

# C3M0045065K

## Silicon Carbide Power MOSFET

### C3M™ MOSFET Technology

#### N-Channel Enhancement Mode

#### Features

- C3M™ SiC MOSFET technology
- Optimized package with separate driver source pin
- 8mm of creepage distance between drain and source
- High blocking voltage with low on-resistance
- High-speed switching with low capacitances
- Fast intrinsic diode with low reverse recovery ( $Q_{rr}$ )
- Halogen free, RoHS compliant

#### Benefits

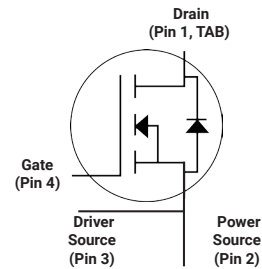
- Reduce switching losses and minimize gate ringing
- Higher system efficiency
- Reduce cooling requirements
- Increase power density
- Increase system switching frequency

#### Applications

- EV chargers
- Server & Telecom PSU
- UPS
- Solar inverters
- SMPS
- DC/DC converters

$V_{DS}$	650 V
$I_D @ 25^\circ\text{C}$	49 A
$R_{DS(on)}$	45 mΩ

#### Package



Part Number	Package	Marking
C3M0045065K	TO 247-4	C3M0045065K

#### 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, $V_{GS} = 15\text{ V}$ , $T_C = 25^\circ\text{C}$	49	A	Fig. 19
	Continuous Drain Current, $V_{GS} = 15\text{ V}$ , $T_C = 100^\circ\text{C}$	35		
$I_{D(pulse)}$	Pulsed Drain Current, Pulse width $t_p$ limited by $T_{jmax}$	132	A	
$P_D$	Power Dissipation, $T_C = 25^\circ\text{C}$ , $T_J = 175^\circ\text{C}$	176	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	
		8.8		

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	2.6	3.6	V	$V_{DS} = V_{GS}, I_D = 4.84\ \text{mA}$	Fig. 11
			2.2		V	$V_{DS} = V_{GS}, I_D = 4.84\ \text{mA}, T_J = 175^\circ\text{C}$	
$I_{DSS}$	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		45	60	m $\Omega$	$V_{GS} = 15\ \text{V}, I_D = 17.6\ \text{A}$	Fig. 4, 5, 6
			61			$V_{GS} = 15\ \text{V}, I_D = 17.6\ \text{A}, T_J = 175^\circ\text{C}$	
$g_{fs}$	Transconductance		12		S	$V_{DS} = 20\ \text{V}, I_{DS} = 17.6\ \text{A}$	Fig. 7
			11			$V_{DS} = 20\ \text{V}, I_{DS} = 17.6\ \text{A}, T_J = 175^\circ\text{C}$	
$C_{iss}$	Input Capacitance		1621		pF	$V_{GS} = 0\ \text{V}, V_{DS} = 0\ \text{V to } 600\ \text{V}$ $F = 1\ \text{MHz}$ $V_{AC} = 25\ \text{mV}$	Fig. 17, 18
$C_{oss}$	Output Capacitance		101				
$C_{rss}$	Reverse Transfer Capacitance		8				
$C_{o(er)}$	Effective Output Capacitance (Energy Related)		126			$V_{GS} = 0\ \text{V}, V_{DS} = 0\ \text{V to } 400\ \text{V}$	Note: 1
$C_{o(tr)}$	Effective Output Capacitance (Time Related)		178				Note: 1
$E_{oss}$	$C_{oss}$ Stored Energy		20		$\mu\text{J}$	$V_{DS} = 600\ \text{V}, F = 1\ \text{MHz}$	Fig. 16
$E_{ON}$	Turn-On Switching Energy (Body Diode)		57		$\mu\text{J}$	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}, I_D = 17.6\ \text{A},$ $R_{G(ext)} = 2.5\ \Omega, L = 99\ \mu\text{H}, T_J = 175^\circ\text{C}$ FWD = Internal Body Diode of MOSFET	Fig. 25
$E_{OFF}$	Turn Off Switching Energy (Body Diode)		14				
$E_{ON}$	Turn-On Switching Energy (External Diode)		44		$\mu\text{J}$	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}, I_D = 17.6\ \text{A},$ $R_{G(ext)} = 2.5\ \Omega, L = 99\ \mu\text{H}, T_J = 175^\circ\text{C}$ FWD = External SiC DIODE	Fig. 25
$E_{OFF}$	Turn Off Switching Energy (External Diode)		14				
$t_{d(on)}$	Turn-On Delay Time		9		ns	$V_{DD} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}$ $I_D = 17.6\ \text{A}, R_{G(ext)} = 2.5\ \Omega, L = 99\ \mu\text{H}$ Timing relative to $V_{DS}$ Inductive load	Fig. 26
$t_r$	Rise Time		12				
$t_{d(off)}$	Turn-Off Delay Time		18				
$t_f$	Fall Time		6				
$R_{G(int)}$	Internal Gate Resistance		3		$\Omega$	$f = 1\ \text{MHz}, V_{AC} = 25\ \text{mV}$	
$Q_{gs}$	Gate to Source Charge		21		nC	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}$ $I_D = 17.6\ \text{A}$ Per IEC60747-8-4 pg 21	Fig. 12
$Q_{gd}$	Gate to Drain Charge		18				
$Q_g$	Total Gate Charge		63				

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	4.8		V	$V_{GS} = -4\text{ V}, I_{SD} = 8.8\text{ A}, T_J = 25^\circ\text{C}$	Fig. 8, 9, 10
		4.2		V	$V_{GS} = -4\text{ V}, I_{SD} = 8.8\text{ A}, T_J = 175^\circ\text{C}$	
$I_S$	Continuous Diode Forward Current		29	A	$V_{GS} = -4\text{ V}, T_c = 25^\circ\text{C}$	
$I_{S, pulse}$	Diode pulse Current		132	A	$V_{GS} = -4\text{ V}$ , pulse width $t_p$ limited by $T_{jmax}$	
$t_{rr}$	Reverse Recover time	13		ns	$V_{GS} = -4\text{ V}, I_{SD} = 17.6\text{ A}, V_R = 400\text{ V}$ $dif/dt = 5215\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
$Q_{rr}$	Reverse Recovery Charge	247		nC		
$I_{rrm}$	Peak Reverse Recovery Current	36		A		
$t_{rr}$	Reverse Recover time	18		ns	$V_{GS} = -4\text{ V}, I_{SD} = 17.6\text{ A}, V_R = 400\text{ V}$ $dif/dt = 1775\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
$Q_{rr}$	Reverse Recovery Charge	171		nC		
$I_{rrm}$	Peak Reverse Recovery Current	16		A		

