

# CCS050M12CM2

## 1.2kV, 25mΩ All-Silicon Carbide Six-Pack (Three Phase) Module

### C2M MOSFET and Z-Rec™ Diode

$V_{DS}$	1.2 kV
$E_{SW, Total} @ 50A, 150^{\circ}C$	1.7 mJ
$R_{DS(on)}$	25 mΩ

#### Features

- Ultra Low Loss
- Zero Reverse Recovery Current
- Zero Turn-off Tail Current
- High-Frequency Operation
- Positive Temperature Coefficient on  $V_F$  and  $V_{DS(on)}$
- Cu Baseplate, AlN DBC

#### System Benefits

- Enables Compact and Lightweight Systems
- High Efficiency Operation
- Ease of Transistor Gate Control
- Reduced Cooling Requirements
- Reduced System Cost

#### Applications

- Solar Inverters
- UPS and SMPS
- Induction Heating
- Regen Drives
- 3-Phase PFC
- Motor Drives

#### Package



Part Number	Package	Marking
CCS050M12CM2	Six-Pack	CCS050M12CM2

#### Maximum Ratings ( $T_C = 25^{\circ}C$ unless otherwise specified)

Symbol	Parameter	Value	Unit	Test Conditions	Notes
$V_{DS}$	Drain - Source Voltage	1.2	kV		
$V_{GS}$	Gate - Source Voltage	-10/+25	V	Absolute maximum values	
$V_{GS}$	Gate - Source Voltage	-5/+20	V	Recommended operational values	
$I_D$	Continuous Drain Current	87	A	$V_{GS} = 20 V, T_C = 25^{\circ}C$	Fig. 26
		59		$V_{GS} = 20 V, T_C = 90^{\circ}C$	
$I_{D(pulse)}$	Pulsed Drain Current	250	A	Pulse width $t_p$ limited by $T_{jmax}$	Fig. 28
$I_F$	Continuous Diode Forward Current	102	A	$V_{GS} = -5 V, T_C = 25^{\circ}C$	
		62		$V_{GS} = -5 V, T_C = 90^{\circ}C$	
$I_{FSM}$	Non-Repetitive Diode Forward Surge Current	400	A	$V_{GS} = -5 V, T_C = 110^{\circ}C, t_p = 10 ms,$ Half Sine Pulse,	
$T_j$	Junction Temperature	-40 to +150	$^{\circ}C$		
$T_C, T_{STG}$	Case and Storage Temperature Range	-40 to +125	$^{\circ}C$		
$V_{isol}$	Case Isolation Voltage	5.0	kV	AC, 50 Hz, 1 min	
$L_{Stray}$	Stray Inductance	30	nH	Measured from pins 25-26 to 27-28	
$P_D$	Power Dissipation	312	W	$T_C = 25^{\circ}C, T_j \leq 150^{\circ}C$	Fig. 27



## Electrical Characteristics ( $T_c = 25^\circ\text{C}$ unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions	Note
$V_{(BR)DSS}$	Drain - Source Breakdown Voltage	1.2			kV	$V_{GS} = 0\text{ V}, I_D = 250\ \mu\text{A}$	
$V_{GS(th)}$	Gate Threshold Voltage		2.3		V	$V_D = V_G, I_D = 2.5\ \text{mA}$	
			1.6			$V_{DS} = 10\ \text{V}, I_D = 2.5\ \text{mA}, T_J = 150^\circ\text{C}$	
$I_{DSS}$	Zero Gate Voltage Drain Current		2	250	$\mu\text{A}$	$V_{DS} = 1.2\ \text{kV}, V_{GS} = 0\text{V}$	
$I_{GSS}$	Gate-Source Leakage Current			100	nA	$V_{GS} = 25\ \text{V}, V_{DS} = 0\text{V}$	
$R_{DS(on)}$	On State Resistance		25	36	m $\Omega$	$V_{GS} = 20\ \text{V}, I_{DS} = 50\ \text{A}$	Figs. 4-7
			43	63		$V_{GS} = 20\ \text{V}, I_{DS} = 50\ \text{A}, T_J = 150^\circ\text{C}$	
$g_{fs}$	Transconductance		22		S	$V_{DS} = 20\ \text{V}, I_{DS} = 50\ \text{A}$	Fig. 8
			21			$V_{DS} = 20\ \text{V}, I_D = 50\ \text{A}, T_J = 150^\circ\text{C}$	
$C_{iss}$	Input Capacitance		2.810		nF	$V_{DS} = 800\ \text{V}, V_{GS} = 0\ \text{V}$ $f = 1\ \text{MHz}, V_{AC} = 25\ \text{mV}$	Figs. 16,17
$C_{oss}$	Output Capacitance		0.393				
$C_{rss}$	Reverse Transfer Capacitance		0.014				
$E_{on}$	Turn-On Switching Energy		1.1		mJ	$V_{DD} = 600\ \text{V}, V_{GS} = +20\text{V}/-5\text{V}$ $I_D = 50\ \text{A}, R_G = 20\ \Omega$ Load = 200 $\mu\text{H}$ $T_J = 150^\circ\text{C}$ Note: IEC 60747-8-4 Definitions	Fig. 18
$E_{off}$	Turn-Off Switching Energy		0.6				
$R_{G(int)}$	Internal Gate Resistance		1.5		$\Omega$	$f = 1\ \text{MHz}, V_{AC} = 25\ \text{mV}$	
$Q_{GS}$	Gate-Source Charge		32		nC	$V_{DD} = 800\ \text{V}, I_D = 50\ \text{A}$	Fig. 15
$Q_{GD}$	Gate-Drain Charge		30				
$Q_G$	Total Gate Charge		180				
$t_{d(on)}$	Turn-on delay time		21		ns	$V_{DD} = 800\text{V}, R_{LOAD} = 8\ \Omega$ $V_{GS} = +20/-2\text{V}, R_G = 3.8\ \Omega$ $T_J = 25^\circ\text{C}$ Note: IEC 60747-8-4 Definitions	Figs. 20-25
$t_r$	Rise time		30				
$t_{d(off)}$	Turn-off delay time		50				
$t_f$	Fall time		19				
$V_{SD}$	Diode Forward Voltage		1.5	1.8	V	$I_F = 50\ \text{A}, V_{GS} = 0$	Figs. 10-11
			2.0	2.3		$I_F = 50\ \text{A}, T_J = 150^\circ\text{C}$	
$Q_C$	Total Capacitive Charge		0.28		$\mu\text{C}$		

