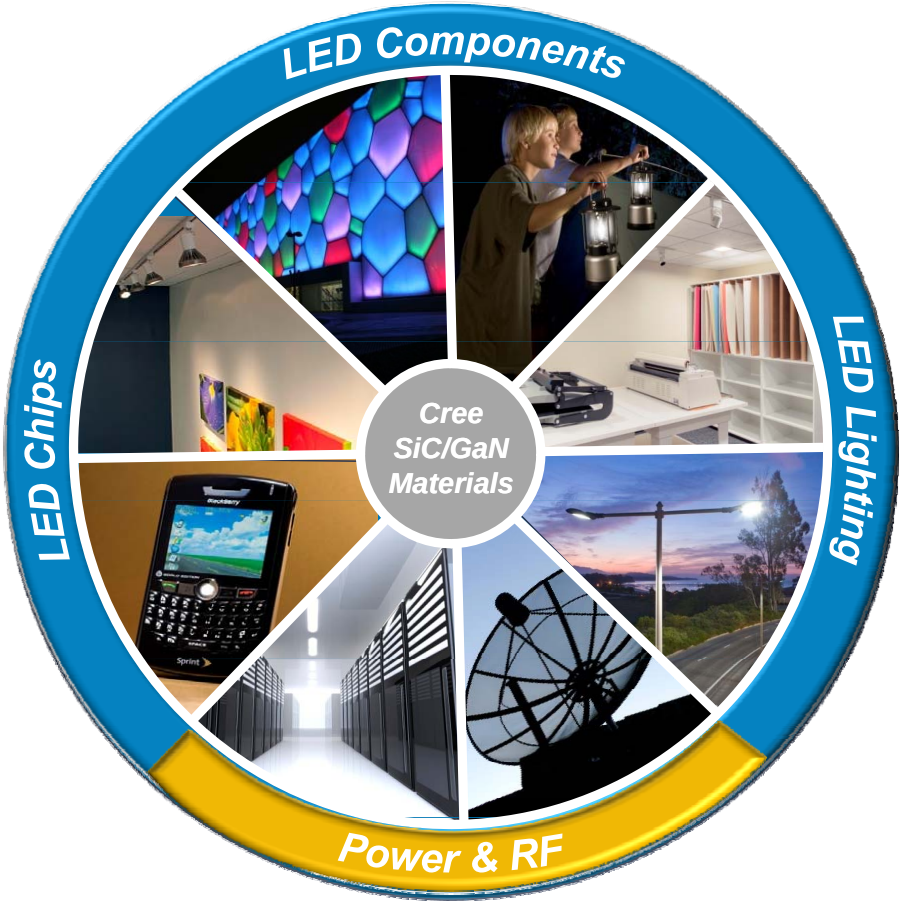
Introducing SiC Schottky Diode QFN Package

2012

Agenda

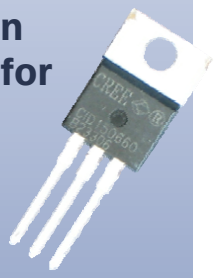
- Introduction to Cree Power
- Schottky Diode QFN Package
- Benefits in LED and Lighting Applications
- Reference Design Test Data

Cree businesses



Power and RF Components

World's leading manufacturer of silicon carbide-based diodes for power control and management.



