

# C3M0060065D

## Silicon Carbide Power MOSFET

### C3M™ MOSFET Technology

#### N-Channel Enhancement Mode

#### Features

- 3<sup>rd</sup> Generation SiC MOSFET technology
- High blocking voltage with low on-resistance
- High speed switching with low capacitances
- Fast intrinsic diode with low reverse recovery (Qrr)
- Halogen free, RoHS compliant

#### Benefits

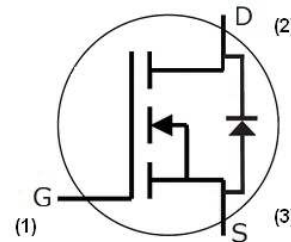
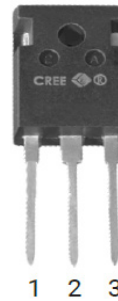
- Higher system efficiency
- Reduced cooling requirements
- Increased power density
- Increased system switching frequency
- Easy to parallel and simple to drive
- Enable new hard switching PFC topologies (Totem-Pole)

#### Applications

- EV charging
- Server power supplies
- Solar PV inverters
- UPS
- DC/DC converters

$V_{DS}$	650 V
$I_D @ 25^\circ\text{C}$	29 A
$R_{DS(on)}$	60 mΩ

#### Package



Part Number	Package	Marking
C3M0060065D	TO-247-3	C3M0060065D

#### Maximum Ratings

Symbol	Parameter	Value	Unit	Note
$V_{DSS}$	Drain - Source Voltage, $T_c = 25^\circ\text{C}$	650	V	
$V_{GS}$	Gate - Source voltage (Under transient events < 100 ns)	-8/+19	V	Fig. 29
$I_D$	Continuous Drain Current, $V_{GS} = 15\text{ V}$ , $T_c = 25^\circ\text{C}$	29	A	Fig. 19 Note 1
	Continuous Drain Current, $V_{GS} = 15\text{ V}$ , $T_c = 100^\circ\text{C}$	20		
$I_{D(pulse)}$	Pulsed Drain Current, Pulse width $t_p$ limited by $T_{jmax}$	99	A	
$P_D$	Power Dissipation, $T_c=25^\circ\text{C}$ , $T_J = 175^\circ\text{C}$	150	W	Fig. 20
$T_J, T_{stg}$	Operating Junction and Storage Temperature	-40 to +175	$^\circ\text{C}$	
$T_L$	Solder Temperature, 1.6mm (0.063") from case for 10s	260	$^\circ\text{C}$	
$M_d$	Mounting Torque, (M3 or 6-32 screw)	1	Nm lbf-in	
		8.8		

Note (1): Die limits are 37A (25°C) and 27A (100°C)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions	Note
$V_{(BR)DSS}$	Drain-Source Breakdown Voltage	650			V	$V_{GS} = 0\text{ V}, I_D = 100\ \mu\text{A}$	
$V_{GSon}$	Gate-Source Recommended Turn-On Voltage		15		V	Static	Fig. 29
$V_{GSoff}$	Gate-Source Recommended Turn-Off Voltage		-4		V		
$V_{GS(th)}$	Gate Threshold Voltage	1.8	2.3	3.6	V	$V_{DS} = V_{GS}, I_D = 5\ \text{mA}$	Fig. 11
			1.9		V	$V_{DS} = V_{GS}, I_D = 5\ \text{mA}, T_J = 175^\circ\text{C}$	
$I_{DSS}$	Zero Gate Voltage Drain Current		1	50	$\mu\text{A}$	$V_{DS} = 650\ \text{V}, V_{GS} = 0\ \text{V}$	
$I_{GSS}$	Gate-Source Leakage Current		10	250	nA	$V_{GS} = 15\ \text{V}, V_{DS} = 0\ \text{V}$	
$R_{DS(on)}$	Drain-Source On-State Resistance	42	60	79	m $\Omega$	$V_{GS} = 15\ \text{V}, I_D = 13.2\ \text{A}$	Fig. 4, 5, 6
			80			$V_{GS} = 15\ \text{V}, I_D = 13.2\ \text{A}, T_J = 175^\circ\text{C}$	
$g_{fs}$	Transconductance		10		S	$V_{DS} = 20\ \text{V}, I_{DS} = 13.2\ \text{A}$	Fig. 7
			9			$V_{DS} = 20\ \text{V}, I_{DS} = 13.2\ \text{A}, T_J = 175^\circ\text{C}$	
$C_{iss}$	Input Capacitance		1020		pF	$V_{GS} = 0\ \text{V}, V_{DS} = 600\ \text{V}$ $f = 1\ \text{MHz}$ $V_{AC} = 25\ \text{mV}$	Fig. 17, 18
$C_{oss}$	Output Capacitance		80				
$C_{rss}$	Reverse Transfer Capacitance		9				
$C_{o(er)}$	Effective Output Capacitance (Energy Related)		95		pF	$V_{GS} = 0\ \text{V}, V_{DS} = 0\text{V to } 400\ \text{V}$	Note 1
$C_{o(tr)}$	Effective Output Capacitance (Time Related)		132				
$E_{oss}$	$C_{oss}$ Stored Energy		15		$\mu\text{J}$	$V_{DS} = 600\ \text{V}, 1\ \text{MHz}$	Fig. 16
$E_{ON}$	Turn-On Switching Energy (Body Diode)		110		$\mu\text{J}$	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}, I_D = 13.2\ \text{A},$ $R_{G(ext)} = 2.5\ \Omega, L = 135\ \mu\text{H}, T_J = 175^\circ\text{C}$ FWD = Internal Body Diode of MOSFET	Fig. 25
$E_{OFF}$	Turn Off Switching Energy (Body Diode)		22				
$E_{ON}$	Turn-On Switching Energy (External SiC Diode)		63		$\mu\text{J}$	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}, I_D = 13.2\ \text{A},$ $R_{G(ext)} = 2.5\ \Omega, L = 135\ \mu\text{H}, T_J = 175^\circ\text{C}$ FWD = External SiC Diode	Fig. 25
$E_{OFF}$	Turn Off Switching Energy (External SiC Diode)		28				
$t_{d(on)}$	Turn-On Delay Time		9		ns	$V_{DD} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}$ $I_D = 13.2\ \text{A}, R_{G(ext)} = 2.5\ \Omega, L = 135\ \mu\text{H}$ Timing relative to $V_{DS}$ Inductive load	Fig. 26
$t_r$	Rise Time		20				
$t_{d(off)}$	Turn-Off Delay Time		17				
$t_f$	Fall Time		8				
$R_{G(int)}$	Internal Gate Resistance		3		$\Omega$	$f = 1\ \text{MHz}, V_{AC} = 25\ \text{mV}$	
$Q_{gs}$	Gate to Source Charge		14		nC	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}$ $I_D = 13.2\ \text{A}$ Per IEC60747-8-4 pg 21	Fig. 12
$Q_{gd}$	Gate to Drain Charge		14				
$Q_g$	Total Gate Charge		46				