## Thermal Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions	Note
$R_{thJCM}$	Thermal Resistance Junction-to-Case for MOSFET		0.37	0.40	$^\circ\text{C}/\text{W}$	$T_c = 90^\circ\text{C}, P_D = 150\ \text{W}$	
$R_{thJCD}$	Thermal Resistance Junction-to-Case for Diode		0.42	0.43		$T_c = 90^\circ\text{C}, P_D = 130\ \text{W}$	

## NTC Characteristics

Symbol	Condition	Typ.	Max.	Unit
$R_{25}$	$T_c = 25^\circ\text{C}$	5		k $\Omega$
Delta R/R	$T_c = 100^\circ\text{C}, R_{100} = 481\ \Omega$		$\pm 5$	%
$P_{25}$	$T_c = 25^\circ\text{C}$			mW
$B_{25/50}$	$R_2 = R_{25} \exp[B_{25/50}(1/T_2 - 1/(298.15\text{K}))]$	3380		K

## Additional Module Data

Symbol	Condition	Max	Unit	Test Condition
W	Weight	180	g	
M	Mounting Torque	5	Nm	To heatsink

# Typical Performance

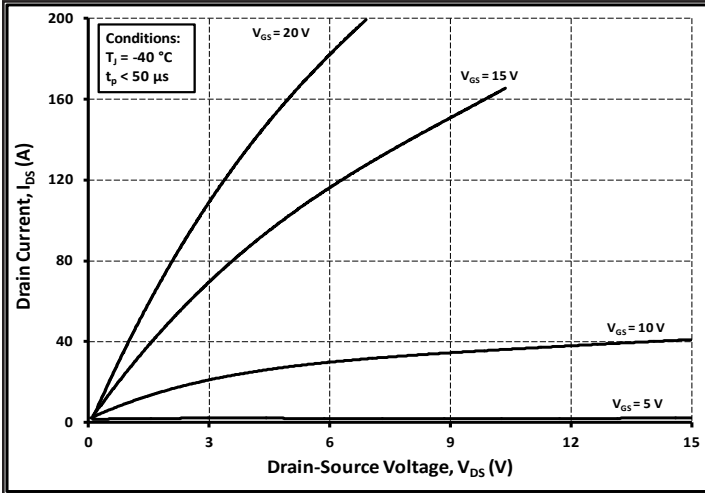


Figure 1. Typical Output Characteristics  $T_j = -40\text{ }^\circ\text{C}$

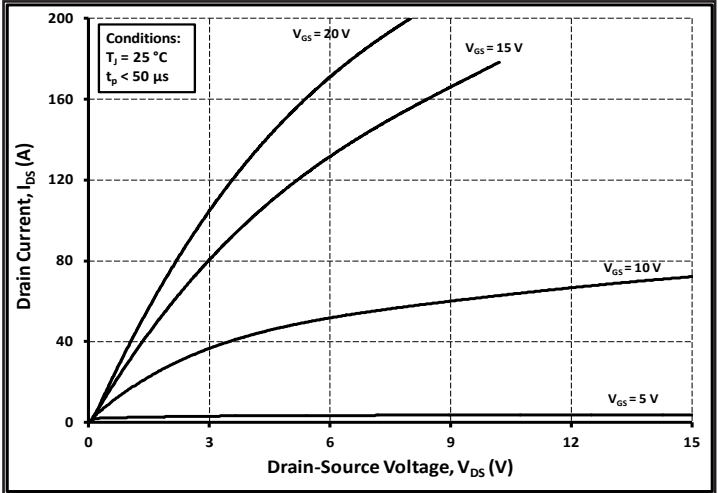


Figure 2. Typical Output Characteristics  $T_j = 25\text{ }^\circ\text{C}$

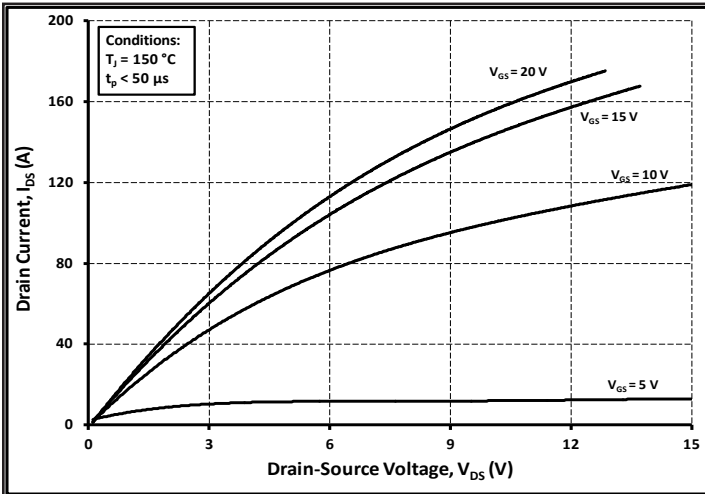


Figure 3. Typical Output Characteristics  $T_j = 150\text{ }^\circ\text{C}$

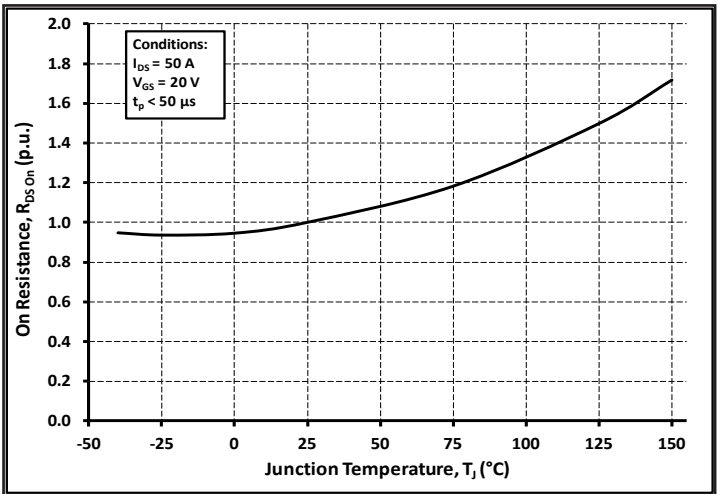


Figure 4. Normalized On-Resistance vs. Temperature

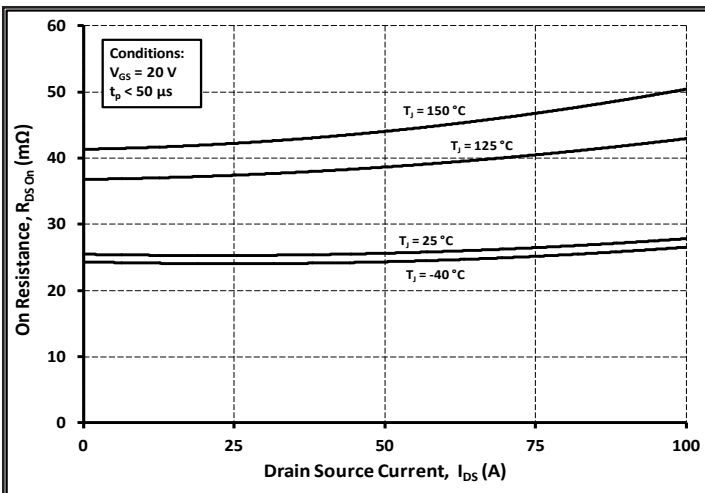


Figure 5. Normalized On-Resistance vs. Drain Current For Various Temperatures

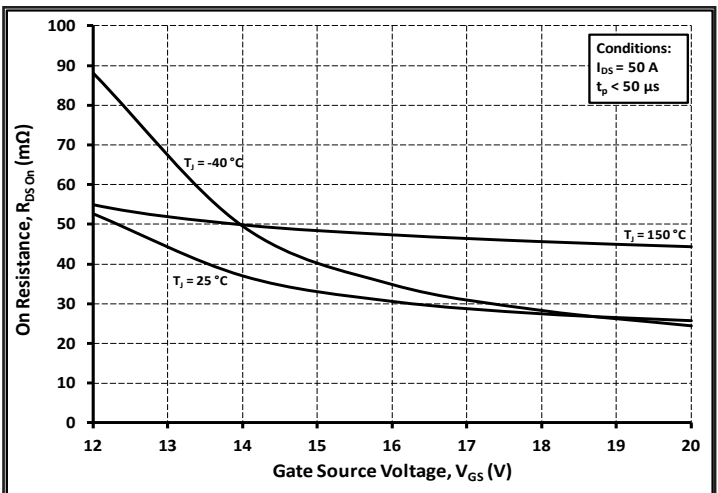


Figure 6. Normalized On-Resistance vs. Gate-Source Voltage for Various Temperatures

