

650 V 20.5 mΩ SiC MOSFET

Silicon Carbide MOSFET

Trench-Assisted Planar Technology

V _{DS}	=	650 V
R _{DS(ON)} (Typ.)	=	20.5 mΩ
I _D (T _C = 100°C)	=	88 A

Features

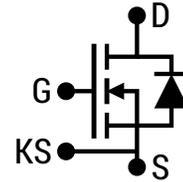
- Gen3F (3rd Generation) Technology
- Most Stable R_{DS(ON)} over Temperature
- Low C_{OSS}, C_{RSS} and Balanced C_{ISS}/C_{RSS}
- Lower Q_{GD} and Balanced R_{G(INT)}
- Electromagnetically Optimized Design
- Robust Body Diode with Low V_F and Low Q_{RR}
- 100% Avalanche (UIL) Tested
- AEC-Q101 Qualified

Package

Case (D)



TOLL



D = Drain
G = Gate
S = Source
KS = Kelvin Source



Advantages

- Superior Performance and Robustness
- Lowest Conduction Losses at all Temperatures
- Lesser Switching Spikes and Lower Losses
- Faster and More Efficient Switching
- Reduced Ringing
- Ease of Paralleling without Thermal Runaway
- Excellent Power Density and System Efficiency
- Enhanced System Reliability

Applications

- xEV - OBC & DC-DC
- EV Fast Charging Infrastructure
- Solar / PV
- Energy Storage System
- Server & Telecom Power Supply
- Uninterruptible Power Supply
- Motor Control
- Class D Amplifiers

Absolute Maximum Ratings (At T_C = 25°C Unless Otherwise Stated)

Parameter	Symbol	Conditions	Values	Unit	Note
Drain-Source Voltage	V _{DS(max)}	V _{GS} = 0 V, I _D = 100 μA	650	V	
Gate-Source Voltage (Dynamic)	V _{GS(max)}		-10 / +22	V	
Gate-Source Voltage (Static)	V _{GS(op)-ON}	Recommended Operation	15 to 18	V	Note 1
	V _{GS(op)-OFF}		-5 to -3		
Continuous Drain Current	I _D	T _C = 25°C, V _{GS} = -5 / +18 V	125	A	Fig. 16
		T _C = 100°C, V _{GS} = -5 / +18 V	88		
		T _C = 135°C, V _{GS} = -5 / +18 V	64		
Pulsed Drain Current	I _{D(pulse)}	t _p ≤ 3μs, D ≤ 1%, V _{GS} = 18 V	175	A	Note 2
Power Dissipation	P _D	T _C = 25°C	455	W	Fig. 17
Non-Repetitive Avalanche Energy	E _{AS}	L = 36 mH, I _{AV} = 5 A	540	mJ	
Operating Junction and Storage Temperature	T _j , T _{stg}		-55 to 175	°C	

Note 1: This product can support 0V turn-off gate drive voltage with optimized PCB layout and gate drive circuit configuration.

Note 2: Pulse Width t_p Limited by T_{j(max)}

Electrical Characteristics (At $T_C = 25^\circ\text{C}$ Unless Otherwise Stated)

Parameter	Symbol	Conditions	Values			Unit	Note
			Min.	Typ.	Max.		
Drain-Source Breakdown Voltage	V_{DSS}	$V_{GS} = 0\text{ V}, I_D = 100\ \mu\text{A}$	650			V	
Zero Gate Voltage Drain Current	I_{DSS}	$V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$		1	100	μA	
Gate Source Leakage Current	I_{GSS}	$V_{DS} = 0\text{ V}, V_{GS} = 22\text{ V}$ $V_{DS} = 0\text{ V}, V_{GS} = -10\text{ V}$			100 -100	nA	
Gate Threshold Voltage	$V_{GS(th)}$	$V_{DS} = V_{GS}, I_D = 15\text{ mA}$	2.2	2.8	4.3	V	Note 3
Transconductance	g_{fs}	$V_{DS} = 10\text{ V}, I_D = 35\text{ A}$ $V_{DS} = 10\text{ V}, I_D = 35\text{ A}, T_j = 175^\circ\text{C}$		19.2 19.3		S	Fig. 5
Drain-Source On-State Resistance	$R_{DS(on)}$	$V_{GS} = 18\text{ V}, I_D = 35\text{ A}, T_j = 175^\circ\text{C}$ $V_{GS} = 15\text{ V}, I_D = 35\text{ A}$ $V_{GS} = 15\text{ V}, I_D = 35\text{ A}, T_j = 175^\circ\text{C}$		20.5 27 29 32	27.5	m Ω	Fig. 5-9
Input Capacitance	C_{iss}			2939			
Output Capacitance	C_{oss}			212		pF	Fig. 12
Reverse Transfer Capacitance	C_{rss}			12.4			
C_{oss} Stored Energy	E_{oss}	$V_{DS} = 400\text{ V}, V_{GS} = 0\text{ V}$		19		μJ	Fig. 13
C_{oss} Stored Charge	Q_{oss}	$f = 500\text{ KHz}, V_{AC} = 25\text{ mV}$		134		nC	
Effective Output Capacitance (Energy Related)	$C_{o(er)}$			238			
Effective Output Capacitance (Time Related)	$C_{o(tr)}$			335		pF	Note 4
Gate-Source Charge	Q_{gs}	$V_{DS} = 400\text{ V}, V_{GS} = -5 / +18\text{ V}$		26			
Gate-Drain Charge	Q_{gd}	$I_D = 35\text{ A}$		31		nC	Fig. 11
Total Gate Charge	Q_g	Per JEDEC JEP-192		108			
Internal Gate Resistance	$R_{G(int)}$	$V_{GS} = 18\text{ V}, f = 1\text{ MHz}, V_{AC} = 25\text{ mV}$		1.3		Ω	
Turn-On Switching Energy (Body Diode)	E_{on}	$T_j = 25^\circ\text{C}, V_{GS} = -5/+18\text{V}, R_{G(ext)} = 2.2\ \Omega, L = 80.0\ \mu\text{H}, I_D = 35\text{ A}, V_{DD} = 400\text{ V}$		44		μJ	Fig. 24-27
Turn-Off Switching Energy (Body Diode)	E_{off}			24			
Turn-On Delay Time	$t_{d(on)}$			23			
Rise Time	t_r	$V_{DD} = 400\text{ V}, V_{GS} = -5/+18\text{V}$		8			
Turn-Off Delay Time	$t_{d(off)}$	$R_{G(ext)} = 2.2\ \Omega, L = 80.0\ \mu\text{H}, I_D = 35\text{ A}$		16		ns	Fig. 26
Fall Time	t_f	Timing relative to V_{DS} , Inductive load		7			

Note 3: Tested after applying 30ms pulse at $V_{GS} = +25\text{V}$

Note 4: $C_{o(er)}$, 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 times as C_{oss} while V_{DS} is rising from 0 to 400V.

