

E3M0060065D

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



Features

- 3rd generation SiC MOSFET technology
- 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

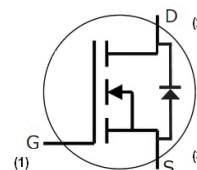
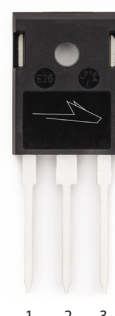
Benefits

- 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
E3M0060065D	TO-247-3L	E3M0060065D

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	$V_{GS} = 0\text{ V}, I_D = 100\text{ }\mu\text{A}$	
$V_{GS(th)}$	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	$V_{GS} = 0\text{ V}, V_{DS} = 0\text{... } 400\text{ V}$	Note: 3
$C_{o(tr)}$	Effective Output Capacitance (Time Related)		122		pF		
E_{ON}	Turn-On Switching Energy (External Diode)		126		μJ	$V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}, I_D = 13.2\text{ A},$ $R_{G(ext)} = 2.5\text{ }\Omega, L = 135\text{ }\mu\text{H}, T_J = 175^\circ\text{C}$ FWD = External SiC DIODE	Fig. 26
E_{OFF}	Turn Off Switching Energy (External Diode)		25				
E_{ON}	Turn-On Switching Energy (Body Diode FWD)		169		μJ	$V_{DS} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}, I_D = 13.2\text{ A},$ $R_{G(ext)} = 2.5\text{ }\Omega, L = 135\text{ }\mu\text{H}, T_J = 175^\circ\text{C}$ FWD = Internal Body Diode	Fig. 26
E_{OFF}	Turn-Off Switching Energy (Body Diode FWD)		23				
$t_{d(on)}$	Turn-On Delay Time		10		ns	$V_{DD} = 400\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}$ $I_D = 13.2\text{ A}, R_{G(ext)} = 2.5\text{ }\Omega,$ Timing relative to V_{DS} Inductive load	Fig. 27
t_r	Rise Time		33				
$t_{d(off)}$	Turn-Off Delay Time		17				
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		13				
Q_g	Total Gate Charge		46				

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	$V_{GS} = -4\text{ V}, T_c = 25^\circ\text{C}$	
$I_{S, \text{pulse}}$	Diode pulse Current		99	A	$V_{GS} = -4\text{ V}$, pulse width t_p limited by $T_{J\text{max}}$	
t_{rr}	Reverse Recover time	23		ns	$V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$ $dif/dt = 1720\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
Q_{rr}	Reverse Recovery Charge	108		nC		
I_{rm}	Peak Reverse Recovery Current	8		A		
t_{rr}	Reverse Recover time	30		ns	$V_{GS} = -4\text{ V}, I_{SD} = 13.2\text{ A}, V_R = 400\text{ V}$ $dif/dt = 790\text{ A}/\mu\text{s}, T_J = 175^\circ\text{C}$	
Q_{rr}	Reverse Recovery Charge	97		nC		
I_{rm}	Peak Reverse Recovery Current	6		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