A leading supplier of SiC and GaN RF devices for wireless communications

Solar Inverters

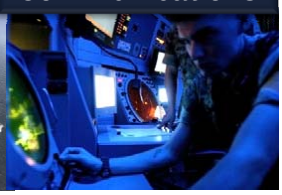
Power Factor Correction

Industrial Motor Drivers

Broadband Amplifiers

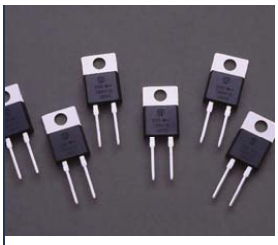
Cellular Infrastructure

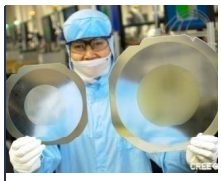
Secure Military Communications



CREE

Revolutionizing the power semiconductors





2002
First 600V commercial SiC Schottky diode

2006
First 1200V SiC Schottky diode

2007
Cree converts to 100mm wafers for Power

2009
Fraunhoefer Inst. Shows world's best solar inverter efficiency, >98% with Cree SiC devices

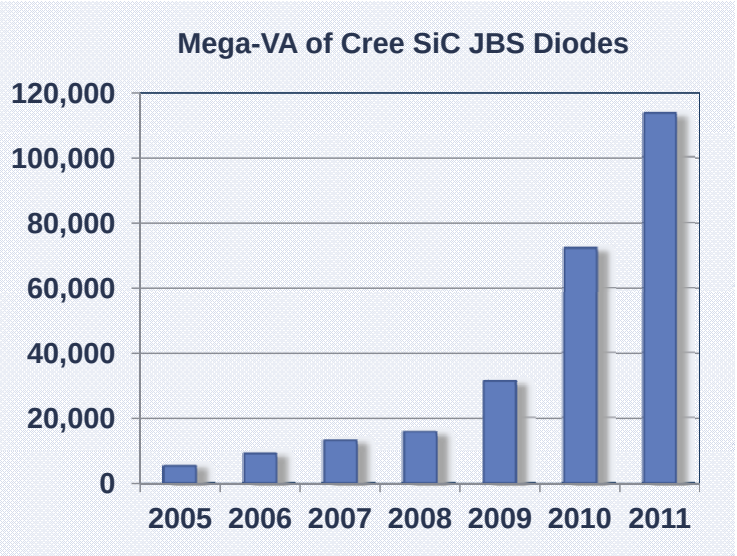
2010
First 1700V Schottky diodes

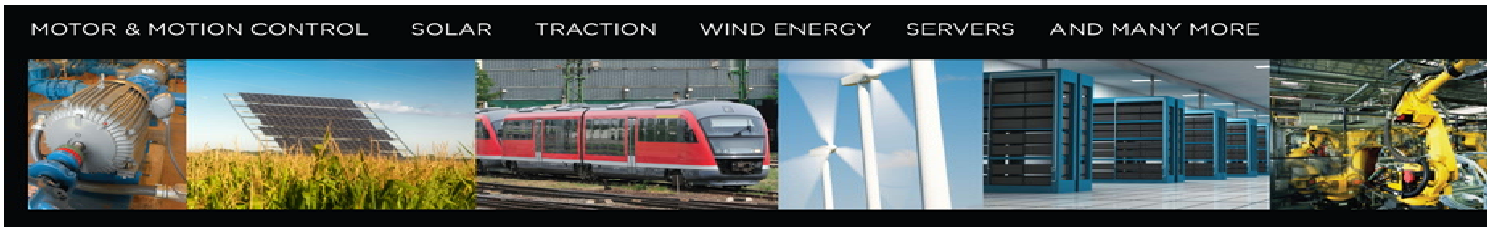
Cree demonstrates first 150mm SiC wafer

2011
First SiC MOSFET 80mΩ, 1200V

Cree Has Shipped 200 GVA of SiC Diodes

- **SiC diodes have significant penetration in applications where efficiency is essential**
  - **Servers fro data centers**
  - **Telecom power supplies**
  - **Solar inverters**
- **SiC MOSFETs enable even greater efficiency improvements**





Cree SiC Diodes: Proven Quality and Reliability

Cree SiC Diode Field Failure Rate Data since Jan. 2004

Product	Device Hours	FIT (fails/billion hrs)
CSDxxx60	205,000,000,000	0.16
C3Dxxx60	81,000,000,000	0.09
C2Dxx120	46,000,000,000	1.35
Total	**332,000,000,000**	**0.31**

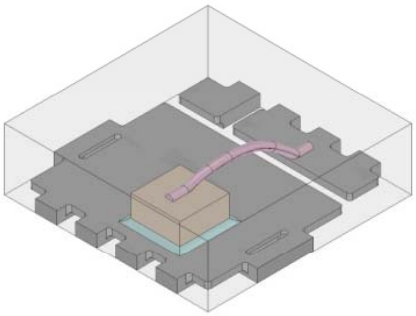
More than 10X lower than typical silicon