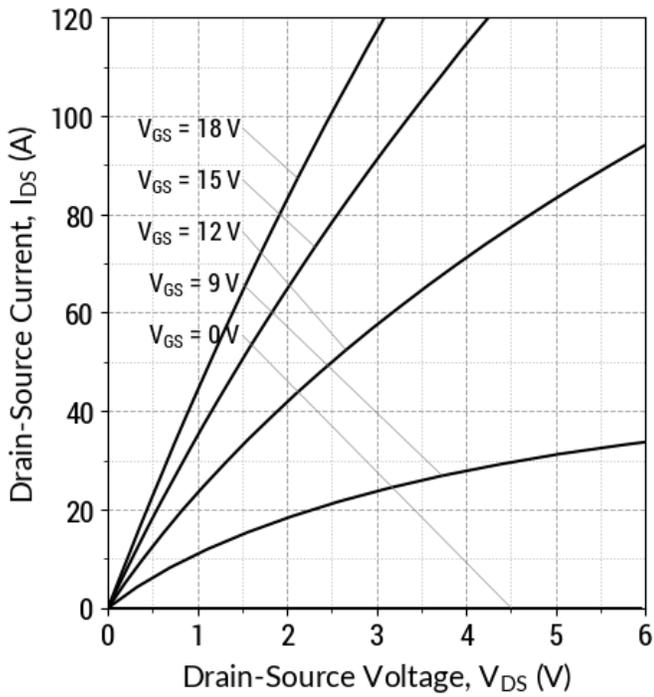
Reverse Diode Characteristics

Parameter	Symbol	Conditions	Values			Unit	Note
			Min.	Typ.	Max.		
Diode Forward Voltage	V_{SD}	$V_{GS} = -5\text{ V}, I_{SD} = 17\text{ A}$		4.4		V	Fig. 18-19
		$V_{GS} = -5\text{ V}, I_{SD} = 17\text{ A}, T_j = 175^\circ\text{C}$		3.9			
Continuous Diode Forward Current	I_S	$V_{GS} = -5\text{ V}, T_c = 25^\circ\text{C}$			68	A	
		$V_{GS} = -5\text{ V}, T_c = 100^\circ\text{C}$			41		
Diode Pulse Current	$I_{S(\text{pulse})}$	$V_{GS} = -5\text{ V}$		164		A	Note 2
Reverse Recovery Time	t_{rr}			16		ns	
Reverse Recovery Charge	Q_{rr}	$V_{GS} = -5\text{ V}, I_{SD} = 35\text{ A}, V_R = 400\text{ V}$ $dif/dt = 2400\text{ A}/\mu\text{s}, T_j = 25^\circ\text{C}$		165		nC	
Peak Reverse Recovery Current	I_{rrm}			34		A	
Reverse Recovery Time	t_{rr}			20		ns	
Reverse Recovery Charge	Q_{rr}	$V_{GS} = -5\text{ V}, I_{SD} = 35\text{ A}, V_R = 400\text{ V}$ $dif/dt = 2400\text{ A}/\mu\text{s}, T_j = 175^\circ\text{C}$		320		nC	
Peak Reverse Recovery Current	I_{rrm}			47		A	

Package Characteristics

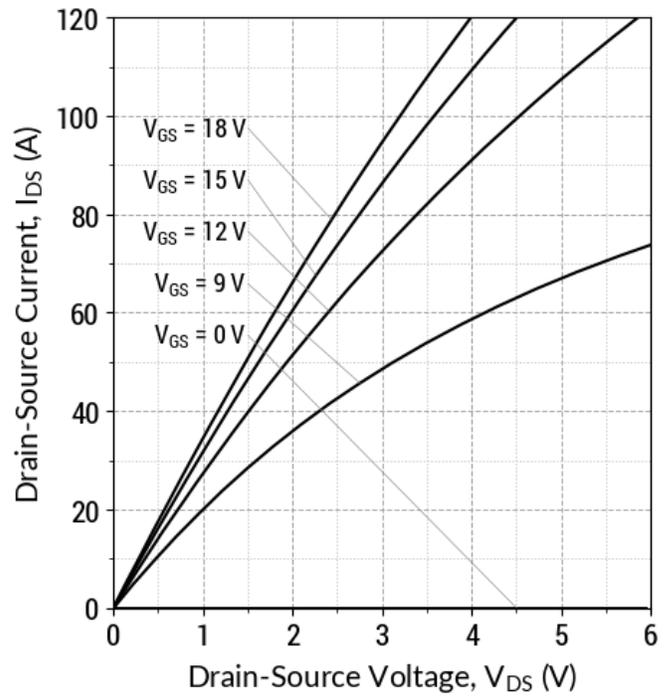
Parameter	Symbol	Conditions	Values	Unit	Note
Max Thermal Resistance, Junction - Case	$R_{thJC-Max}$	Maximum	0.33	$^\circ\text{C}/\text{W}$	Fig. 14
Weight	W_T		1.2	g	
Moisture Sensitivity Level	MSL		1		
EMC Material Group			II		

Fig 1: Typical Output Characteristics ($T_j = 25^\circ\text{C}$)



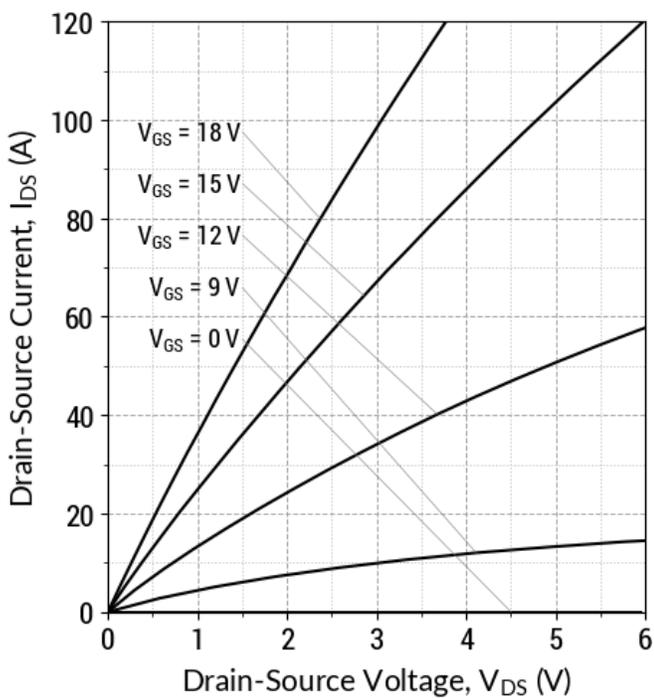
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 2: Typical Output Characteristics ($T_j = 175^\circ\text{C}$)



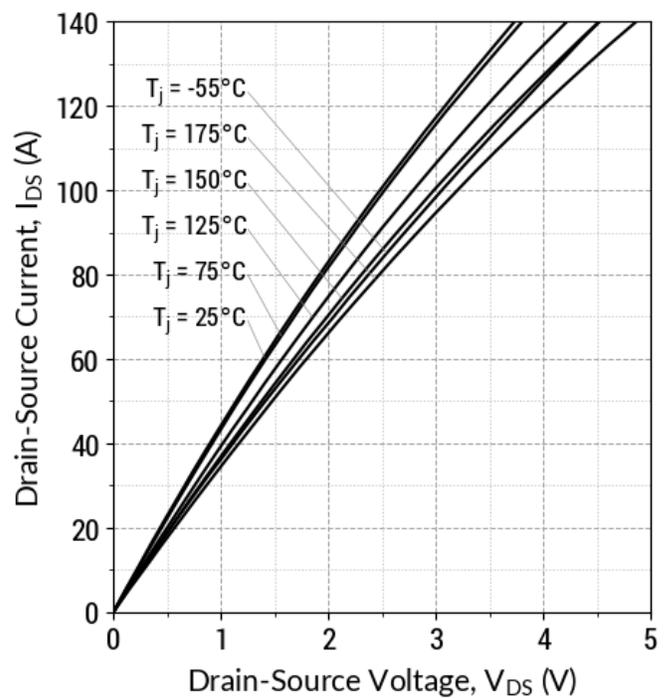
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 3: Typical Output Characteristics ($T_j = -55^\circ\text{C}$)



