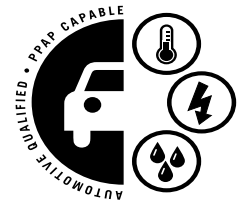


E3M0060065K

Silicon Carbide Power MOSFET
E-Series Automotive
N-Channel Enhancement Mode



Features

- 3rd generation 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
- Automotive Qualified (AEC-Q101) and PPAP Capable

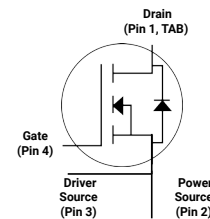
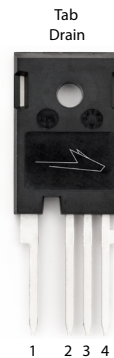
Benefits

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

Applications

- EV Battery Chargers
- High Voltage DC/DC Converters

Package



Part Number	Package	Marking
E3M0060065K	TO-247-4L	E3M0060065K

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

Symbol	Parameter	Value	Unit	Note	
V_{DSmax}	Drain - Source Voltage	650	V		
V_{GSmax}	Gate - Source Voltage	-8/+19	V	Note: 1	
I_D	Continuous Drain Current, $V_{GS} = 15\text{ V}$	$T_c = 25^\circ\text{C}$	37	A	Fig. 19 Note: 2
		$T_c = 100^\circ\text{C}$	26		
$I_{D(pulse)}$	Pulsed Drain Current, Pulse width t_p limited by T_{jmax}	99	A	Fig. 22	
P_D	Power Dissipation, $T_c=25^\circ\text{C}$, $T_j = 175^\circ\text{C}$	131	W	Fig. 20 Note: 2	
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	lbf-in		

Note (1): Recommended turn off / turn on gate voltage $V_{GS} = -4V..0V / +15V$

Note (2): Verified by design

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	650			V	$V_{GS} = 0\text{ V}, I_D = 100\ \mu\text{A}$	
$V_{GS(th)}$	Gate Threshold Voltage	1.8	2.8	3.6	V	$V_{DS} = V_{GS}, I_D = 3.6\ \text{mA}$	Fig. 11
			2.2		V	$V_{DS} = V_{GS}, I_D = 3.6\ \text{mA}, T_J = 175^\circ\text{C}$	
I_{DSS}	Zero Gate Voltage Drain Current		1	50	μA	$V_{DS} = 650\ \text{V}, V_{GS} = 0\ \text{V}$	
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		60	79	m Ω	$V_{GS} = 15\ \text{V}, I_D = 13.2\ \text{A}$	Fig. 4, 5, 6
			83			$V_{GS} = 15\ \text{V}, I_D = 13.2\ \text{A}, T_J = 175^\circ\text{C}$	
g_{fs}	Transconductance		9		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		1170		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		72				
C_{rss}	Reverse Transfer Capacitance		6				
E_{oss}	C_{oss} Stored Energy		14		μJ		Fig. 16
$C_{o(er)}$	Effective Output Capacitance (Energy Related)		85		pF	$V_{GS} = 0\ \text{V}, V_{DS} = 0\ \dots\ 400\ \text{V}$	Note: 3
$C_{o(tr)}$	Effective Output Capacitance (Time Related)		122				
E_{oN}	Turn-On Switching Energy (External Diode)		29		μJ	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}, I_D = 13.2\ \text{A},$ $R_{G(ext)} = 2.5\ \Omega, L = 135\ \mu\text{H}, T_J = 175^\circ\text{C}$ FWD = External SiC DIODE	Fig. 25
E_{oOFF}	Turn Off Switching Energy (External Diode)		12				
E_{oN}	Turn-On Switching Energy (Body Diode FWD)		40		μJ	$V_{DS} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}, I_D = 13.2\ \text{A},$ $R_{G(ext)} = 2.5\ \Omega, L = 135\ \mu\text{H}, T_J = 175^\circ\text{C}$ FWD = Internal Body Diode	Fig. 25
E_{oOFF}	Turn-Off Switching Energy (Body Diode FWD)		11				
$t_{d(on)}$	Turn-On Delay Time		9		ns	$V_{DD} = 400\ \text{V}, V_{GS} = -4\ \text{V}/15\ \text{V}$ $I_D = 13.2\ \text{A}, R_{G(ext)} = 2.5\ \Omega,$ Timing relative to V_{DS} Inductive load	Fig. 26
t_r	Rise Time		10				
$t_{d(off)}$	Turn-Off Delay Time		16				
t_f	Fall Time		8				
$R_{G(int)}$	Internal Gate Resistance		4		Ω	$f = 1\ \text{MHz}, V_{AC} = 25\ \text{mV}$	
Q_{gs}	Gate to Source Charge		16		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		16				
Q_g	Total Gate Charge		49				

Note (3): $C_{o(er)}$, 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	4.6		V	$V_{GS} = -4\text{ V}, I_{SD} = 6.6\text{ A}, T_J = 25^\circ\text{C}$	Fig. 8, 9, 10
		4.1		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	12		ns	$V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$ $dif/dt = 4770\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
Q_{rr}	Reverse Recovery Charge	173		nC		
I_{rrm}	Peak Reverse Recovery Current	28		A		
t_{rr}	Reverse Recover time	15		ns	$V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$ $dif/dt = 2200\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
Q_{rr}	Reverse Recovery Charge	122		nC		
I_{rrm}	Peak Reverse Recovery Current	13		A		

Thermal Characteristics

Symbol	Parameter	Typ.	Max.	Unit	Test Conditions	Note
$R_{\theta JC}$	Thermal Resistance from Junction to Case	1.02	1.14	$^\circ\text{C}/\text{W}$		Fig. 21