## Typical Performance

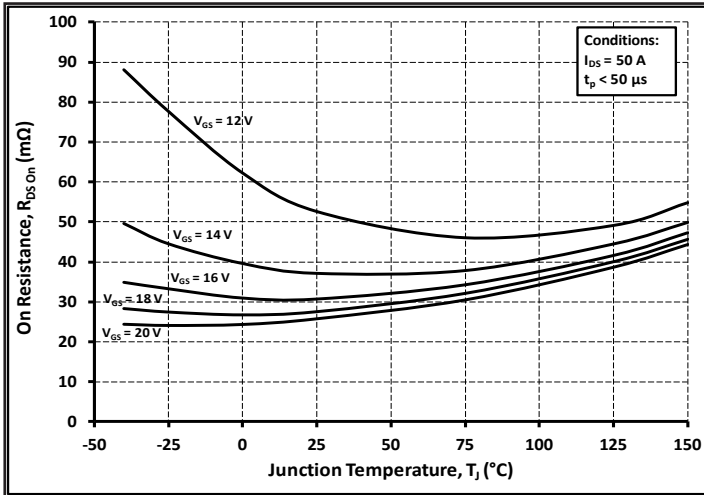


Figure 7. On-Resistance vs. Temperature for Various Gate-Source Voltages

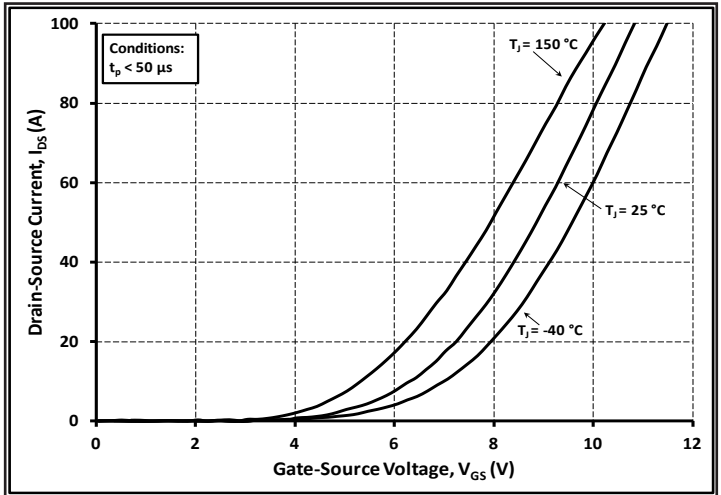


Figure 8. Transfer Characteristic for Various Junction Temperatures

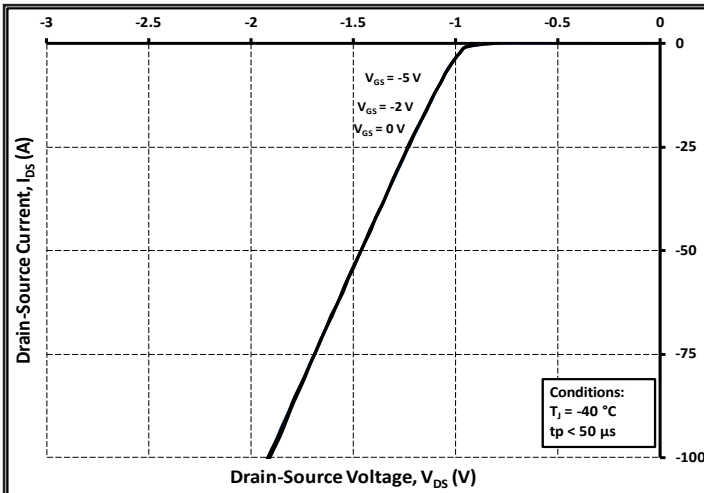


Figure 9. Diode Characteristic at -40 °C

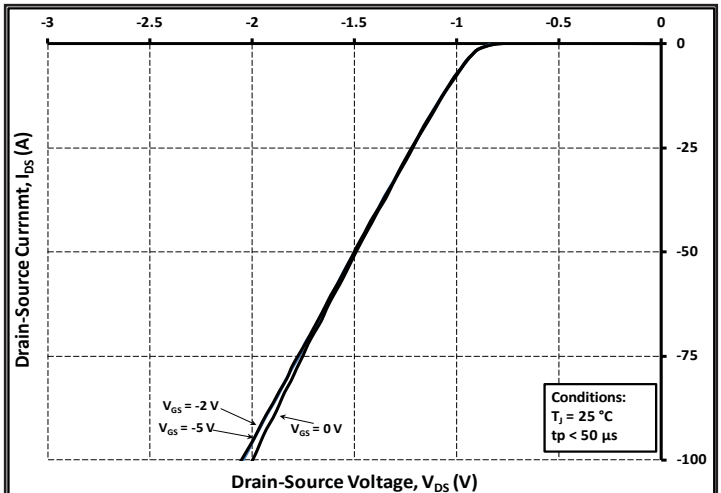


Figure 10. Diode Characteristic at 25 °C

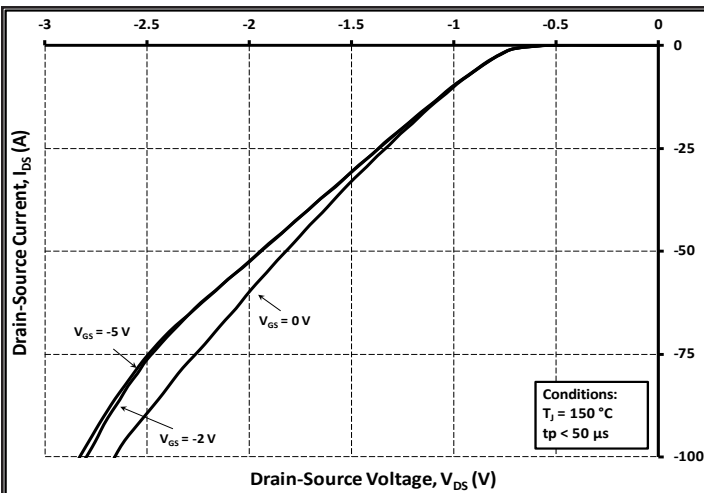


Figure 11. Diode Characteristic at 150 °C