Note (1):  $C_{o(er)}$ , a lumped capacitance that gives same stored energy as  $C_{oss}$  while  $V_{ds}$  is rising from 0 to 400V  
 $C_{o(tr)}$ , a lumped capacitance that gives same charging time as  $C_{oss}$  while  $V_{ds}$  is rising from 0 to 400V

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

Symbol	Parameter	Typ.	Max.	Unit	Test Conditions	Note
$V_{SD}$	Diode Forward Voltage	5.1		V	$V_{GS} = -4\text{ V}, I_{SD} = 6.6\text{ A}, T_J = 25^\circ\text{C}$	Fig. 8, 9, 10
		4.8		V	$V_{GS} = -4\text{ V}, I_{SD} = 6.6\text{ A}, T_J = 175^\circ\text{C}$	
$I_S$	Continuous Diode Forward Current		23	A	$V_{GS} = -4\text{ V}, T_c = 25^\circ\text{C}$	
$I_{S, pulse}$	Diode pulse Current		99	A	$V_{GS} = -4\text{ V}$ , pulse width $t_p$ limited by $T_{jmax}$	
$t_{rr}$	Reverse Recover time	20		ns	$V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$ $dif/dt = 1200\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
$Q_{rr}$	Reverse Recovery Charge	190		nC		
$I_{rrm}$	Peak Reverse Recovery Current	16		A		
$t_{rr}$	Reverse Recover time	29		ns	$V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$ $dif/dt = 750\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
$Q_{rr}$	Reverse Recovery Charge	181		nC		
$I_{rrm}$	Peak Reverse Recovery Current	9		A		

### Thermal Characteristics

Symbol	Parameter	Typ.	Unit	Test Conditions	Note
$R_{\theta JC}$	Thermal Resistance from Junction to Case	0.99	$^\circ\text{C}/\text{W}$		Fig. 21
$R_{\theta JA}$	Thermal Resistance From Junction to Ambient	40			