Typical Performance

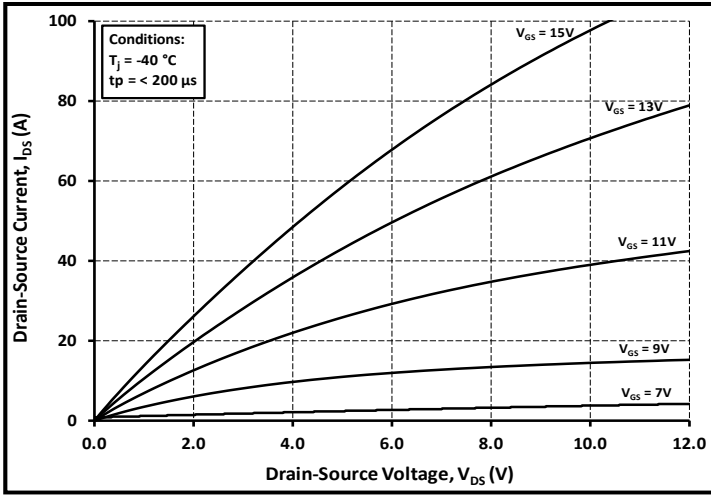


Figure 1. Output Characteristics $T_j = -40\text{ }^\circ\text{C}$

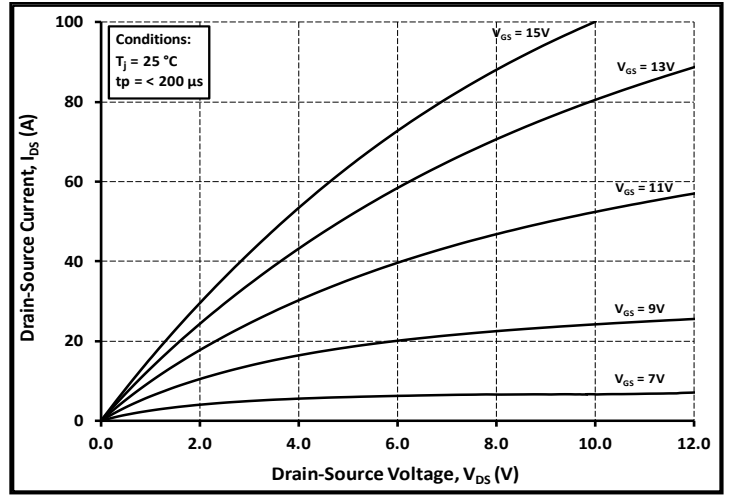


Figure 2. Output Characteristics $T_j = 25\text{ }^\circ\text{C}$

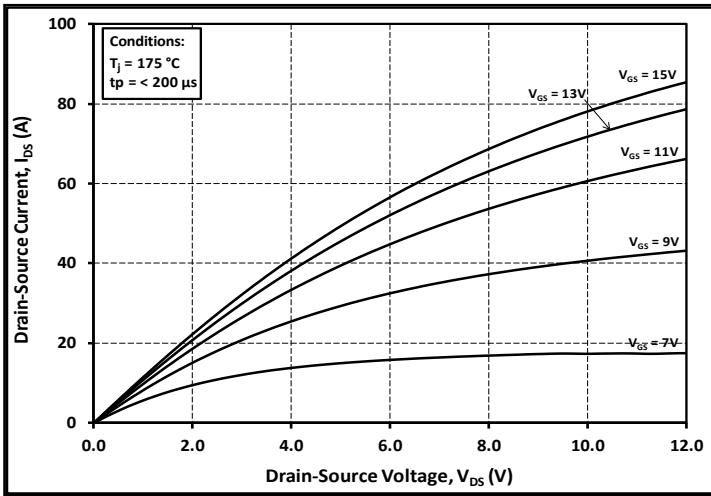


Figure 3. Output Characteristics $T_j = 175\text{ }^\circ\text{C}$

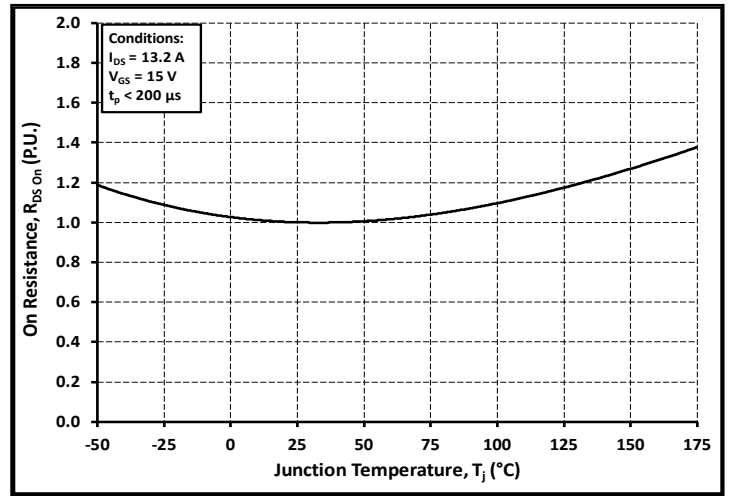


Figure 4. Normalized On-Resistance vs. Temperature

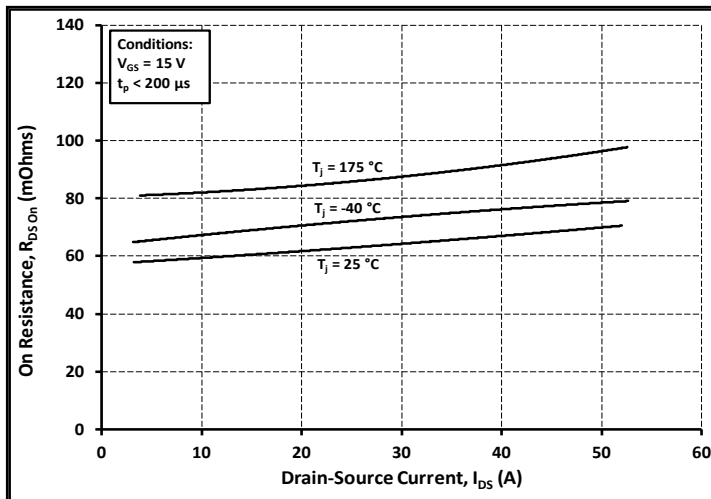


Figure 5. On-Resistance vs. Drain Current For Various Temperatures

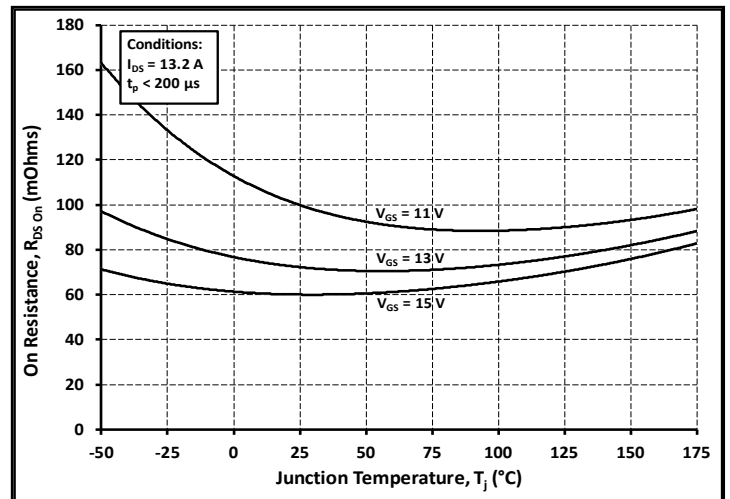