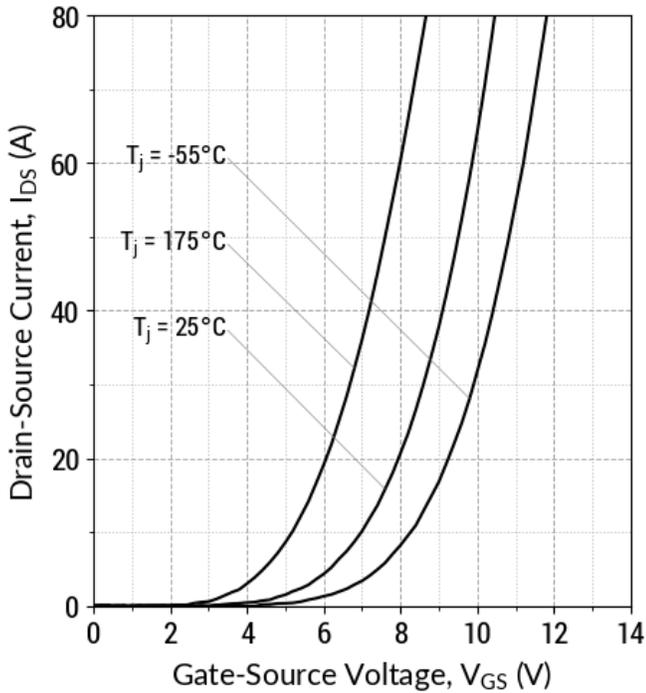
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 4: Typical Output Characteristics ($V_{GS} = 18 \text{ V}$)



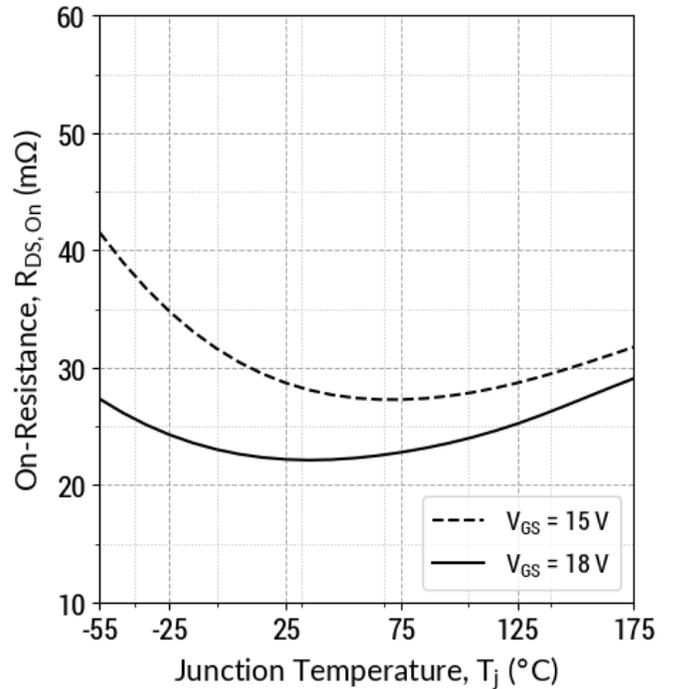
$I_D = f(V_{DS}, T_j); t_P = 50 \mu\text{s}$

Fig 5: Typical Transfer Characteristics ($V_{DS} = 10\text{ V}$)



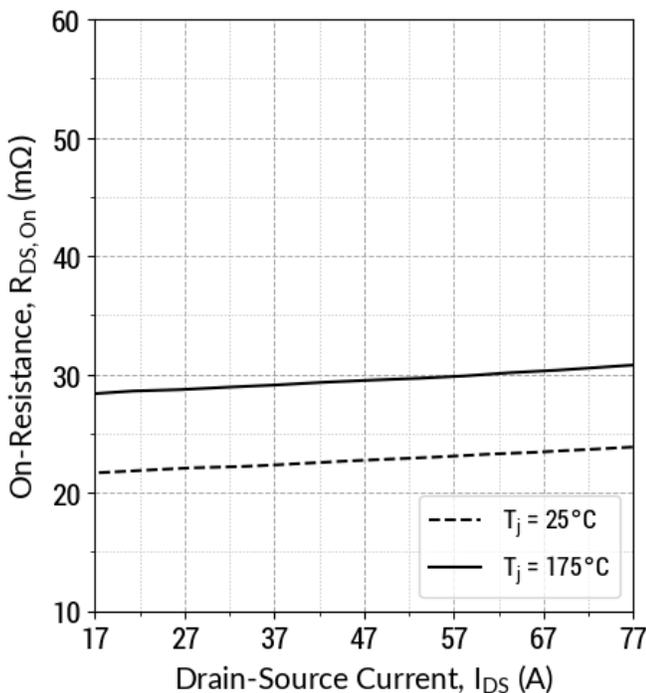
$I_D = f(V_{GS}, T_j); t_p = 100\ \mu\text{s}$

Fig 6: Typical $R_{DS(ON)}$ v/s Temperature



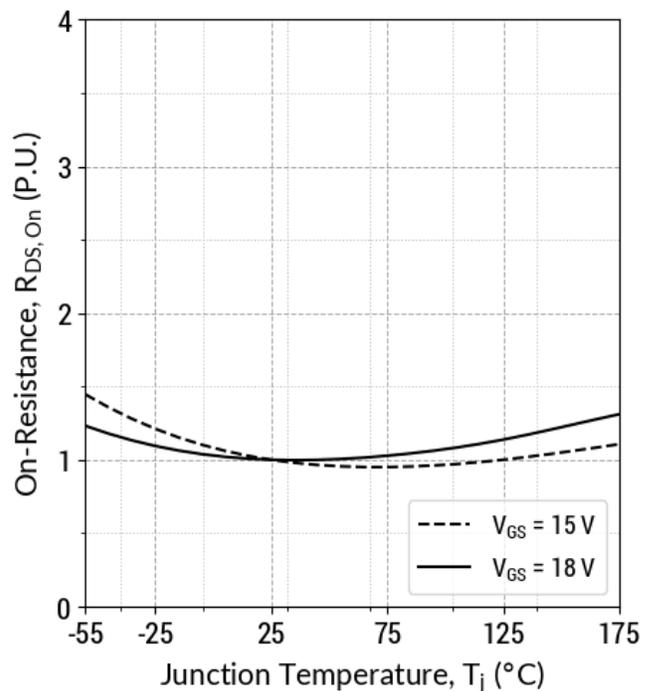
$R_{DS(ON)} = f(T_j, V_{GS}); t_p = 50\ \mu\text{s}; I_D = 35\text{ A}$