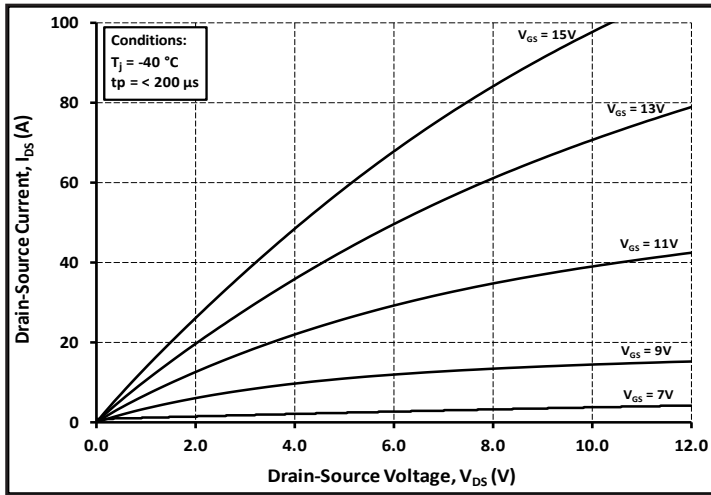
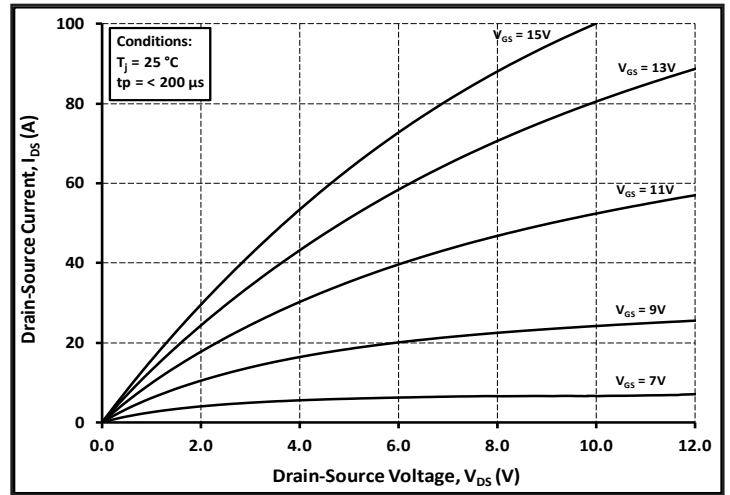
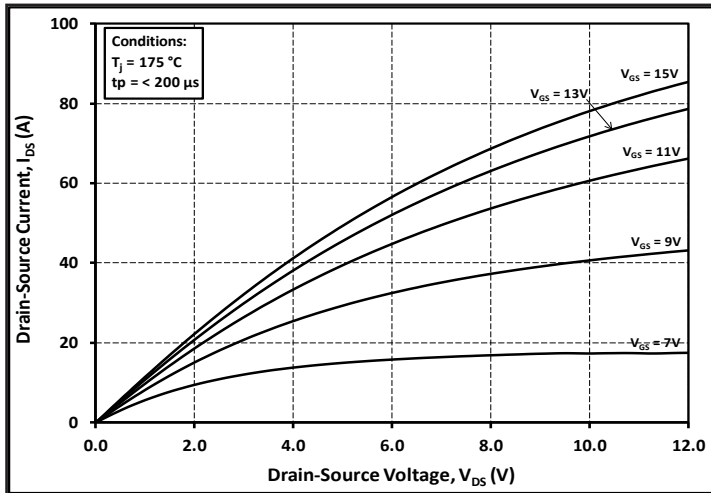
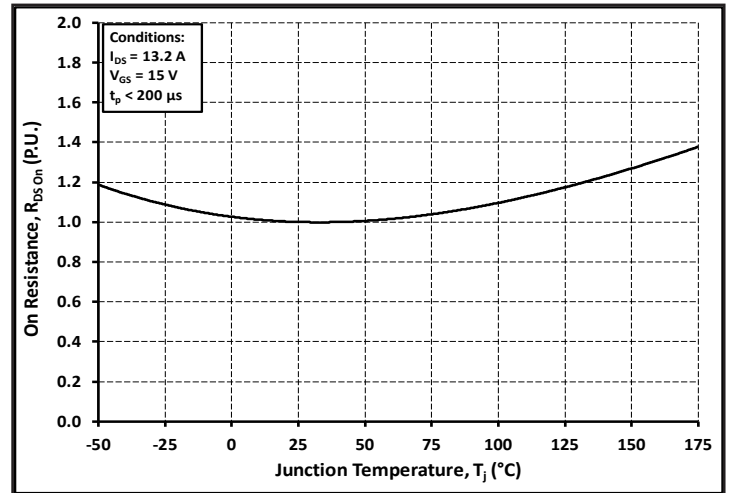
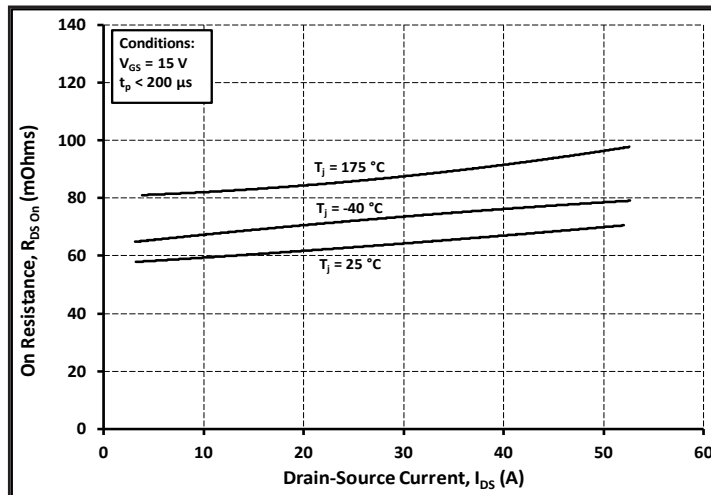
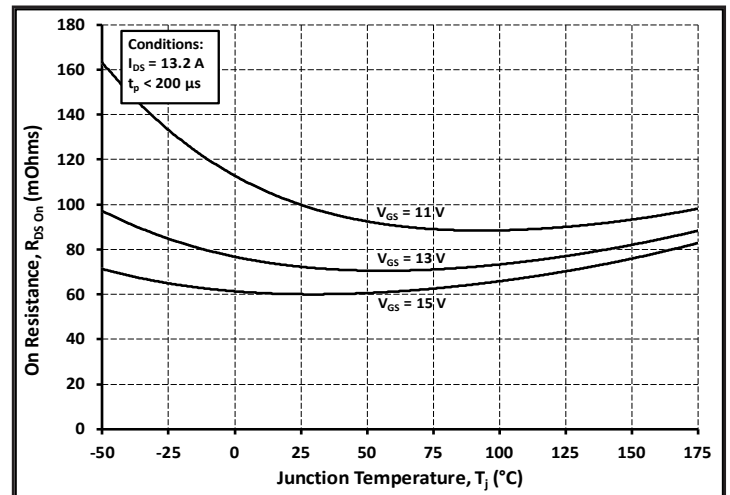
Figure 1. Output Characteristics $T_j = -40\text{ }^{\circ}\text{C}$ Figure 2. Output Characteristics $T_j = 25\text{ }^{\circ}\text{C}$ Figure 3. Output Characteristics $T_j = 175\text{ }^{\circ}\text{C}$ 

Figure 4. Normalized On-Resistance vs. Temperature

Figure 5. On-Resistance vs. Drain Current
For Various TemperaturesFigure 6. On-Resistance vs. Temperature
For Various Gate Voltage