Typical FIT rate for Si PiN diodes is ~ 5

300 billion device hours in the field with an industry-leading FIT rate of only 0.31

New “QFN” Package - C3D1P7060Q

- **Key Electrical Parameters**
  - Forward Rated Current: 1.7A @ T_C < 150 ˚C
  - Reverse Blocking Voltage: 600V
  - Forward Voltage: 1.7V @ 100˚C
  - Total Charge Q_C : 5.6 nC



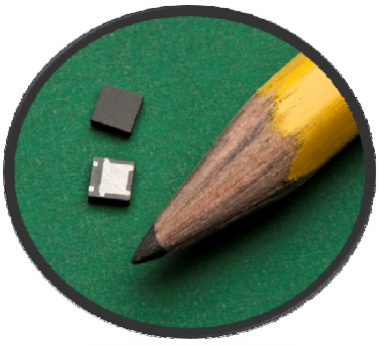
- **Package**
  - Smallest SiC package in the market
  - 3.3 x 3.3 x 1mm QFN Surface Mount

- **Benefits**
  - Higher driver efficiency = **Higher Lm/W**
  - Lower thermals for diode, surrounding components
  - Smaller footprint

Why Cree Schottky Diodes?

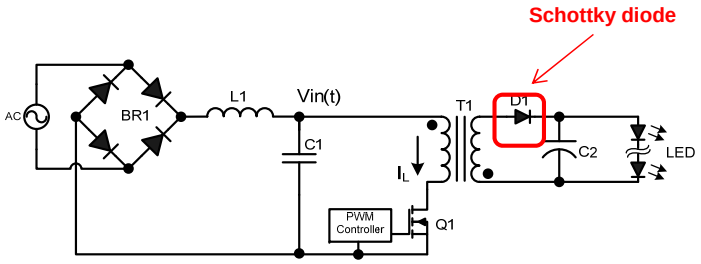
Cree C3D1P7060Q in Light Bulb applications

- Cree's new C3D1P7060Q well suited for new Non-Isolated lighting applications
- Industry's smallest SiC package well suited for space constrained application such as Lighting
- Improved Switching behavior reduces thermals and stress on MOSFET