Fig 7: Typical $R_{DS(ON)}$ v/s Drain Current



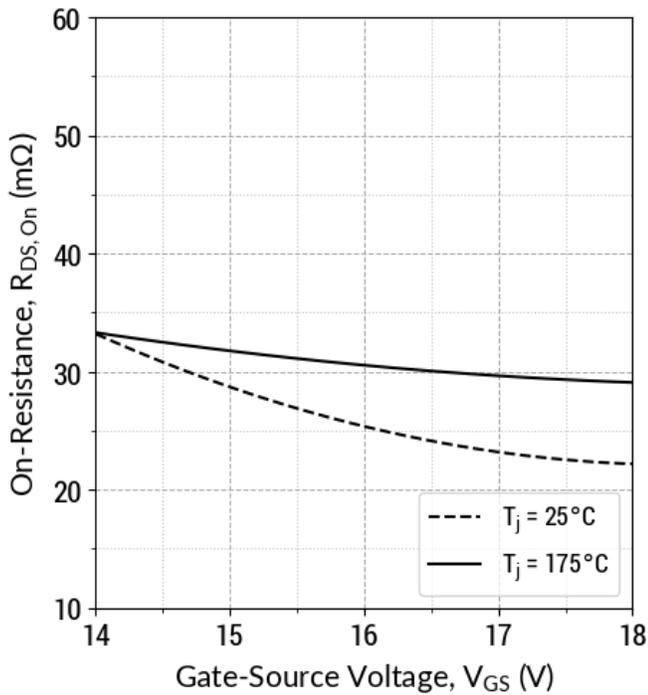
$R_{DS(ON)} = f(T_j, I_D); t_p = 50\ \mu\text{s}; V_{GS} = 18\text{ V}$

Fig 8: Typical Normalized $R_{DS(ON)}$ v/s Temperature



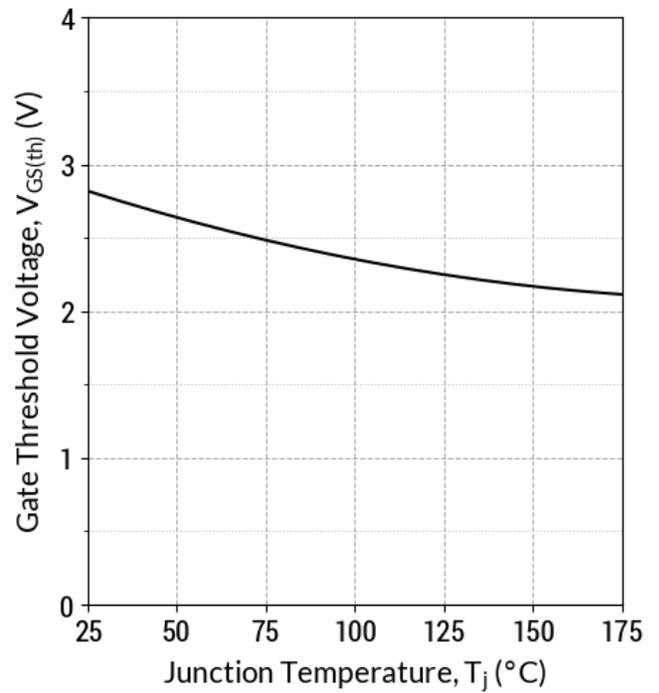
$R_{DS(ON)} = f(T_j); t_p = 50\ \mu\text{s}; I_D = 35\text{ A}$

Fig 9: Typical $R_{DS(ON)}$ v/s Gate Voltage



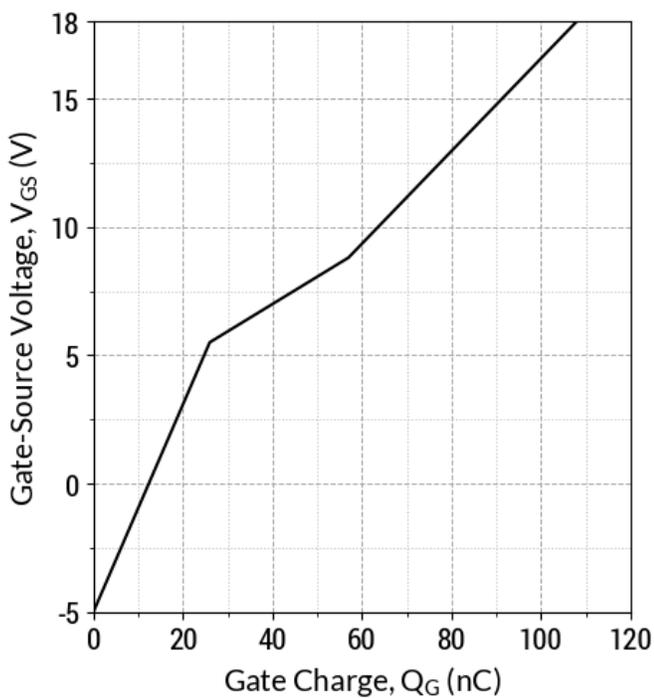
$R_{DS(ON)} = f(T_j, V_{GS}); t_p = 50 \mu\text{s}; I_D = 35 \text{ A}$

Fig 10: Typical Threshold Voltage Characteristics



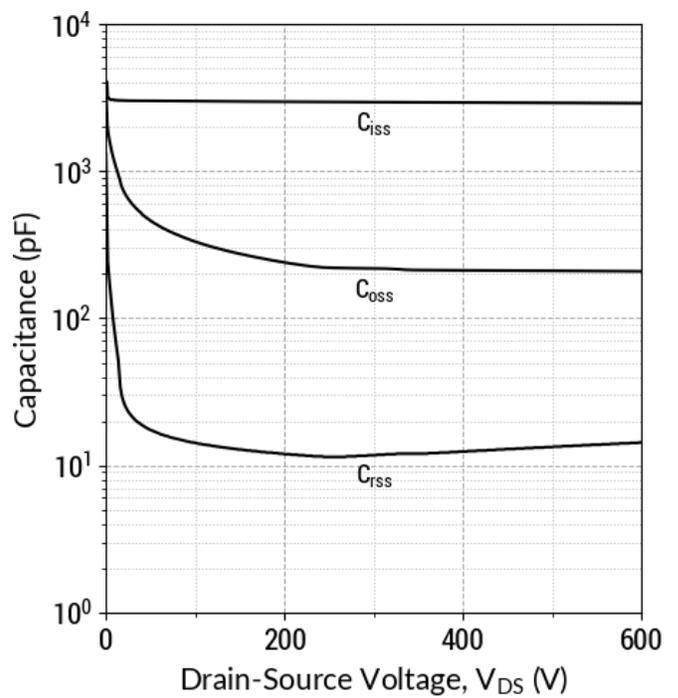
$V_{GS(th)} = f(T_j); V_{DS} = V_{GS}; I_D = 15 \text{ mA}$

Fig 11: Typical Gate Charge Characteristics



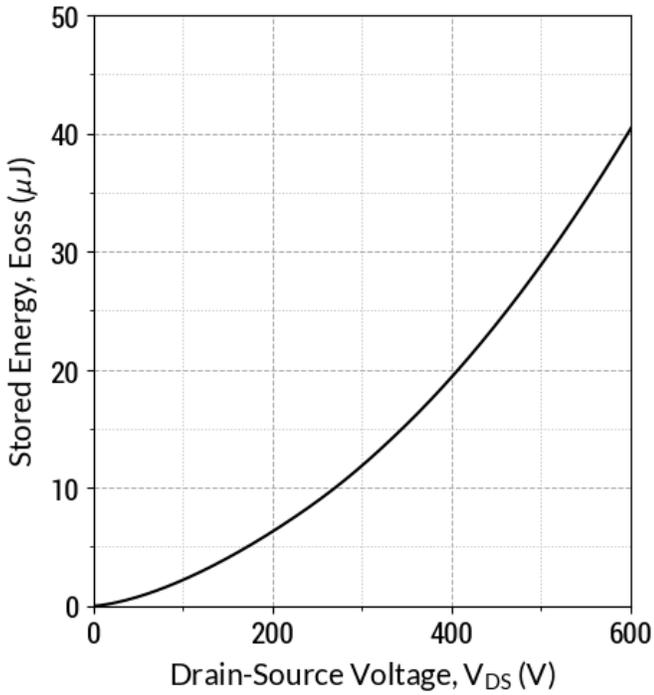
$I_D = 35 \text{ A}; V_{DS} = 400 \text{ V}; T_c = 25^\circ\text{C}$

