SiC power solutions
- Practical Implementation of SiC MOSFET

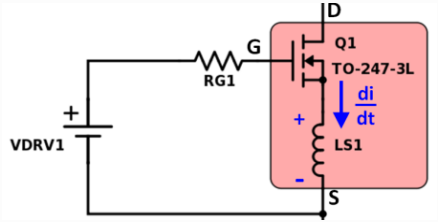
Practical Implementation of SiC MOSFET

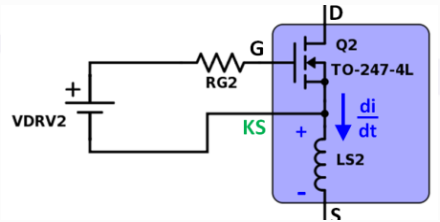
- Package Selection
- Gate Driver Design
- PCB Layout Considerations
- Helpful resources for you to implement SiC system advantages

Package Selection

Recommended Optimized Packages with Kelvin Source Pin

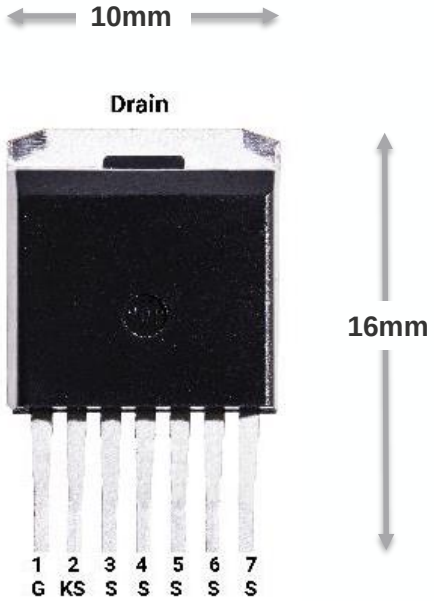






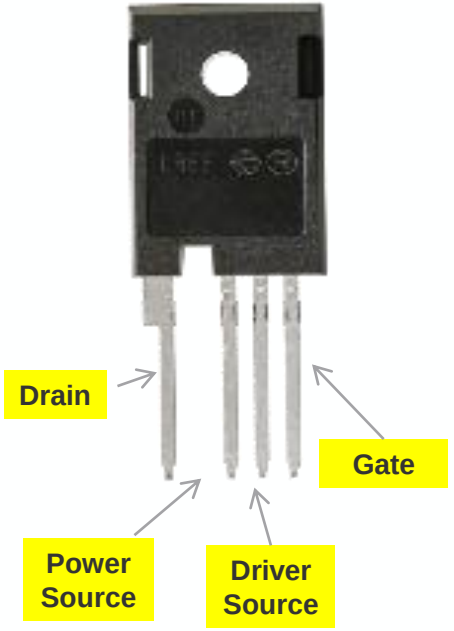
TO-263-7L Package with Kelvin Source

- 7mm of Creepage distance between Drain and Source
- Low source inductance < 2nH
- Design for automatic assembly
- Separated power source pin provides lower switching losses



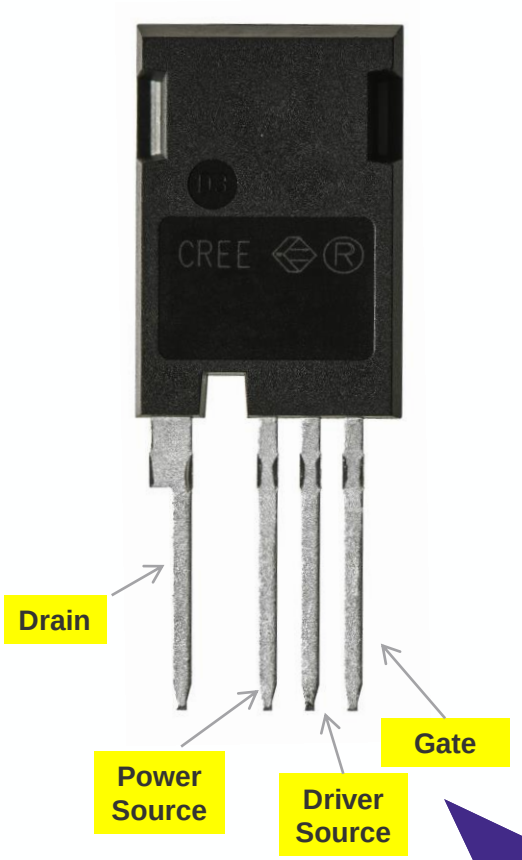
TO-247 Package with source kelvin

- Optimized package design with wide creepage/clearance between drain and source for high-voltage capability in high-pollution environments
- Optimized package for SiC for higher current capability
- 8mm of creepage distance between Drain and source
- Separated power source pin provides lower switching losses
- Capable of 5kV isolation



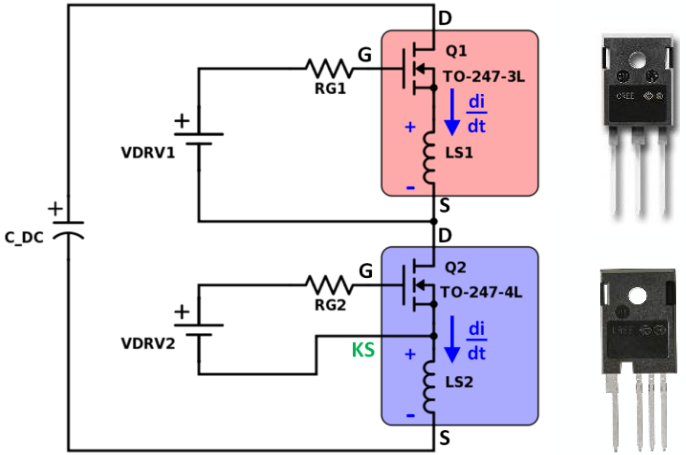
New TO-247-4L Plus Package

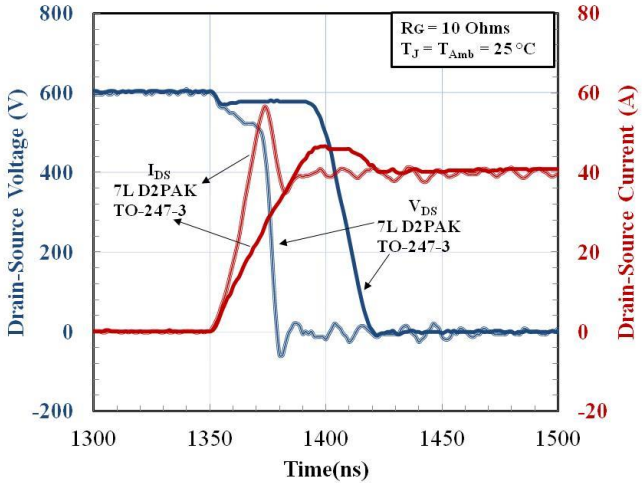
- Optimized package design with wide creepage/clearance between drain and source for high-voltage capability in high-pollution environments
- Larger lead-frame with 10mil stitch wire-bonding for increased current handling
- Separated power source pin provides lower switching losses
- Clip-mount design with no center mounting hole provides improved electrical isolation