### Thermal Characteristics

Symbol	Parameter	Typ.	Unit	Test Conditions	Note
$R_{\theta JC}$	Thermal Resistance from Junction to Case	0.85	$^\circ\text{C}/\text{W}$		Fig. 21
$R_{\theta JA}$	Thermal Resistance From Junction to Ambient	40			

## Typical Performance

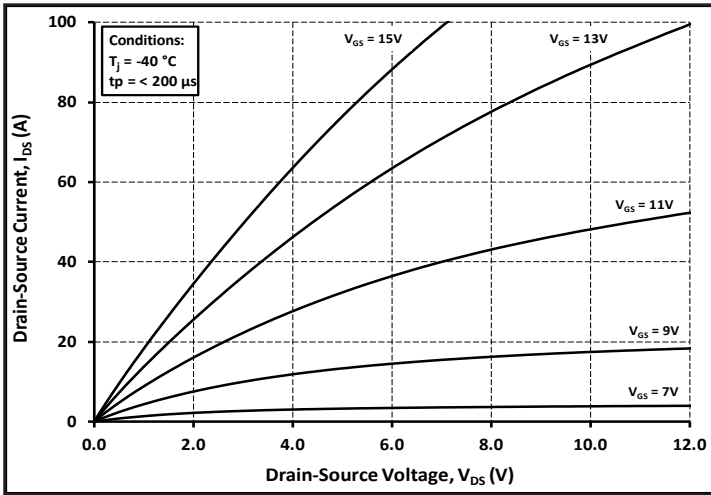


Figure 1. Output Characteristics  $T_J = -40\text{ }^\circ\text{C}$

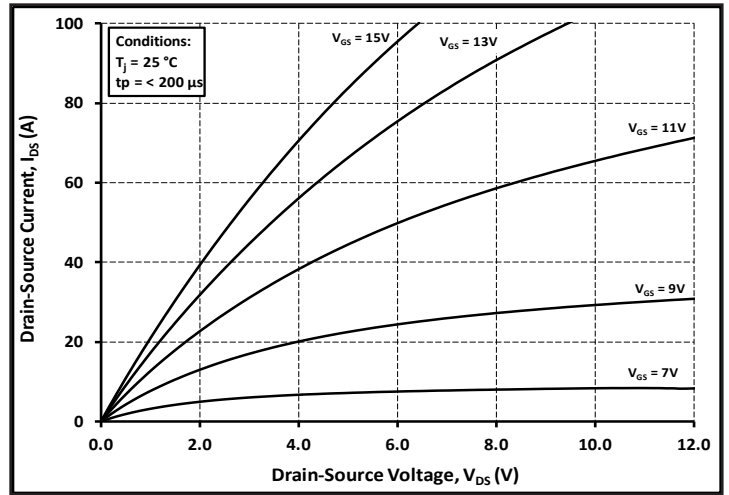


Figure 2. Output Characteristics  $T_J = 25\text{ }^\circ\text{C}$

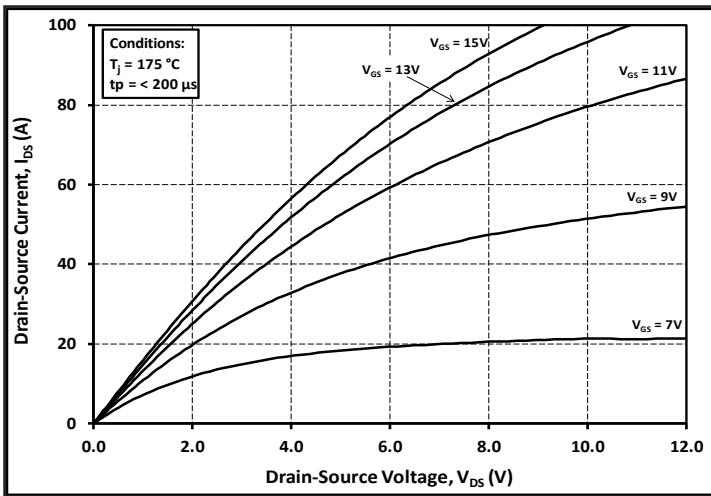