Fig 12: Typical Capacitance v/s Drain-Source Voltage



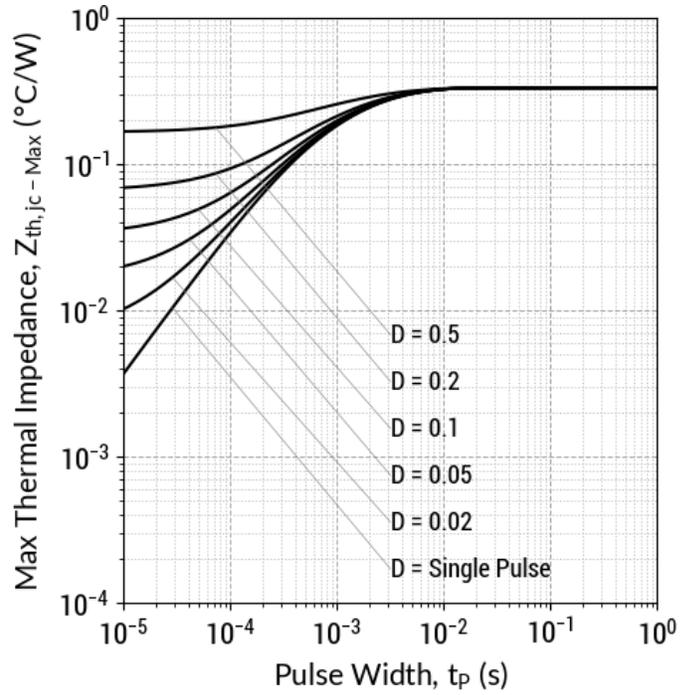
$f = 500 \text{ KHz}; V_{AC} = 25 \text{ mV}$

Fig 13: Output Capacitor Stored Energy



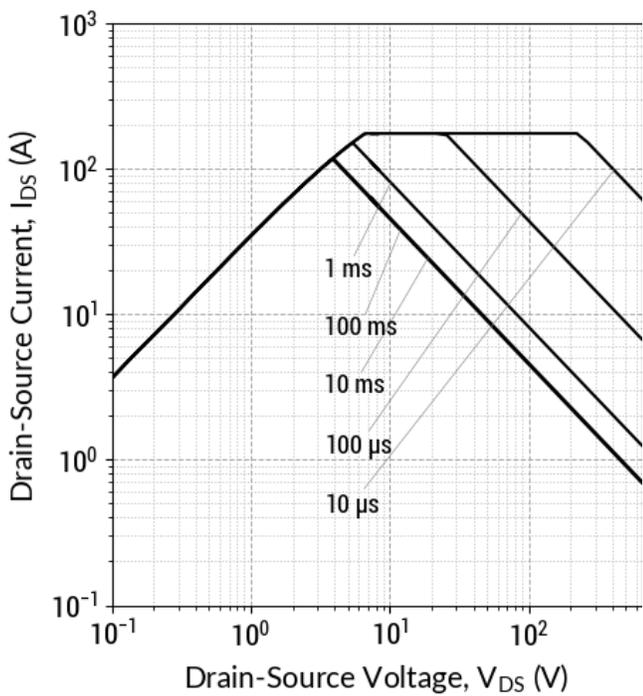
$E_{oss} = f(V_{DS})$

Fig 14: Max. Transient Thermal Impedance



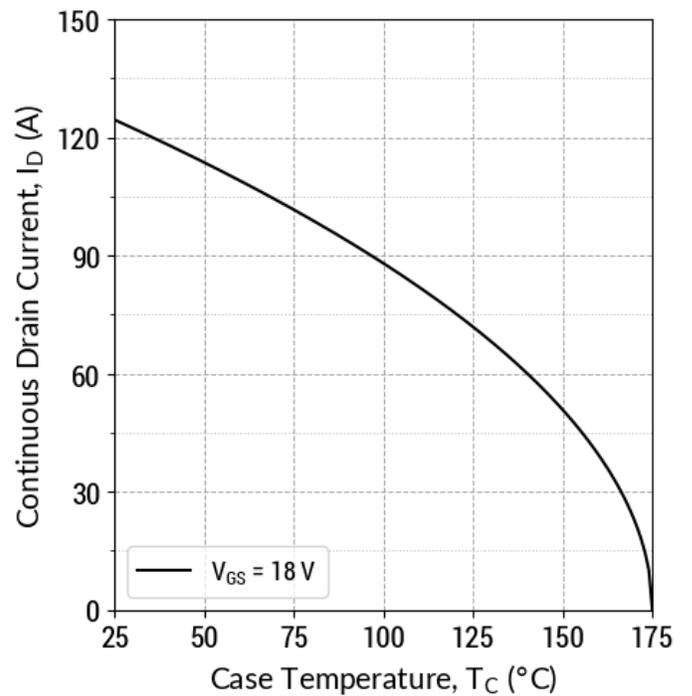
$Z_{th,jc} = f(t_p, D); D = t_p/T$

Fig 15: Safe Operating Area ($T_c = 25^{\circ}C$)



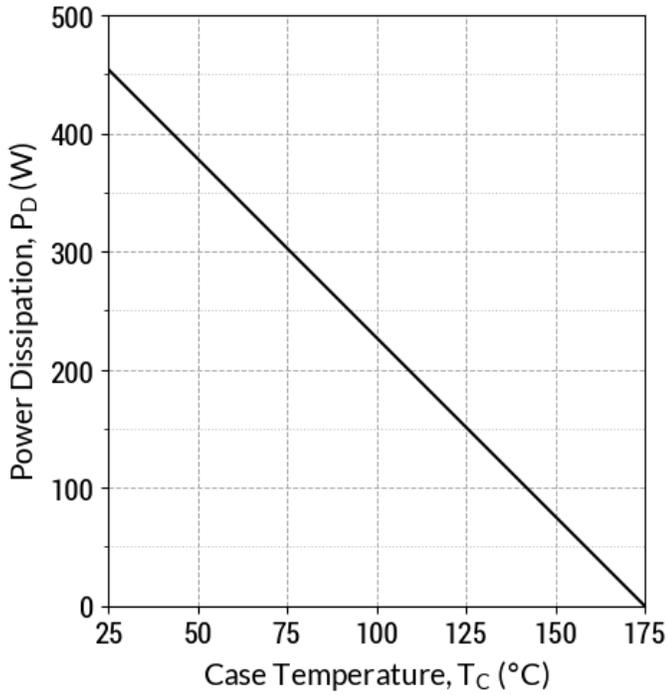
$I_D = f(V_{DS}, t_p); T_j \leq 175^{\circ}C; D = 0$