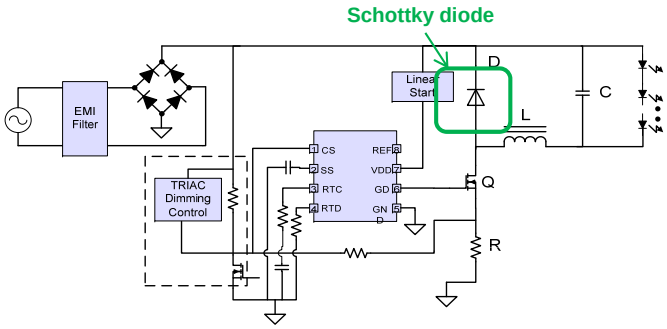
Isolated Vs Non-Isolated LED Lighting

Isolated Single Stage Flyback



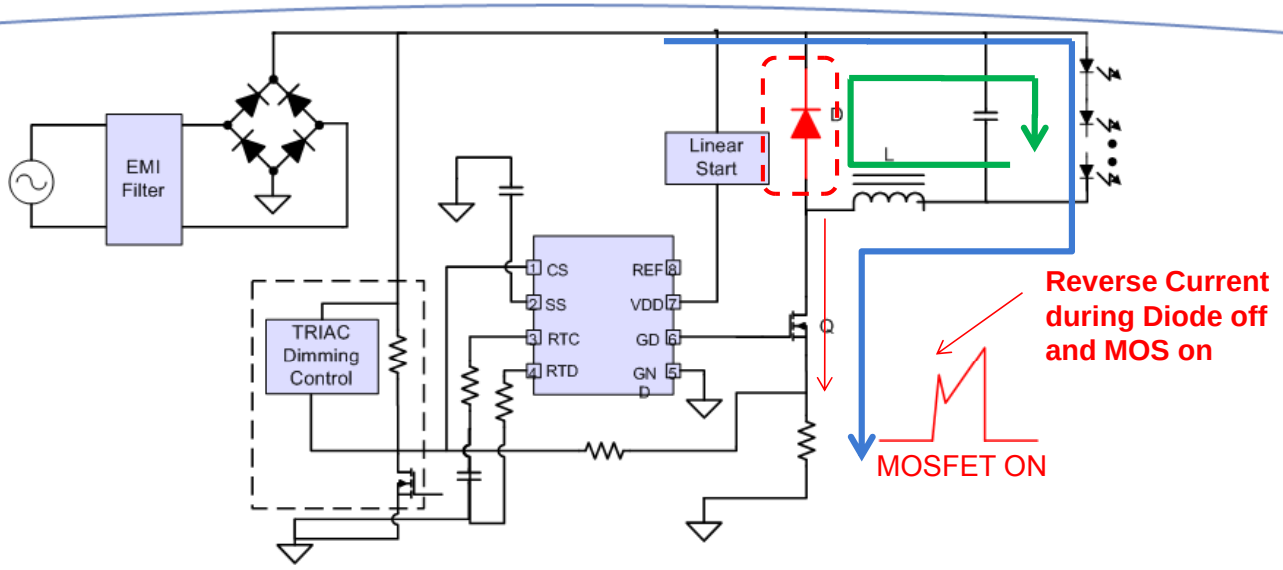
- Transformer for isolation
- Single Stage Flyback
- Typical Eff. 80%
- Freewheeling Schottky output diode
  - Diode blocking DC voltage <200V, Si Schottky diodes ok

Non-Isolated Low-Side Buck



- Inductor with no isolation
- Low Side Buck
- Typical Eff. 85%
- Freewheeling diode during MOSFET off time
  - Diode blocking DC voltage >400V, Si Schottky limit to 200V

Why use a SiC Schottky Diode?



- **Simplified Circuit operation**

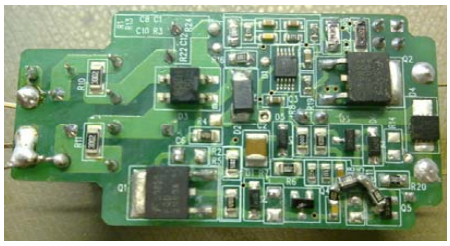
  MOSFET Q is turned on, current ramps up through inductor and LED string

  MOSFET Q is turned off and the freewheeling diode D conducts the current the current through the inductor and LED string

  Any reverse recover current from diode will flow into the MOSFET.