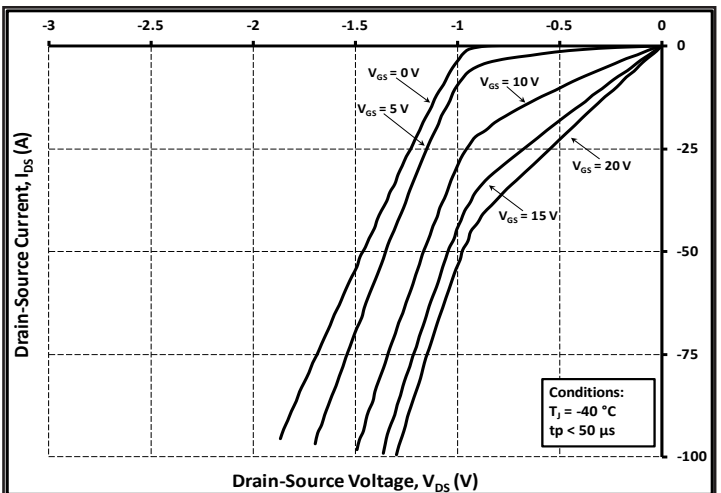


Figure 12. 3<sup>rd</sup> Quadrant Characteristic at -40 °C

# Typical Performance

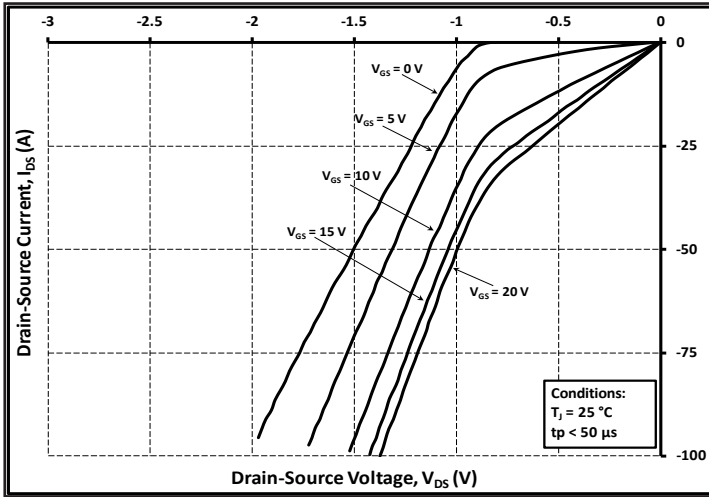


Figure 13. 3<sup>rd</sup> Quadrant Characteristic at 25 °C

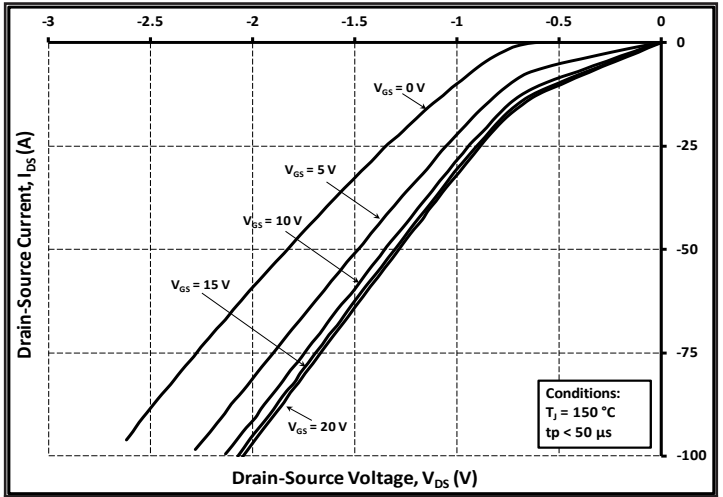


Figure 14. 3<sup>rd</sup> Quadrant Characteristic at 150 °C

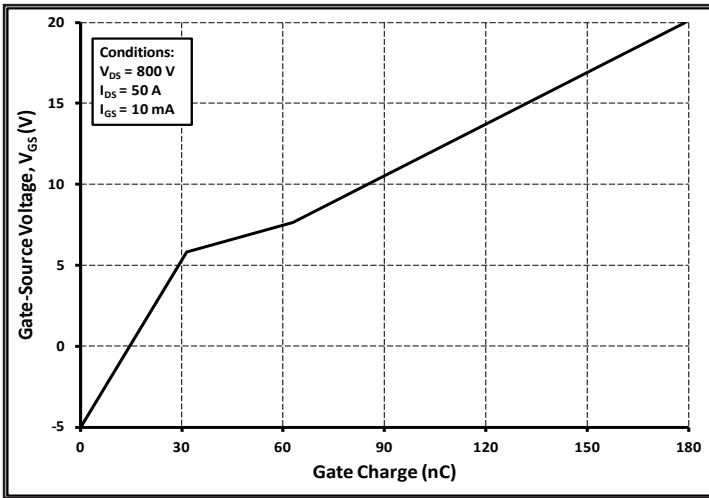


Figure 15. Typical Gate Charge Characteristics

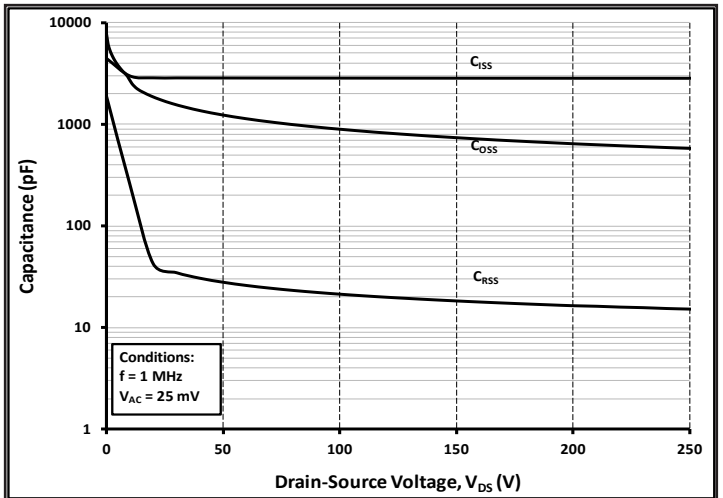