Fig 16: Current De-rating Curve



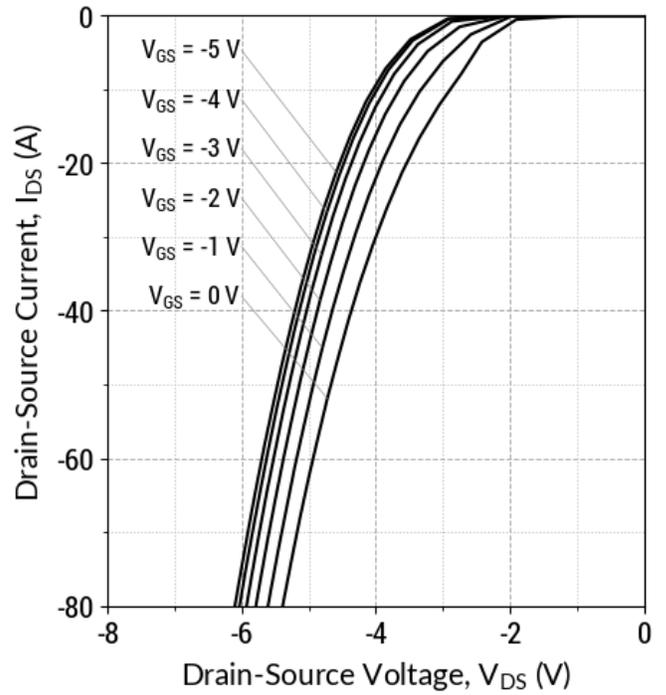
$I_D = f(T_C); T_j \leq 175^{\circ}C$

Fig 17: Power De-rating Curve



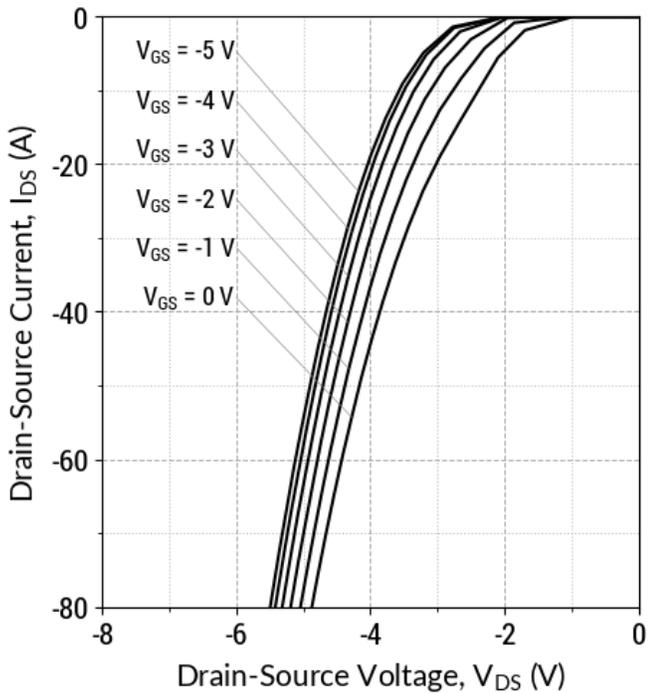
$P_D = f(T_C); T_j \leq 175^\circ\text{C}$

Fig 18: Typical Body Diode Characteristics ($T_j = 25^\circ\text{C}$)



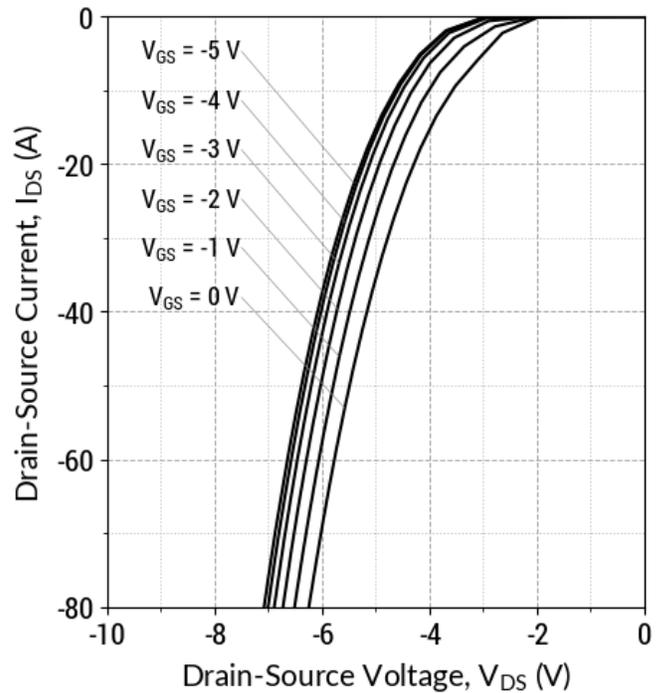
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 19: Typical Body Diode Characteristics ($T_j = 175^\circ\text{C}$)



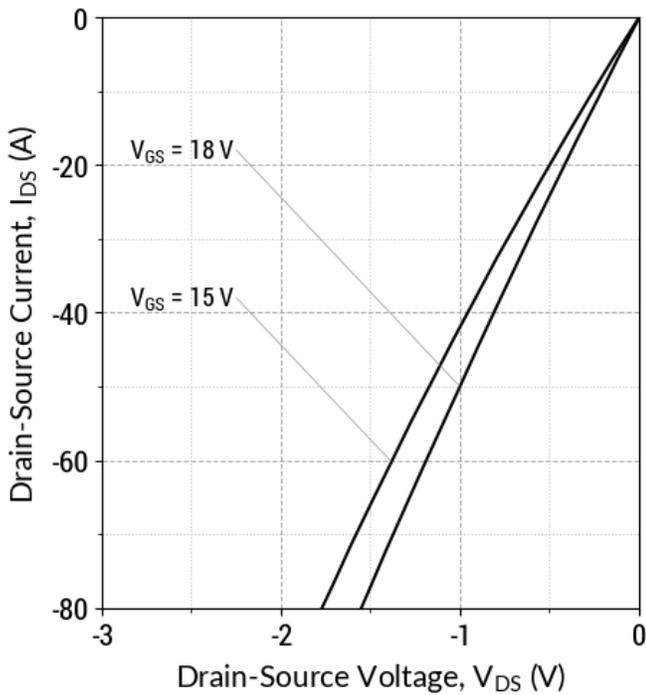
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 20: Typical Body Diode Characteristics ($T_j = -55^\circ\text{C}$)



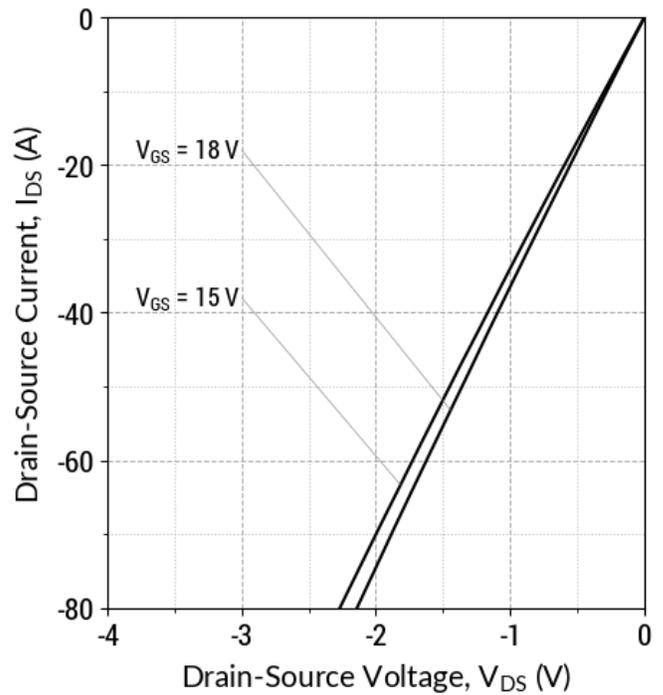
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 21: Typical Third Quadrant Characteristics ($T_j = 25^\circ\text{C}$)



