

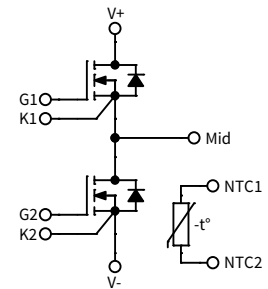
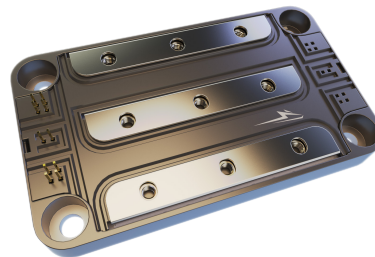
# CAB650M17HM3

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

$V_{DS}$	<b>1700 V</b>
$I_{DS}$	<b>650 A</b>

## 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

## Maximum Parameters (Verified by Design)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Note
Drain-Source Voltage	$V_{DS}$			1700	V		
Gate-Source Voltage, Maximum Value	$V_{GS\ max}$	-8		+19		Transient, <100 ns	Fig. 33
Gate-Source Voltage, Recommended	$V_{GS\ op}$	-4		+15		Static	
DC Continuous Drain Current	$I_D$		916		A	$V_{GS} = 15\ V, T_c = 25\ ^\circ C, T_{VJ} \leq 175\ ^\circ C$	Fig. 20
			694			$V_{GS} = 15\ V, T_c = 90\ ^\circ C, T_{VJ} \leq 175\ ^\circ C$	
DC Source-Drain Current (Body Diode)	$I_{SD\ BD}$		593			$V_{GS} = -4\ V, T_c = 25\ ^\circ C, T_{VJ} \leq 175\ ^\circ C$	
			382			$V_{GS} = -4\ V, T_c = 90\ ^\circ C, T_{VJ} \leq 175\ ^\circ C$	
Pulsed Drain Current	$I_D\ (pulsed)$			1300		$t_{pmax}$ limited by $T_{VJmax}$ $V_{GS} = 15\ V, T_c = 25\ ^\circ C$	
Virtual Junction Temperature	$T_{VJ\ op}$	-40		175	$^\circ C$	Operation	



### MOSFET Characteristics (Per Position) ( $T_{VJ} = 25\text{ }^{\circ}\text{C}$ unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Note
Drain-Source Breakdown Voltage	$V_{(BR)DSS}$	1700				$V_{GS} = 0\text{ V}, T_{VJ} = -40\text{ }^{\circ}\text{C}$	
Gate Threshold Voltage	$V_{GS(th)}$	1.8	2.5	3.6	V	$V_{DS} = V_{GS}, I_D = 305\text{ mA}$	
			2.0			$V_{DS} = V_{GS}, I_D = 305\text{ mA}, T_{VJ} = 175\text{ }^{\circ}\text{C}$	
Zero Gate Voltage Drain Current	$I_{DSS}$		12	500	$\mu\text{A}$	$V_{GS} = 0\text{ V}, V_{DS} = 1700\text{ V}$	
Gate-Source Leakage Current	$I_{GSS}$		0.012	3		$V_{GS} = 15\text{ V}, V_{DS} = 0\text{ V}$	
Drain-Source On-State Resistance (Devices Only)	$R_{DS(on)}$		1.42	1.86	m $\Omega$	$V_{GS} = 15\text{ V}, I_D = 650\text{ A}$	Fig. 2 Fig. 3
			3.26			$V_{GS} = 15\text{ V}, I_D = 650\text{ A}, T_{VJ} = 175\text{ }^{\circ}\text{C}$	
Transconductance	$g_{fs}$		553		S	$V_{DS} = 20\text{ V}, I_D = 650\text{ A}$	Fig. 4
			561			$V_{DS} = 20\text{ V}, I_D = 650\text{ A}, T_{VJ} = 175\text{ }^{\circ}\text{C}$	
Turn-On Switching Energy, $T_{VJ} = 25\text{ }^{\circ}\text{C}$ $T_{VJ} = 125\text{ }^{\circ}\text{C}$ $T_{VJ} = 175\text{ }^{\circ}\text{C}$	$E_{On}$		38.8		mJ	$V_{DD} = 900\text{ V}$ $I_D = 650\text{ A},$ $V_{GS} = -4\text{ V}/15\text{ V},$ $R_{G(OFF)} = 1.5\text{ }\Omega, R_{G(ON)} = 1.5\text{ }\Omega,$ $L = 14\text{ }\mu\text{H}$	Fig. 11 Fig. 13
Turn-Off Switching Energy, $T_{VJ} = 25\text{ }^{\circ}\text{C}$ $T_{VJ} = 125\text{ }^{\circ}\text{C}$ $T_{VJ} = 175\text{ }^{\circ}\text{C}$			25.6				
			26.2				
			27.6				
Internal Gate Resistance	$R_{G(int)}$		0.62		$\Omega$	$f = 1\text{ MHz}, V_{AC} = 25\text{ mV}$	
Input Capacitance	$C_{iss}$		97.3		nF	$V_{GS} = 0\text{ V}, V_{DS} = 1200\text{ V}$ $V_{AC} = 25\text{ mV}, f = 100\text{ kHz}$	Fig. 9
Output Capacitance	$C_{oss}$		2.3				
Reverse Transfer Capacitance	$C_{rss}$		63		pF		
Gate to Source Charge	$Q_{GS}$		960		nC	$V_{DS} = 1200\text{ V}, V_{GS} = -4\text{ V}/15\text{ V}$ $I_D = 1100\text{ A}$ Per IEC60747-8-4 pg 21	
Gate to Drain Charge	$Q_{GD}$		840				
Total Gate Charge	$Q_G$		2988				
FET Thermal Resistance, Junction to Case	$R_{thJC}$		0.054		$^{\circ}\text{C}/\text{W}$		Fig. 17

