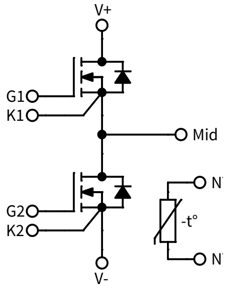
CAB650M17HM3

1700 V, 650 A, Silicon Carbide, Half-Bridge Module

V_{DS}	**1700 V**
I_{DS}	**650 A**

Technical Features

- Ultra-Low Loss
- High Frequency Operation
- Zero Turn-Off Tail Current from MOSFET
- Normally-Off, Fail-Safe Device Operation



Applications

- Railway, Traction, and Motor Drives
- EV Chargers
- High-Efficiency Converters/Inverters
- Renewable Energy
- Smart-Grid/Grid-Tied Distributed Generation

System Benefits

- Enables Compact, Lightweight Systems
- Increased System Efficiency, due to Low Switching & Conduction Losses of SiC
- Reduced Thermal Requirements and System Cost

Key Parameters

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Note
Drain-Source Voltage	V_{DS}			1700	V	T_C = 25 °C	
Gate-Source Voltage, Maximum Value	$V_{GS(max)}$	-8		+19	V	Transient	Note 1 Fig. 32
Gate-Source Voltage, Recommended	$V_{GS(op)}$		-4/+15		V	Static	Note 1 Fig. 32
DC Continuous Drain Current	I_D		916		A	V_{GS} = 15 V, T_C = 25 °C, T_{VJ} ≤ 175 °C	Notes 2, 3 Fig. 20
			694		A	V_{GS} = 15 V, T_C = 90 °C, T_{VJ} ≤ 175 °C	Notes 2, 3 Fig. 20
DC Source-Drain Current (Body Diode)	$I_{SD(BD)}$		593		A	V_{GS} = -4 V, T_C = 25 °C, T_{VJ} ≤ 175 °C	Notes 2, 3 Fig. 20
Pulsed Drain-Source Current	I_{DM}		1300		A	t_{Pmax} limited by T_{VJmax} V_{GS} = 15 V, T_C = 25 °C	Notes 2, 3 Fig. 20
Power Dissipation	P_D		2778		W	T_C = 25 °C, T_{VJ} ≤ 175 °C	Note 4 Fig. 20
Virtual Junction Temperature	$T_{VJ(op)}$	-40		175	°C		

Note (1): Recommended turn-on gate voltage is 15 V with ±5 % regulation tolerance
Note (2): Current limit at T_C = 90 °C calculated by $I_{D(max)} = \sqrt{(P_D/R_{DS(typ)}(T_{VJ(max)},I_{D(max)}))}$
Note (3): Verified by design
Note (4): $P_D = (T_{VJ} - T_C)/R_{TH(JC,typ)}$

MOSFET Characteristics (Per Position) (T_{VJ} = 25 °C Unless Otherwise Specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions	Note
Drain-Source Breakdown Voltage	$V_{(BR)DSS}$	1700			V	V_{GS} = 0 V, T_{VJ} = -40 °C	
Gate Threshold Voltage	$V_{GS(th)}$	1.8	2.5	3.6	V	V_{DS} = V_{GS}, I_D = 305 mA	
			2.0			V_{DS} = V_{GS}, I_D = 305 mA, T_{VJ} = 175 °C	
Zero Gate Voltage Drain Current	I_{DSS}		12	500	µA	V_{GS} = 0 V, V_{DS} = 1700 V	
Gate-Source Leakage Current	I_{GSS}		0.012	3	µA	V_{GS} = 15 V, V_{DS} = 0 V	
Drain-Source On-State Resistance (Devices Only)	$R_{DS(on)}$		1.42	1.86	mΩ	V_{GS} = 15 V, I_D = 650 A	Fig. 2 Fig. 3
			3.26			V_{GS} = 15 V, I_D = 650 A, T_{VJ} = 175 °C	
Transconductance	g_{fs}		553		S	V_{DS} = 20 V, I_D = 650 A	Fig. 4
			561			V_{DS} = 20 V, I_D = 650 A, T_{VJ} = 175 °C	
Turn-On Switching Energy, T_{VJ} = 25 °C T_{VJ} = 125 °C T_{VJ} = 175 °C	E_{On}		38.8 44.0 50.8		mJ	V_{DD} = 900 V I_D = 650 A, V_{GS} = -4 V/15 V, $R_{G(OFF)}$ = 1.5 Ω, $R_{G(ON)}$ = 1.5 Ω, L = 14 µH	Fig. 11 Fig. 13
Turn-Off Switching Energy, T_{VJ} = 25 °C T_{VJ} = 125 °C T_{VJ} = 175 °C	E_{Off}		25.6 26.2 27.6		mJ		
Internal Gate Resistance	$R_{G(int)}$		0.62		Ω	f = 100 kHz, V_{AC} = 25 mV	
Input Capacitance	C_{iss}		97.3		nF	V_{GS} = 0 V, V_{DS} = 1200 V V_{AC} = 25 mV, f = 100 kHz	Fig. 9
Output Capacitance	C_{oss}		2.3		nF		
Reverse Transfer Capacitance	C_{rss}		63		pF		
Gate to Source Charge	Q_{GS}		960		nC	V_{DS} = 1200 V, V_{GS} = -4 V/15 V I_D = 1100 A Per IEC60747-8-4 pg 21	
Gate to Drain Charge	Q_{GD}		840		nC		
Total Gate Charge	Q_G		2988		nC		
FET Thermal Resistance, Junction to Case	$R_{th\ JC}$		0.054		°C/W		Fig. 17

Diode Characteristics (Per Position) (T_{VJ} = 25 °C Unless Otherwise Specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Note
Body Diode Forward Voltage	V_{SD}		5.4		V	V_{GS} = -4 V, I_{SD} = 650 A	Fig. 7
			4.7			V_{GS} = -4 V, I_{SD} = 650 A, T_{VJ} = 175 °C	
Reverse Recovery Time	t_{RR}		83		ns	V_{GS} = -4 V, I_{SD} = 650 A, V_R = 900 V di/dt = 13 A/ns, T_{VJ} = 175 °C	Fig. 32
Reverse Recovery Charge	Q_{RR}		24		µC		
Peak Reverse Recovery Current	I_{RRM}		420		A		
Reverse Recovery Energy, T_{VJ} = 25 °C T_{VJ} = 125 °C T_{VJ} = 175 °C	E_{RR}		0.9 5.3 9.2		mJ	V_{DD} = 900 V, I_D = 650 A, V_{GS} = -4 V/15 V, $R_{G(ON)}$ = 1.5 Ω, L = 14 µH	Fig. 14