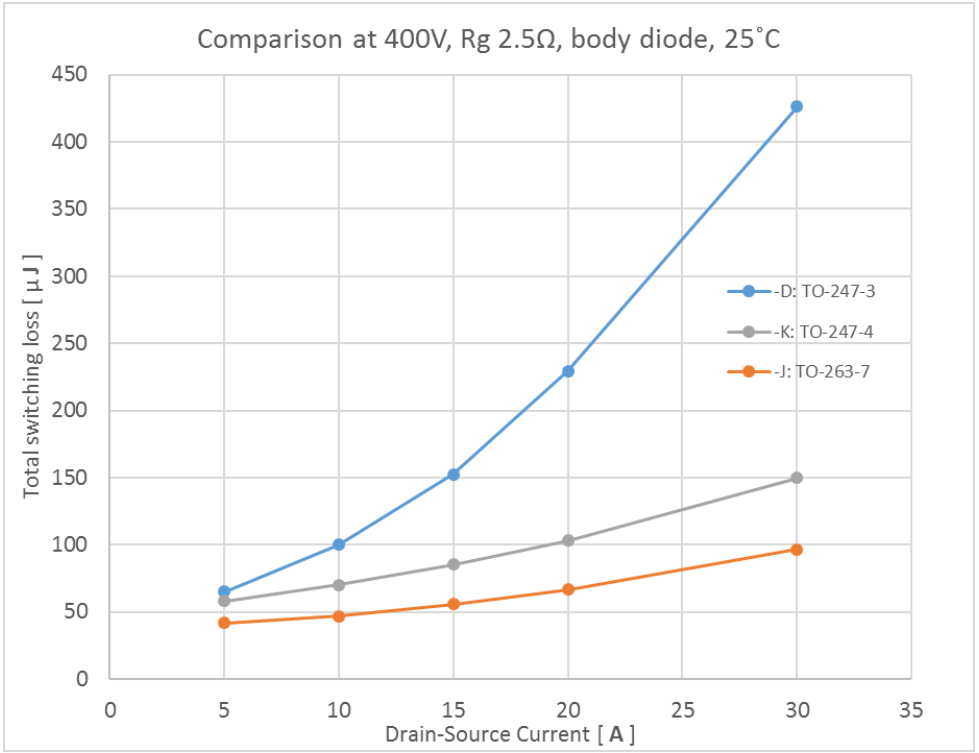
Advantage of the Kelvin Source Pin

- SiC MOSFET chip is capable of extremely fast transitions.
- In TO-247-3, L_S in the gate driver loop will limit the switching speed.
- TO-247-4 has a separate source return pin for the gate driver equivalent circuit. $V_{G,KS}$ is not affected by the voltage drop in the source inductance L_{S2} introduced by the *di/dt* of the drain-source current.





Switching Loss Comparison @ Vdd=400V, Rg.ext=2.5ohm, Vgs=-4/+15V



TO-247-3
NO - Kelvin Pin
2.6mm Creepage
8nH Inductance

TO-247-4
Kelvin Pin
8mm Creepage
8nH Inductance

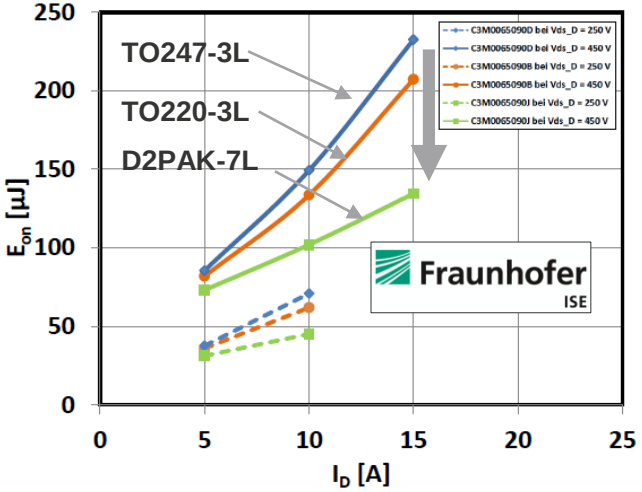
TO-263-7
Kelvin Pin
7mm Creepage
2nH Inductance

Lower switching losses and for higher creepage

External testing on Impact of discrete package on switching energy

900V, 65mΩ SiC MOSFET from Wolfspeed
D2PAK-7L offers up to 44% reduction over TO247-3L

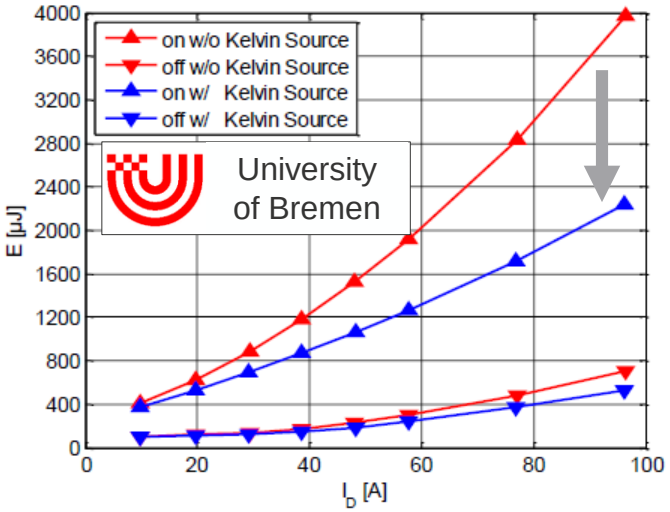
Switching energies @ 450V, 15A (solid lines)
TO247-3L (blue), TO220-3L (orange), D2PAK-7L (orange)
Turn-on (E_{ON}) losses are dominant (~90% of total)



C. Schöner, "Switching Energy Comparison of 900V SiC MOSFET Chip in Different Transistor Packages," internal report, April 2017.

900V, 10mΩ SiC MOSFET from Wolfspeed
Up to 42% reduction in TO247 if using Kelvin

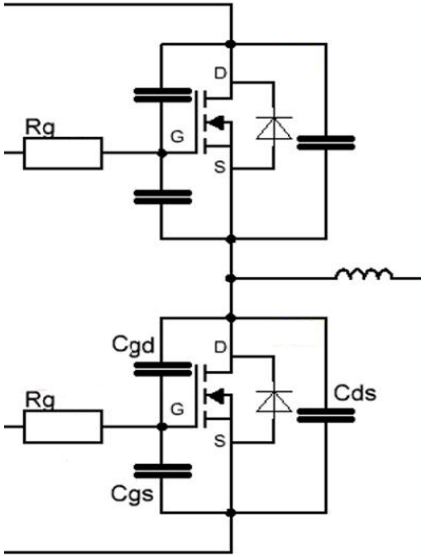
Switching energies @ 600V, 96A, $R_{G,ext}$ = 5.1Ω



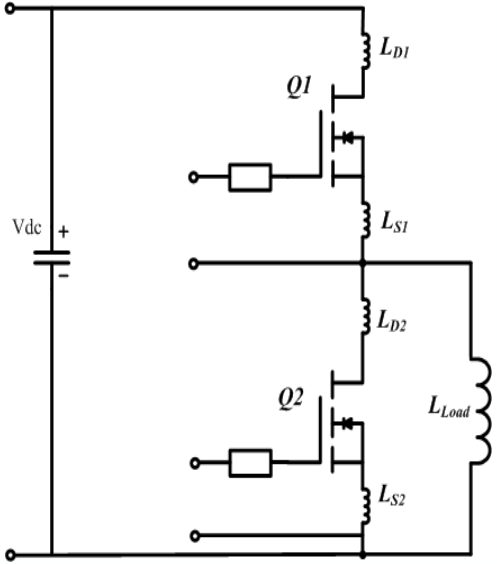
C. Bödeker, N. Kaminski, "Impact of a Kelvin Source Connection on Discrete High Power SiC-MOSFETs," ICSCRM 2017 pre-print.