Figure 6. On-Resistance vs. Temperature For Various Gate Voltage



Typical Performance

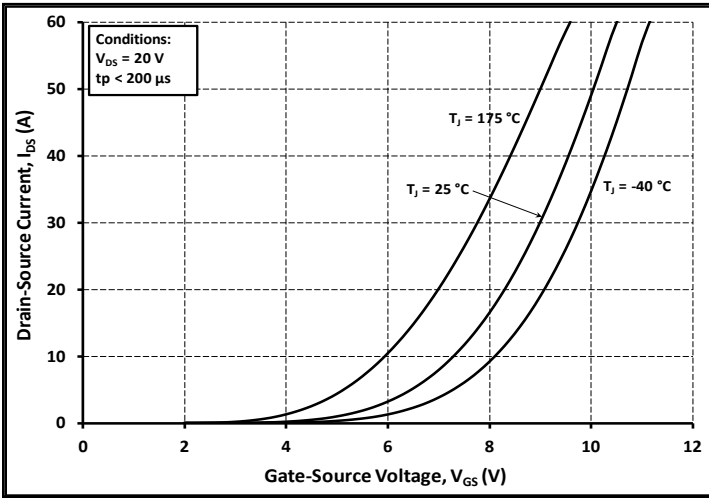


Figure 7. Transfer Characteristic for Various Junction Temperatures

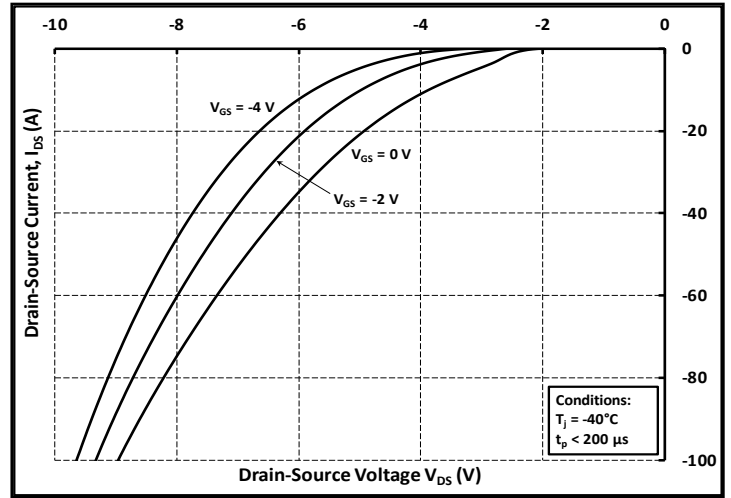


Figure 8. Body Diode Characteristic at -40 °C

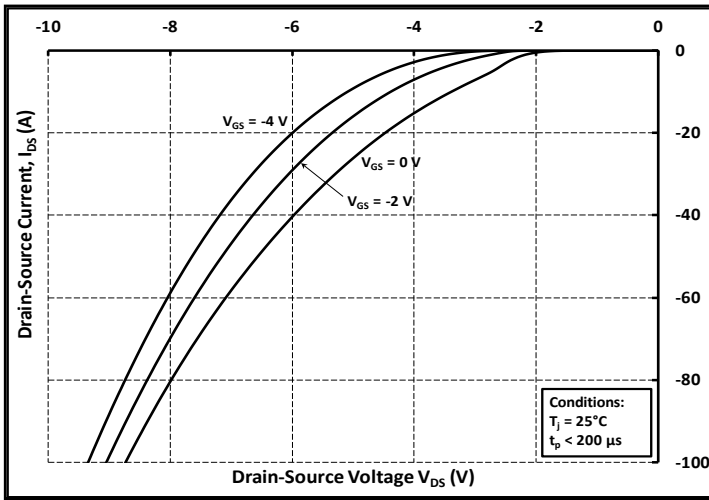


Figure 9. Body Diode Characteristic at 25 °C

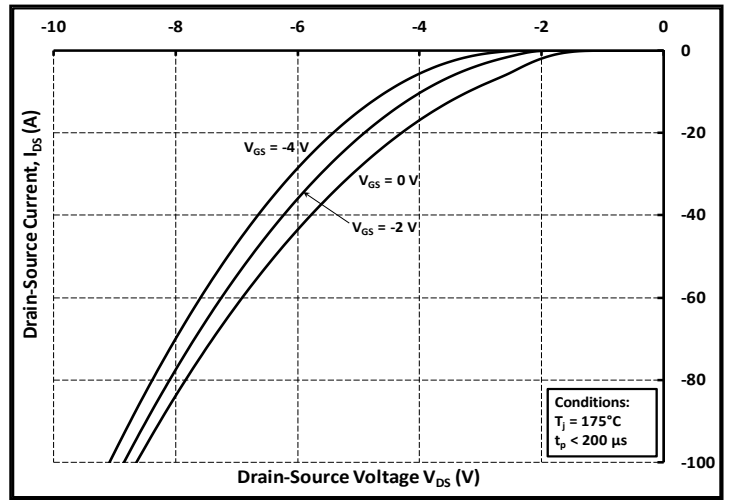


Figure 10. Body Diode Characteristic at 175 °C

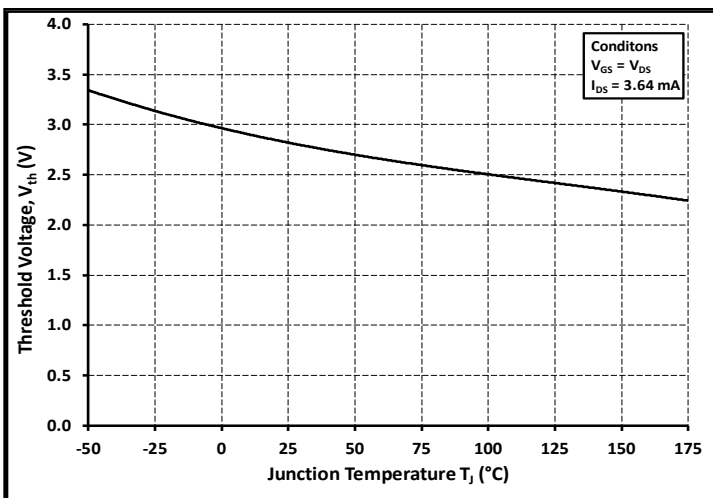


Figure 11. Threshold Voltage vs. Temperature

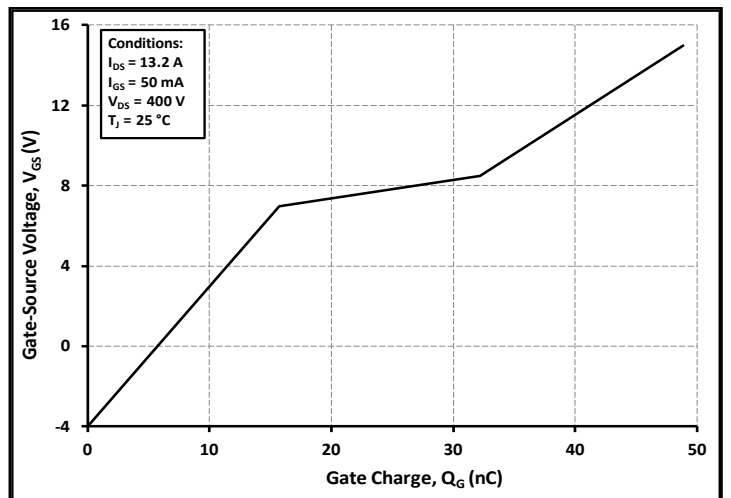


Figure 12. Gate Charge Characteristics