### Diode Characteristics (Per Position) ( $T_{VJ} = 25\text{ }^{\circ}\text{C}$ unless otherwise specified)

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



## Module Physical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions
Package Resistance, M1 (High-Side)	$R_{1-2}$		106.5		$\mu\Omega$	$T_c = 125^\circ\text{C}$ , Note 1
Package Resistance, M2 (Low-Side)	$R_{2-3}$		126.3			$T_c = 125^\circ\text{C}$ , Note 1
Stray Inductance	$L_{\text{Stray}}$		4.9		nH	Between DC- and DC+, $f = 10 \text{ MHz}$
Case Temperature	$T_c$	-40		125	$^\circ\text{C}$	
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	$V_{\text{isol}}$	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:

<sup>1</sup>Total Effective Resistance (Per Switch Position) = MOSFET  $R_{\text{DS(on)}}$  + Switch Position Package Resistance

## NTC Characteristics ( $T_{\text{NTC}} = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Notes
Resistance at 25°C	$R_{25}$		4700		$\Omega$	
Tolerance of $R_{25}$			$\pm 1$		%	
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 $B_{25/85}$			$\pm 1$		%	
Maximum Power Dissipation	$P_{\text{Max}}$		50		mW	

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

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

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

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

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



Typical Performance

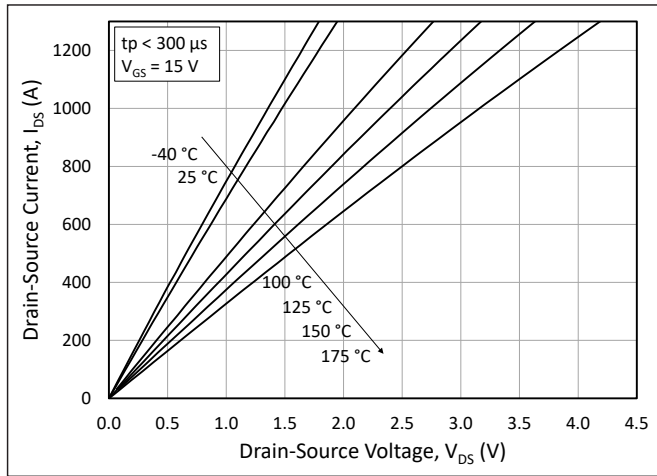


Figure 1. Output Characteristics for Various Junction Temperatures

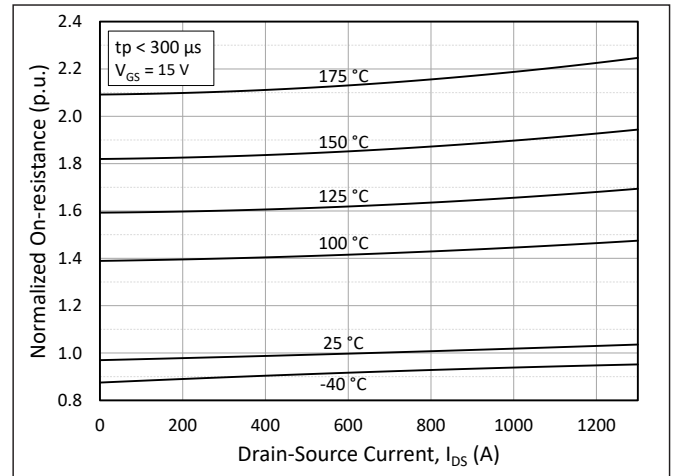


Figure 2. Normalized On-State Resistance vs. Drain Current for Various Junction Temperatures

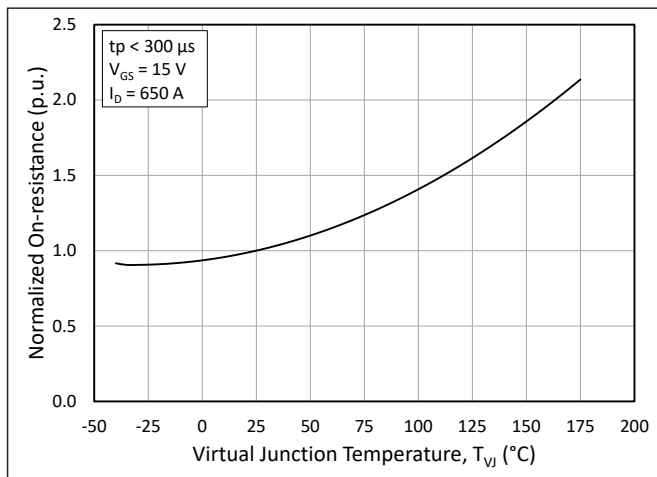


Figure 3. Normalized On-State Resistance vs. Junction Temperature

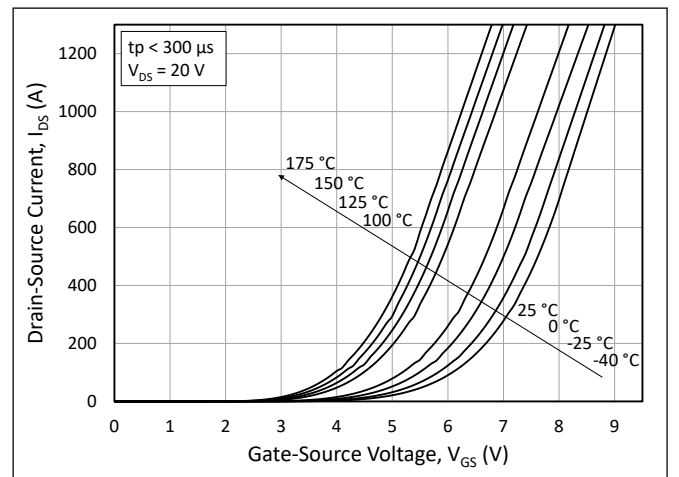


Figure 4. Transfer Characteristic for Various Junction Temperatures

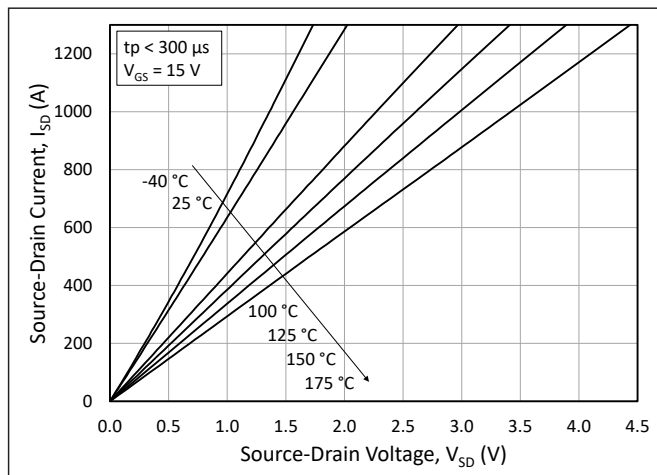


Figure 5. 3<sup>rd</sup> Quadrant Characteristic vs. Junction Temperatures at  $V_{GS} = 15\text{ V}$