7W Non-Isolated LED Reference design

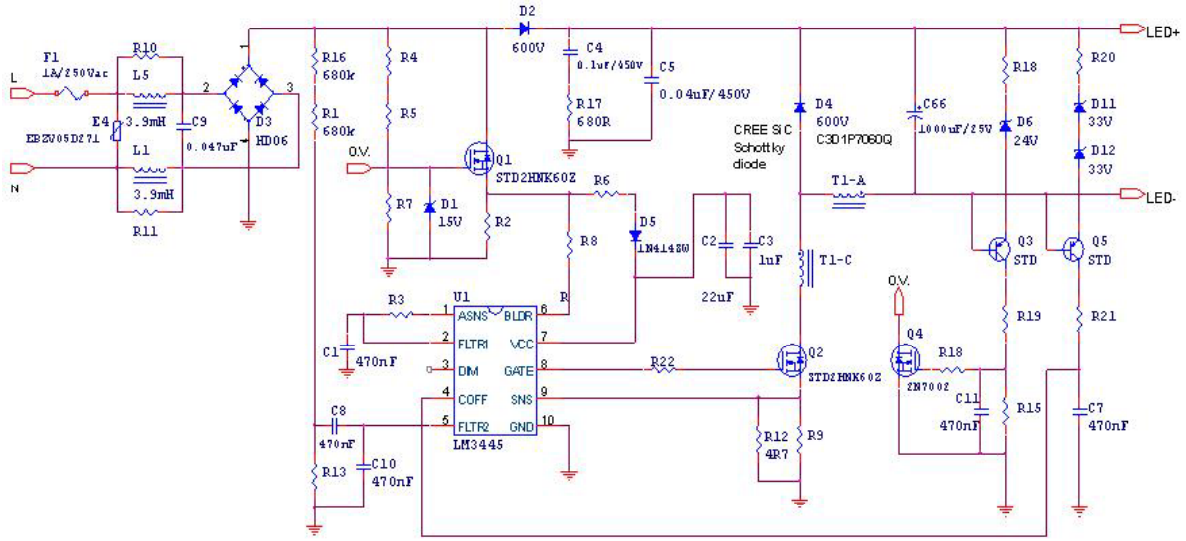
55mmx28mmx13mm



Specification Items	Min	Typical	Max
Input AC Voltage	180Vac	220Vac	264Vac
Output Voltage Tolerance	20Vdc	26Vdc	28Vdc
Output current per string	250mA	270mA	285mA
Output current tolerance			+-5%
Efficiency with Cree SiC		82%	
Power Factor	0.8	0.85	
Controller	LM3445		
Dimming	Phase cutting dimmable		
LED	Cree XPE 10pcs [100mA to 400mA]		

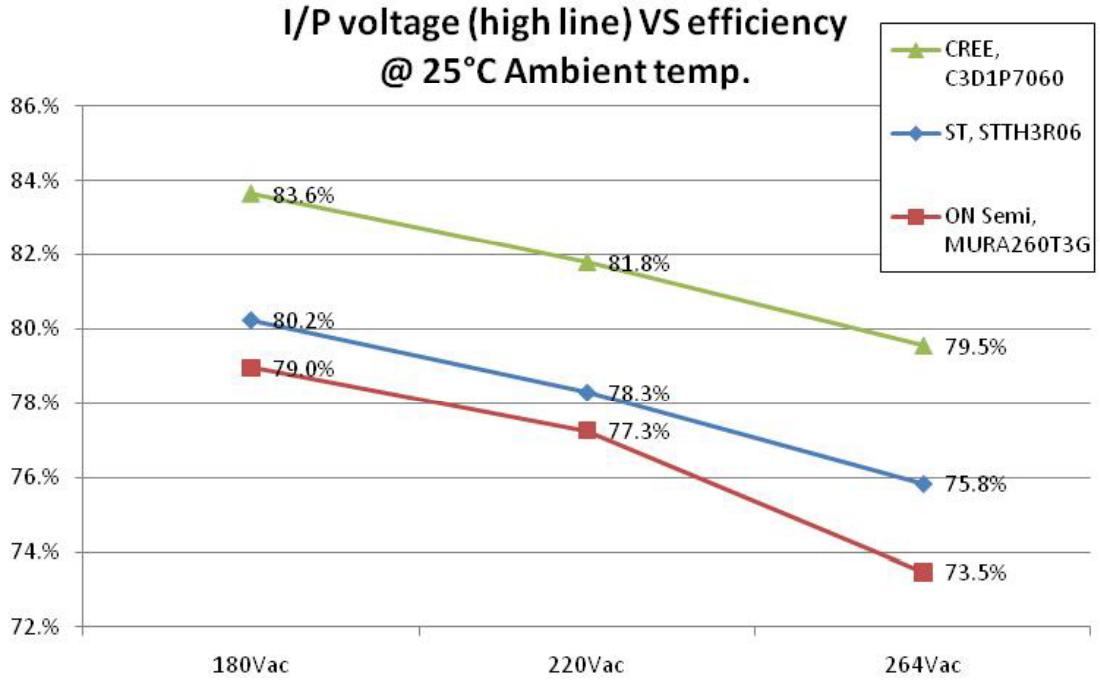
7W Cree Reference Design - Schematic

- **Driver Spec**
  - Input: 240Vac
  - Output: 25Vdc, 270mA (7W) – 40W Incandescent Replacement
  - Switching Freq: 125kHz
  - Driver IC: TI/National LM3445