Figure 16. Typical Capacitances vs. Drain-Source Voltage (0 - 250 V)

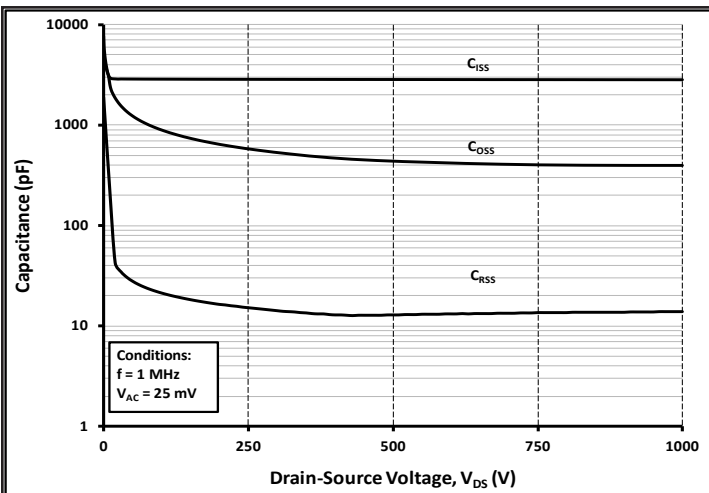


Figure 17. Typical Capacitances vs. Drain-Source Voltage (0 - 1 kV)

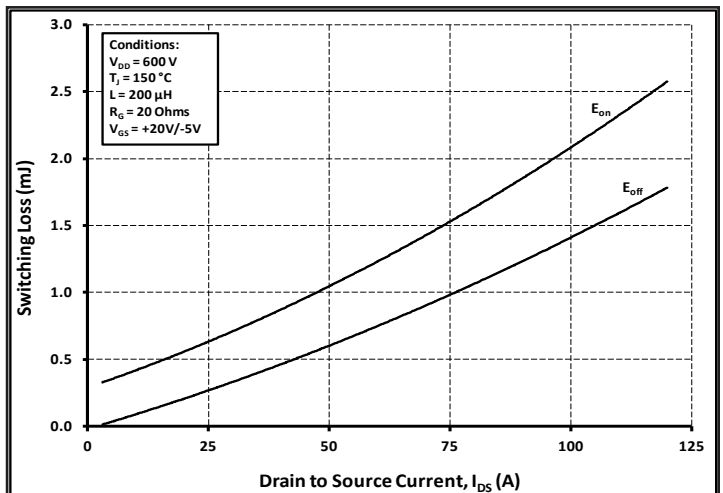


Figure 18. Inductive Switching Energy vs. Drain Current For  $V_{DS} = 600V$ ,  $R_G = 20 \Omega$

## Typical Performance

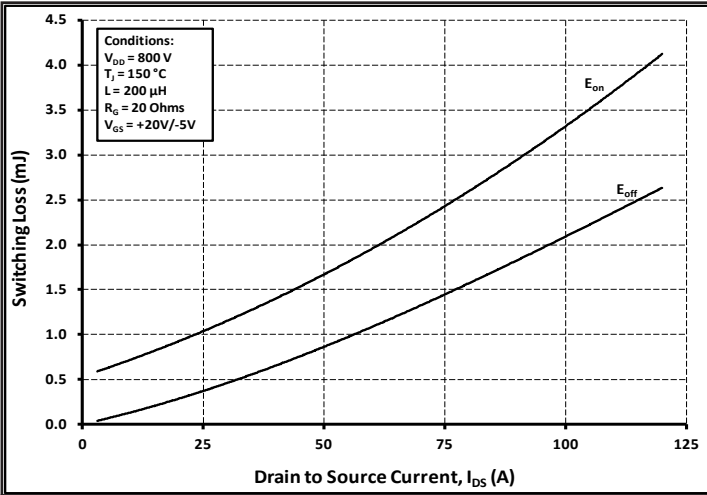


Figure 19. Inductive Switching Energy vs. Drain Current For  $V_{DS} = 800\text{ V}$ ,  $R_G = 20\text{ }\Omega$