## Typical Performance

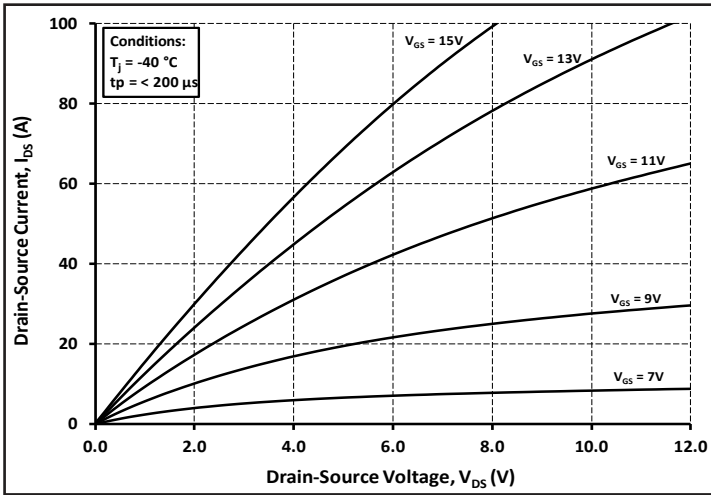


Figure 1. Output Characteristics  $T_J = -40\text{ }^\circ\text{C}$

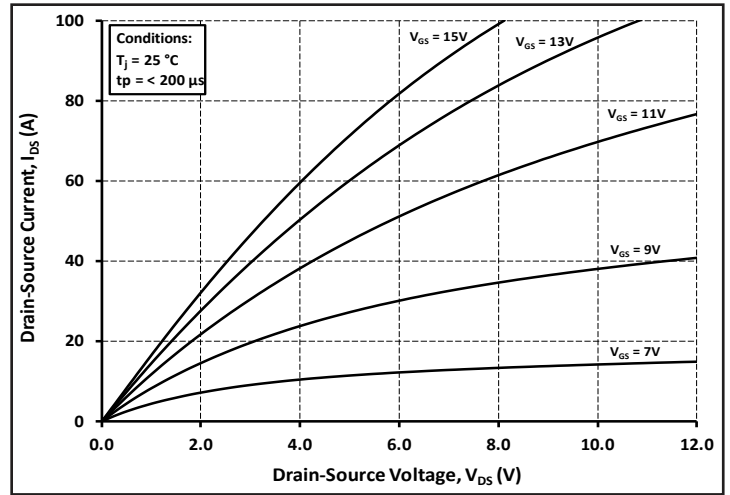


Figure 2. Output Characteristics  $T_J = 25\text{ }^\circ\text{C}$

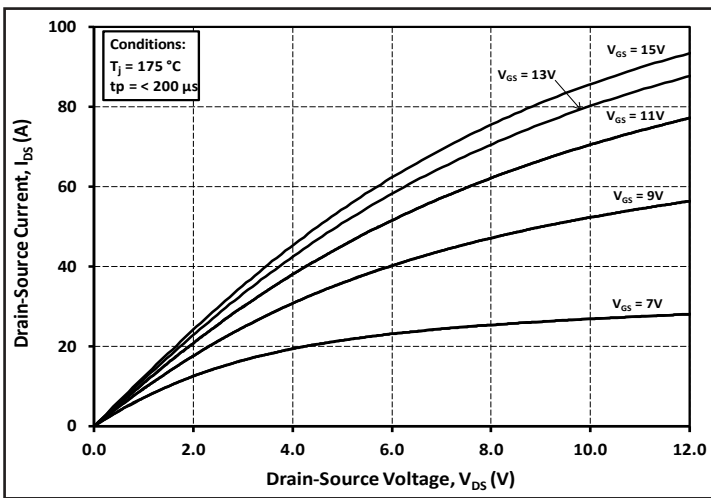


Figure 3. Output Characteristics  $T_J = 175\text{ }^\circ\text{C}$

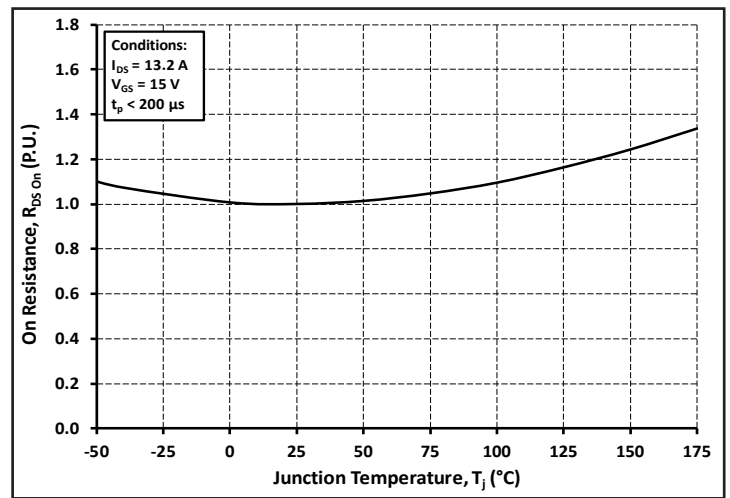


Figure 4. Normalized On-Resistance vs. Temperature

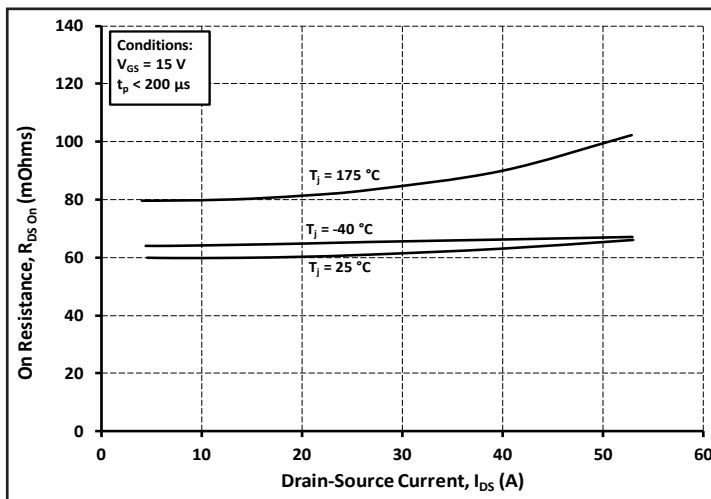


Figure 5. On-Resistance vs. Drain Current For Various Temperatures

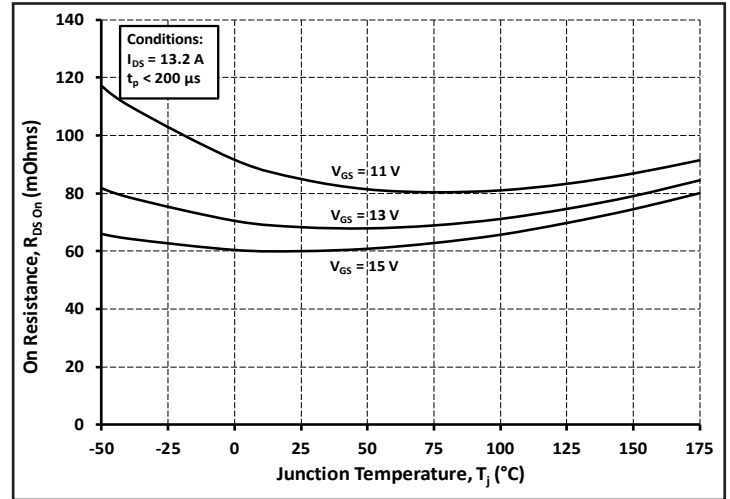