Typical Performance

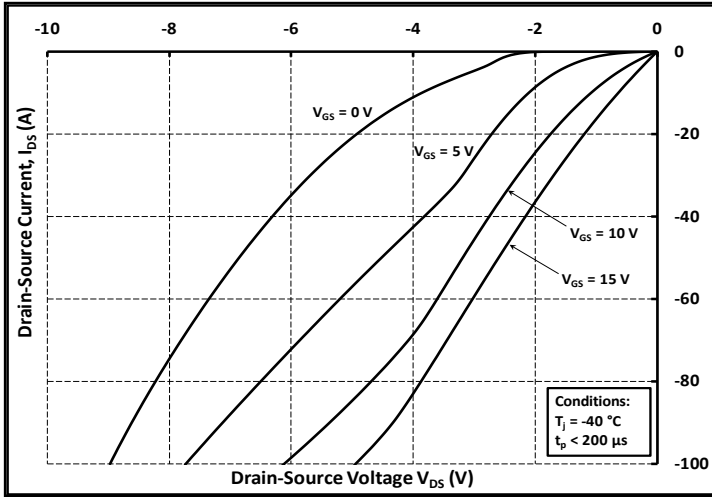


Figure 13. 3rd Quadrant Characteristic at -40 °C

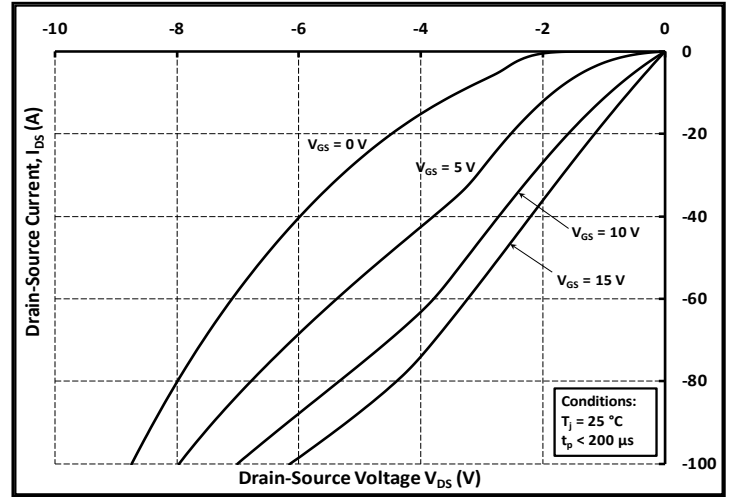


Figure 14. 3rd Quadrant Characteristic at 25 °C

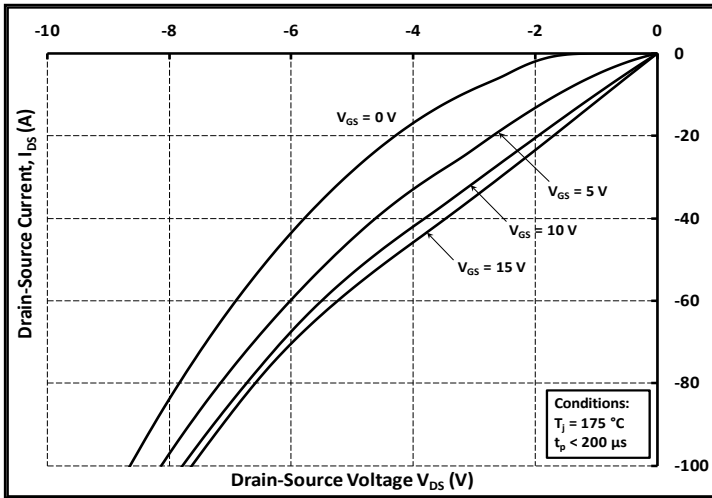


Figure 15. 3rd Quadrant Characteristic at 175 °C

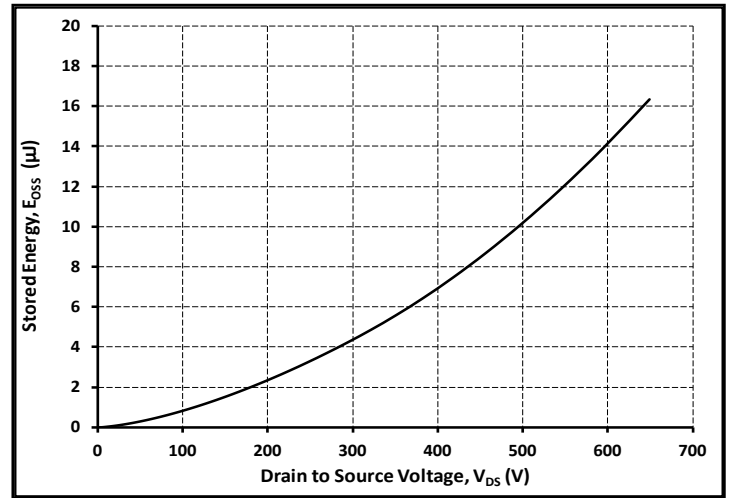


Figure 16. Output Capacitor Stored Energy

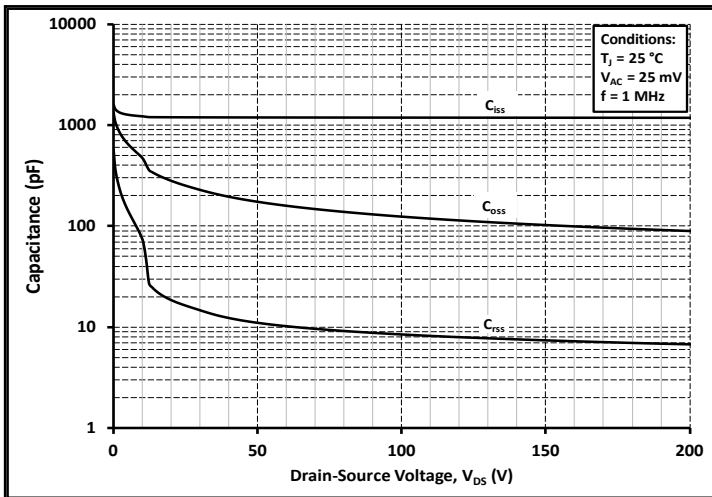


Figure 17. Capacitances vs. Drain-Source Voltage (0 - 200V)

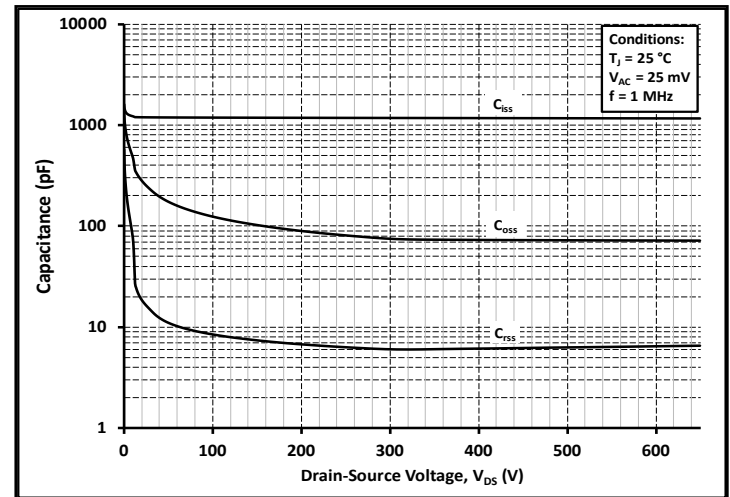


Figure 18. Capacitances vs. Drain-Source Voltage (0 - 650V)