Typical Performance

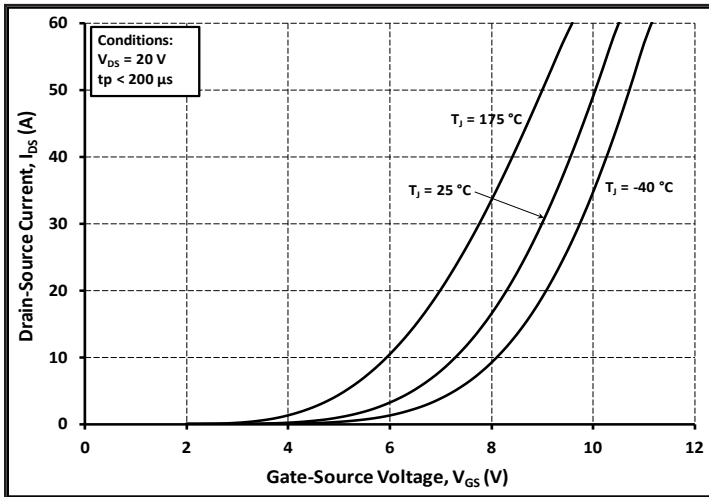


Figure 7. Transfer Characteristic for Various Junction Temperatures

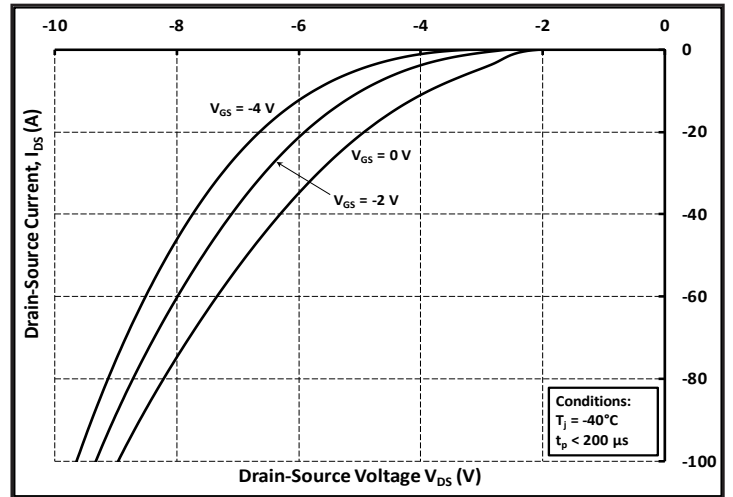
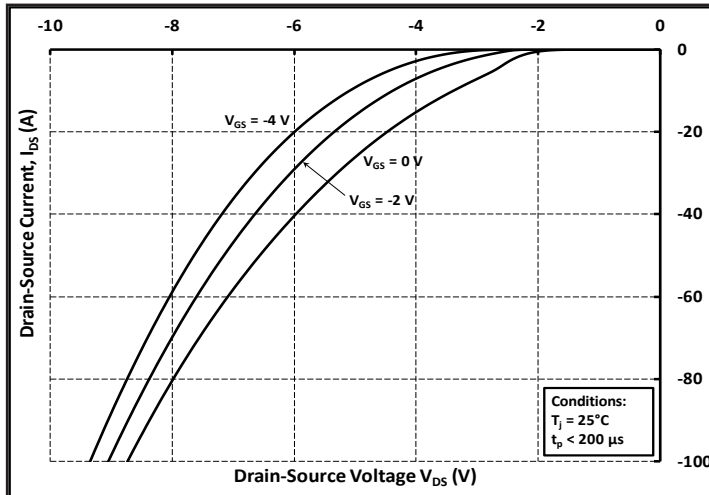
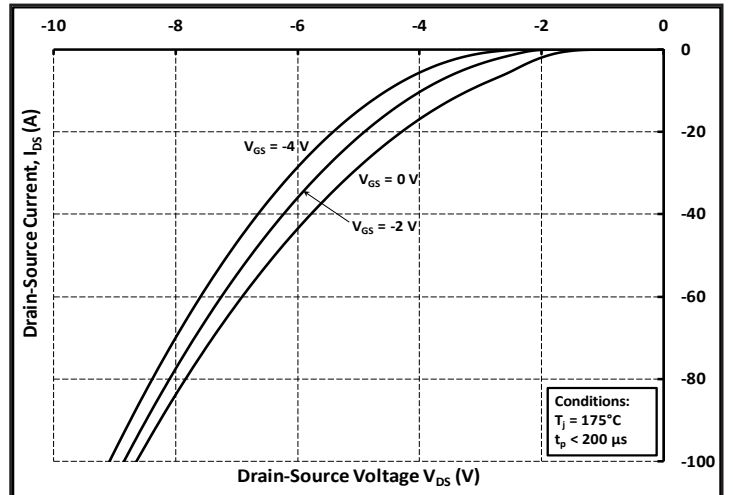
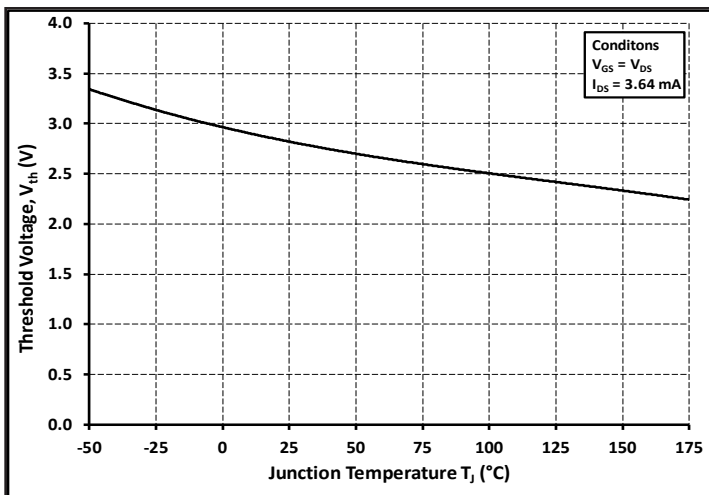
Figure 8. Body Diode Characteristic at -40°C Figure 9. Body Diode Characteristic at 25°C Figure 10. Body Diode Characteristic at 175°C 