Module Physical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Package Resistance, M1 (High-Side)	$R_{1\text{-}2}$		106.5		µΩ	T_C = 125 °C, Note 5
Package Resistance, M2 (Low-Side)	$R_{2\text{-}3}$		126.3		µΩ	T_C = 125 °C, Note 5
Stray Inductance	L_{Stray}		4.9		nH	Between DC- and DC+, f = 10 MHz
Case Temperature	T_C	-40		125	°C	
Mounting Torque	M_S	3	4.5	5	N-m	Baseplate, M6 Bolts
		0.9	1.1	1.3		Power Terminals, M4 Bolts
Weight	W		167		g	
Case Isolation Voltage	V_{isol}	4			kV	AC, 50 Hz, 1 minute
Comparative Tracking Index	CTI	600				
Clearance Distance		13.07			mm	Terminal to Terminal
		6.00				Terminal to Heatsink
Creepage Distance		14.27				Terminal to Terminal
		12.34				Terminal to Heatsink

Note (5): Total Effective Resistance (Per Switch Position) = MOSFET $R_{DS(on)}$ + Switch Position Package Resistance

NTC Characteristics (T_{NTC} = 25 °C Unless Otherwise Specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Notes
Resistance at 25 °C	R_{25}		4700		Ω	
Tolerance of R_{25}			±1		%	
Beta Value for 25 °C to 85 °C	$B_{25/85}$		3435		K	
Beta Value for 0 °C to 100 °C	$B_{0/100}$		3399		K	
Tolerance of $B_{25/85}$			±1		%	
Maximum Power Dissipation	P_{Max}		50		mW	

Steinhart & Hart Coefficients for NTC Resistance & NTC Temperature Computation (T in K)

$$\ln\left(\frac{R}{R_{25}}\right) = A + \frac{B}{T} + \frac{C}{T^2} + \frac{D}{T^3}$$

A	B	C	D
-1.289E+01	4.245E+03	-8.749E+04	-9.588E+06

$$\frac{1}{T} = A_1 + B_1 \ln\left(\frac{R}{R_{25}}\right) + C_1 \ln^2\left(\frac{R}{R_{25}}\right) + D_1 \ln^3\left(\frac{R}{R_{25}}\right)$$

A_1	B_1	C_1	D_1
3.354E-03	3.001E-04	5.085E-06	2.188E-07

Typical Performance

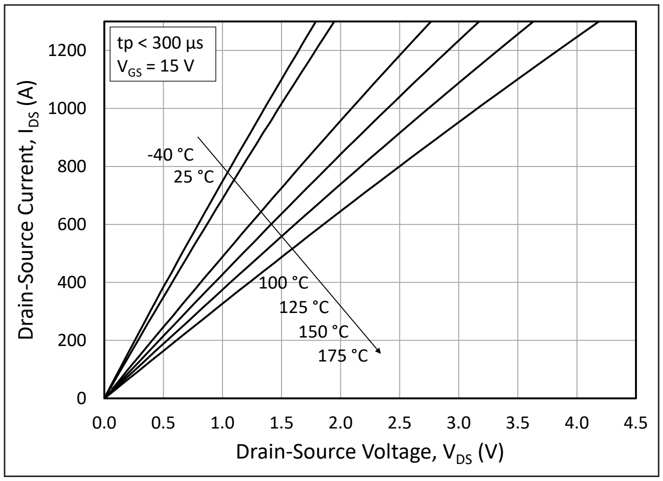


Figure 1. Output Characteristics for Various Junction Temperatures

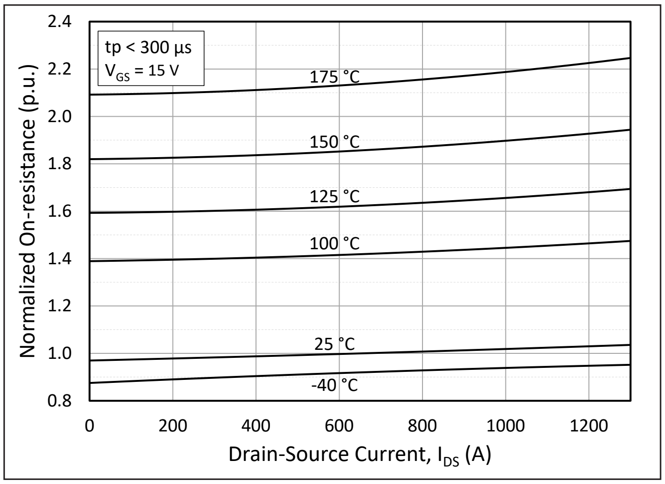


Figure 2. Normalized On-State Resistance vs. Drain Current for Various Junction Temperatures