Figure 3. Output Characteristics  $T_J = 175\text{ }^\circ\text{C}$

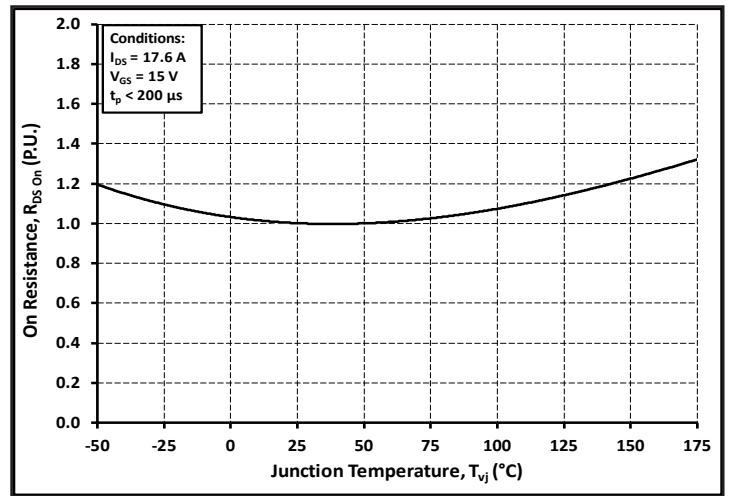


Figure 4. Normalized On-Resistance vs. Temperature

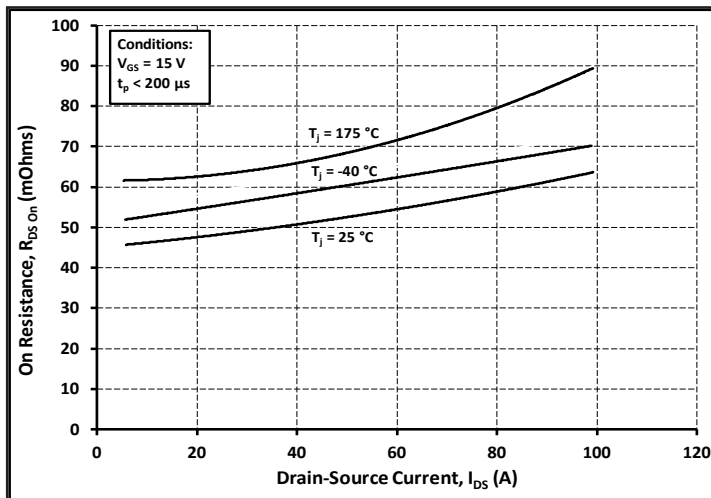


Figure 5. On-Resistance vs. Drain Current For Various Temperatures

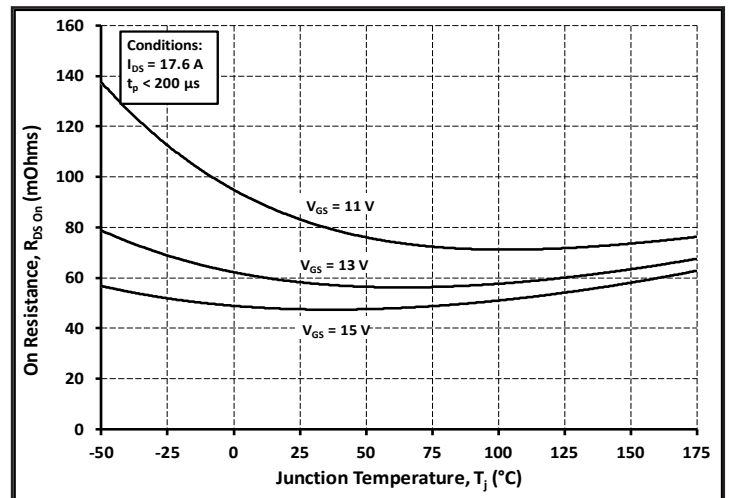


Figure 6. On-Resistance vs. Temperature For Various Gate Voltage

## Typical Performance

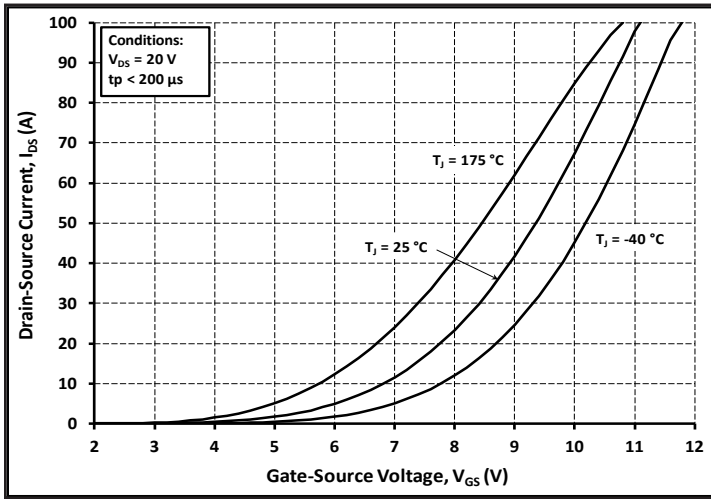


Figure 7. Transfer Characteristic for Various Junction Temperatures

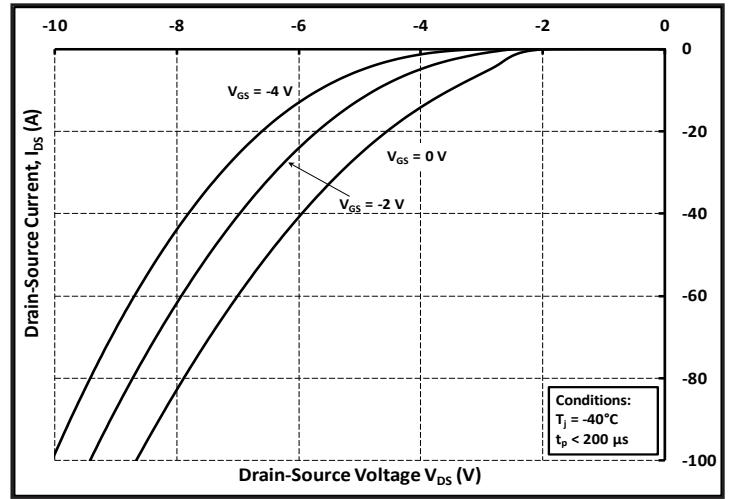