Figure 6. On-Resistance vs. Temperature For Various Gate Voltage

## Typical Performance

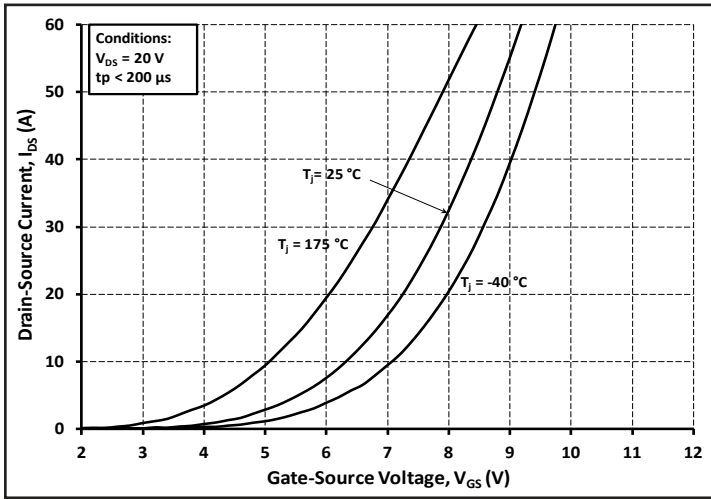


Figure 7. Transfer Characteristic for Various Junction Temperatures

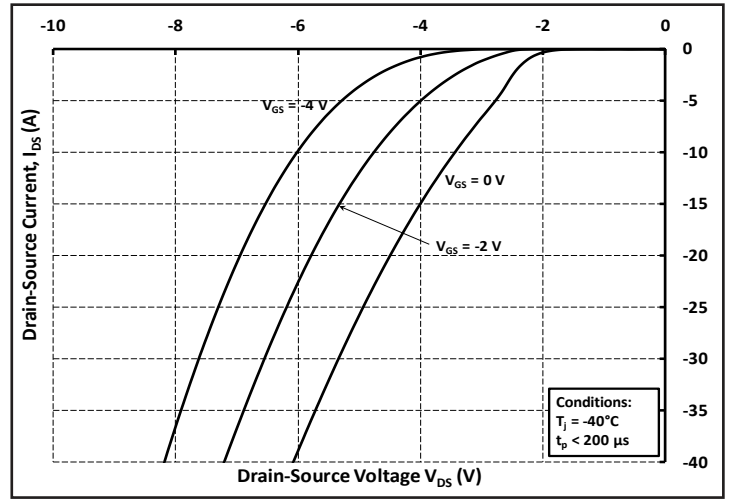


Figure 8. Body Diode Characteristic at  $-40\text{ }^\circ\text{C}$

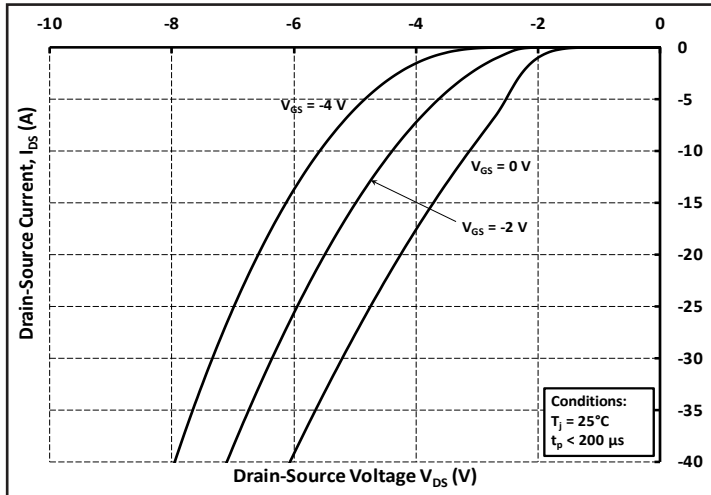


Figure 9. Body Diode Characteristic at  $25\text{ }^\circ\text{C}$

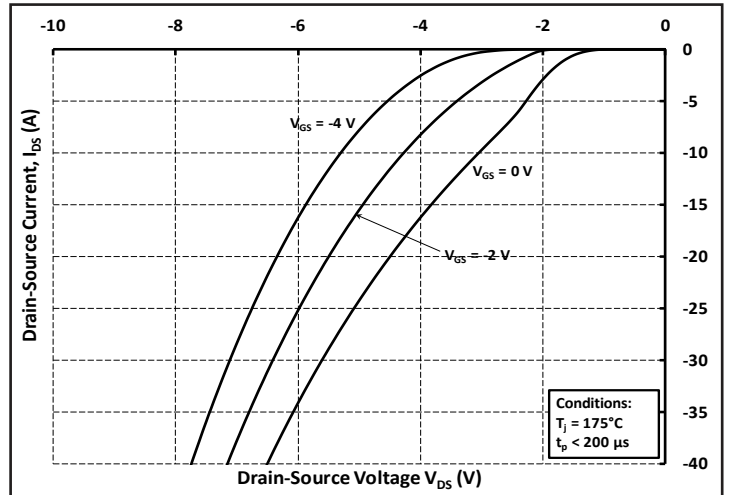


Figure 10. Body Diode Characteristic at  $175\text{ }^\circ\text{C}$

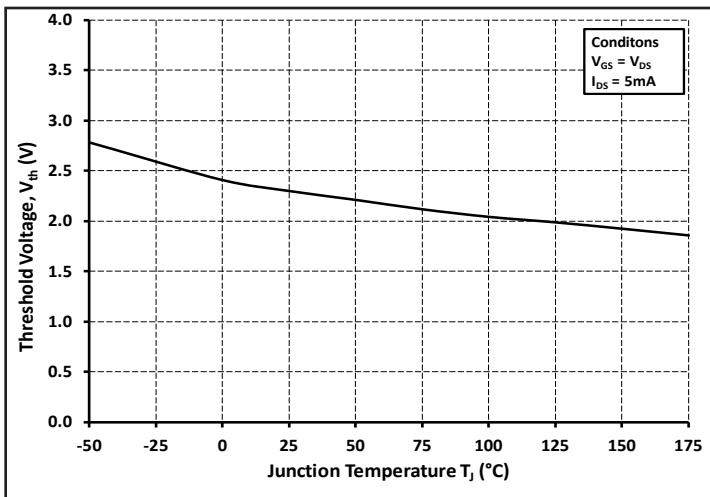


Figure 11. Threshold Voltage vs. Temperature