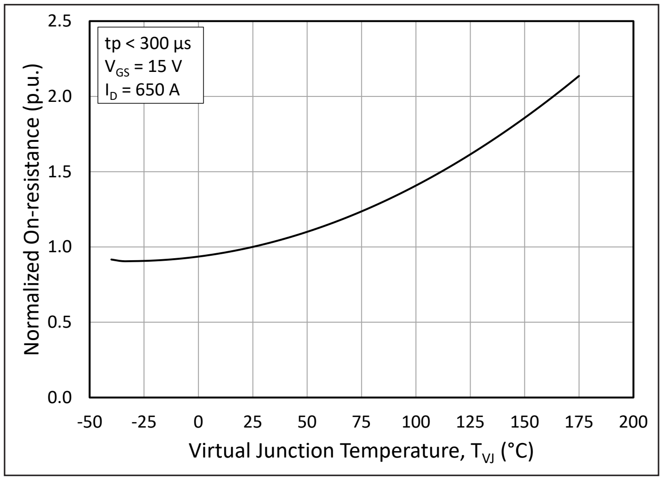


Figure 3. Normalized On-State Resistance vs. Junction Temperature

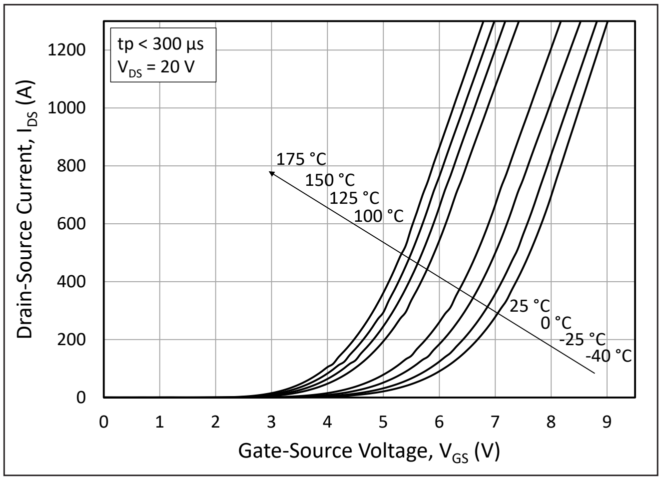


Figure 4. Transfer Characteristic for Various Junction Temperatures

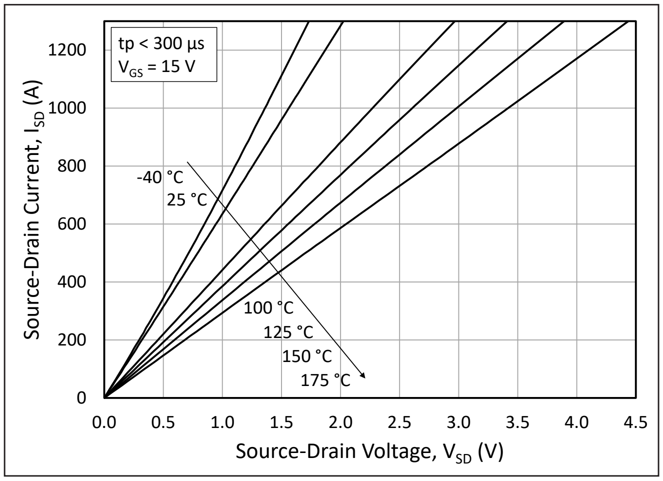


Figure 5. 3rd Quadrant Characteristic vs. Junction Temperatures at V_{GS} = 15 V

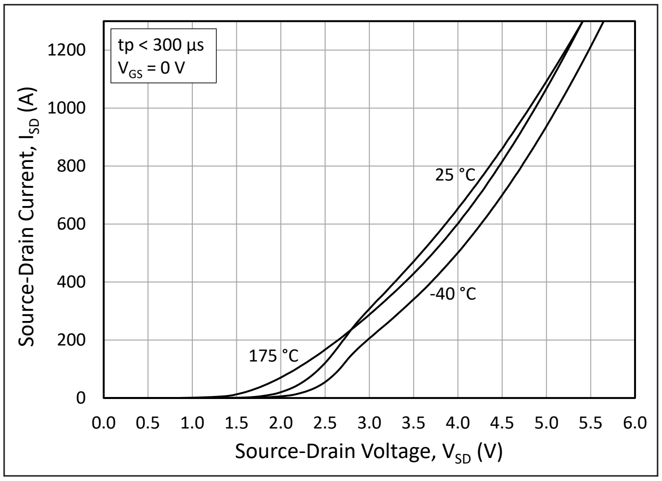


Figure 6. 3rd Quadrant Characteristic vs. Junction Temperatures at V_{GS} = 0 V (Body Diode)

Typical Performance

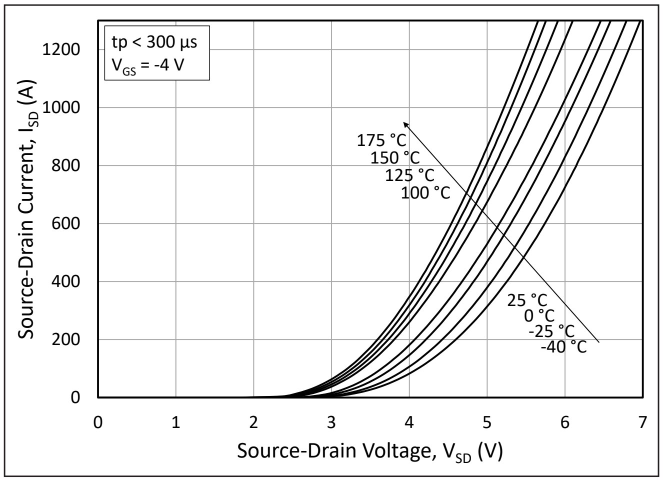


Figure 7. 3rd Quadrant Characteristic vs. Junction Temperatures at V_{GS} = -4 V (Body Diode)

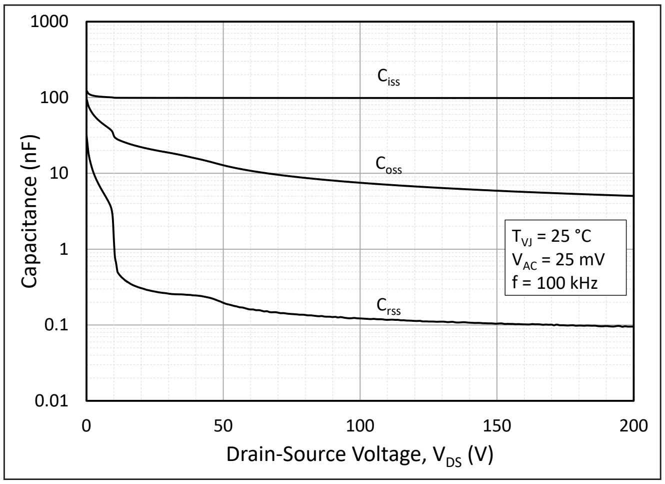


Figure 8. Typical Capacitances vs. Drain to Source Voltage (0 - 200 V)

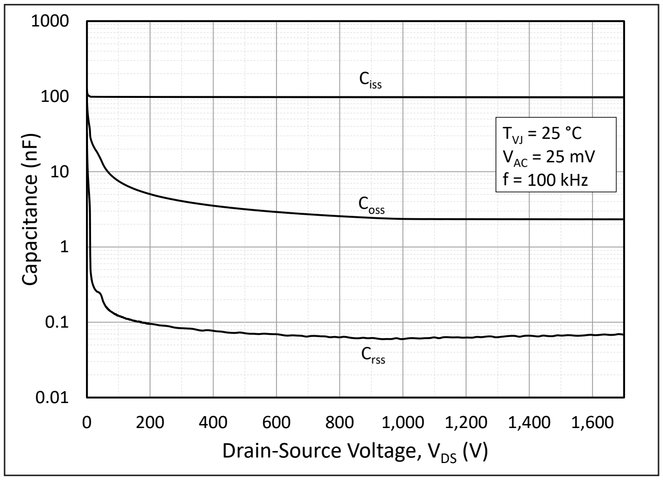


Figure 9. Typical Capacitances vs. Drain to Source Voltage (0 - 1200 V)