Figure 8. Body Diode Characteristic at  $-40\text{ }^\circ\text{C}$

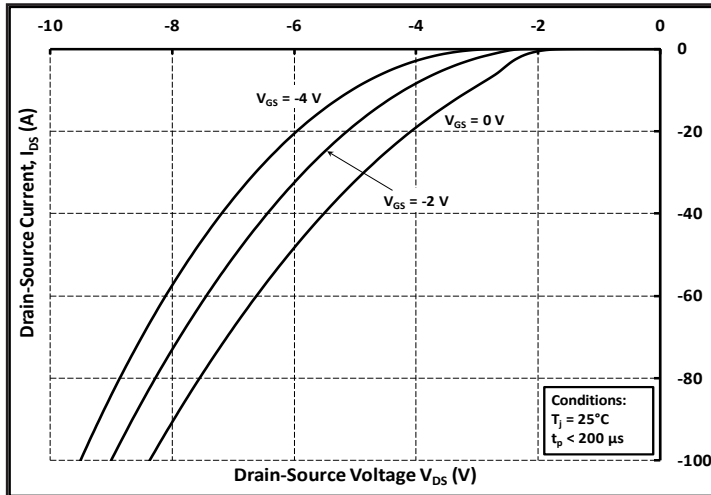


Figure 9. Body Diode Characteristic at  $25\text{ }^\circ\text{C}$

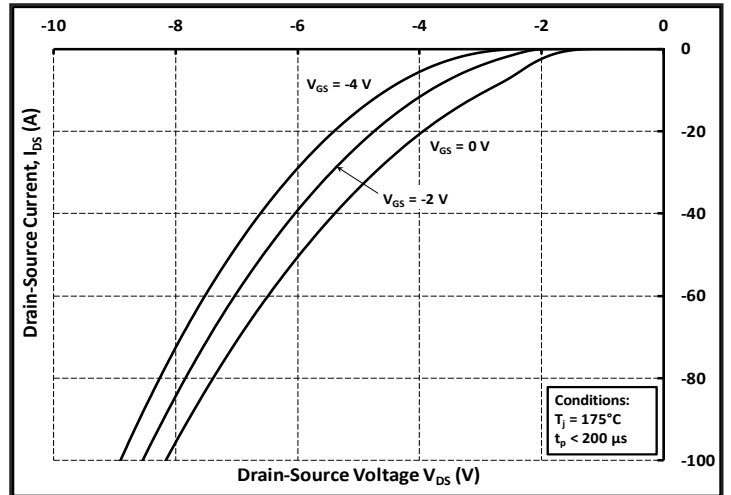


Figure 10. Body Diode Characteristic at  $175\text{ }^\circ\text{C}$

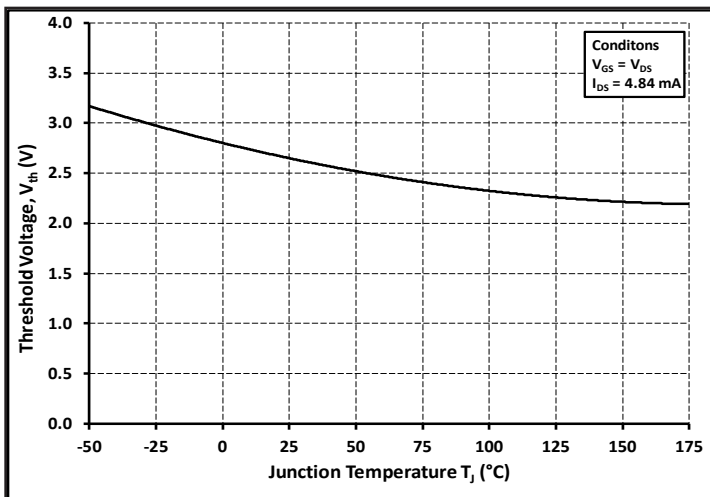


Figure 11. Threshold Voltage vs. Temperature

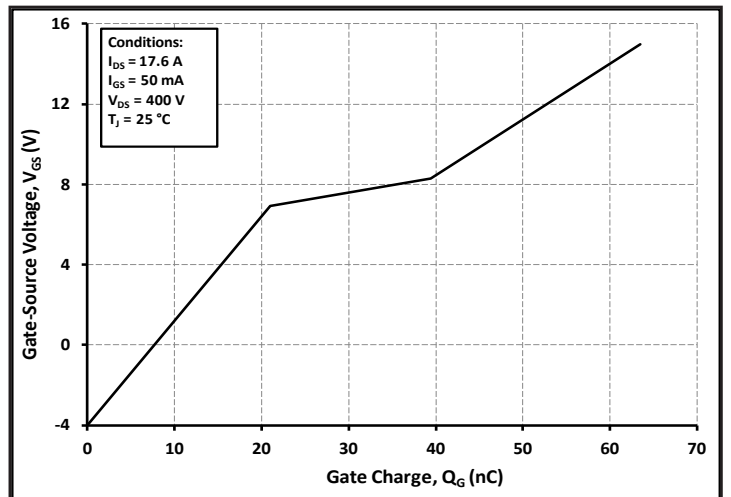


Figure 12. Gate Charge Characteristics

## Typical Performance

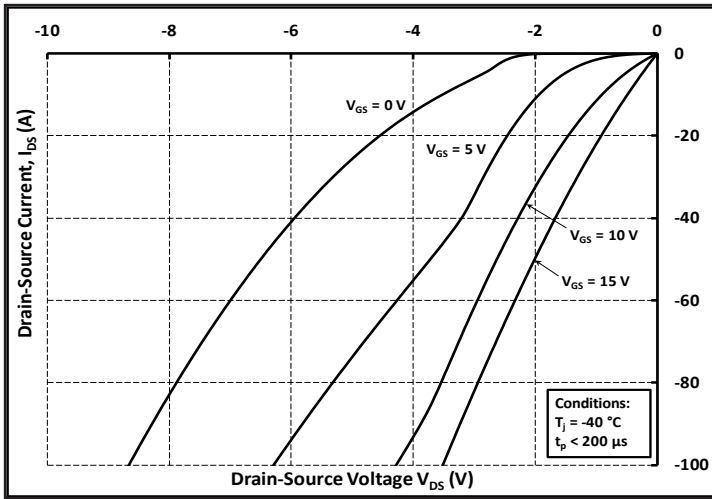


Figure 13. 3rd Quadrant Characteristic at  $-40\text{ }^{\circ}\text{C}$