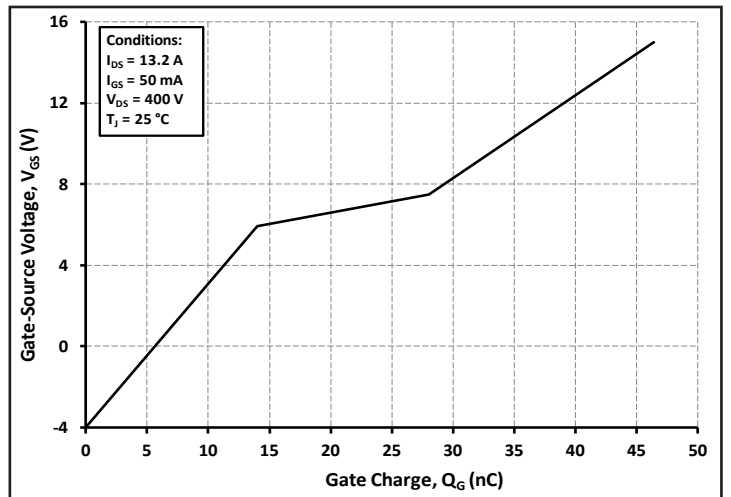


Figure 12. Gate Charge Characteristics

## Typical Performance

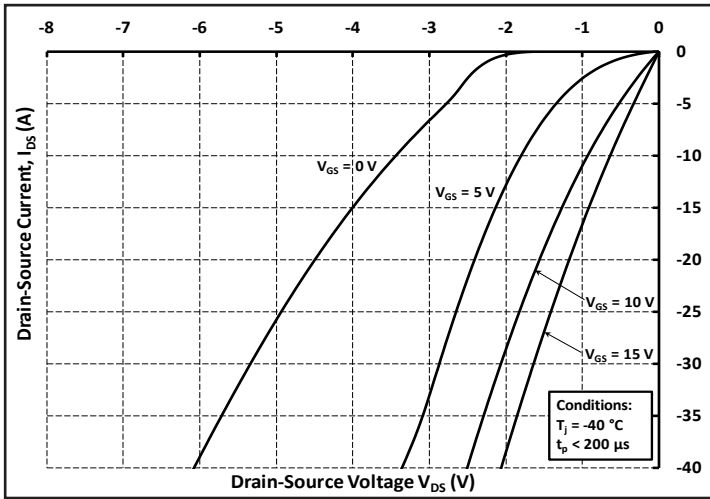


Figure 13. 3rd Quadrant Characteristic at  $-40\text{ }^\circ\text{C}$

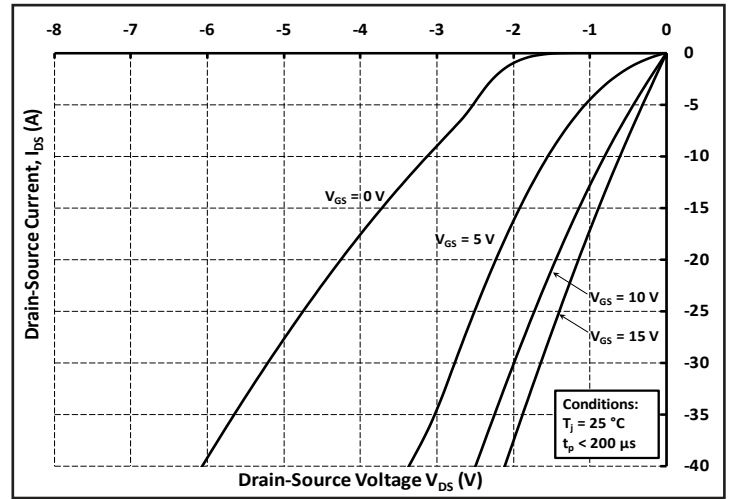


Figure 14. 3rd Quadrant Characteristic at  $25\text{ }^\circ\text{C}$

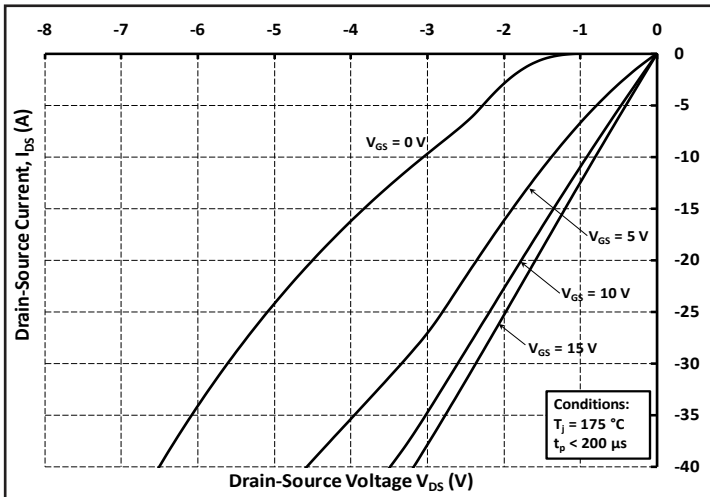


Figure 15. 3rd Quadrant Characteristic at  $175\text{ }^\circ\text{C}$

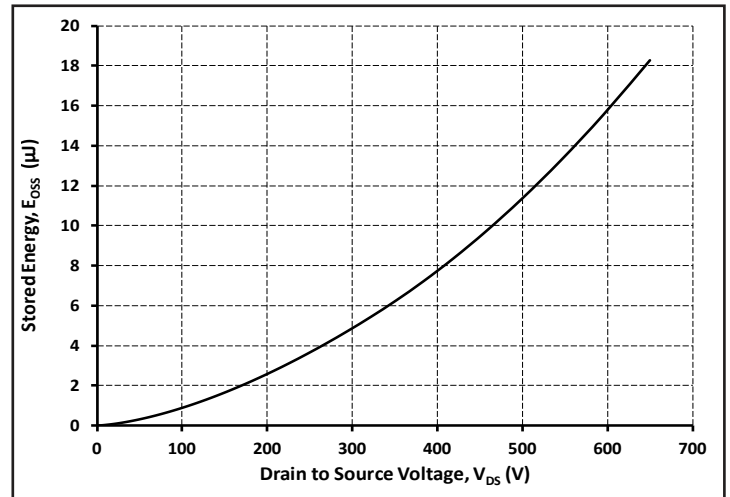


Figure 16. Output Capacitor Stored Energy

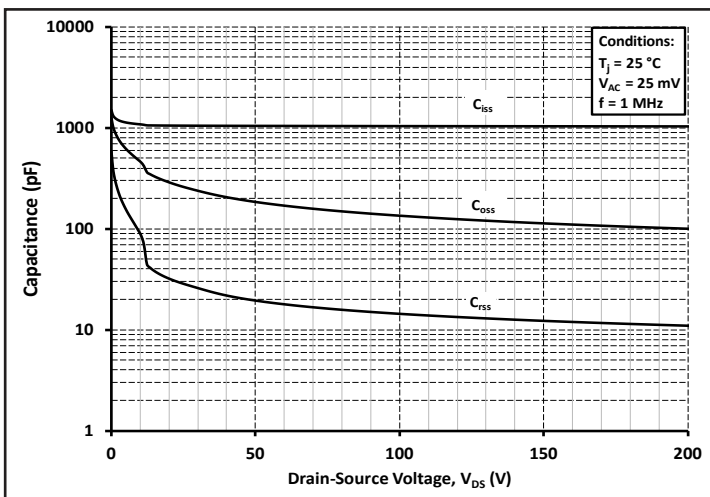


Figure 17. Capacitances vs. Drain-Source Voltage (0 - 200V)