- Fraunhofer ISE (left) measured commercial 900V, 65mΩ SiC MOSFET with three different packages
  - D2PAK-7L with Kelvin Source had ~ 40% lower switching losses than TO247-3L or TO220-3L
- Bremen Univ. (right) measured commercial 900V, 10mΩ SiC MOSFET with two different packages
  - TO247-4L with Kelvin Source had ~ 40% lower switching losses when using Kelvin sense

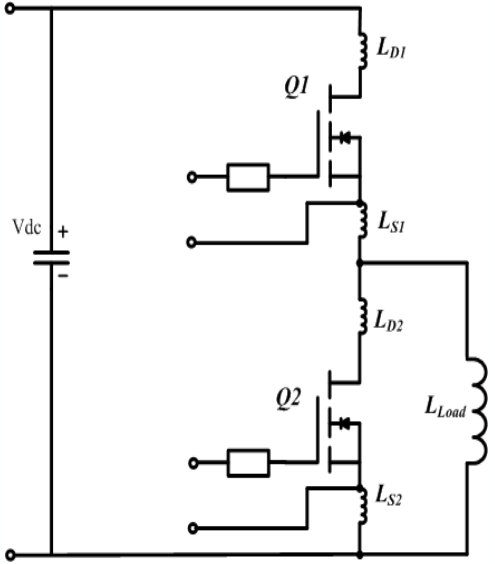
MOSFET Cross-talk in Half bridge



Ideal Switch without package parasitic

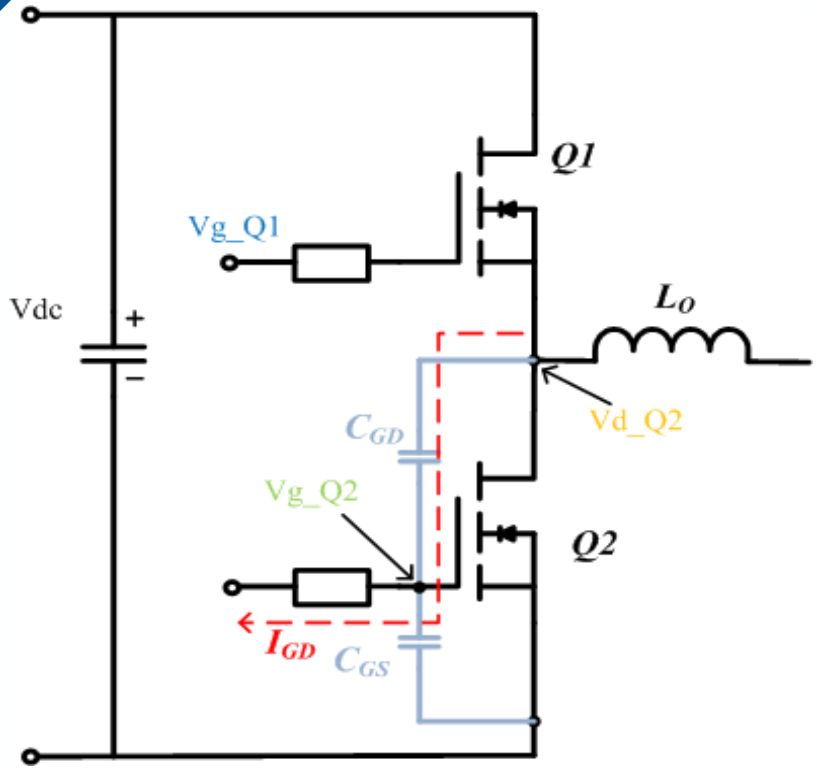


3L package

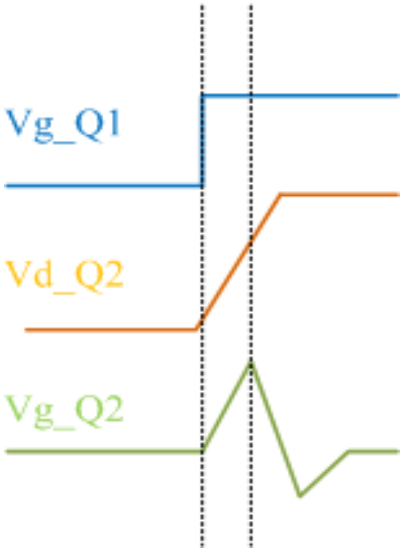


4L package

MOSFET Cross-talk in Half bridge



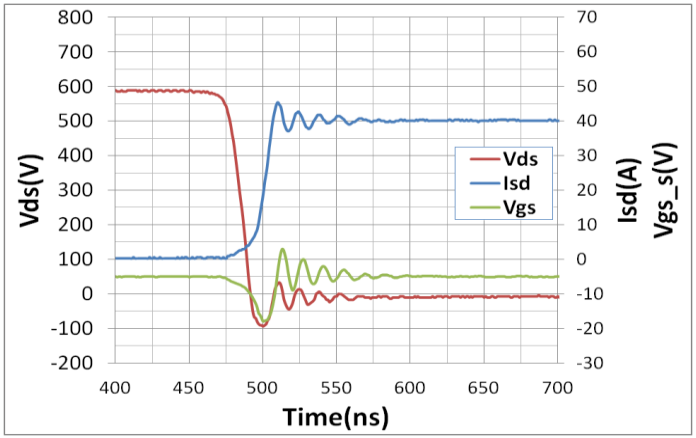
Turn on Q1

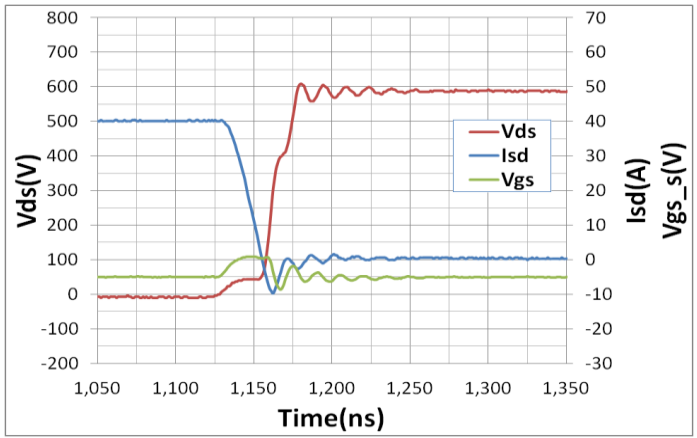


In the off period of the low side MOSFET, the voltage across the Coss of low side MOSFET is nearby zero. When the high side MOSFET is turning on, Coss of high side MOSFET will be discharged. And the Coss of low side MOSFET will be charged. dv/dt will also cause the Cgd of low side MOSFET to charge through Cgs. Thus, a positive voltage is generated. If the voltage spike is over the Vth of low side MOSFET, potential Shoot through risk.

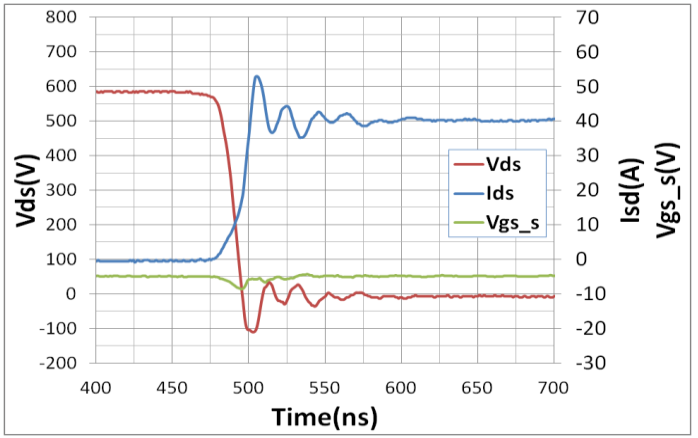
Gate voltage spike comparison 3L VS 4L

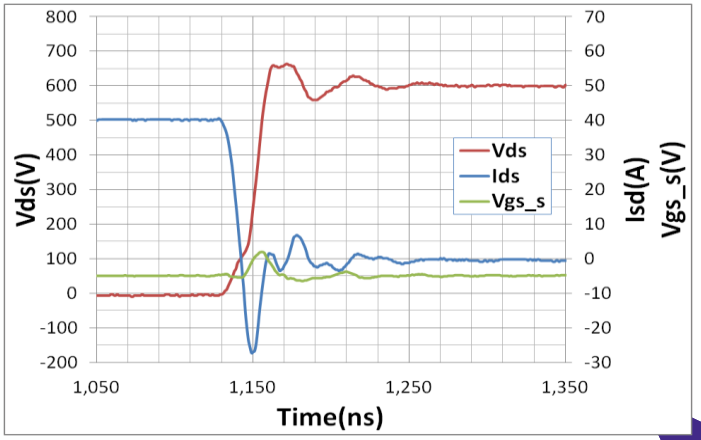
3L





4L





Key Takeaways

1. New K-Source package reduces switching loss
2. New K-Source package reduce cross talk

Gate Drive Considerations

Introduction

Why do we need gate drivers for MOSFETs?