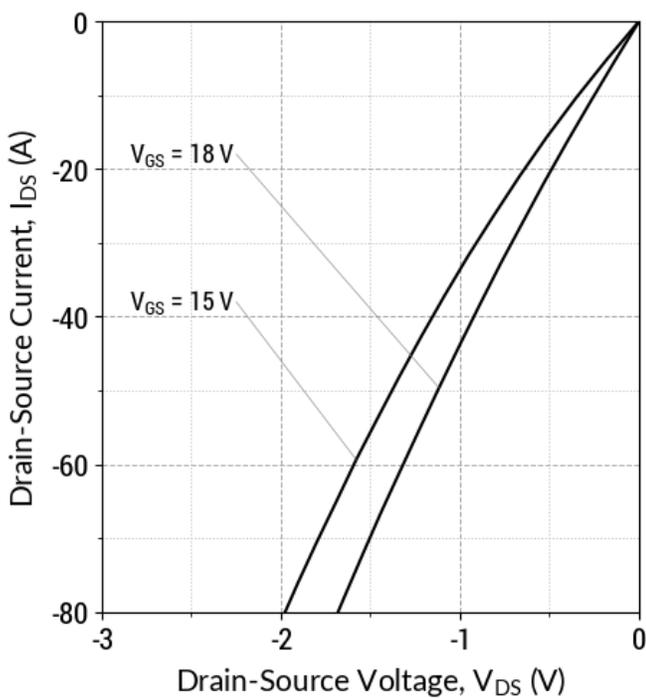
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 22: Typical Third Quadrant Characteristics ($T_j = 175^\circ\text{C}$)



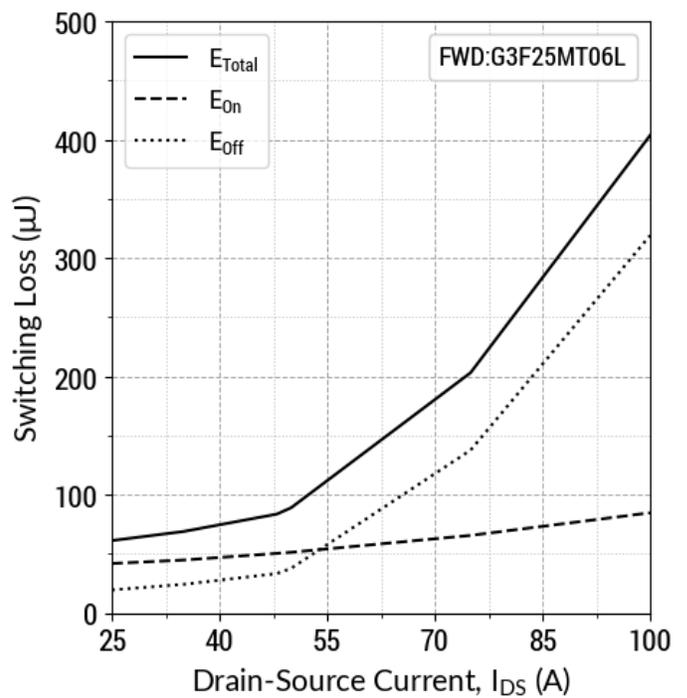
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 23: Typical Third Quadrant Characteristics ($T_j = -55^\circ\text{C}$)



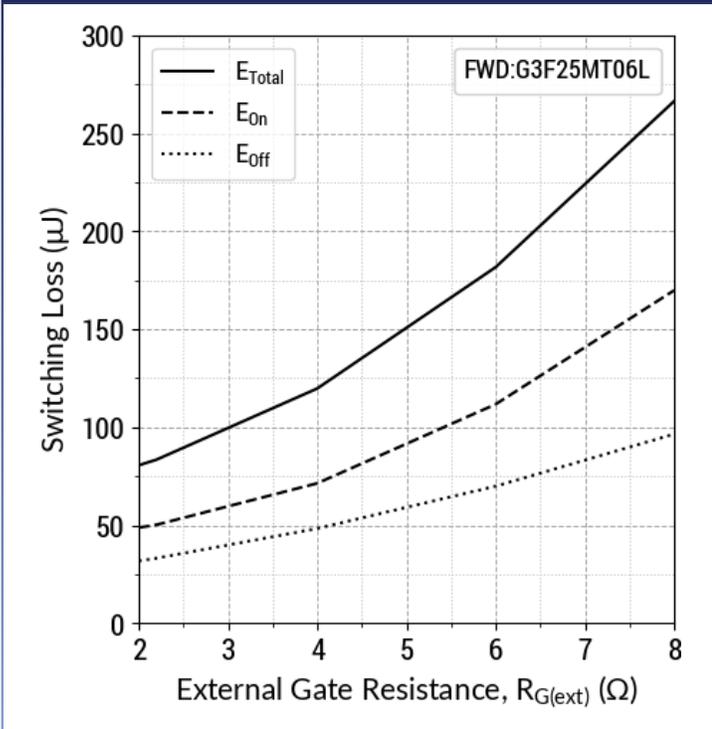
$I_D = f(V_{DS}, V_{GS}); t_P = 50 \mu\text{s}$

Fig 24: Inductive Switching Energy v/s Drain Current ($V_{DD} = 400\text{V}$)



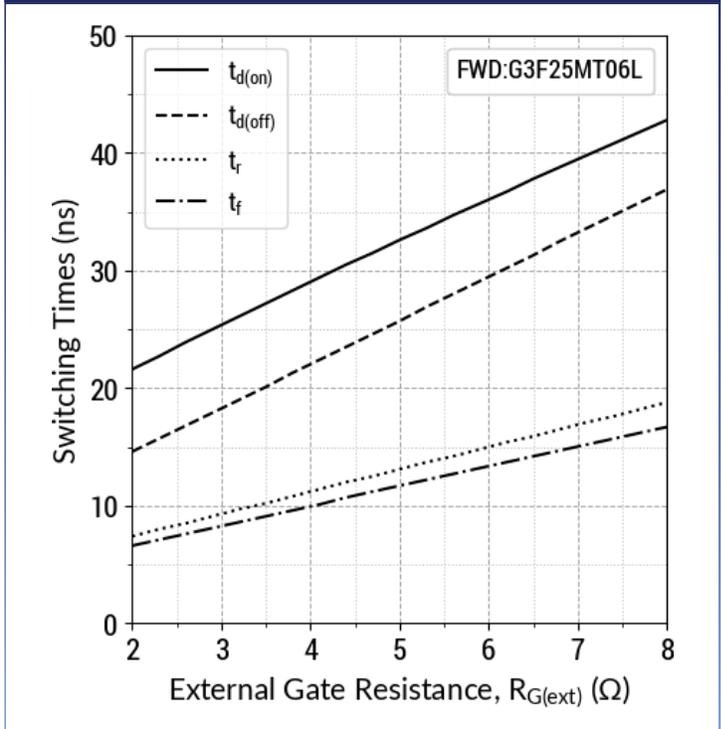
$T_j = 25^\circ\text{C}; V_{GS} = -5/+18\text{V}; R_{G(\text{ext})} = 2.2 \Omega; L = 80.0 \mu\text{H}$