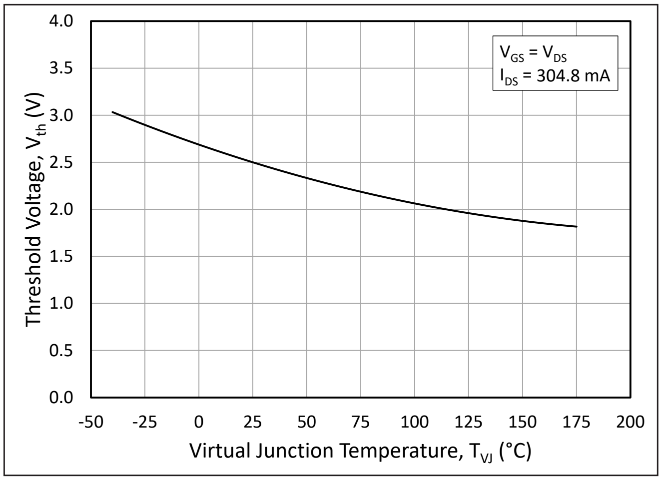


Figure 10. Threshold Voltage vs. Junction Temperature

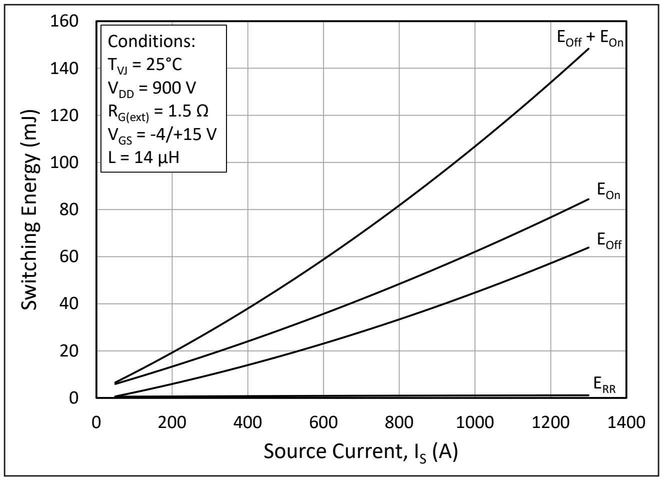


Figure 11. Switching Energy vs. Drain Current (V_{DD} = 900 V)

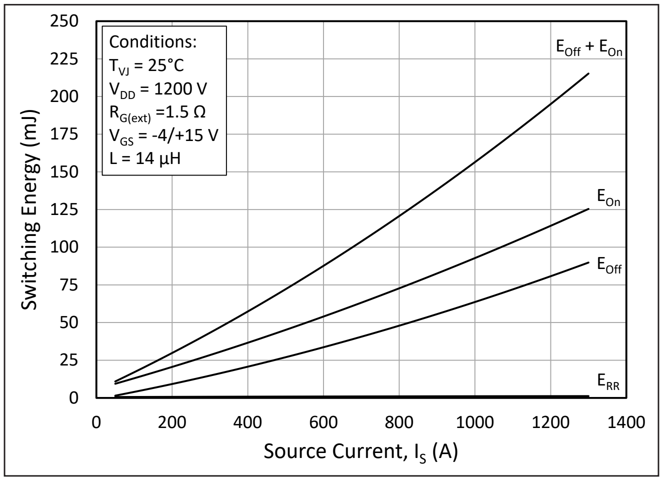


Figure 12. Switching Energy vs. Drain Current (V_{DD} = 1200 V)