Typical Performance

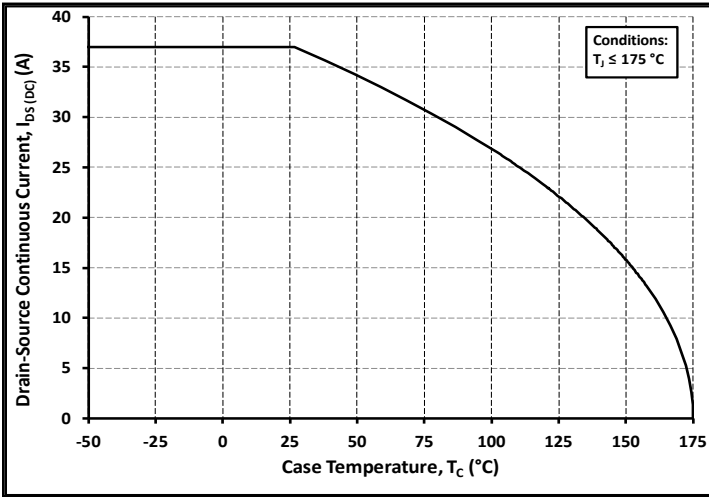


Figure 19. Continuous Drain Current Derating vs. Case Temperature

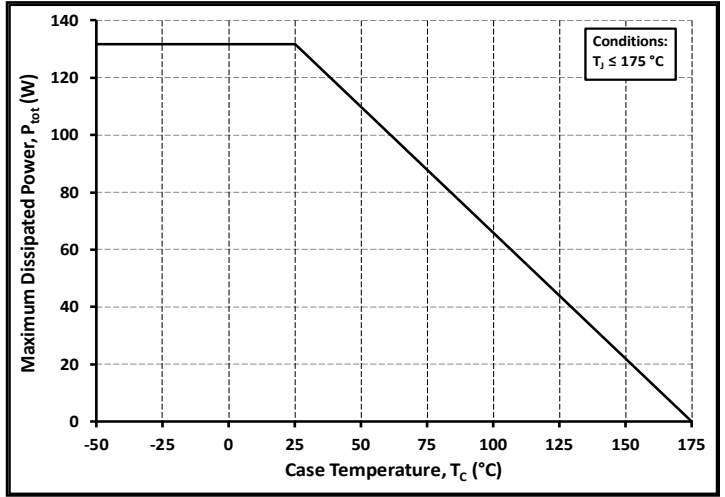


Figure 20. Maximum Power Dissipation Derating vs. Case Temperature

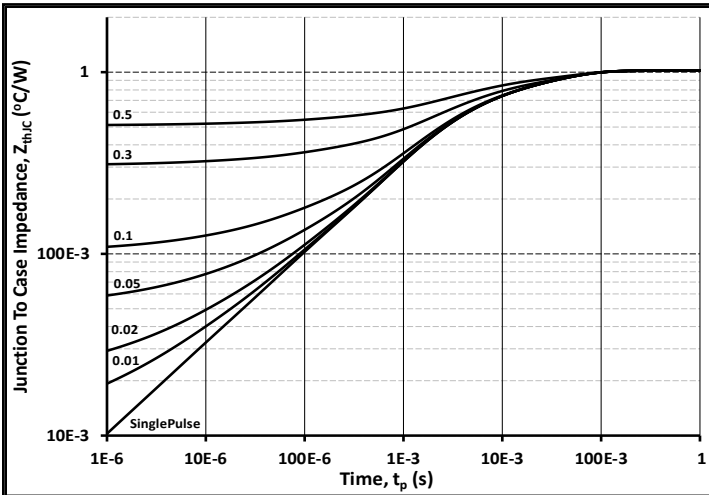


Figure 21. Transient Thermal Impedance (Junction - Case)

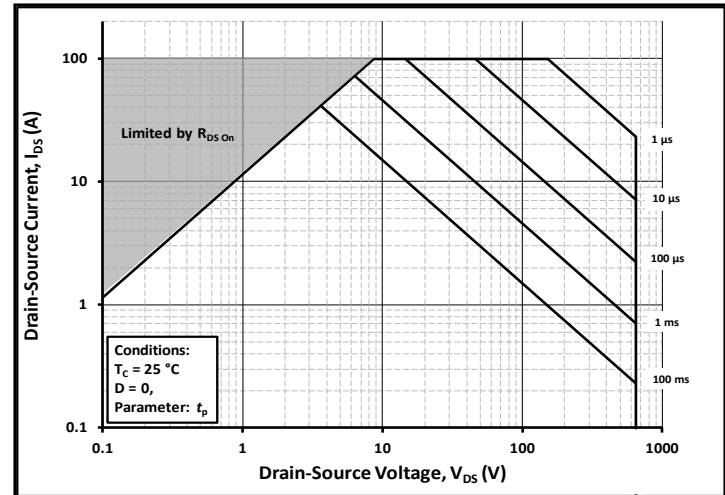


Figure 22. Safe Operating Area

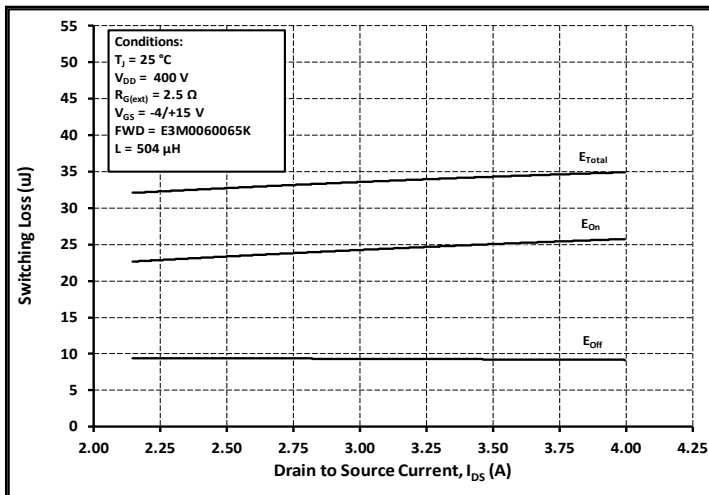


Figure 23. Clamped Inductive Switching Energy vs. Low Drain Current ($V_{DD} = 400V$)