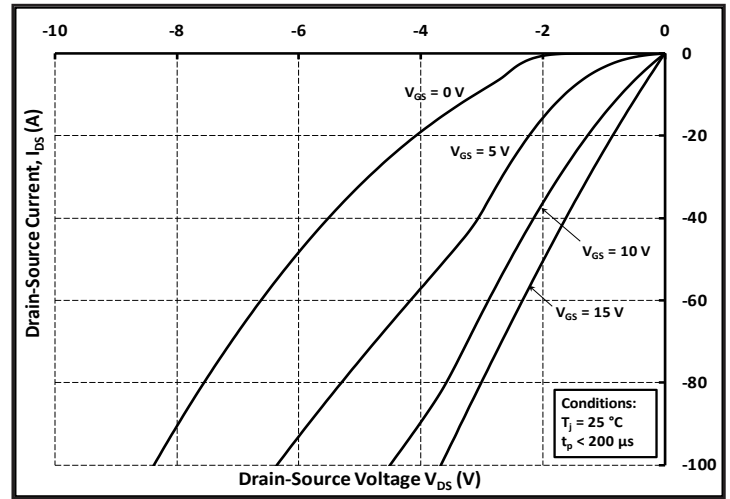


Figure 14. 3rd Quadrant Characteristic at  $25\text{ }^{\circ}\text{C}$

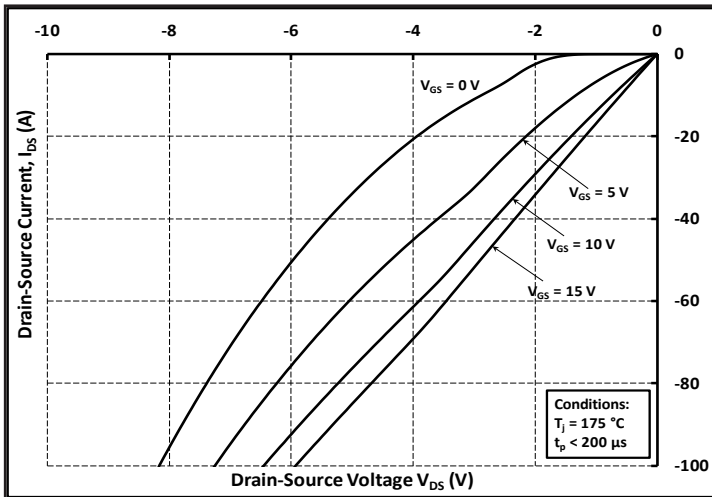


Figure 15. 3rd Quadrant Characteristic at  $175\text{ }^{\circ}\text{C}$

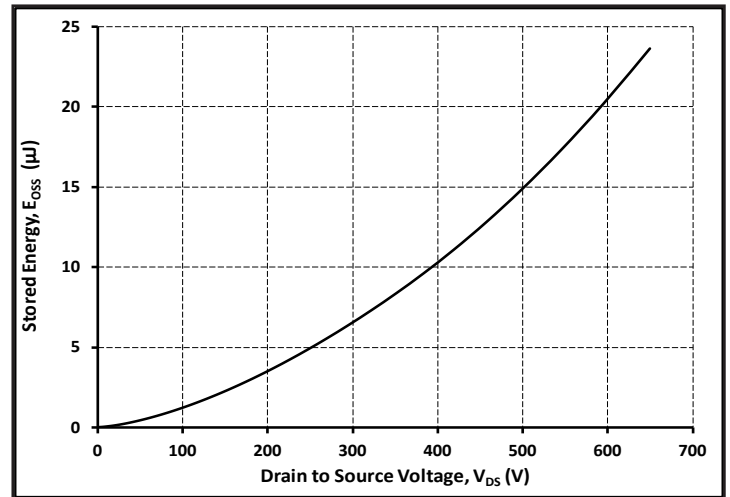


Figure 16. Output Capacitor Stored Energy

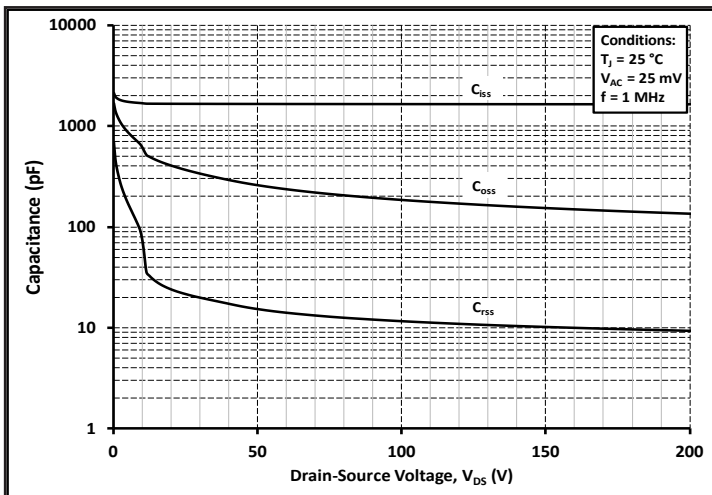


Figure 17. Capacitances vs. Drain-Source Voltage (0 - 200V)

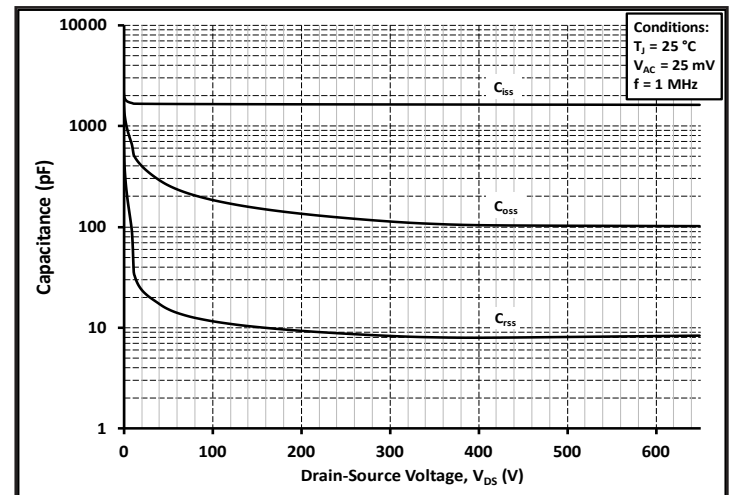


Figure 18. Capacitances vs. Drain-Source Voltage (0 - 650V)