7W Cree Reference Design - Test Data

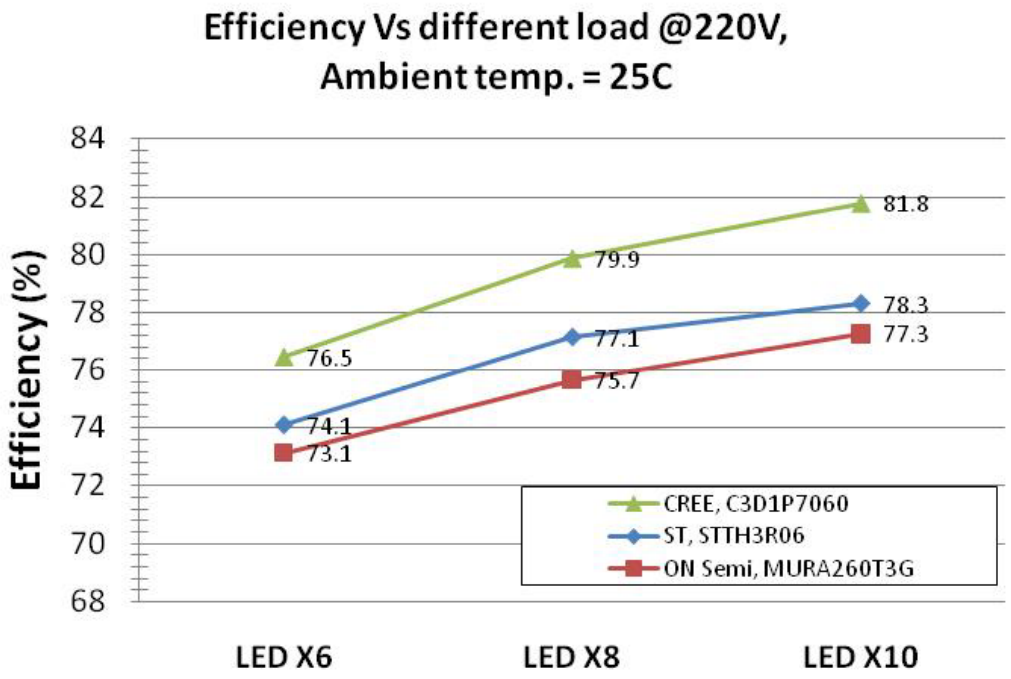
Efficiency Comparison



- ~4% efficiency improvement

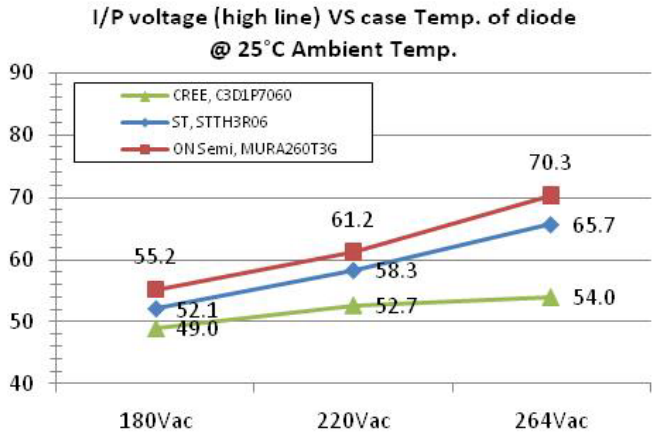
7W Cree Reference Design - Test Data

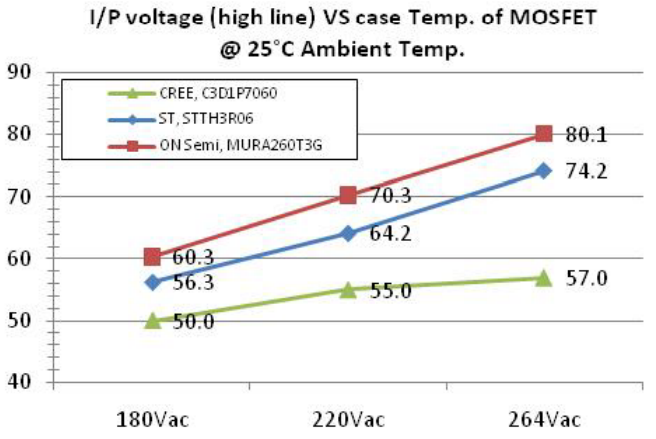
Efficiency Comparison at different load conditions



7W Cree Reference Design - Test Data (cont.)