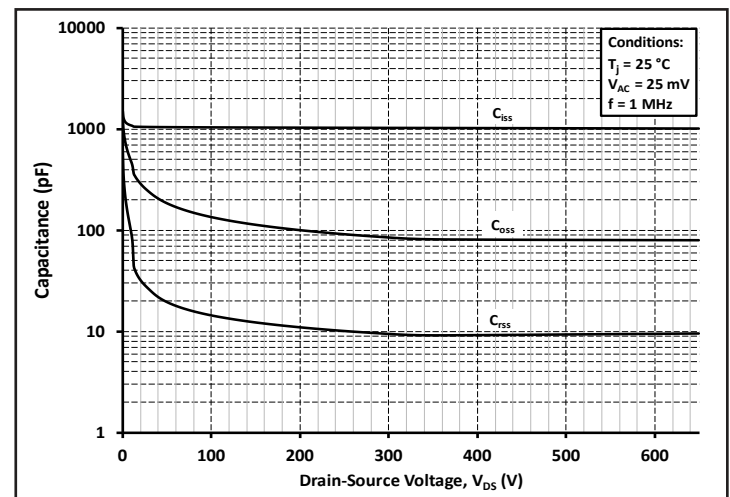


Figure 18. Capacitances vs. Drain-Source Voltage (0 - 650V)

## Typical Performance

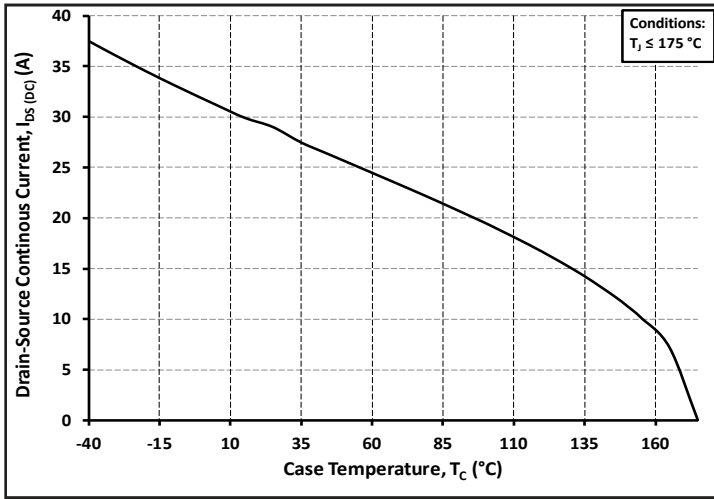


Figure 19. Continuous Drain Current Derating vs. Case Temperature

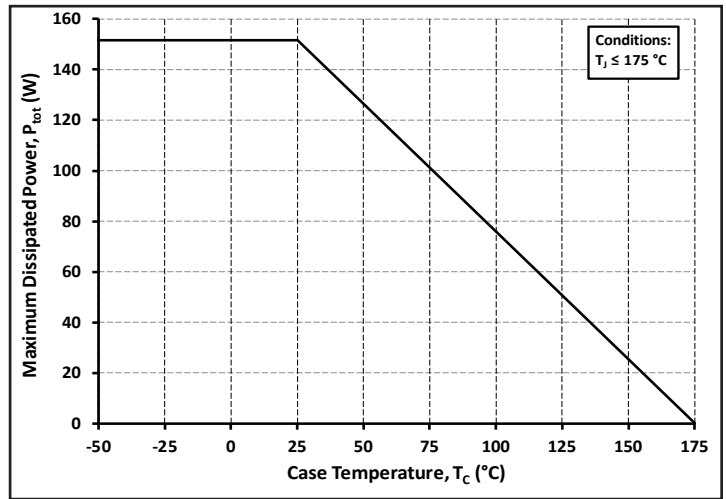


Figure 20. Maximum Power Dissipation Derating vs. Case Temperature

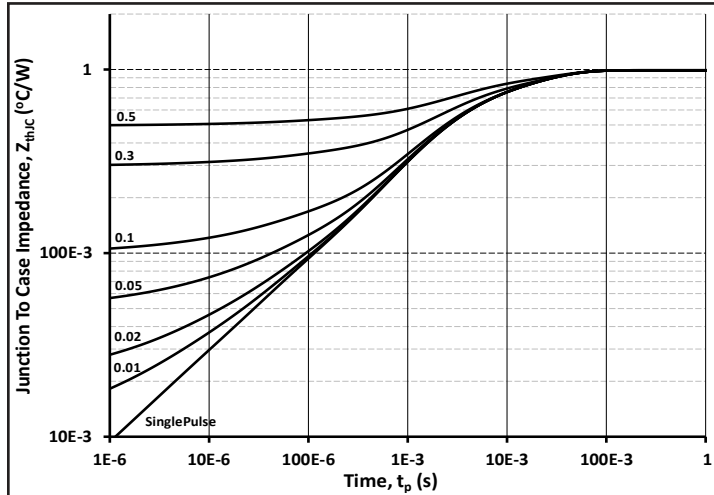


Figure 21. Transient Thermal Impedance (Junction - Case)