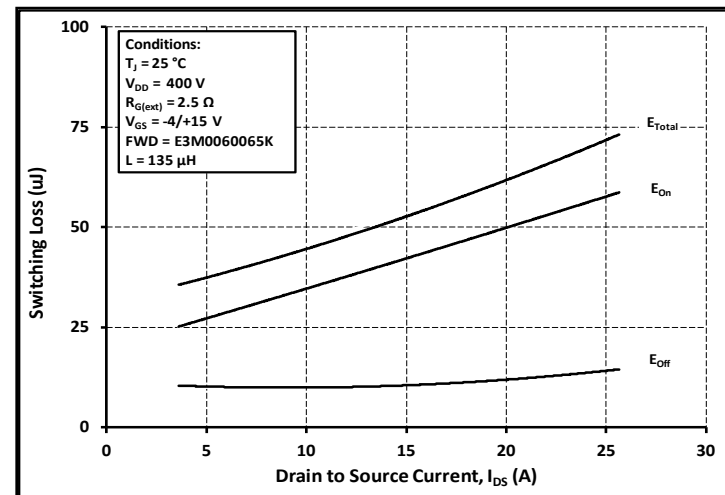


Figure 24. Lamped Inductive Switching Energy vs. High Drain Current ($V_{DD} = 400V$)