Gate drivers provide

- Desired sourcing and sinking current
- Level shifting for high-side MOSFETs
- Isolation between controller ICs and MOSFETs for compliance

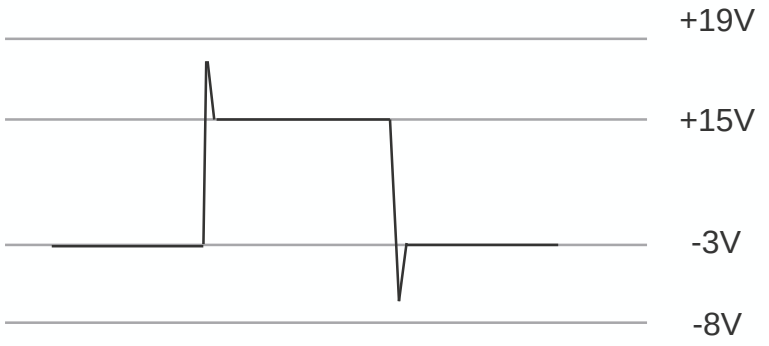
SiC MOSFET Gate Voltage Rating

Symbol	Parameter	Value	Unit	Test Conditions	Note
V_{GSmax}	Gate - Source Voltage (dynamic)	-8/+19	V	AC (f >1 Hz)	Note: 1
V_{GSop}	Gate - Source Voltage (static)	-4/+15	V	Static	Note: 2

1. **VGSmax** -- Maximum allowable peak value of Gate to source voltage.
   The worst case operating voltage should not be over **VGSmax**.

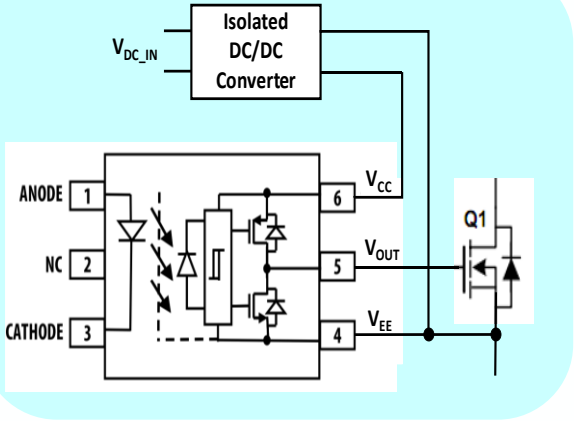
2. **VGSop** -- Maximum allowable static value of Gate to source voltage.
   The worst case operating voltage at static operation mode(f<=1Hz) should be within the rating of **VGSop**.

Design Recommendation:
1. +15V/-3V gate voltage is recommended.
2. The positive and negative voltage spikes don't exceed **VGSmax**



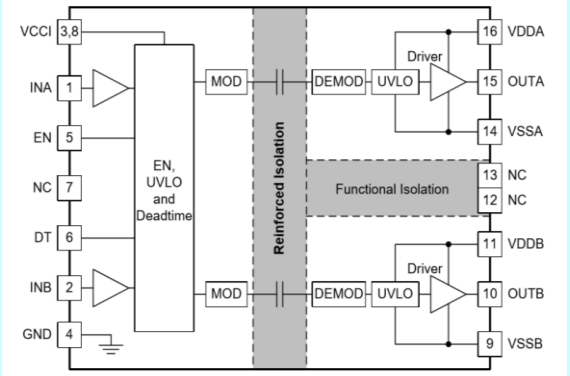
Types of Isolated Gate Driver

Optically Isolated



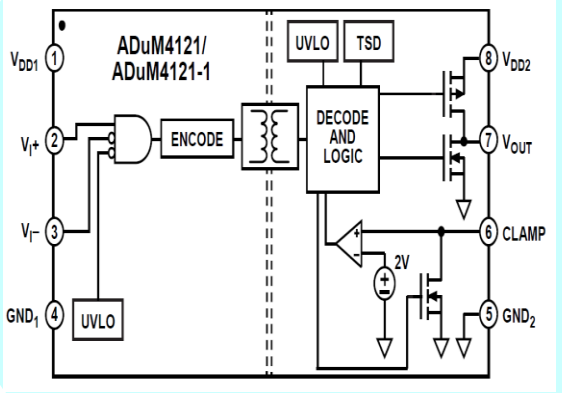
Broadcom

Capacitive Isolated



TI, Silicon Labs

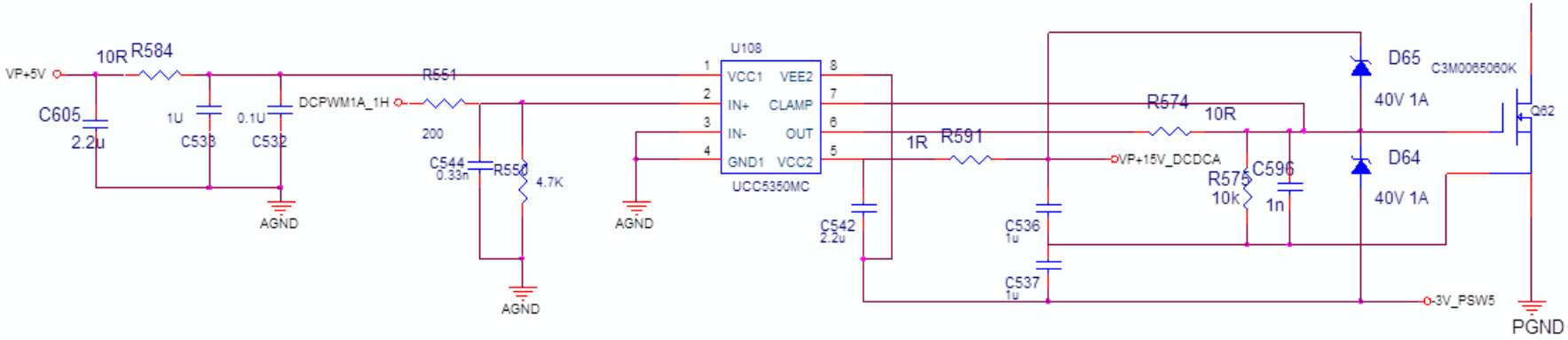
Inductive Isolated



ADI, NXP,

Tips for SiC MOSFET Gate Driver

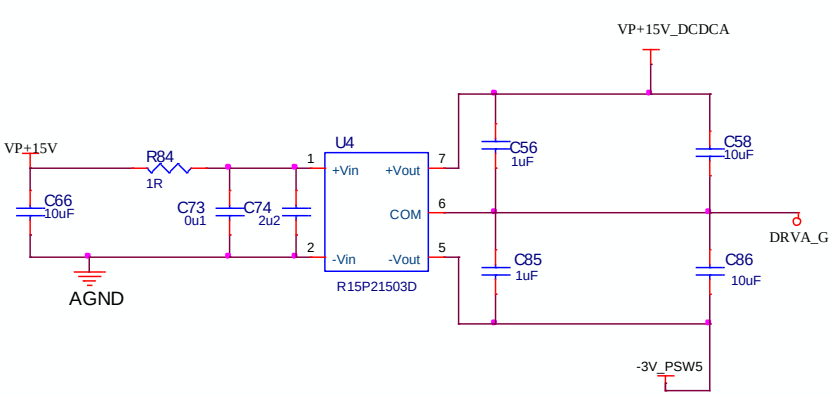
- +15V/-3V power supply
- VIORM Maximum Working Insulation Voltage
- Driving capability
- CMTI
- Active miller clamp
- Additional cap Gate to Source
- Gate voltage clamp if active clamp is not available in gate drive IC