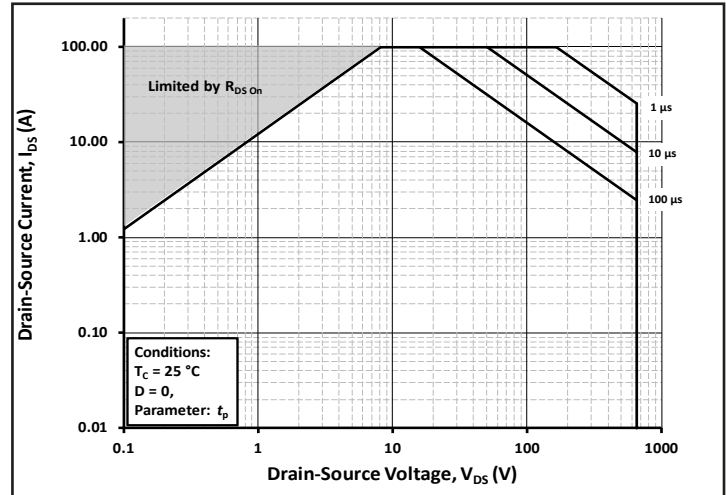


Figure 22. Safe Operating Area

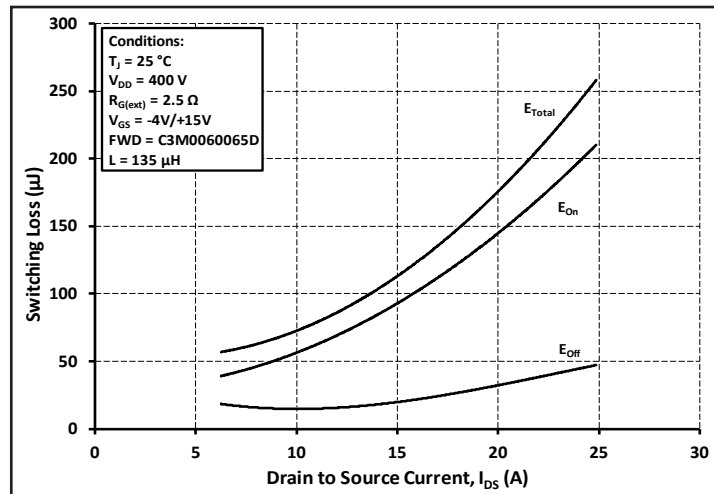


Figure 23. Clamped Inductive Switching Energy vs. Drain Current ( $V_{DD} = 400V$ )