Figure 11. Threshold Voltage vs. Temperature

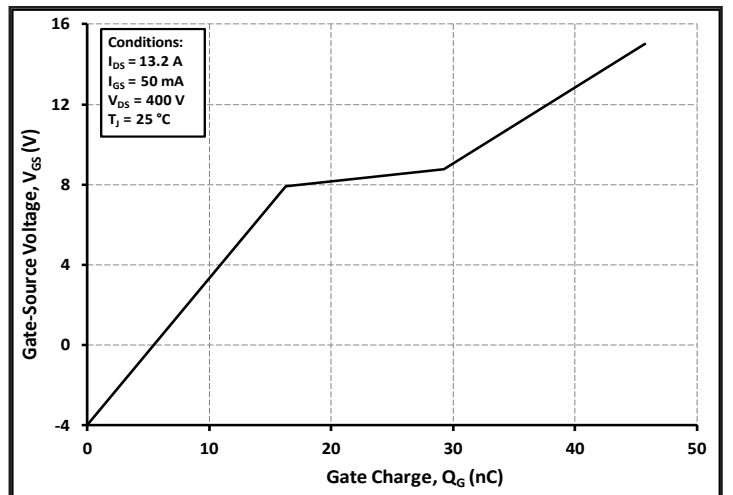


Figure 12. Gate Charge Characteristics

Typical Performance

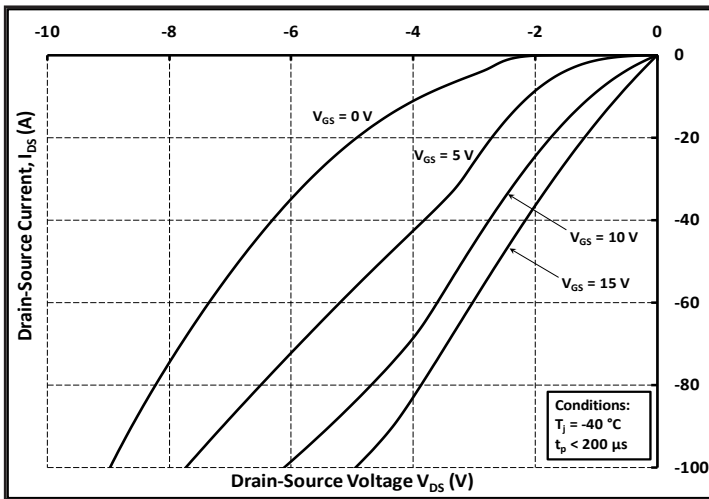
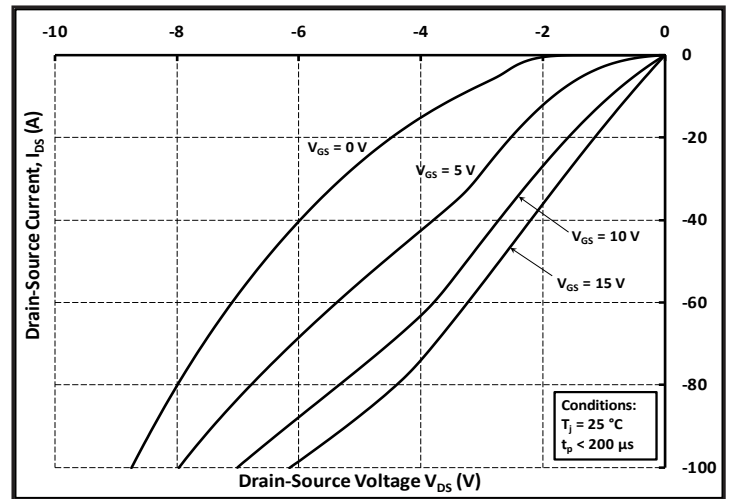
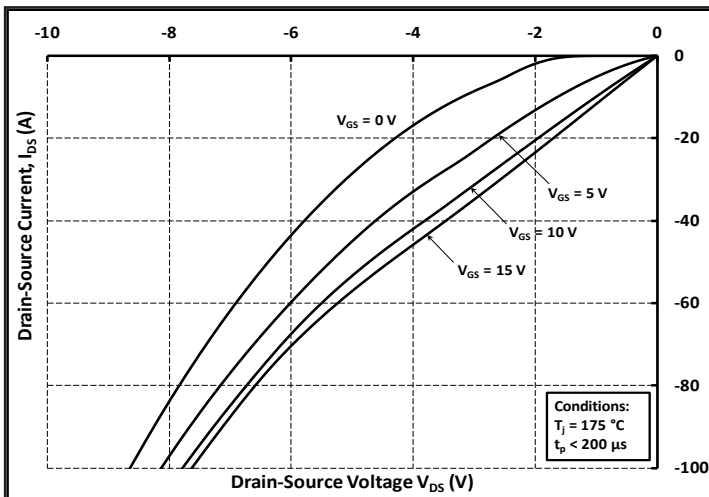
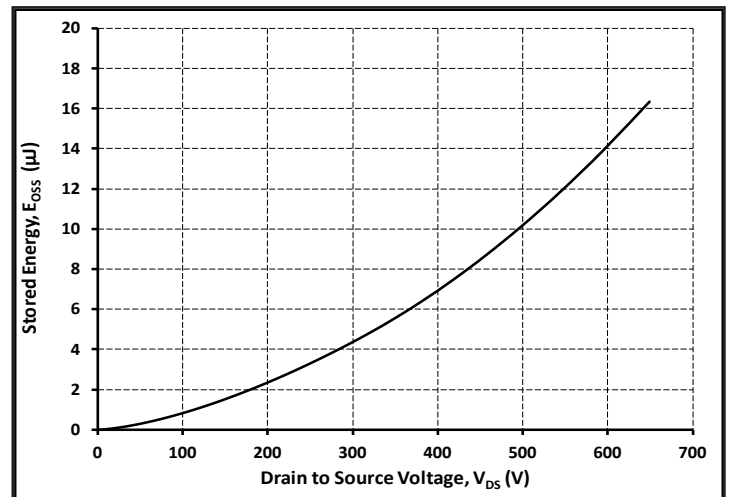
Figure 13. 3rd Quadrant Characteristic at $-40\text{ }^{\circ}\text{C}$ Figure 14. 3rd Quadrant Characteristic at $25\text{ }^{\circ}\text{C}$ Figure 15. 3rd Quadrant Characteristic at $175\text{ }^{\circ}\text{C}$ 