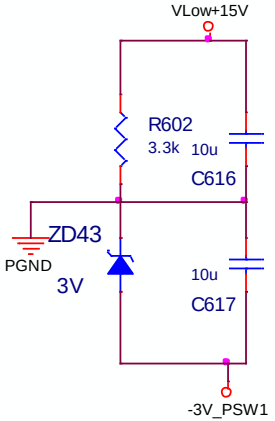
Power Supply Options

+15V/-3V power supply

- DCDC Power supply module like R15P21503D.
- 18V multi-outputs on-board Aux power supply. Generate -3V by resister and Zener.



Easy to use

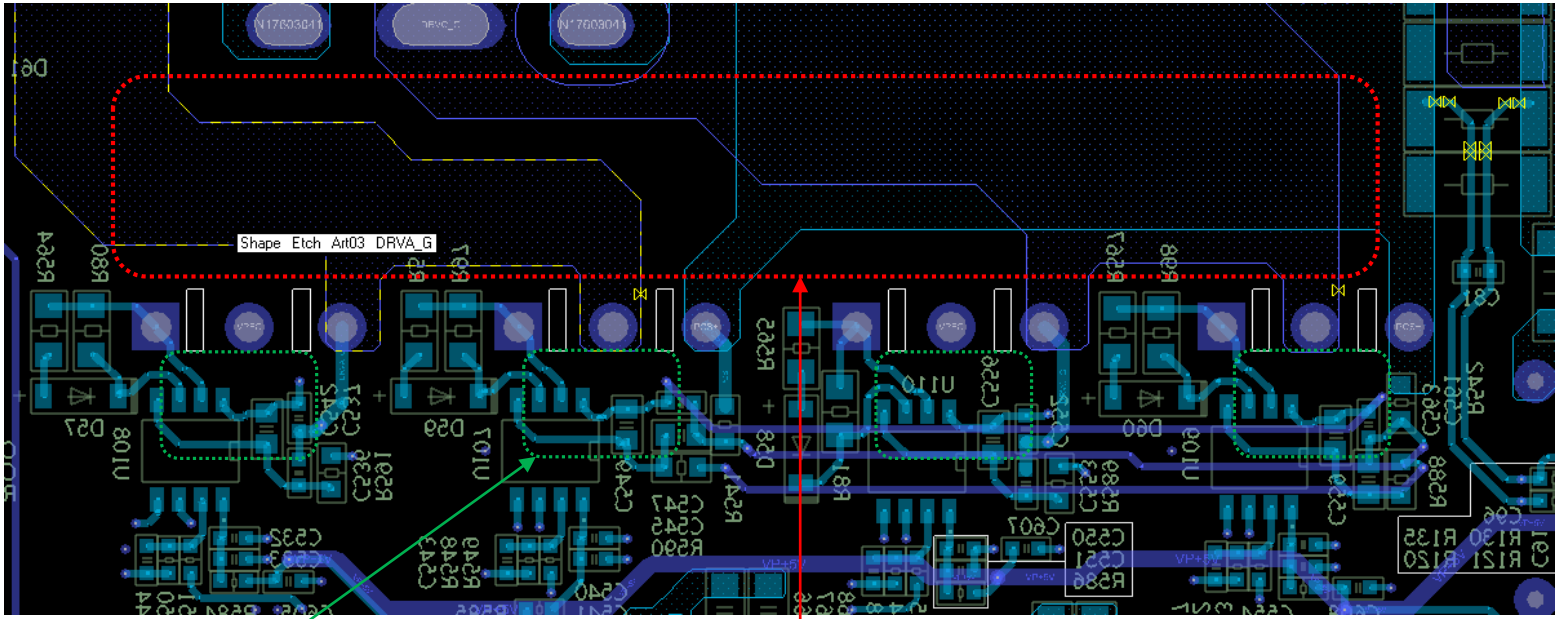


Lower cost

PCB Layout Considerations

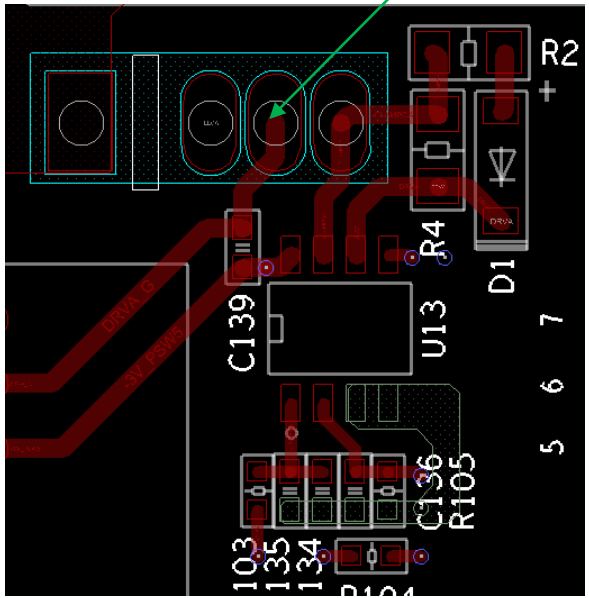
SiC MOSFET Gate Driver

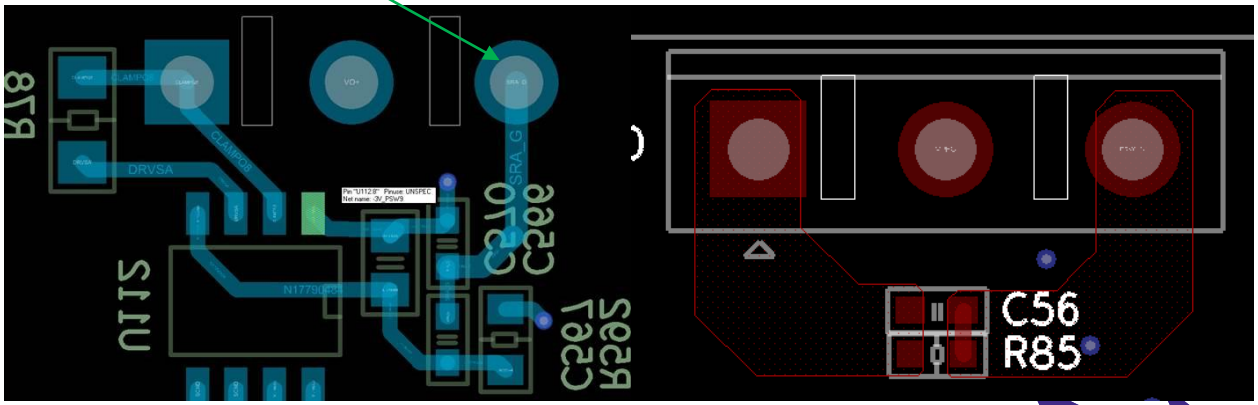
- Avoid overlap between Drain and Gate and Gate drive circuit.