Typical Performance

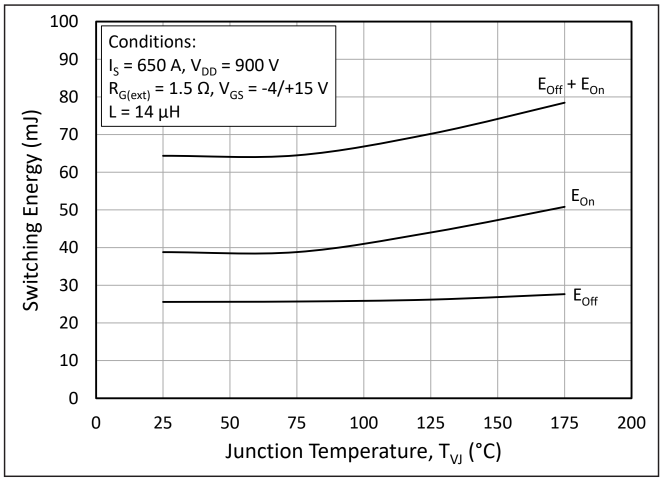


Figure 13. MOSFET Switching Energy vs. Junction Temperature

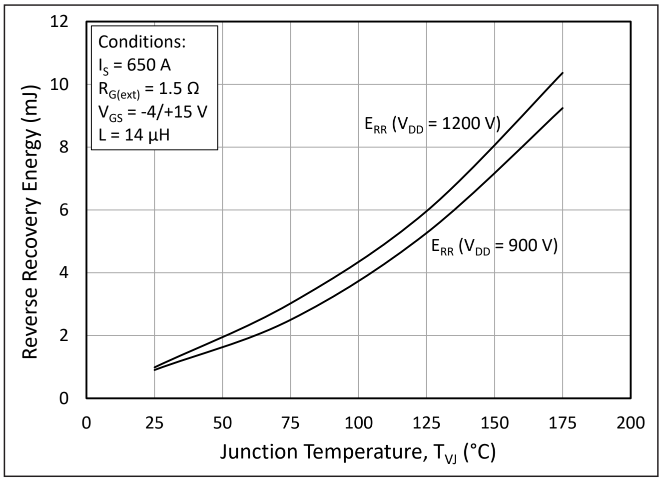


Figure 14. Reverse Recovery Energy vs. Junction Temperature

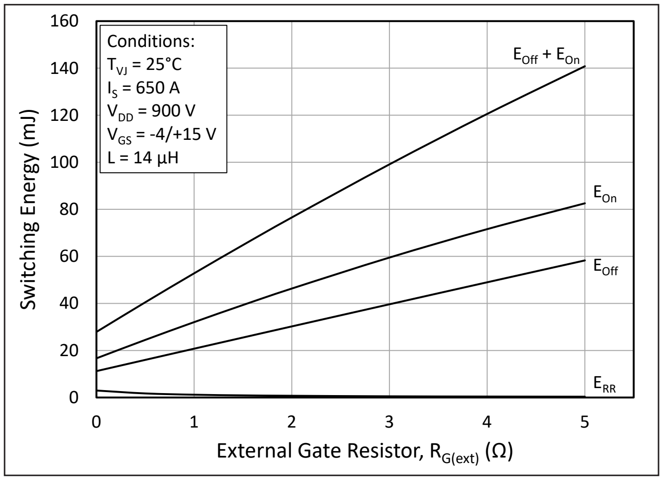


Figure 15. MOSFET Switching Energy vs. External Gate Resistance

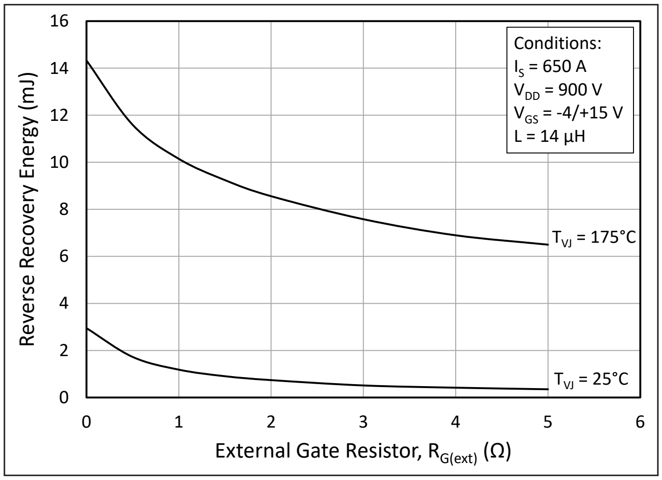


Figure 16. Reverse Recovery Energy vs. External Gate Resistance

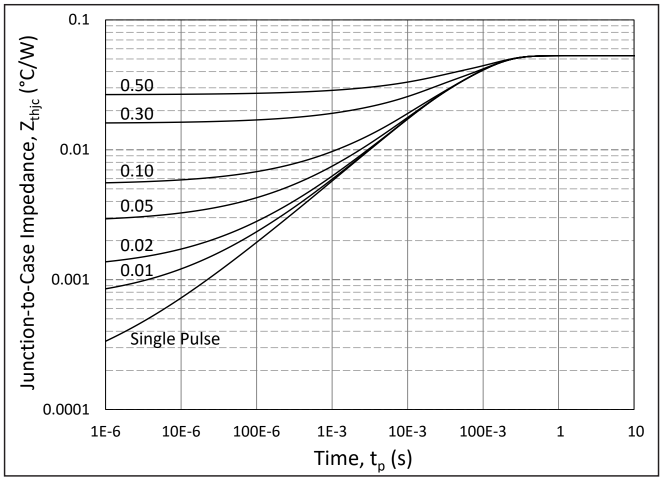


Figure 17. MOSFET Junction to Case Transient Thermal Impedance, $Z_{th\ JC}$ (°C/W)

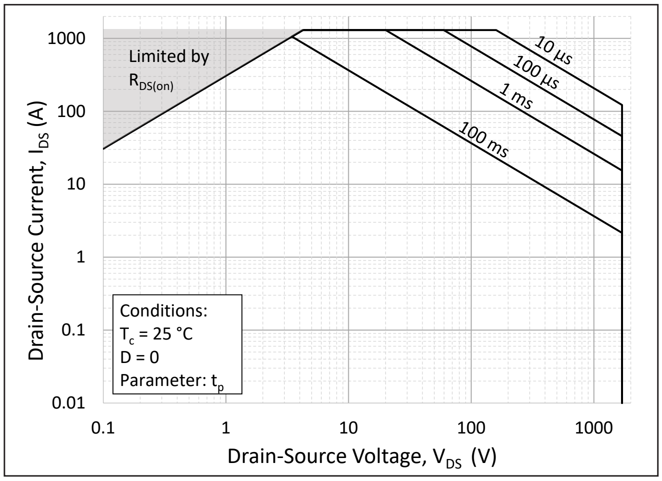


Figure 18. Forward Bias Safe Operating Area (FBSOA)

Typical Performance

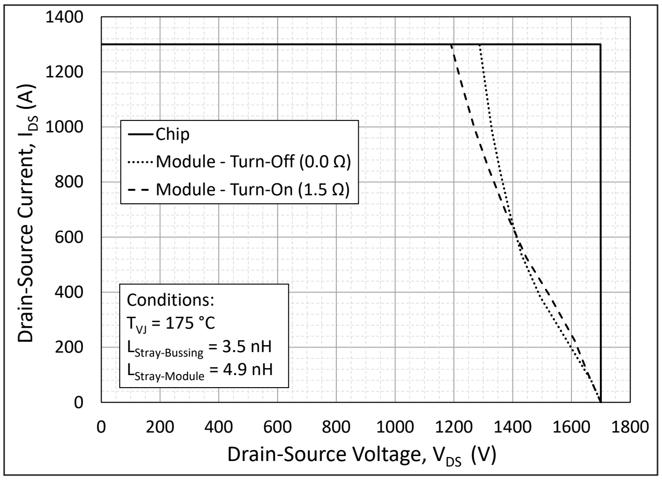


Figure 19. Reverse Bias Safe Operating Area (RBSOA)