## Typical Performance

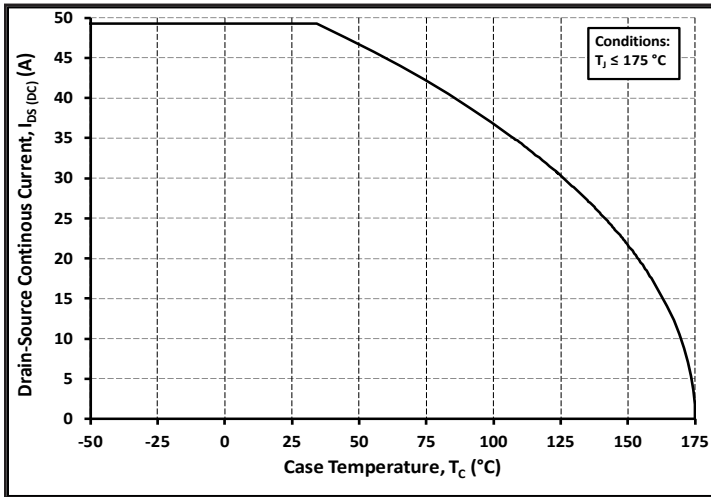


Figure 19. Continuous Drain Current Derating vs. Case Temperature

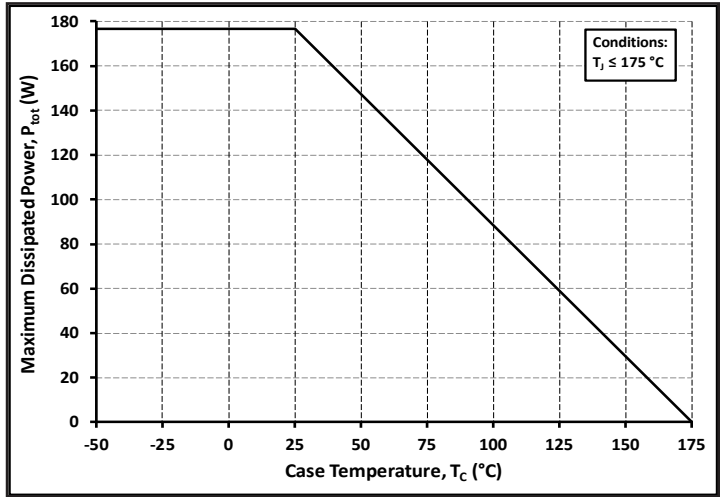


Figure 20. Maximum Power Dissipation Derating vs. Case Temperature

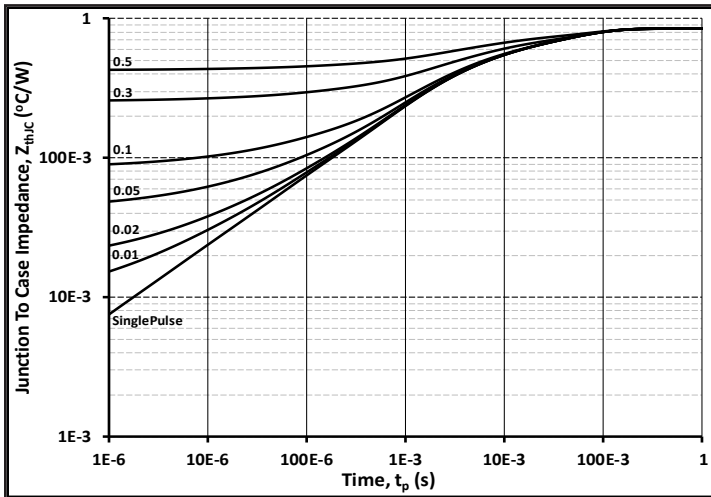


Figure 21. Transient Thermal Impedance (Junction - Case)

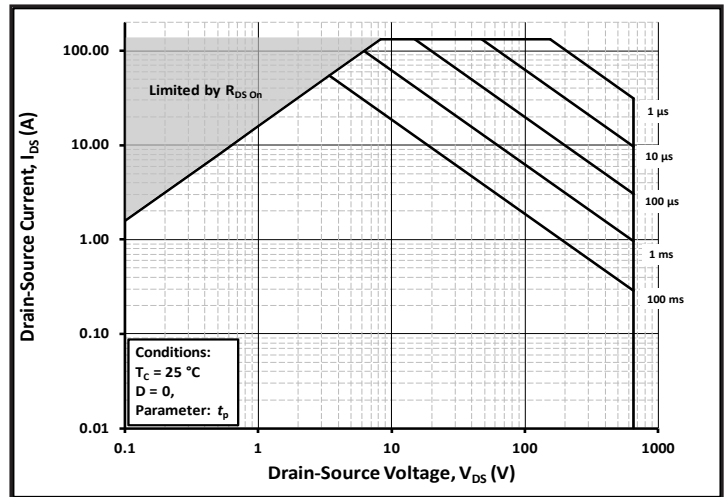


Figure 22. Safe Operating Area

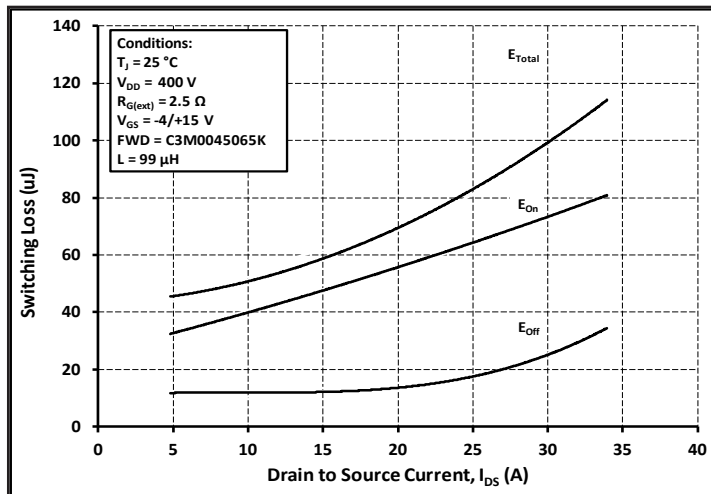


Figure 23. Clamped Inductive Switching Energy vs. Drain Current ( $V_{DD} = 400V$ )