Typical Performance

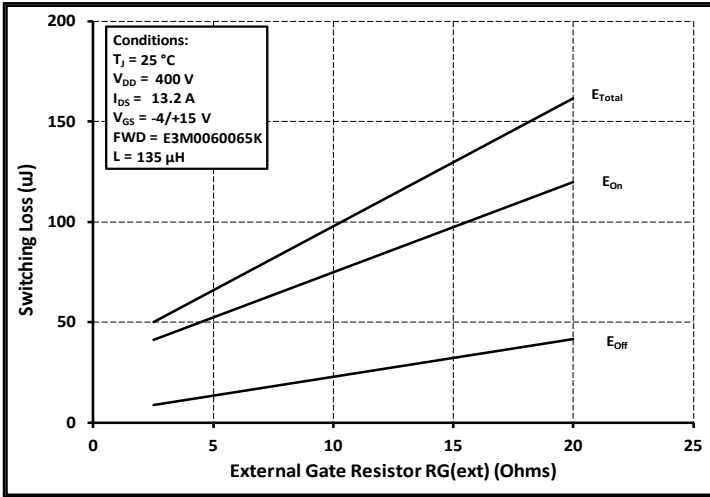


Figure 25. Clamped Inductive Switching Energy vs. $R_{G(ext)}$

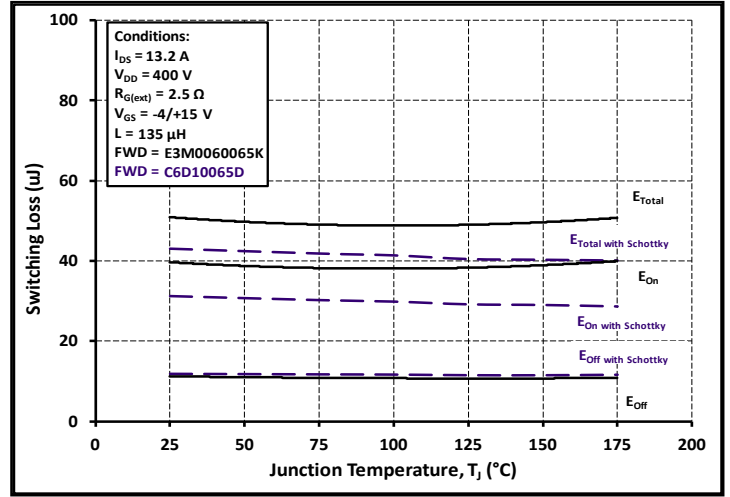


Figure 26. Clamped Inductive Switching Energy vs. Temperature

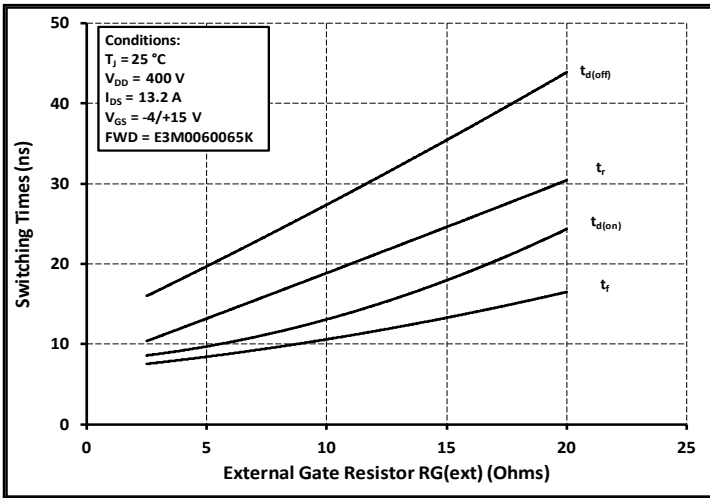


Figure 27. Switching Times vs. $R_{G(ext)}$

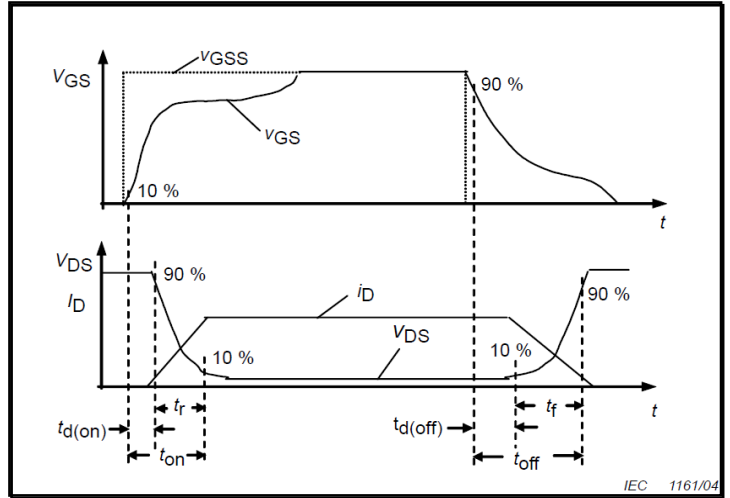


Figure 28. Switching Times Definition

Test Circuit Schematic

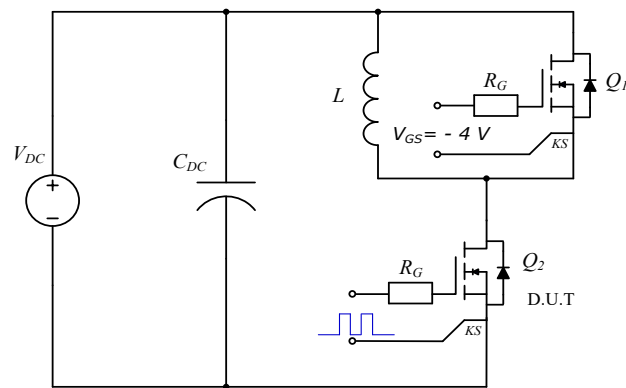
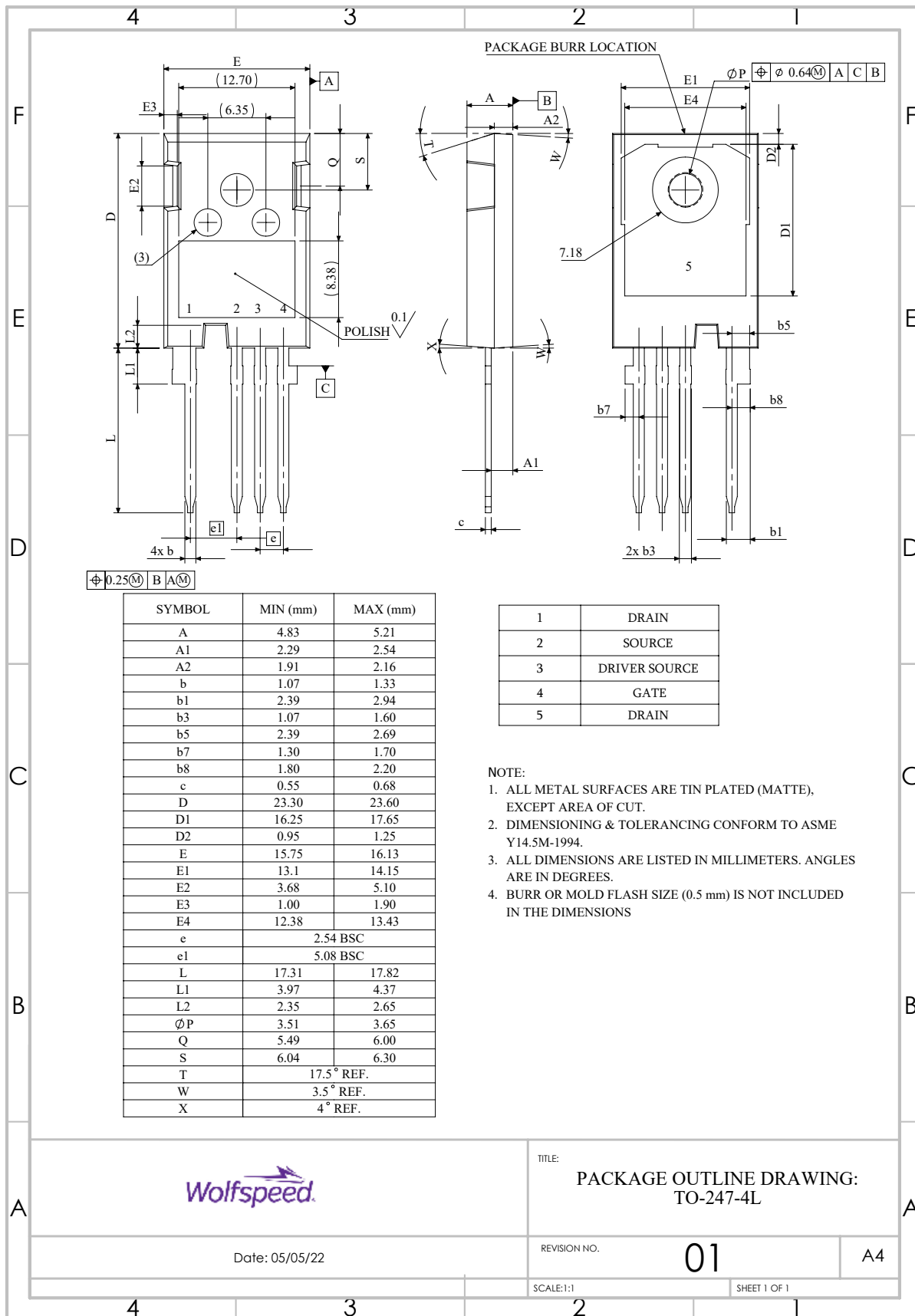