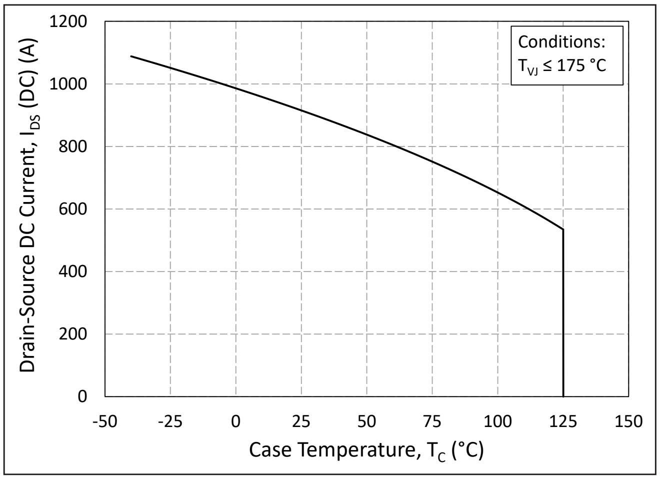


Figure 20. Continuous Drain Current Derating vs. Case Temperature

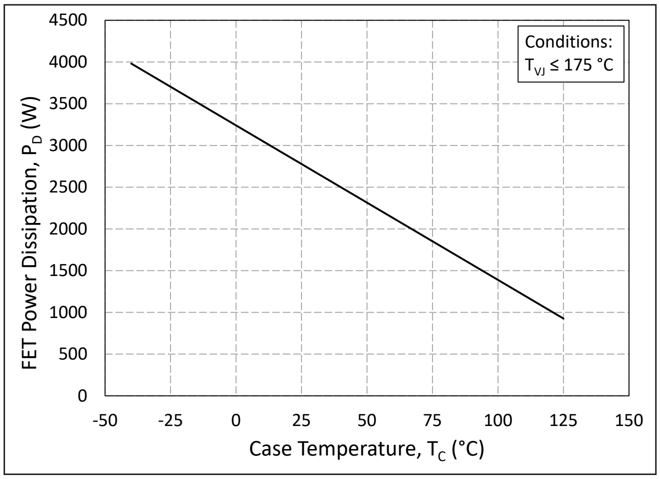


Figure 21. Maximum Power Dissipation Derating vs. Case Temperature

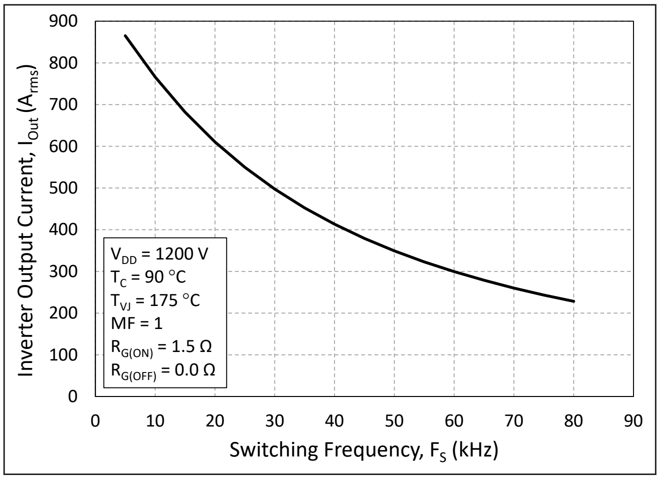


Figure 22. Typical Output Current Capability vs. Switching Frequency (Inverter Application)