Figure 16. Output Capacitor Stored Energy

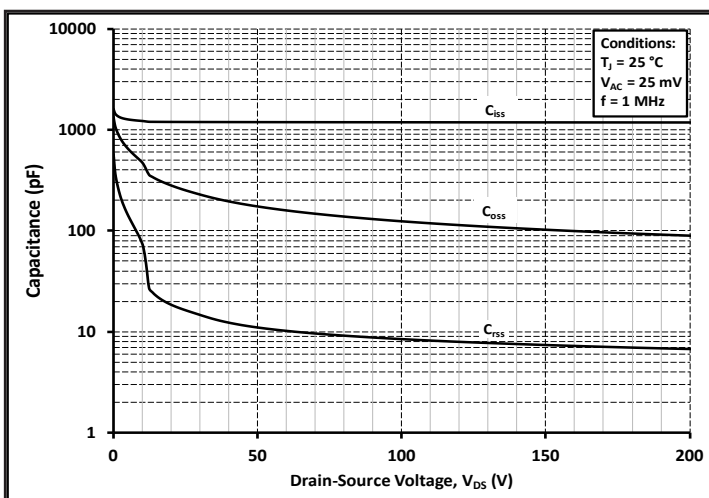


Figure 17. Capacitances vs. Drain-Source Voltage (0 - 200V)

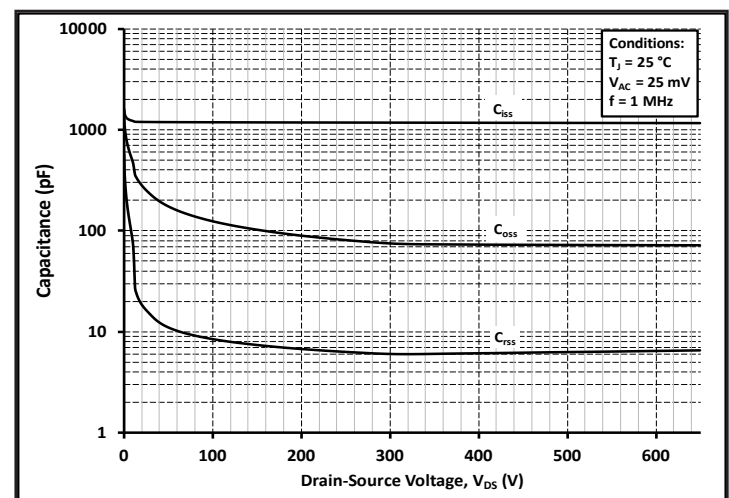


Figure 18. Capacitances vs. Drain-Source Voltage (0 - 650V)