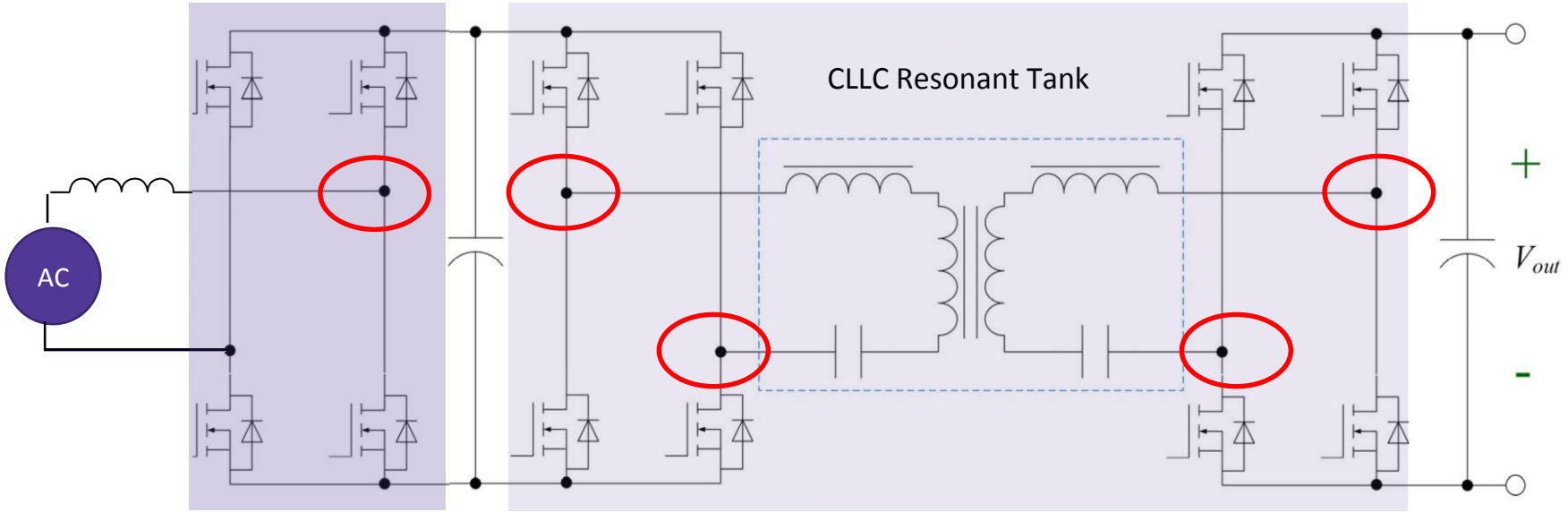
SiC MOSFET Gate Driver

- Minimized the loop of gate drive
- Minimized the loop of active miller clamp
- Separated gate source. Don’t introduce parasitic inductance from power source loop
- Place the external Gate to Source cap as close as possible to the MOSFET
- Minimized the loop of gate voltage clamp if active clamp is not available in gate drive IC



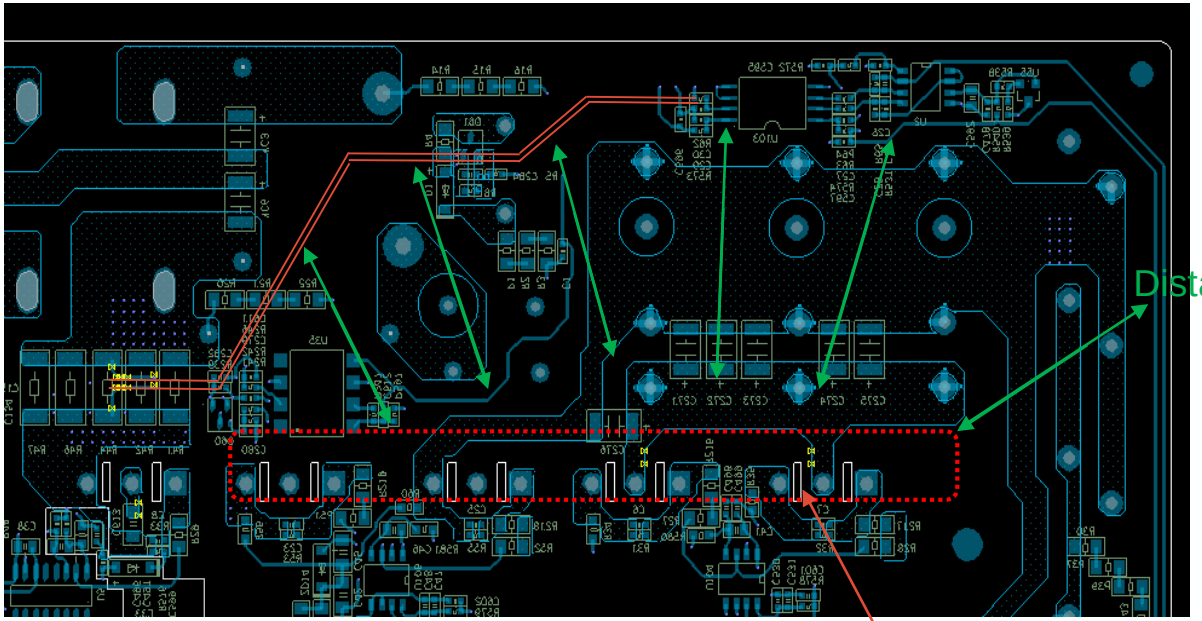


High dv/dt trace/node

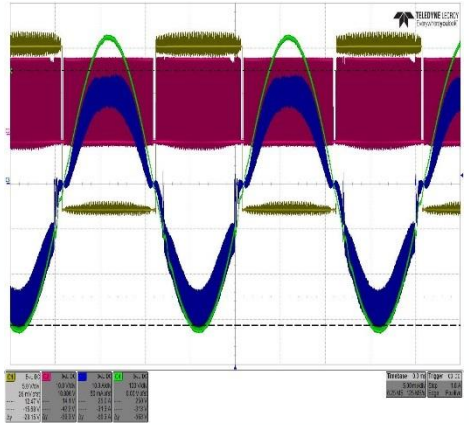


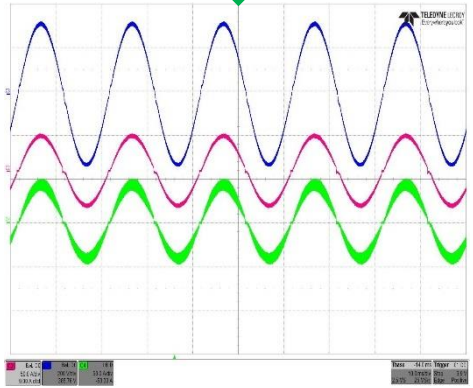
- Keep the sensitive signals far away from the high dV/dt trace/nodes.
- Keep the sensitive signals far away from the high magnetic field such as PFC choke, DCDC power magnetics.
- Small pad size of Drain nodes to reduce the coupling and parasitic capacitance