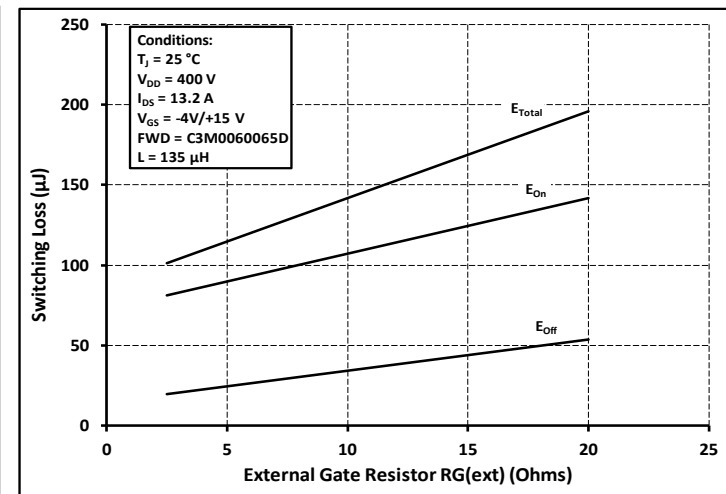


Figure 24. Clamped Inductive Switching Energy vs.  $R_{G(ext)}$

## Typical Performance

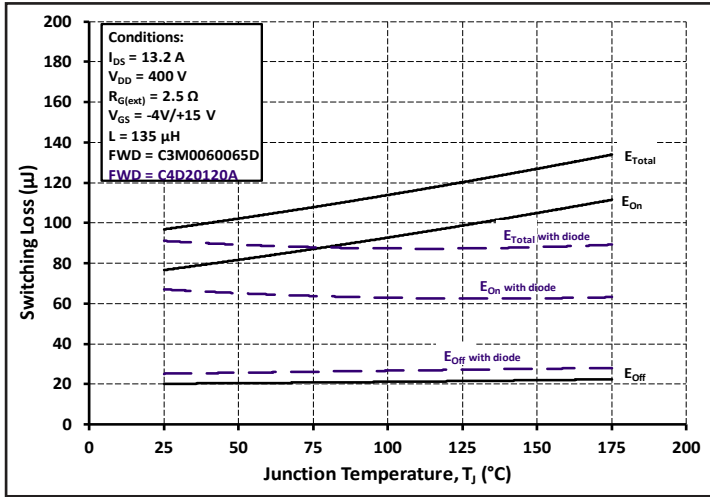


Figure 25. Clamped Inductive Switching Energy vs. Temperature

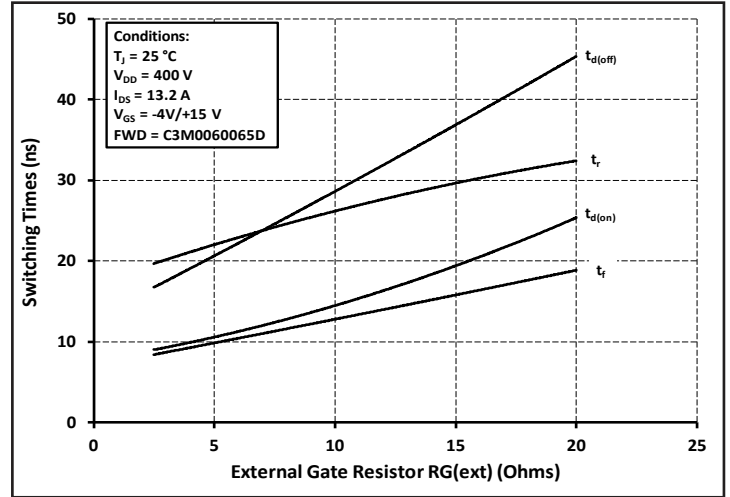


Figure 26. Switching Times vs.  $R_{G(ext)}$



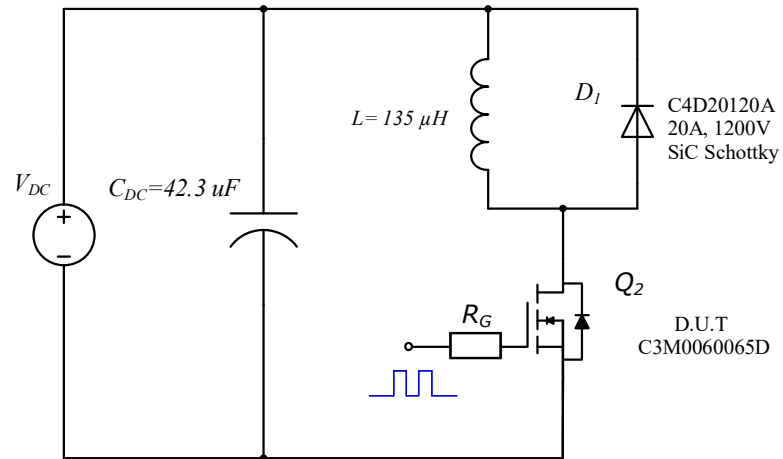


Figure 27. Clamped Inductive Switching Waveform Test Circuit

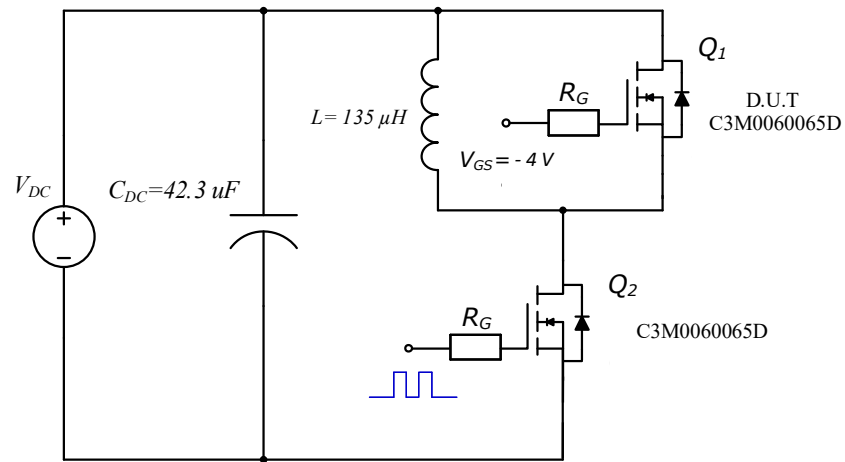


Figure 28. Body Diode Recovery Test Circuit

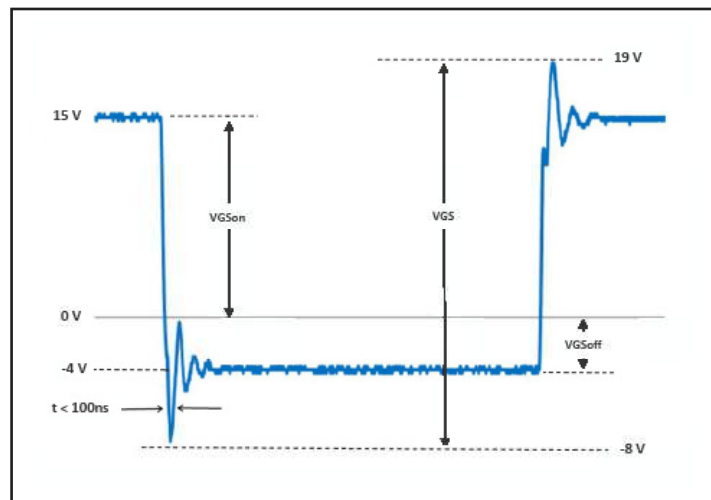
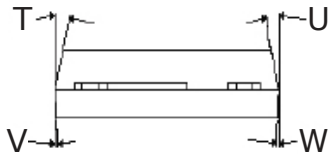
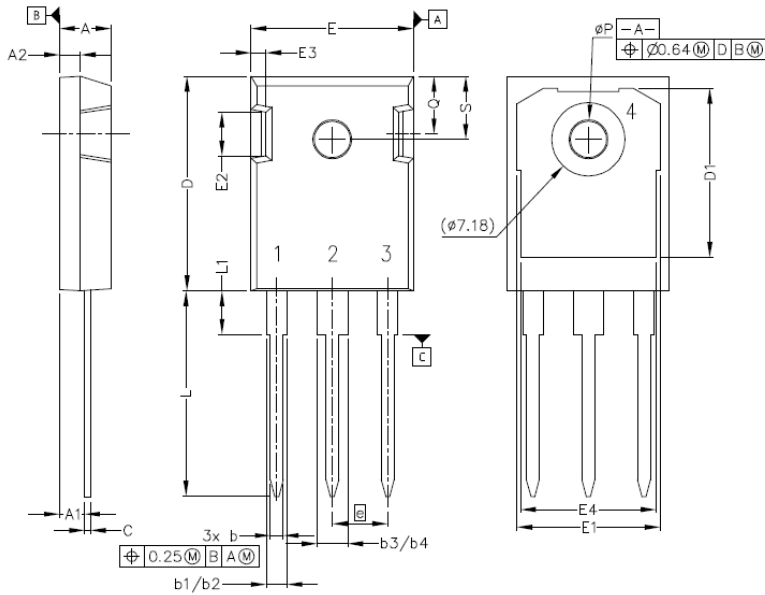


Figure 29.  $V_{GS}$  Waveform Example

## Package Dimensions

Package TO-247-3

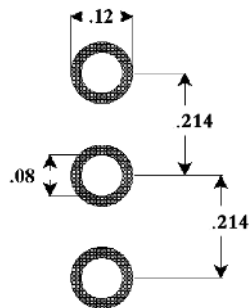


Pinout Information:

- Pin 1 = Gate
- Pin 2, 4 = Drain
- Pin 3 = Source

POS	Inches		Millimeters	
	Min	Max	Min	Max
A	.190	.205	4.83	5.21
A1	.090	.100	2.29	2.54
A2	.075	.085	1.91	2.16
b	.042	.052	1.07	1.33
b1	.075	.095	1.91	2.41
b2	.075	.085	1.91	2.16
b3	.113	.133	2.87	3.38
b4	.113	.123	2.87	3.13
c	.022	.027	0.55	0.68
D	.819	.831	20.80	21.10
D1	.640	.695	16.25	17.65
D2	.037	.049	0.95	1.25
E	.620	.635	15.75	16.13
E1	.516	.557	13.10	14.15
E2	.145	.201	3.68	5.10
E3	.039	.075	1.00	1.90
E4	.487	.529	12.38	13.43
e	.214 BSC		5.44 BSC	
N	3		3	
L	.780	.800	19.81	20.32
L1	.161	.173	4.10	4.40
ØP	.138	.144	3.51	3.65
Q	.216	.236	5.49	6.00
S	.238	.248	6.04	6.30
T	9°	11°	9°	11°
U	9°	11°	9°	11°
V	2°	8°	2°	8°
W	2°	8°	2°	8°

## Recommended Solder Pad Layout



TO-247-3

## 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.

## Related Links

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- **SPICE Models:** <http://wolfspeed.com/power/tools-and-support>
- **SiC MOSFET Isolated Gate Driver reference design:** <http://wolfspeed.com/power/tools-and-support>
- **SiC MOSFET Evaluation Board:** <http://wolfspeed.com/power/tools-and-support>