- **MOSFET and Diode Temperature Comparison**



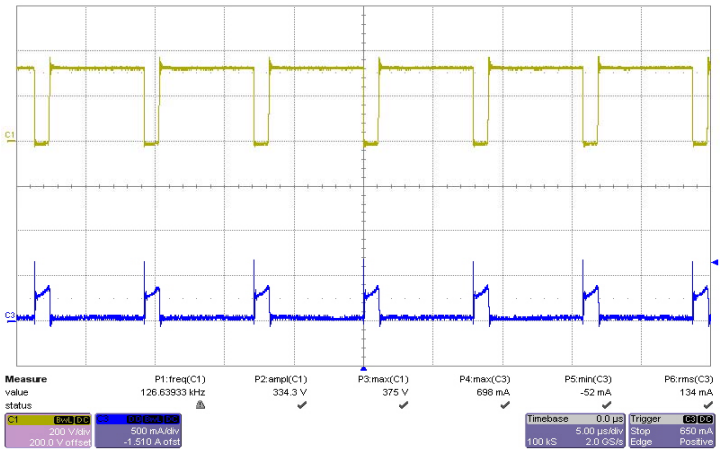


- **12°C cooler on Diode**
- **17°C cooler on MOSFET**

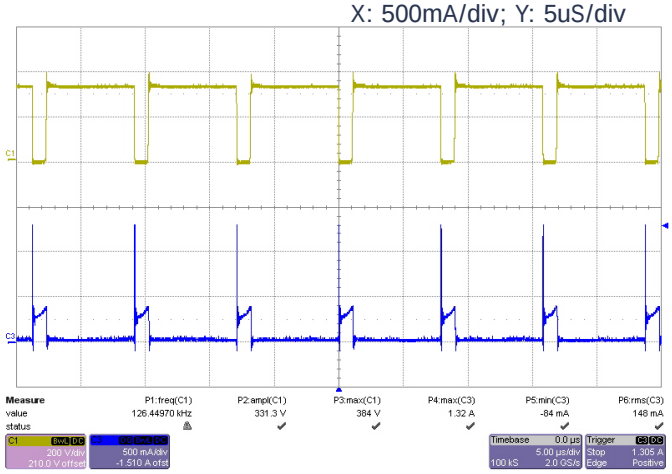
7W Cree Reference Design - Test Data (cont.)

- **MOSFET Comparison**

Brown: V_{ds} MOSFET
X: 200V/div; Y: 5uS/div
Blue: I_{ds} MOSFET
X: 500mA/div; Y: 5uS/div



Cree I_{ds} Max 698mA



ON Semi I_{ds} Max 1.32A

- **Lower MOSFET stress since less reverse recovery current from diode**

Test Data Summary

- **C3D1P7060Q Schottky diode enables highest efficiency solutions**
  1. CCM with low-side BUCK converter
  2. High output current LED>300mA

- **C3D1P7060Q Schottky diode brings system benefits**
  1. Small 3.3 x 3.3 mm footprint saves space
  2. Efficiency improves 4-5%
  3. Thermal reduction 15-20C can shrink heatsink, prolong life of caps
  4. Reduce MOSFET current rating (lower cost part)

Conclusion

- **C3D1P7060Q Schottky diode enables higher Lm/W**
  1. Best fit topology
     - CCM with low-side BUCK converter
     - High output current LED>300mA

- **System benefits**
  1. Space savings/higher density
     - Small 3.3 x 3.3 mm footprint
  2. Efficiency improves 2-5%
  3. Improved reliability
     - SiC more reliable than Si
     - Thermal reduction 15-20C can shrink heatsink, prolong life of caps
     - Reduce MOSFET current rating (lower cost part)