Typical Performance

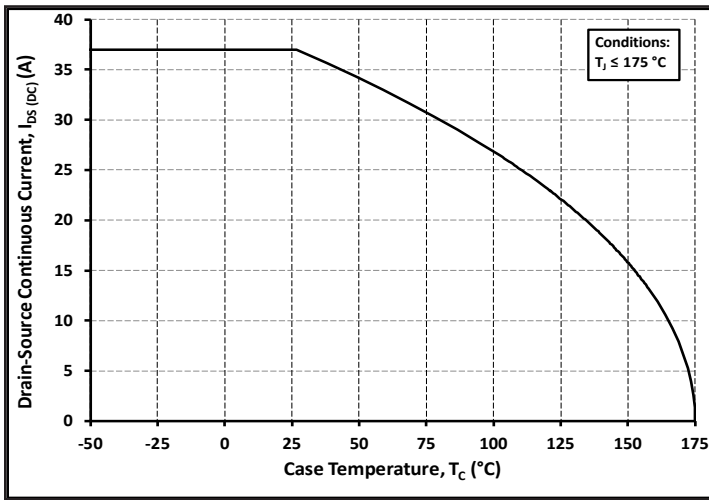


Figure 19. Continuous Drain Current Derating vs. Case Temperature

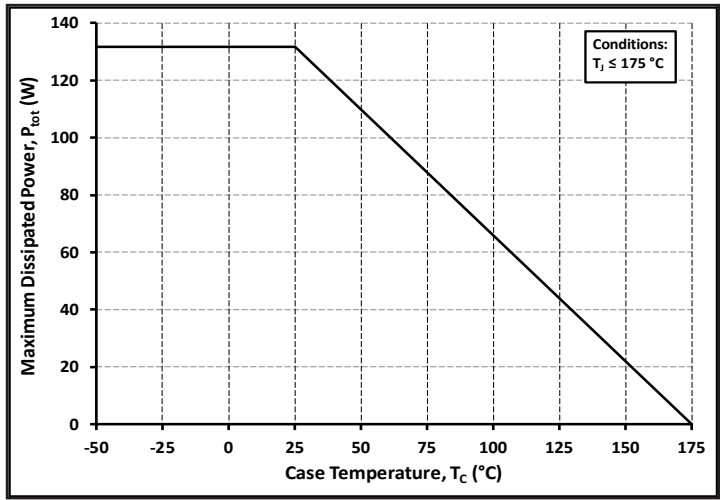


Figure 20. Maximum Power Dissipation Derating vs. Case Temperature

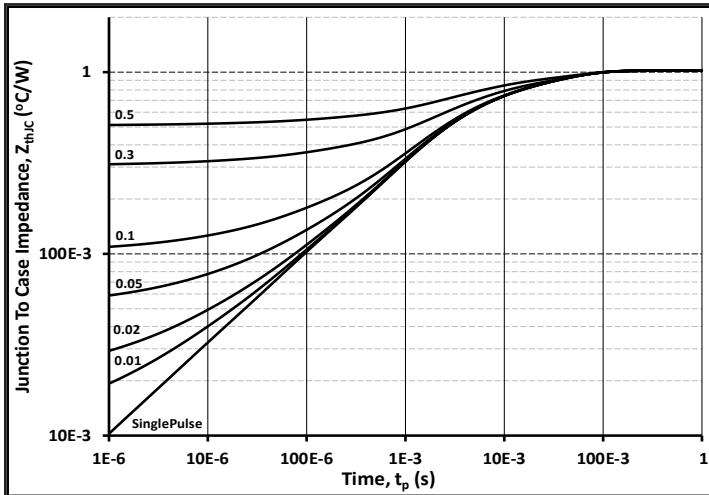


Figure 21. Transient Thermal Impedance (Junction - Case)

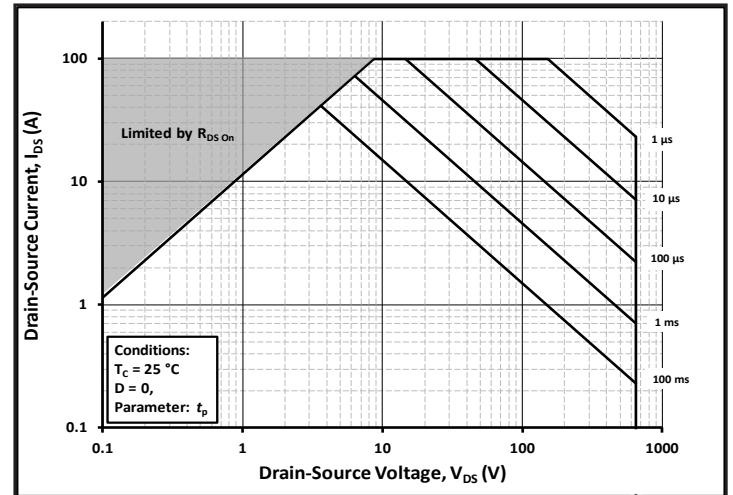
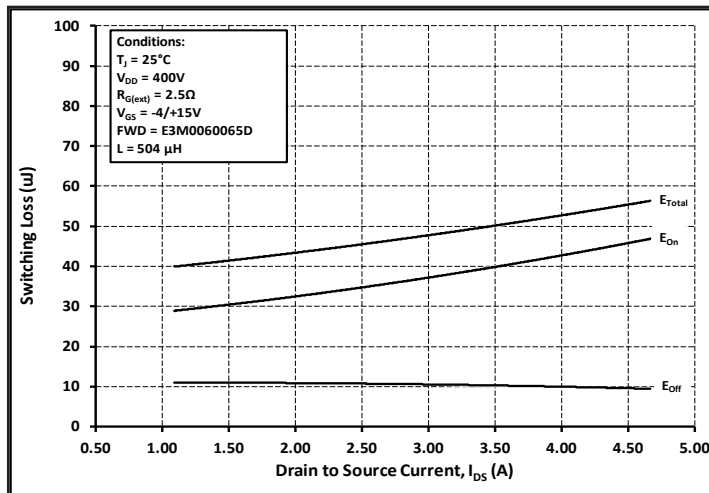
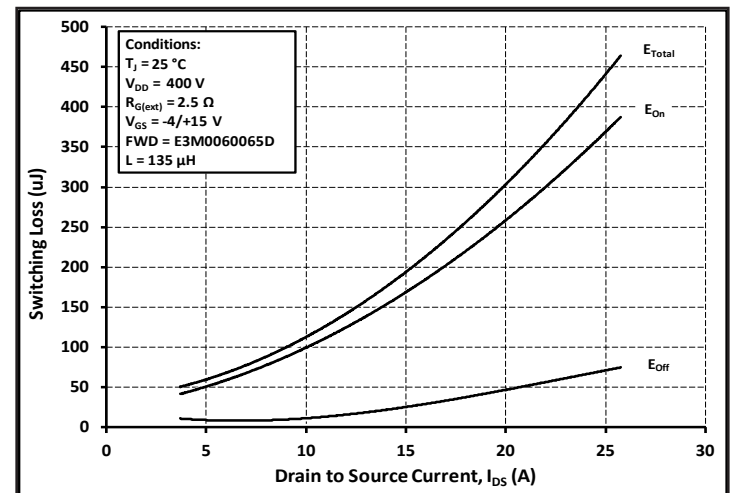