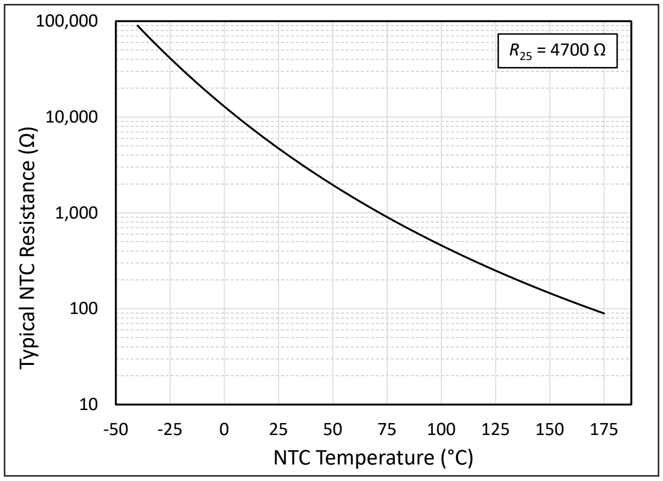


Figure 23. NTC Resistance vs. NTC Temperature

Timing Characteristics

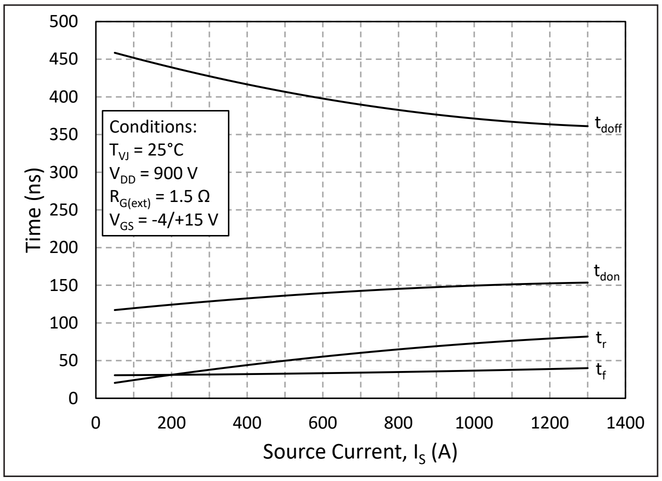


Figure 24. Timing vs. Source Current

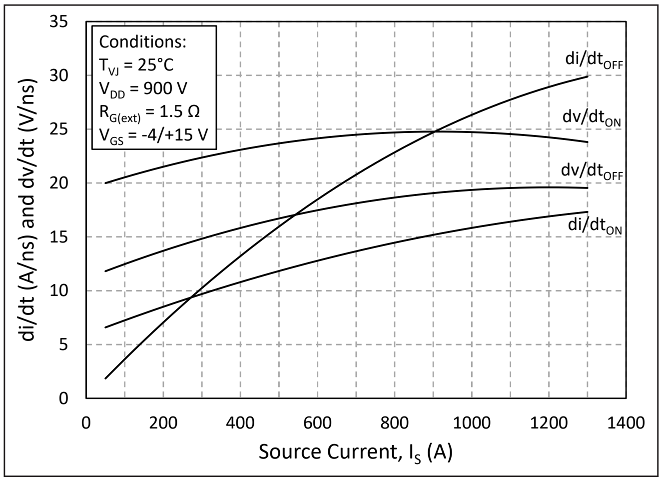


Figure 25. dv/dt and di/dt vs. Source Current

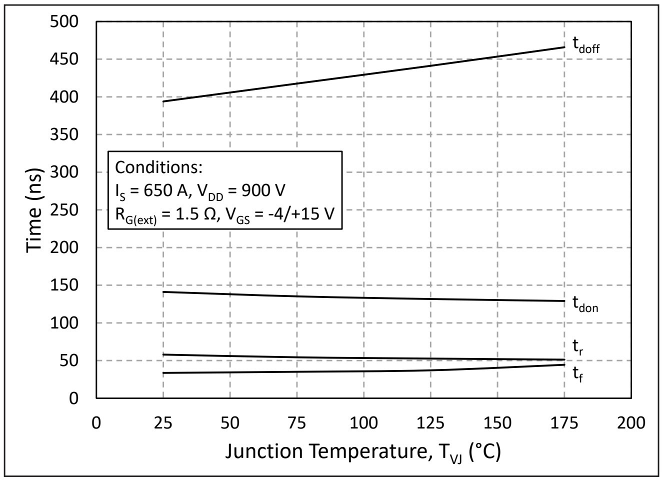


Figure 26. Timing vs. Junction Temperature

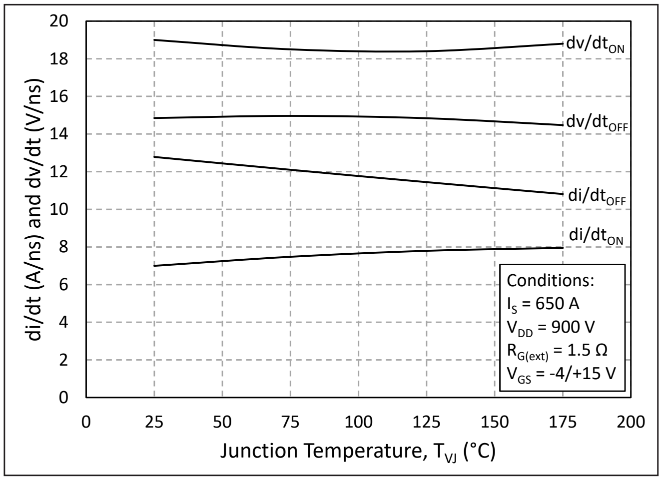


Figure 27. dv/dt and di/dt vs. Junction Temperature

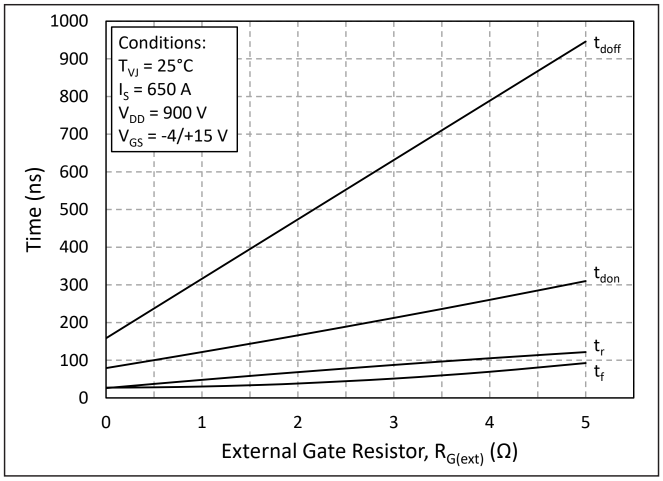


Figure 28. Timing vs. External Gate Resistance

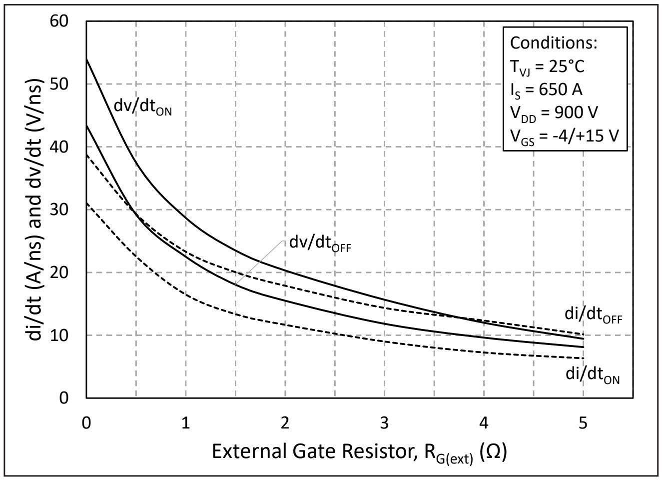


Figure 29. dv/dt and di/dt vs. External Gate Resistance

Definitions

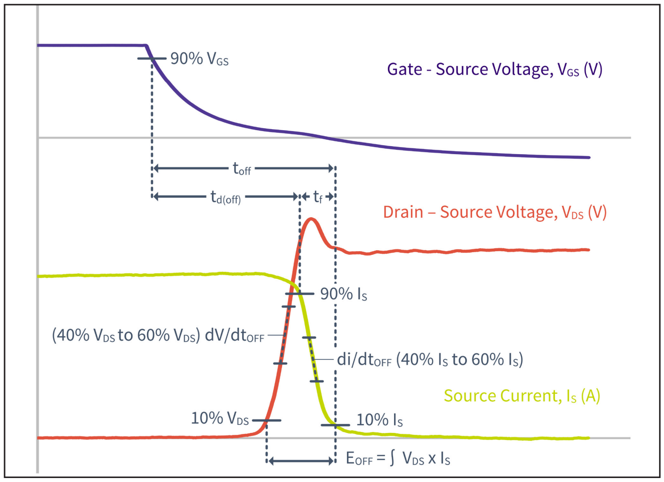


Figure 30. Turn-Off Transient Definitions

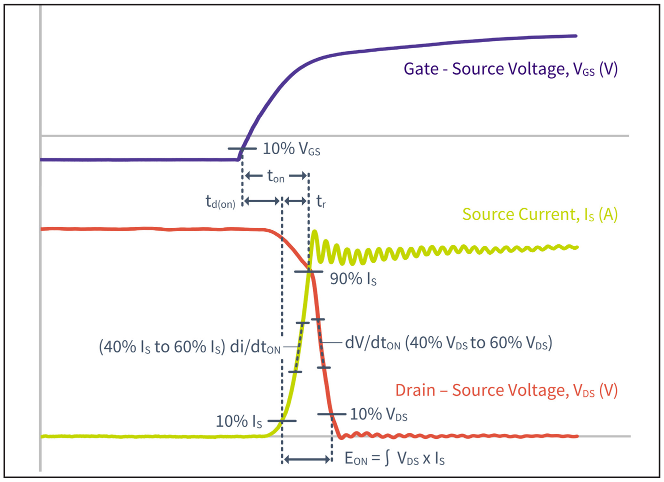


Figure 31. Turn-On Transient Definitions

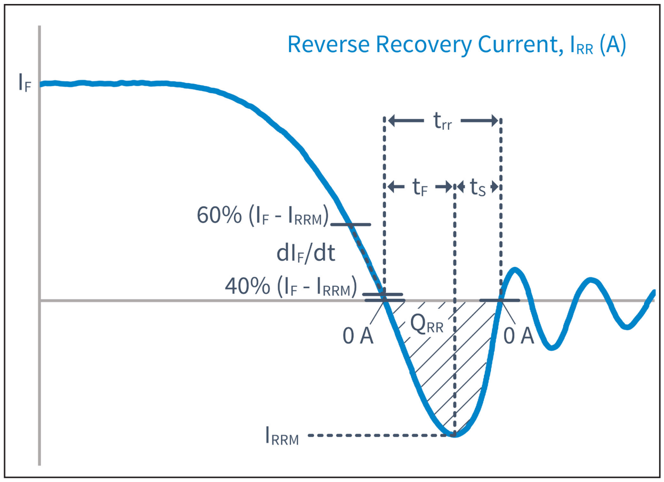


Figure 32. Reverse Recovery Definitions

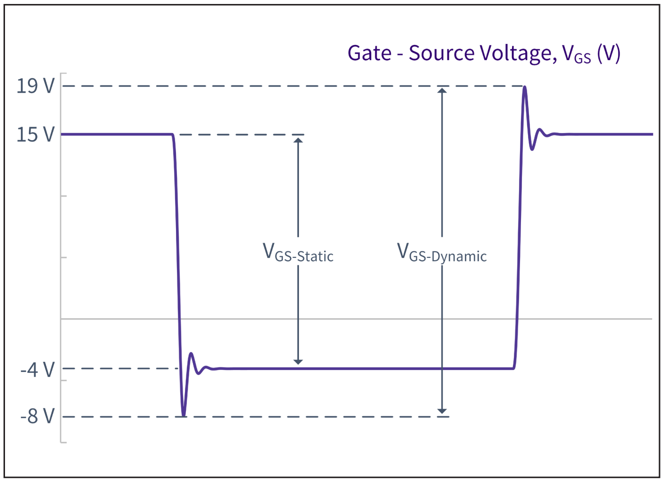


Figure 33. V_{GS} Transient Definitions

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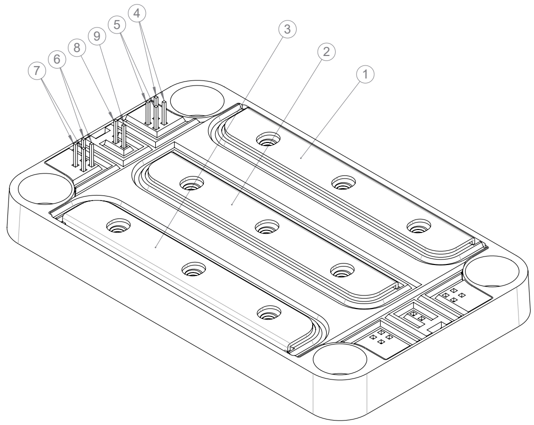
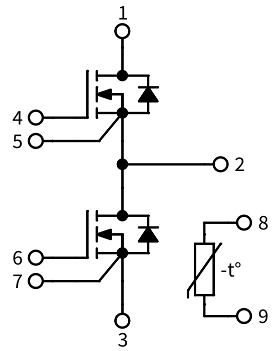
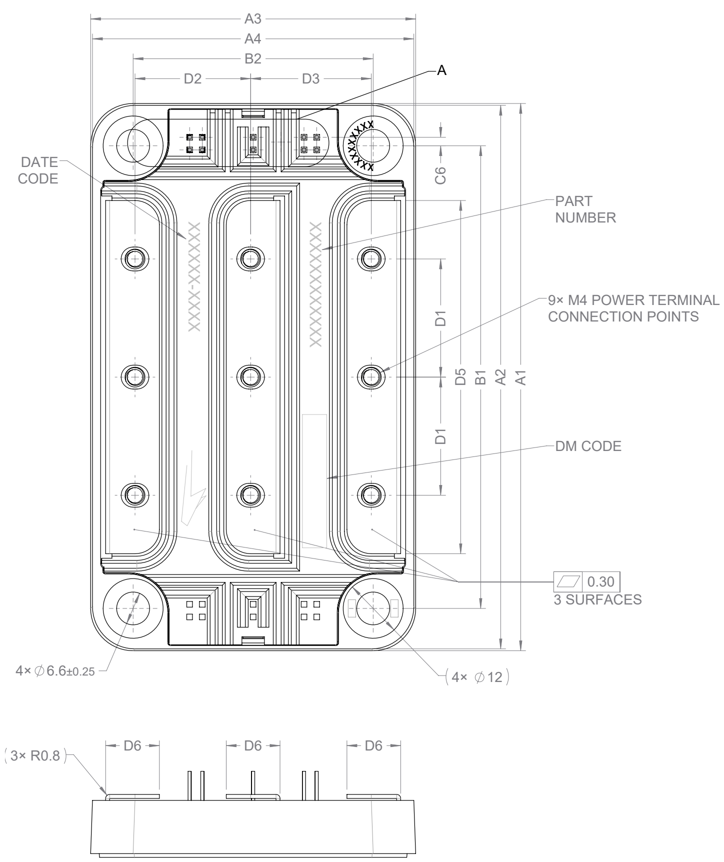
Schematic and Pin Out

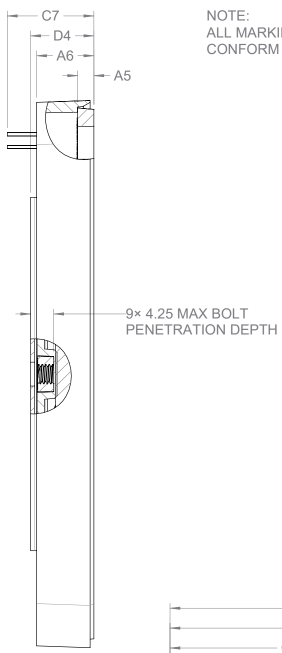


PIN OUT SCHEME	
PIN	LABEL
1	V+
2	Mid
3	V-
4	G1, Top row pins (2)