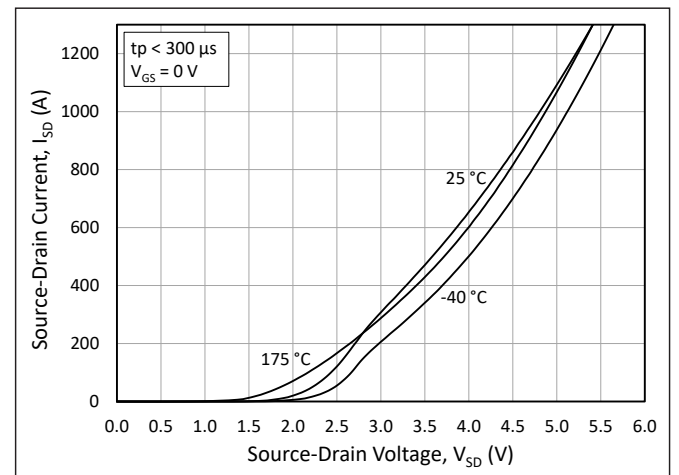


Figure 6. 3<sup>rd</sup> Quadrant Characteristic vs. Junction Temperatures at  $V_{GS} = 0\text{ V}$  (Body Diode)



Typical Performance

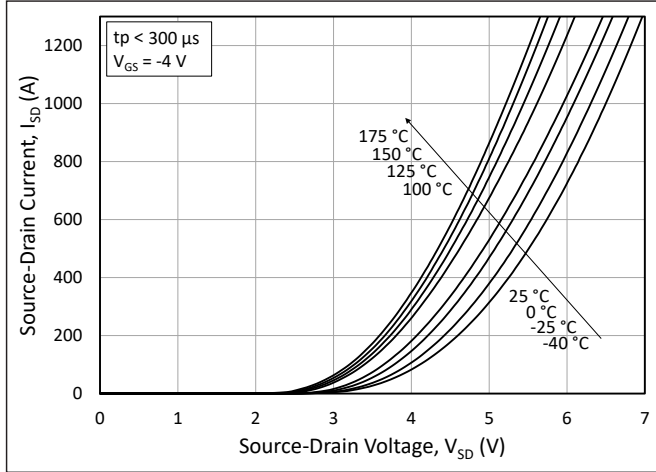


Figure 7. 3<sup>rd</sup> Quadrant Characteristic vs. Junction Temperatures at  $V_{GS} = -4$  V (Body Diode)

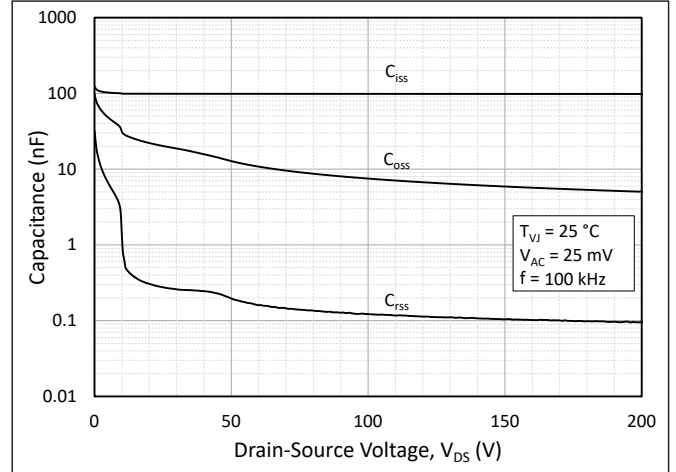


Figure 8. Typical Capacitances vs. Drain to Source Voltage (0 - 200V)