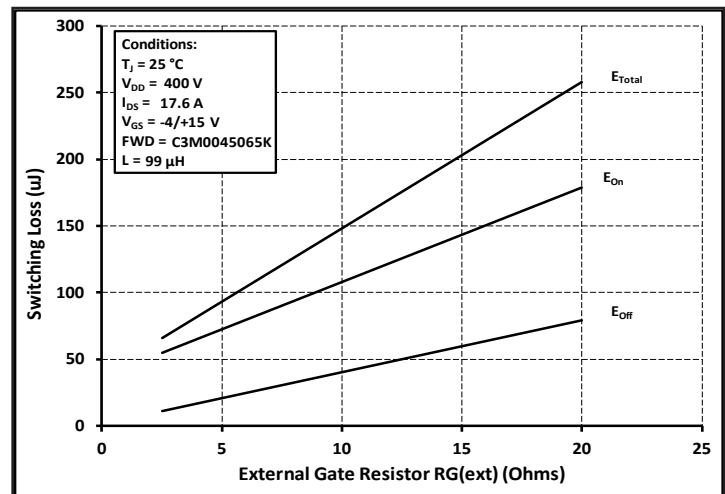


Figure 24. Clamped Inductive Switching Energy vs.  $R_{G(ext)}$

## Typical Performance

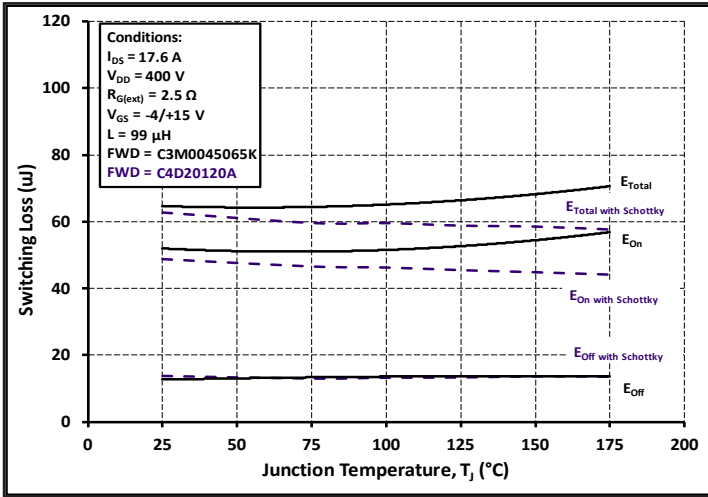


Figure 25. Clamped Inductive Switching Energy vs. Temperature

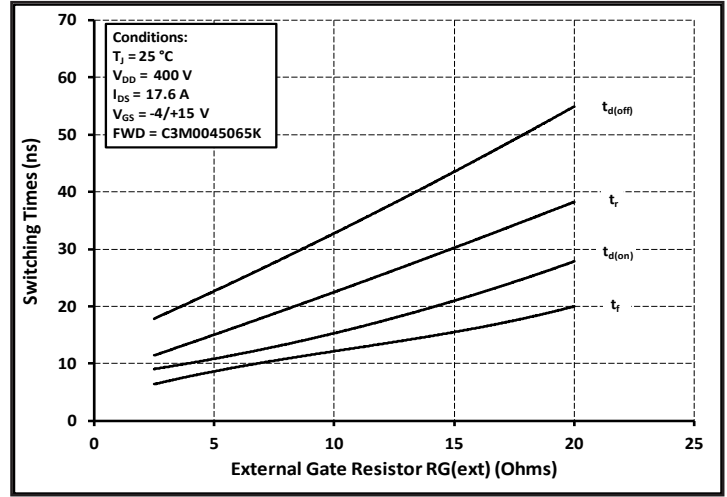


Figure 26. Switching Times vs.  $R_{G(ext)}$



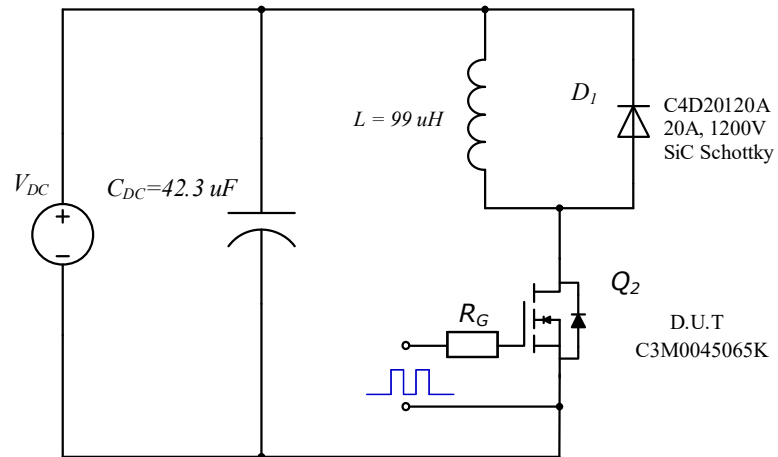


Figure 27. Clamped Inductive Switching Waveform Test Circuit

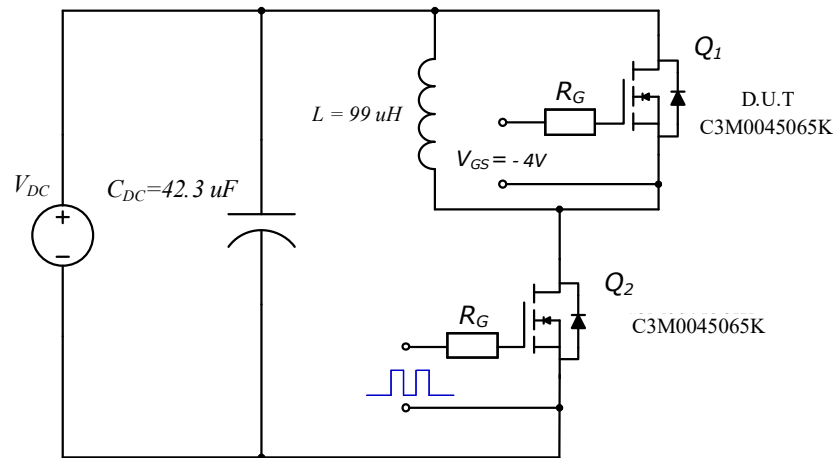


Figure 28. Body Diode Recovery Test Circuit

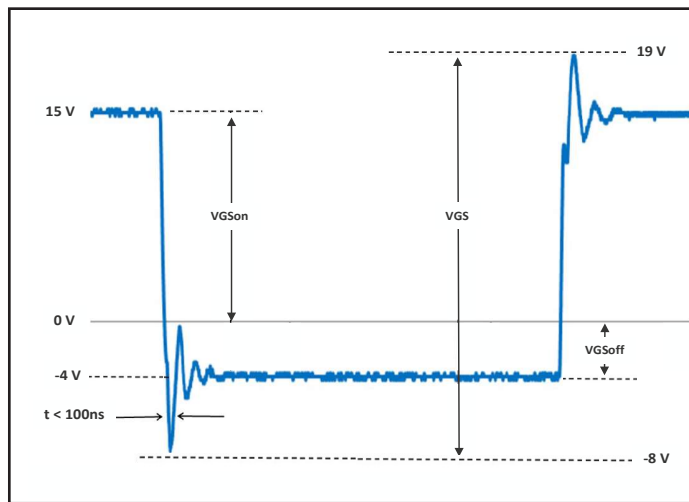
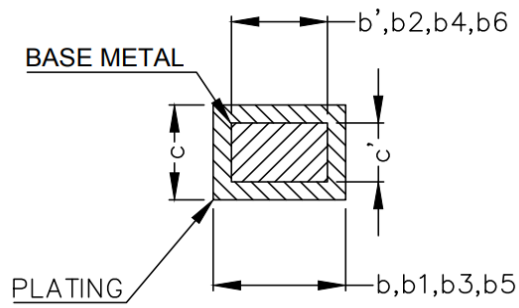
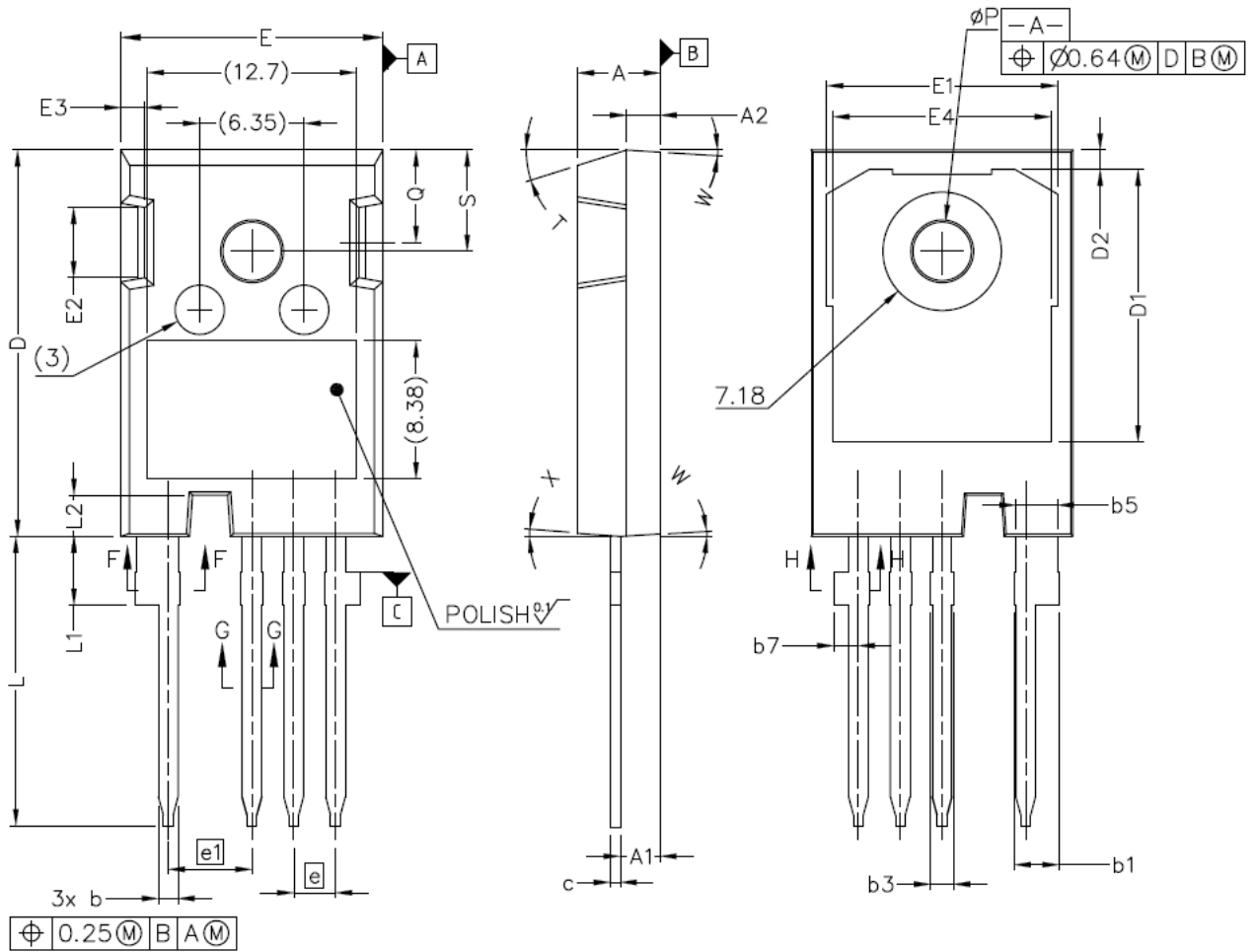


Figure 29.  $V_{GS}$  Waveform Example

## Package Dimensions

Package TO-247-4L



SECTION "F-F", "G-G" AND "H-H"  
SCALE: NONE

## Package Dimensions

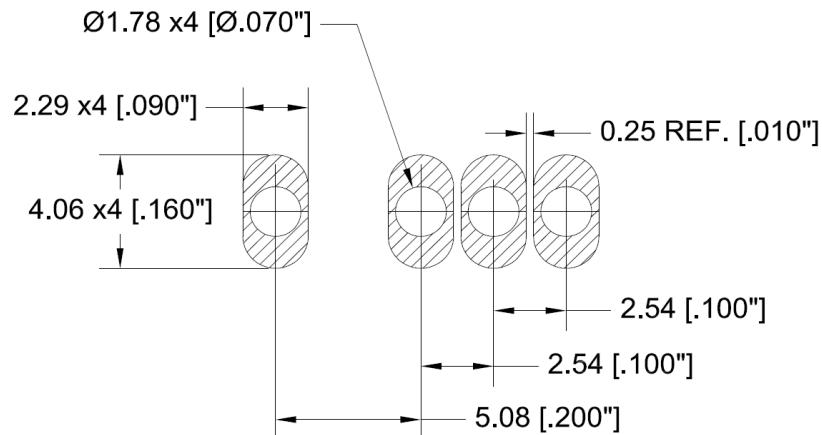
### Package TO-247-4L

NOTE ;