Figure 22. Safe Operating Area

Figure 23. Clamped Inductive Switching Energy vs. Low Drain Current ($V_{DD} = 400V$)Figure 24. Clamped Inductive Switching Energy vs. High Drain Current ($V_{DD} = 400V$)

Typical Performance

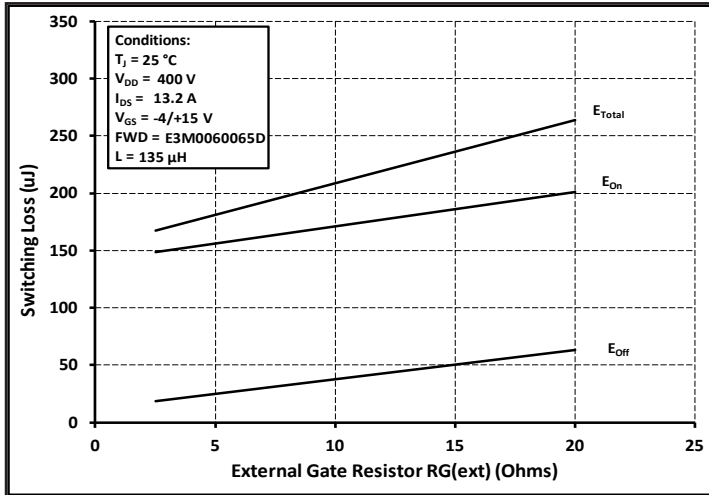
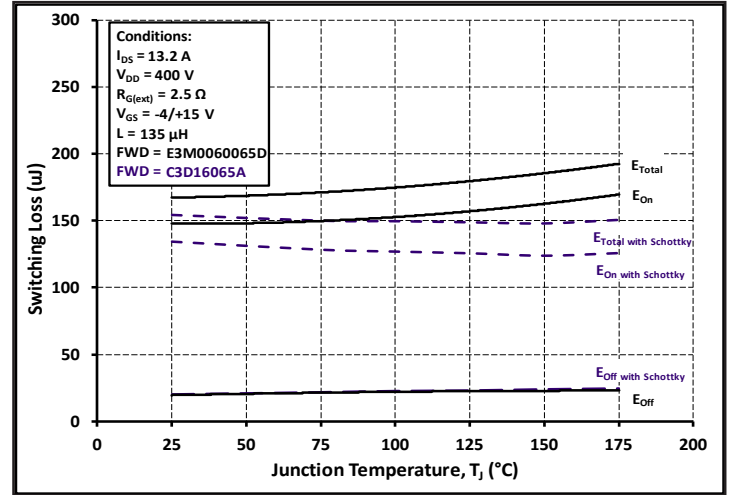
Figure 25. Clamped Inductive Switching Energy vs. $R_{G(\text{ext})}$ 

Figure 26. Clamped Inductive Switching Energy vs. Temperature

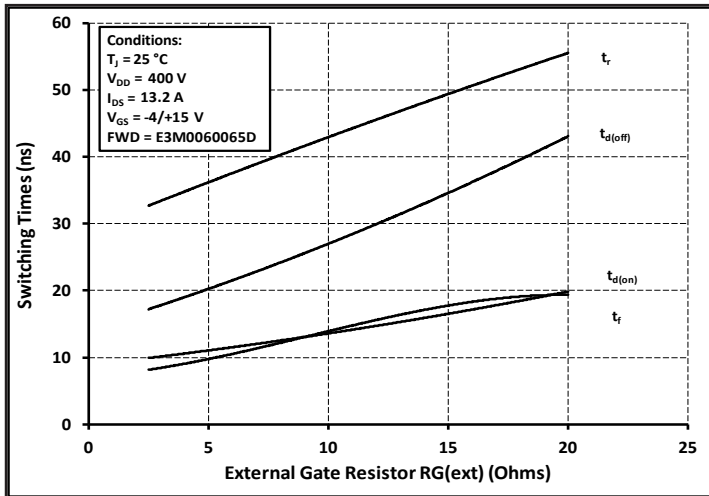
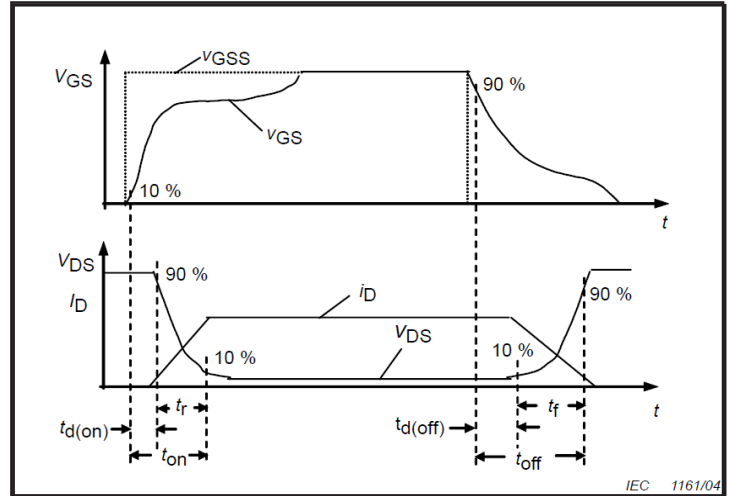
Figure 27. Switching Times vs. $R_{G(\text{ext})}$ 