5	K1, Bottom row pins (2)
6	G2, Top row pins (2)
7	K2, Bottom row pins (2)
8	NTC1
9	NTC2



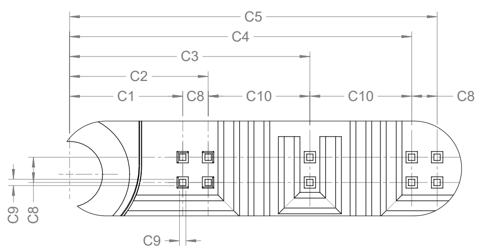
Package Dimension (mm)





NOTE:
ALL MARKINGS SHALL
CONFORM TO PRC-00786.

DIMENSION TABLE		
SYMBOL	DIMENSION	TOLERANCE
A1	110.00	±0.60
A2	109.25	±0.60
A3	65.00	±0.60
A4	64.25	±0.60
A5	3.25	±0.30
A6	11.45	±0.60
B1	93.00	±0.30
B2	48.00	±0.30
C1	11.30	±0.40
C2	13.84	±0.40
C3	24.00	±0.40
C4	34.16	±0.40
C5	36.70	±0.40
C6	1.71	±0.40
C7	17.30	±0.50
C8	2.54	±0.30
C9	0.64	±0.30
C10	10.16	±0.40
D1	23.75	±0.50
D2	23.13	±0.50
D3	24.13	±0.50
D4	12.20	±0.50
D5	71.00	±0.30
D6	10.75	±0.30



DETAIL A
SCALE: 4:1

Supporting Links & Tools

Evaluation Tools & Support

- PLECS Models
- LTSpice Models
- SpeedFit 2.0 Design Simulator™
- Technical Support Forum
- Dynamic Characterization Evaluation Tool for the High Performance 62 mm (HM) Module Platform

Dual-Channel Gate Driver Board

- CGD1700HB3P-HM3: Wolfspeed Gate Driver Board
- CGD12HB00D: Differential Transceiver Daughter Board Companion Tool for Differential Gate Drivers

Application Notes

- CPWR-AN35: 62 mm Thermal Interface Material Application Note
- CPWR-AN39: KIT-CRD-CIL12N-HM User Guide
- PRD-04814: Design Options for Wolfspeed® Silicon Carbide MOSFET Gate Bias Power Supplies

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