High dv/dt trace/node



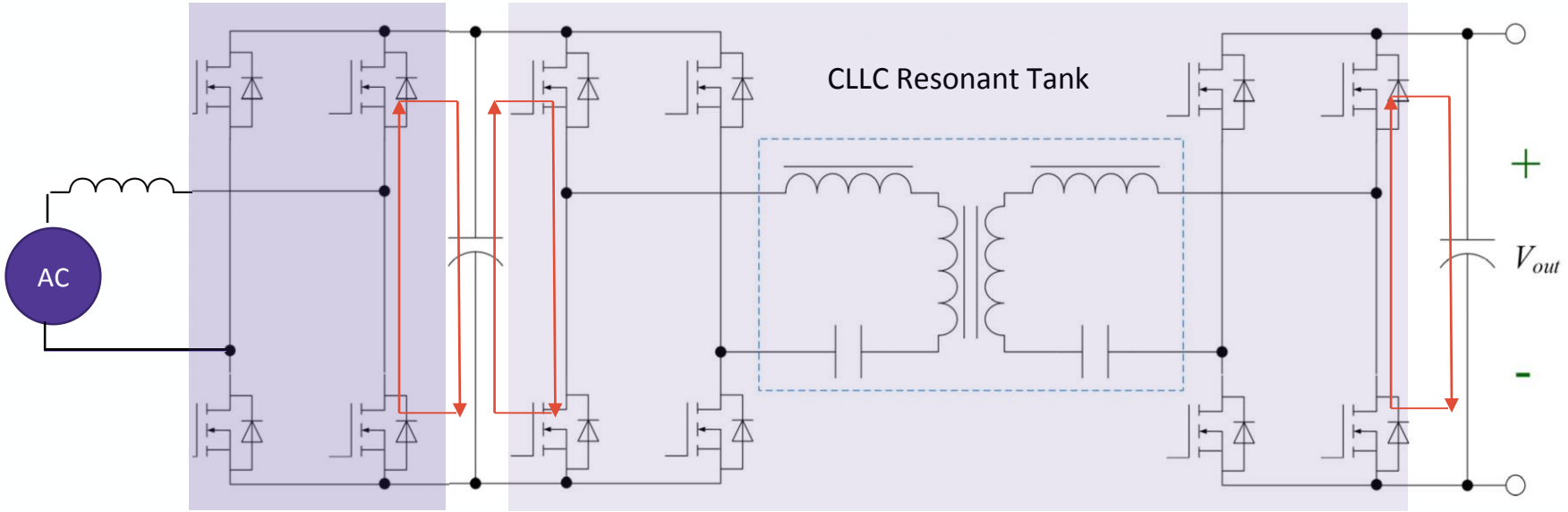
Distance!





- Keep the sensitive signals far away from the high dV/dt trace/nodes.
- Keep the sensitive signals far away from the high magnetic field such as PFC choke, DCDC power magnetics.
- Small pad size of Drain nodes to reduce the coupling and parasitic capacitance

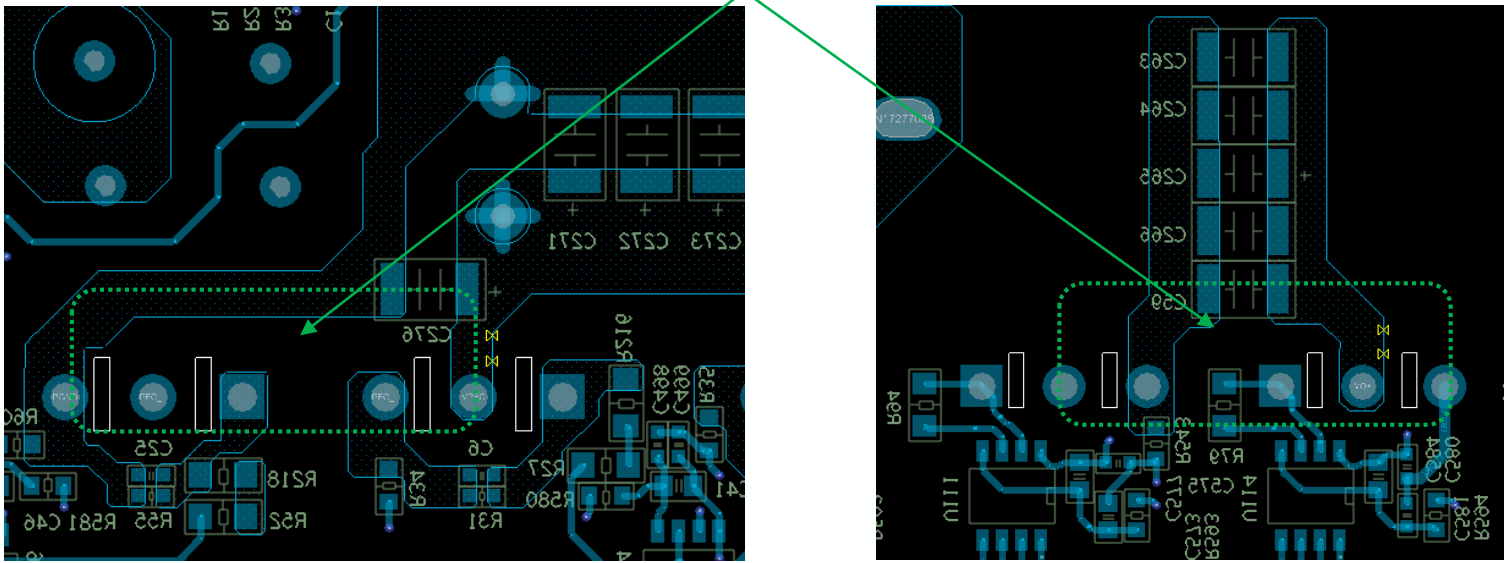
High di/dt loop



- Place ceramic or film caps as close as possible to minimize the high frequency di/dt loop.
- Proper PCB layout of the power components to minimize the high frequency di/dt loop.