Figure 28. Switching Times Definition

Test Circuit Schematic

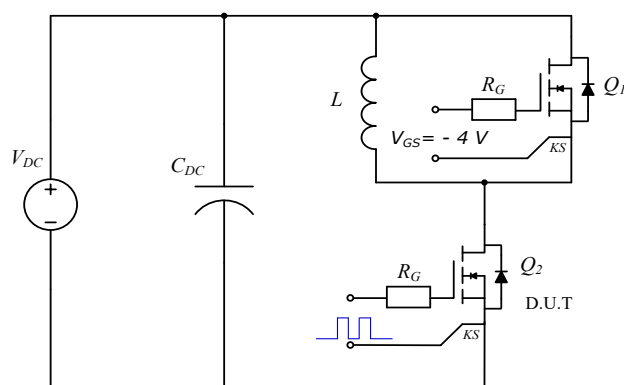
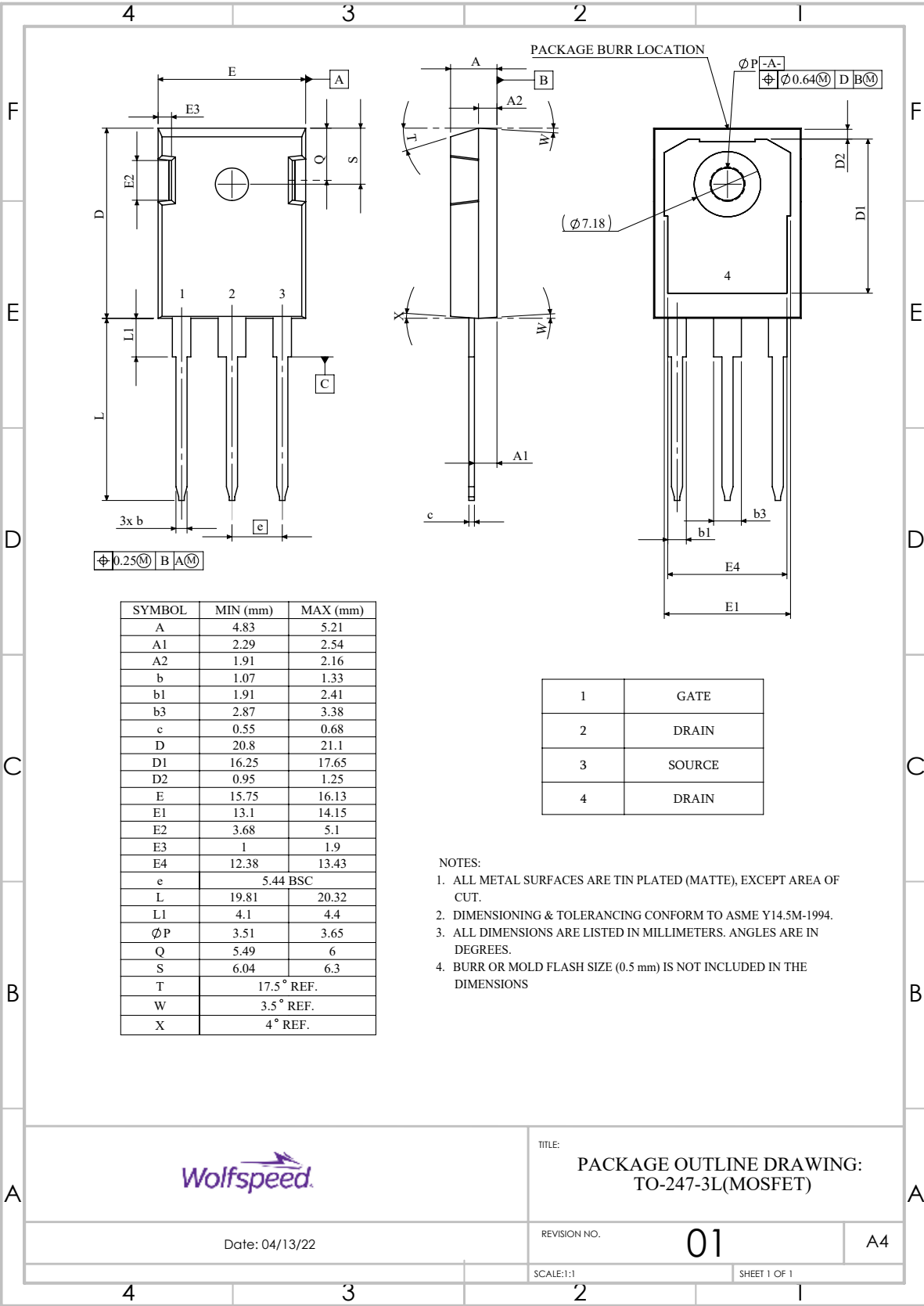
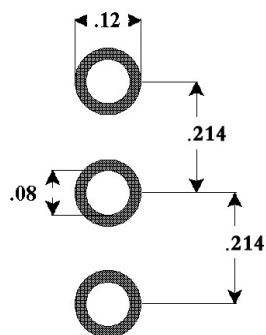


Figure 29. Clamped Inductive Switching
Waveform Test Circuit

Package Dimensions



Recommended Solder Pad Layout



TO-247-3



Revision history

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



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