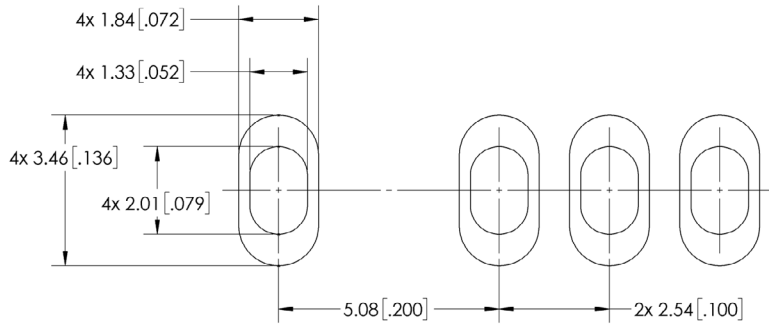
Figure 29. Clamped Inductive Switching Waveform Test Circuit

Package Dimensions





Recommended Solder Pad Layout





Revision history

Document Version	Date of release	Description of changes
1.0	June-2022	Initial datasheet



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[IPLK60R1K0PFD7ATMA1](#) [NTPF450N80S3Z](#) [IPLK60R1K5PFD7ATMA1](#) [IPBE65R190CFD7AATMA1](#) [IPB65R190CFD7AATMA1](#)
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