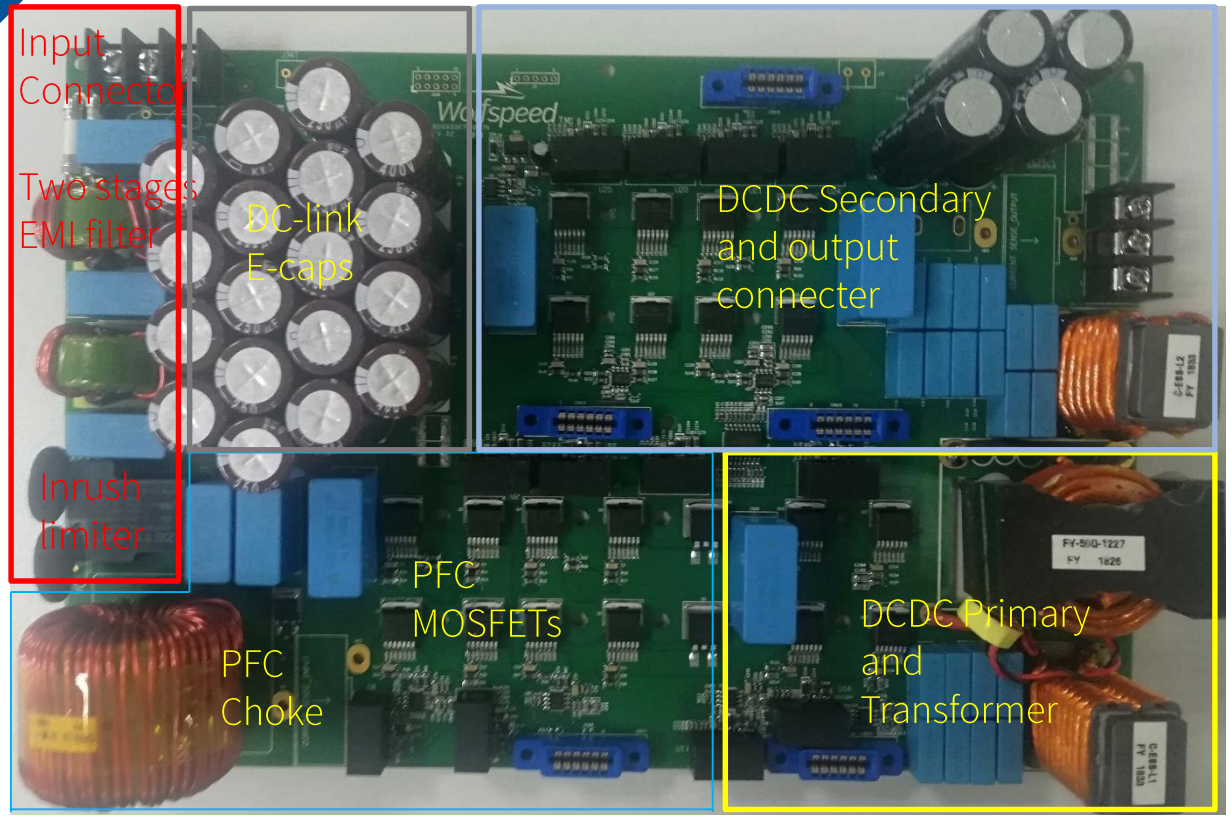
High di/dt loop

small di/dt loop



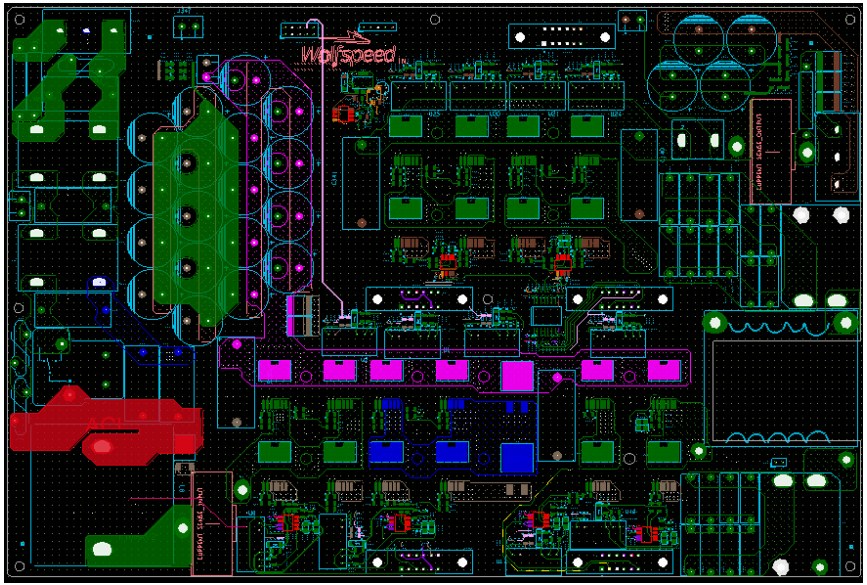
- Place ceramic or film caps as close as possible to minimize the high frequency di/dt loop.
- Proper PCB layout of the power components to minimize the high frequency di/dt loop.

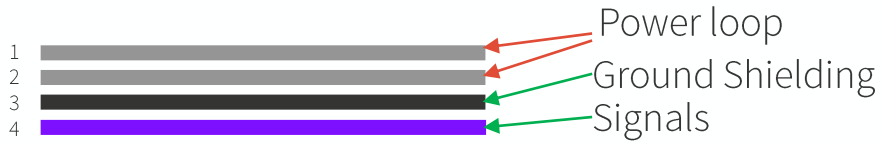
EMI Filter



- Keep the high dV/dt trace/nodes far away from the input EMI filter and connector to minimize the noise coupling.
- Keep the high magnetic field such as PFC choke, DCDC power magnetics far away from the input EMI filter and connector to minimize the noise coupling.

4layers Power Board





Tips(for 4layers PCB):

- 1st and 2nd layers for power loop
- Sensitive signals at bottom layer
- 3rd layer for GND. The ground layer acts as a shielding to cover the signal traces at bottom layer.

THE WOLFSPEED ADVANTAGE

Unprecedented Design Support Tools

Evaluation kits for all discrete packages

Full reference designs

Enabling faster and easier design with Wolfspeed SiC

Gate driver reference designs

Online and offline simulation tools and models

SpeedFit™

LINEAR TECHNOLOGY

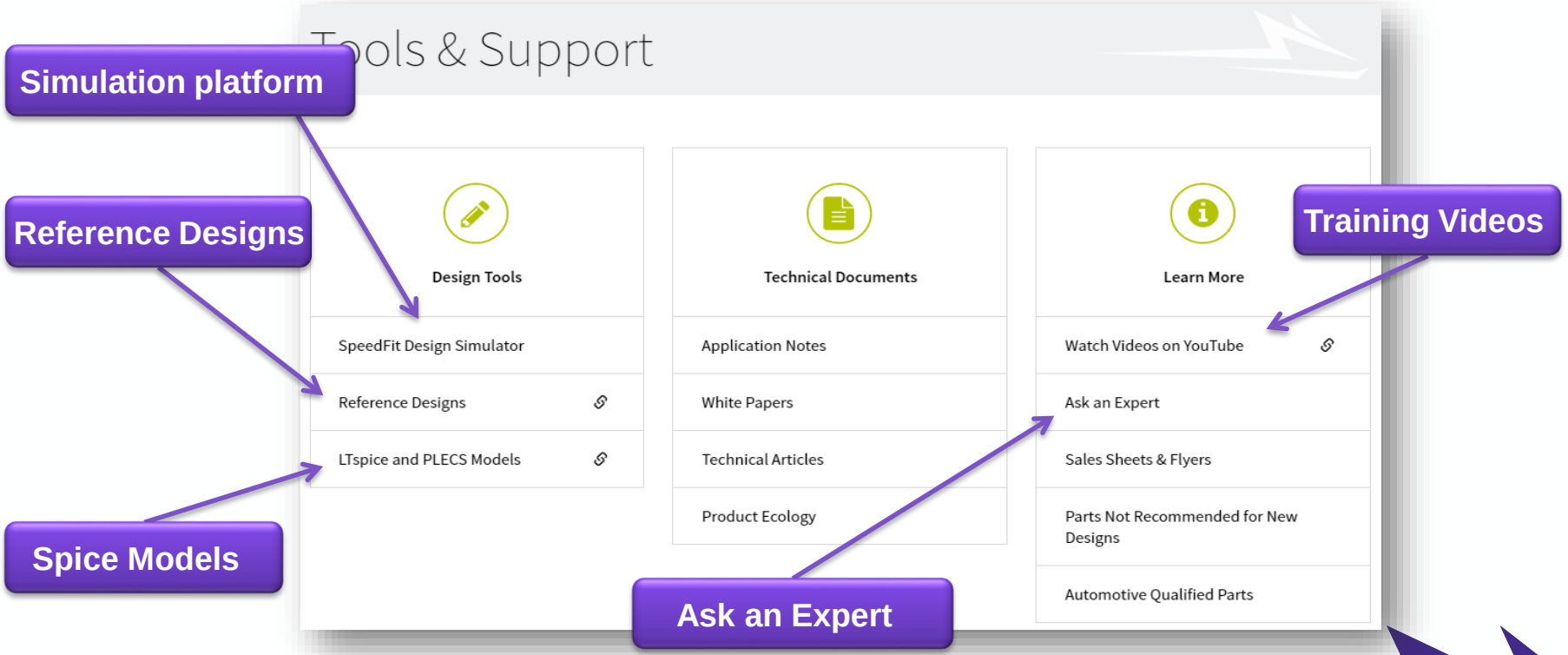
OrCAD CADENCE PCB SOLUTIONS

plecs Simulation Software for Power Electronics

KEY TAKE-AWAYS

Helpful resources

http://www.wolfspeed.com/power/tools-and-support



联系我们

授权代理商

睿查森电子贸易(中国)有限公司

RichardsonRFPD
An Arrow Company

电邮: sales@richardsonrfpd.com

网站: www.richardsonrfpd.com

上海	**021-6235 1788**
深圳	0755-8294 3736
北京	010-6588 5548
成都	028-8620 3488
南京	025-8320 0266
西安	029-8833 8366
苏州	0512-6761 1929
武汉	027-8752 5616
厦门	0592-5033 805
杭州	138-5710-4571
广州	136-0249-2739
青岛	0532-8468 8891
泉州	158-8090-9157