Fig 25: Inductive Switching Energy v/s $R_{G(ext)}$
($V_{DD} = 400V$)



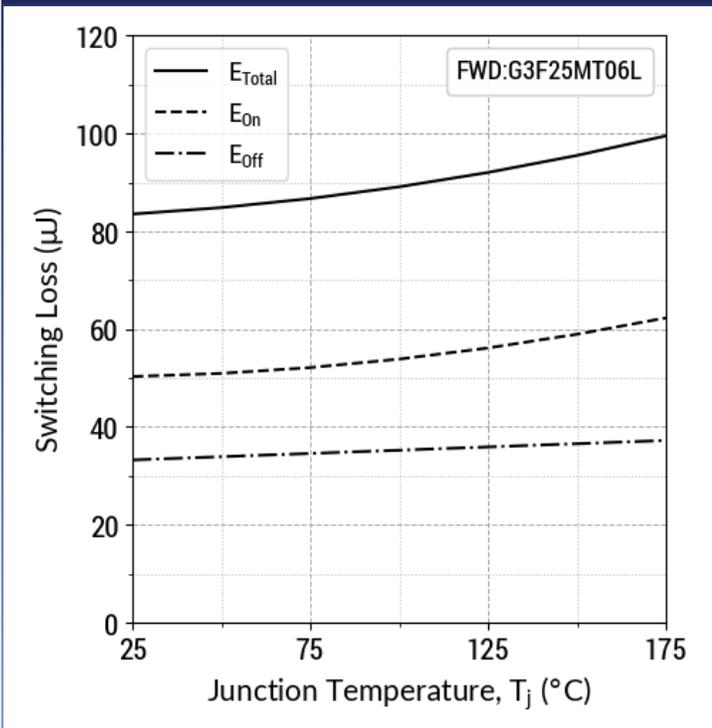
$T_j = 25^\circ C$; $V_{GS} = -5/+18V$; $I_{DS} = 35 A$; $L = 80.0\mu H$

Fig 26: Switching Time v/s $R_{G(ext)}$
($V_{DD} = 400V$)



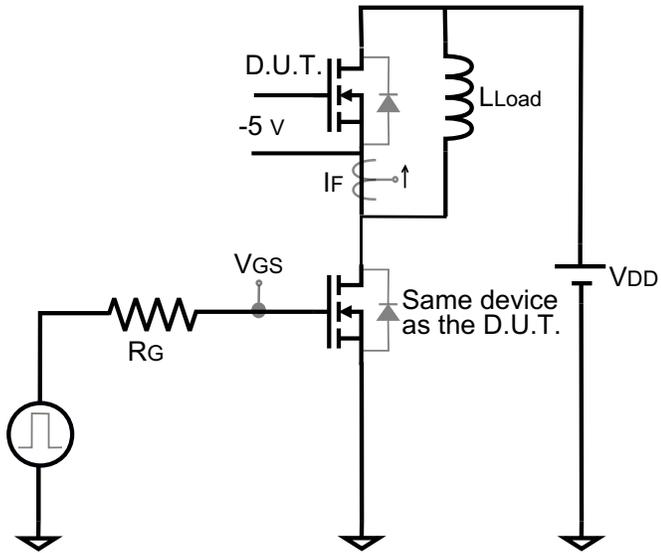
$T_j = 25^\circ C$; $V_{GS} = -5/+18V$; $I_{DS} = 35 A$; $L = 80.0\mu H$

Fig 27: Inductive Switching Energy v/s Temperature
($V_{DD} = 400V$)

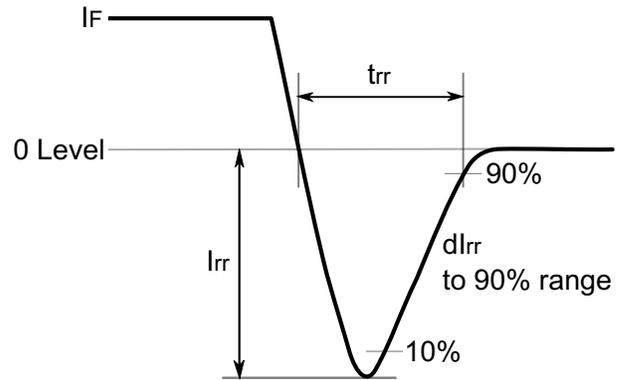


$T_j = 25^\circ C$; $V_{GS} = -5/+18V$; $R_{G(ext)} = 2.2 \Omega$; $I_{DS} = 35 A$; $L = 80.0\mu H$

Reverse Recovery Circuit

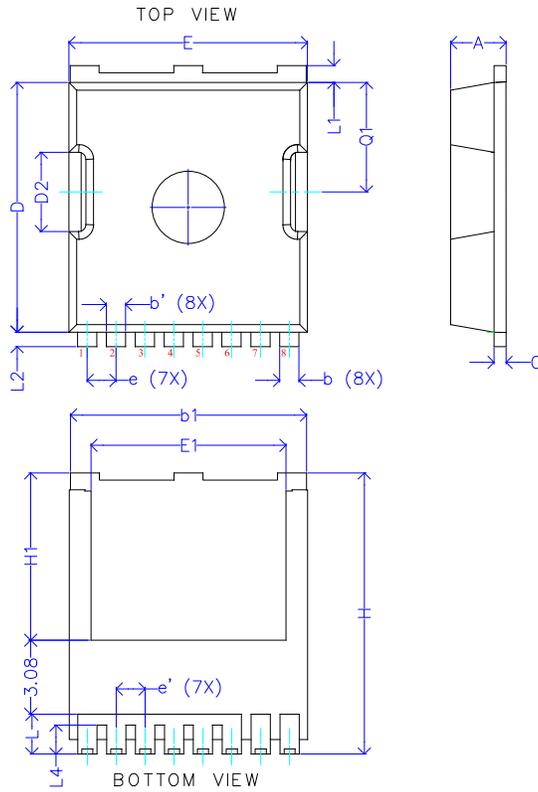


Reverse Recovery Waveform



Package Dimensions

TOLL Package Outline



SYMBOL	COMMON DIMENSIONS (MM)		
	MIN	NOM	MAX
A	2.15	2.30	2.45
b	0.70	0.75	0.85
b'	0.65	0.70	0.80
b1	9.65	9.80	9.95
C	0.45	0.50	0.60
D	10.18	10.38	10.58
D2	3.15	3.30	3.45
E	9.70	9.90	10.10
E1	7.95	8.10	8.25

SYMBOL	COMMON DIMENSIONS (MM)		
	MIN	NOM	MAX
e	BSC 1.225		
e'	BSC 1.20		
Q1	4.40	4.55	4.70
H	11.48	11.68	11.88
H1	6.80	6.95	7.10
L	1.60	1.80	2.00
L1	0.50	0.70	0.90
L2	0.48	0.60	0.72
L4	1.00	1.15	1.30

NOTE

1. CONTROLLED DIMENSION IS MILLIMETER.
2. DIMENSIONS DO NOT INCLUDE END FLASH, MOLD FLASH, MATERIAL PROTRUSIONS.

Revision History

- Rev 24/Aug: Initial Release (Rev 1.0)

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