1. ALL METAL SURFACES: TIN PLATED, EXCEPT AREA OF CUT
2. DIMENSIONING & TOLERANCEING CONFIRM TO ASME Y14.5M-1994.
3. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
4. 'N' IS THE NUMBER OF TERMINAL POSITIONS

SYM	MILLIMETERS	
	MIN	MAX
A	4.83	5.21
A1	2.29	2.54
A2	1.91	2.16
b`	1.07	1.28
b	1.07	1.33
b1	2.39	2.94
b2	2.39	2.84
b3	1.07	1.60
b4	1.07	1.50
b5	2.39	2.69
b6	2.39	2.64
b7	1.30	1.70
c`	0.55	0.65
c	0.55	0.68
D	23.30	23.60
D1	16.25	17.65
D2	0.95	1.25
E	15.75	16.13

SYM	MILLIMETERS	
	MIN	MAX
E1	13.10	14.15
E2	3.68	5.10
E3	1.00	1.90
E4	12.38	13.43
e	2.54 BSC	
e1	5.08 BSC	
N*	4	
L	17.31	17.82
L1	3.97	4.37
L2	2.35	2.65
Ø P	3.51	3.65
Q	5.49	6.00
S	6.04	6.30
T	17.5° REF.	
W	3.5° REF.	
X	4° REF.	



## Notes

---

- **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

---

- **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>