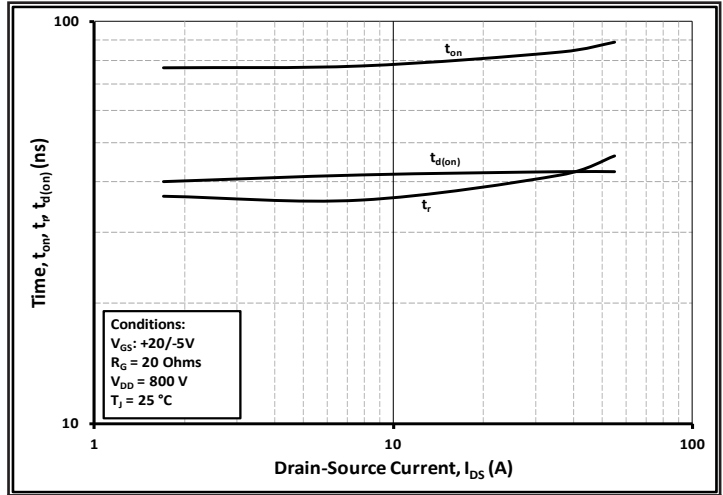


Figure 20. Turn-on Timing vs. Drain Current

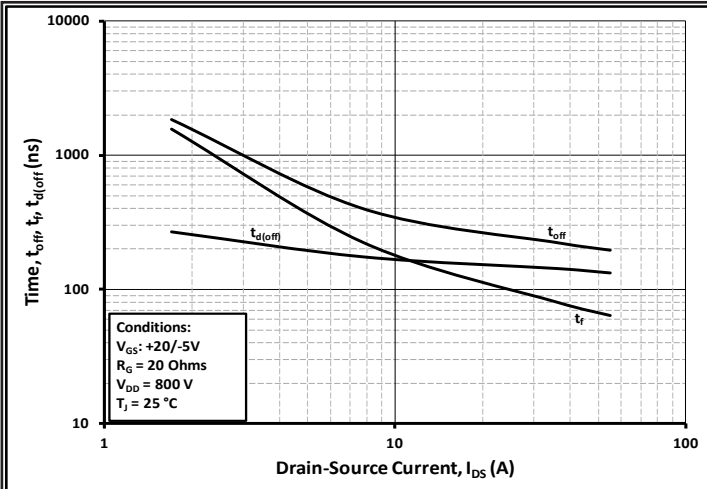


Figure 21. Turn-off Timing vs. Drain Current

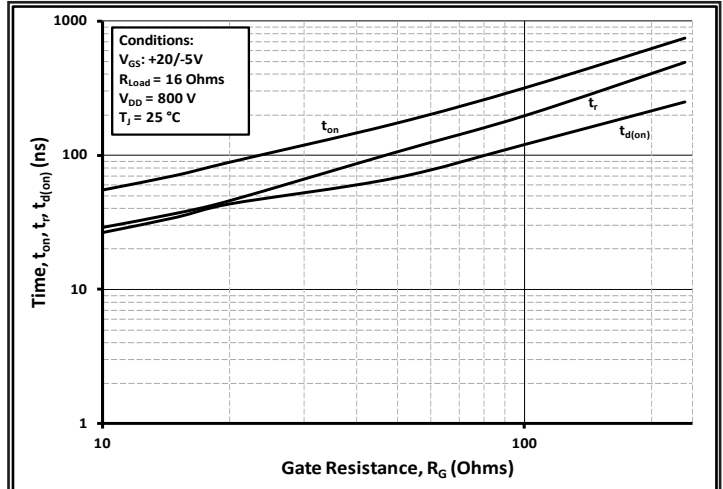


Figure 22. Turn-on Timing vs. External Gate Resistor

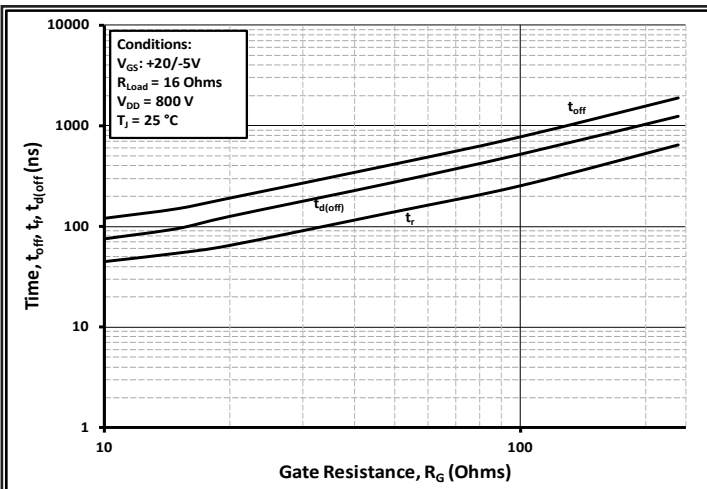


Figure 23. Turn-off Timing vs. External Gate Resistor

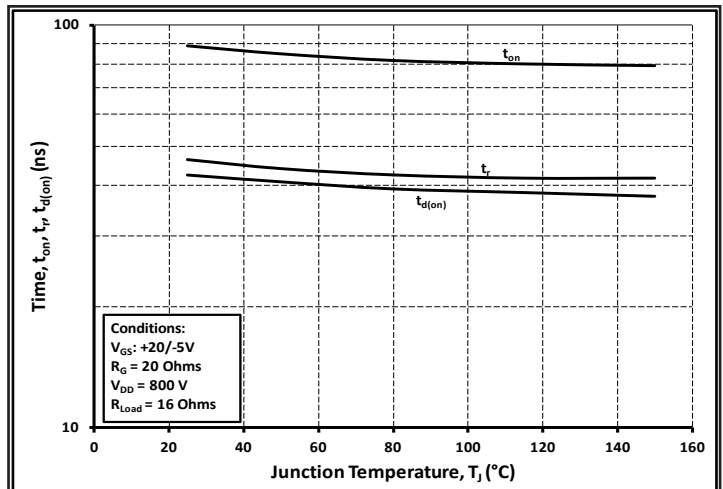


Figure 24. Turn-on Timing vs. Junction Temperature

# Typical Performance

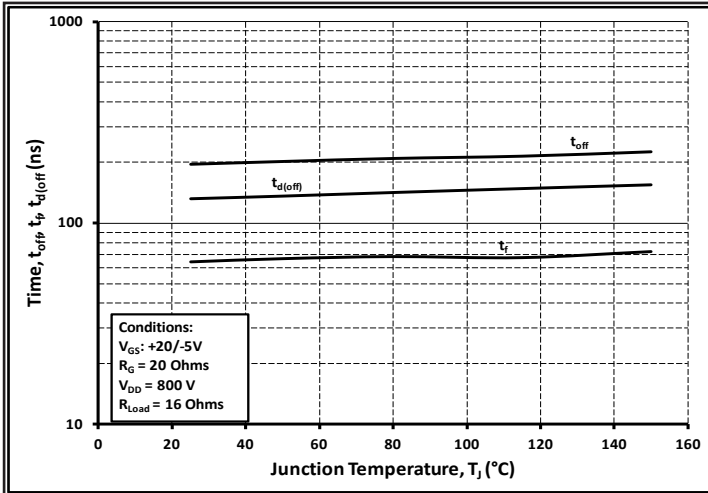


Figure 25. Turn-on Timing vs. Junction Temperature

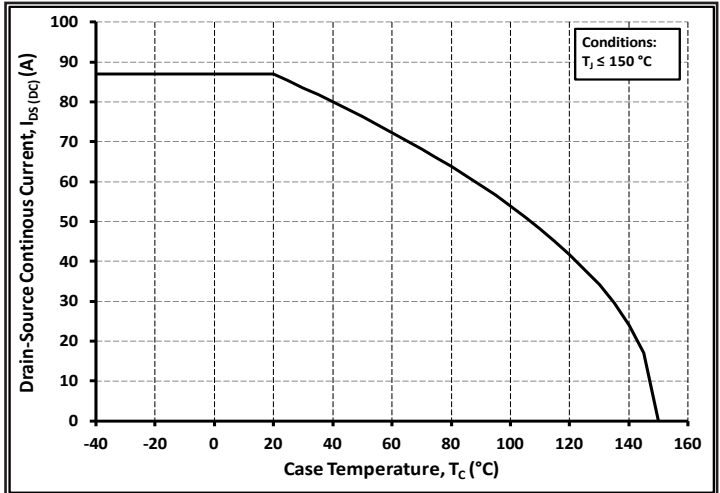


Figure 26. Continuous Drain Current Derating vs. Case Temperature

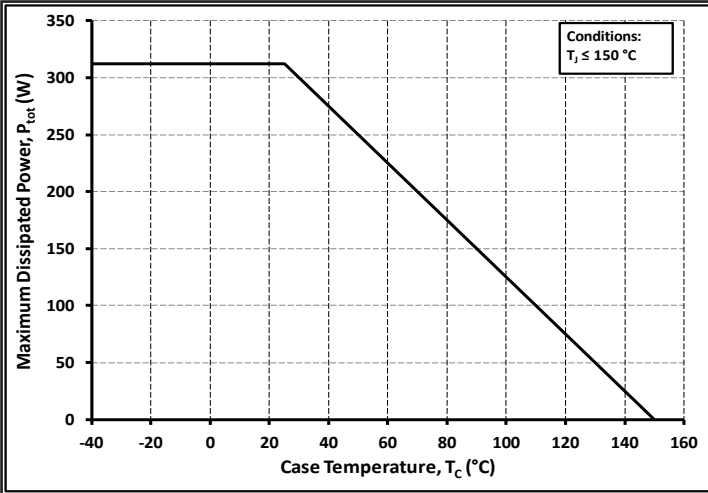


Figure 27. Maximum Power Dissipation (MOSFET) Derating vs. Case Temperature

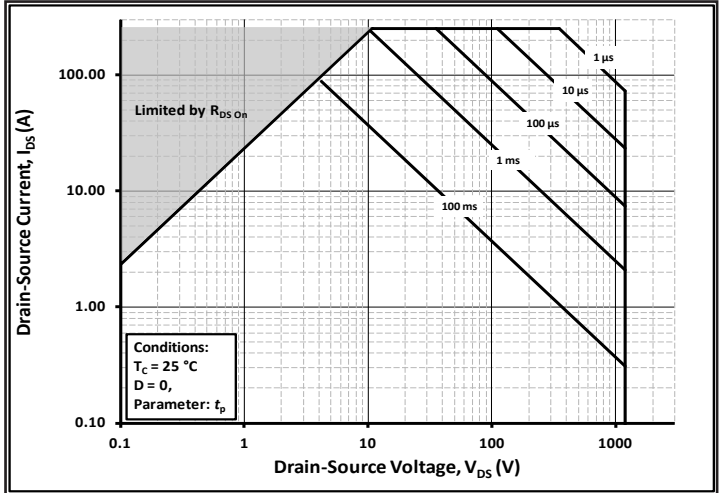


Figure 28. MOSFET Safe Operating Area

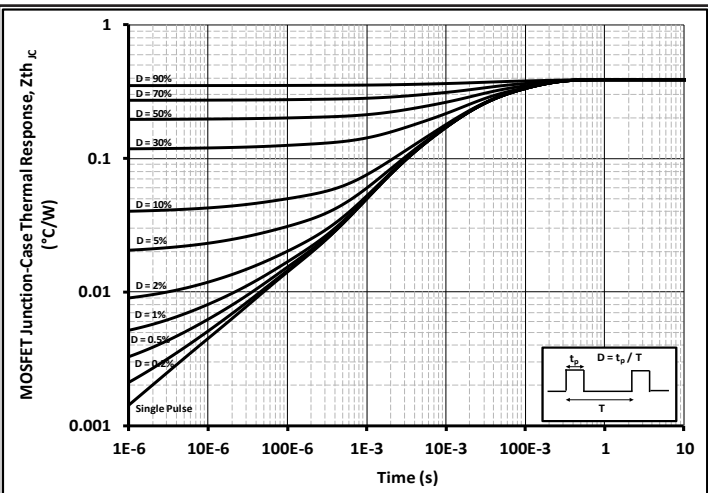


Figure 29. MOSFET Junction to Case Thermal Impedance

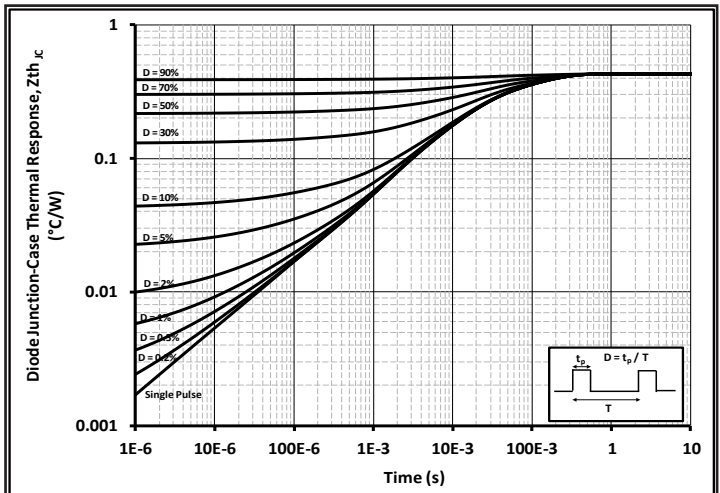


Figure 30. Diode Junction to Case Thermal Impedance

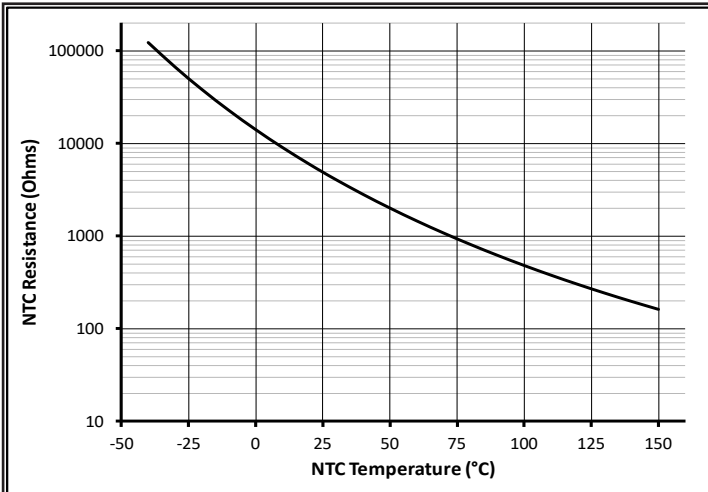


Figure 31. NTC Resistance vs NTC Temperature

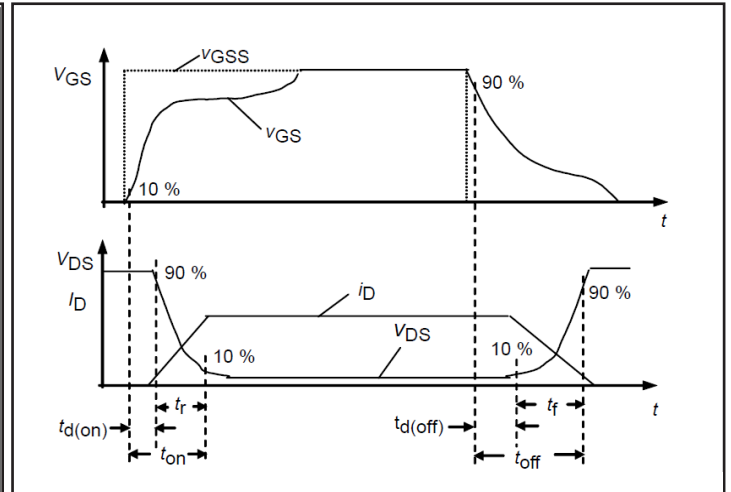


Figure 32. Resistive Switching Time Description

Creepage and Clearance Data

Distance	Creepage	Clearance
Minimum Distance Between Two High Voltage Pins	11.9 mm	6.5 mm
Distance Between High Voltage Pin and Isolated Baseplate	15.6 mm	15.6 mm
Distance Between High Voltage Pin and Mounting Bolt's Head	19.1 mm	8.6 mm
Distance Between High Voltage Pin and Isolated NTC Pin	16.7 mm	11.8 mm





## Recommendations for PCB mounting stand-offs

In order to mount the PCB onto the module, it is recommended to use four PCB mounting stand-offs by using self-tapping screws. Following is the recommended self-tapping screw with its torque requirements:

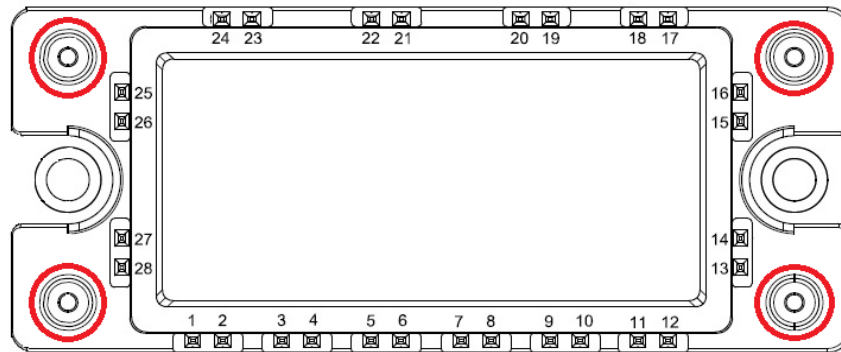
> Ejot DELTA PT WN 5451 K25x8 :  $M_{max} = 0.4Nm \pm 10\%$

Installation of self-tapping screws can be done both by hand or by using an electric screw driver. For an electric screw driver the recommended maximum speed is 300 RPM.

(Note: Do not use pneumatic screw driver to install self-tapping screws).

The recommended effective length of screw threads entering the PCB mounting stand-offs should be in between 4mm to 6.5mm range.

(Note: Self-tapping screws must be inserted straight into the PCB mounting stand-offs)



PCB mounting stand-offs (Marked Red)



## Notes

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- **RoHS Compliance**

The levels of RoHS restricted materials in this product are below the maximum concentration values (also referred to as the threshold limits) permitted for such substances, or are used in an exempted application, in accordance with EU Directive 2011/65/EC (RoHS2), as implemented January 2, 2013. RoHS Declarations for this product can be obtained from your Cree representative or from the Product Documentation sections of [www.cree.com](http://www.cree.com).

- **REACH Compliance**

REACH substances of high concern (SVHCs) information is available for this product. Since the European Chemical Agency (ECHA) has published notice of their intent to frequently revise the SVHC listing for the foreseeable future, please contact a Cree representative to insure you get the most up-to-date REACH SVHC Declaration. REACH banned substance information (REACH Article 67) is also available upon request.

- This product has not been designed or tested for use in, and is not intended for use in, applications implanted into the human body nor in applications in which failure of the product could lead to death, personal injury or property damage, including but not limited to equipment used in the operation of nuclear facilities, life-support machines, cardiac defibrillators or similar emergency medical equipment, aircraft navigation or communication or control systems, air traffic control systems.

### Module Application Note:

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The SiC MOSFET module switches at speeds beyond what is customarily associated with IGBT based modules. Therefore, special precautions are required to realize the best performance. The interconnection between the gate driver and module housing needs to be as short as possible. This will afford the best switching time and avoid the potential for device oscillation. Also, great care is required to insure minimum inductance between the module and link capacitors to avoid excessive  $V_{DS}$  overshoots.

Please Refer to application note: Design Considerations when using Cree SiC Modules Part 1 and Part 2. [CPWR-AN12, CPWR-AN13]