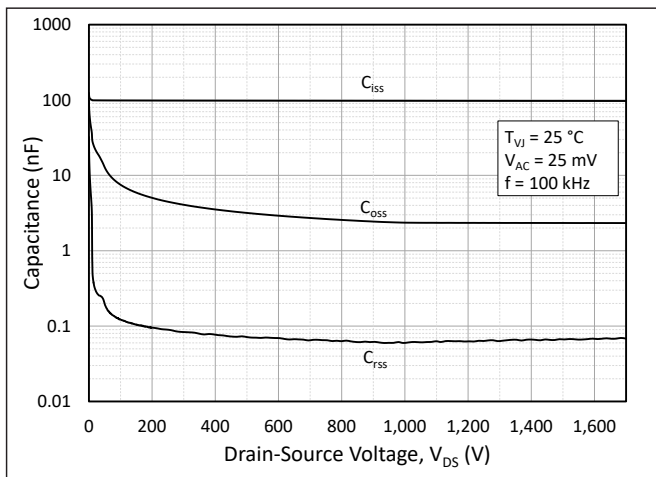


Figure 9. Typical Capacitances vs. Drain to Source Voltage (0 - 1200V)

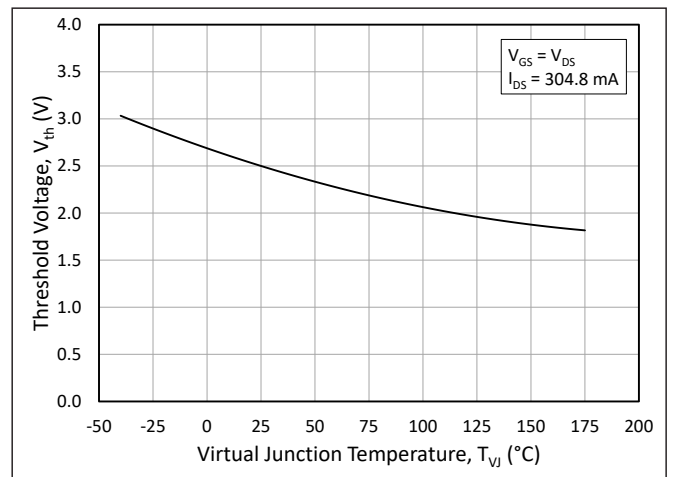


Figure 10. Threshold Voltage vs. Junction Temperature

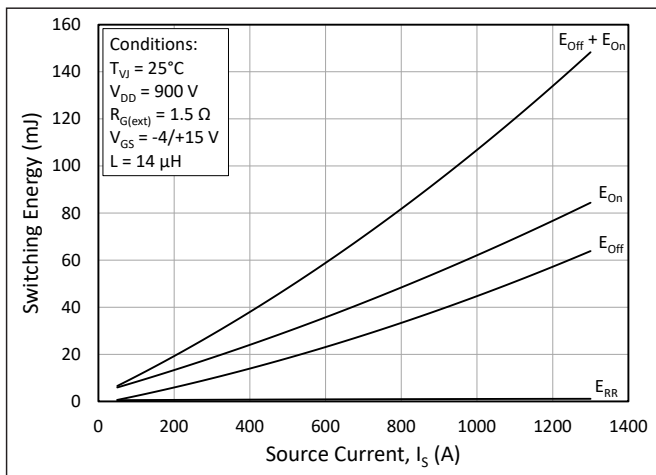


Figure 11. Switching Energy vs. Drain Current ( $V_{DD} = 900$  V)

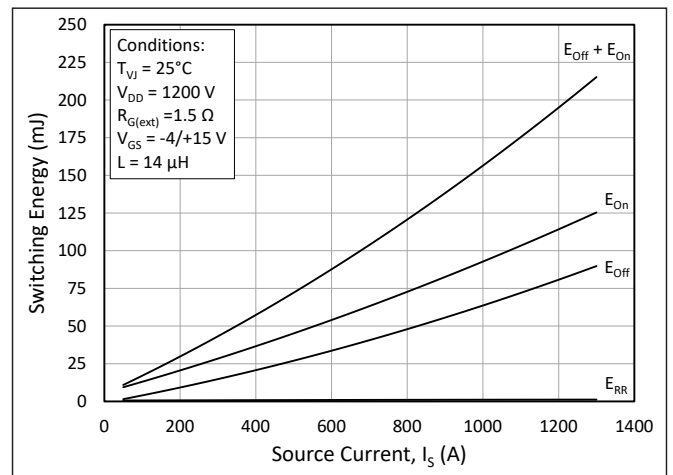


Figure 12. Switching Energy vs. Drain Current ( $V_{DD} = 1200$  V)



Typical Performance

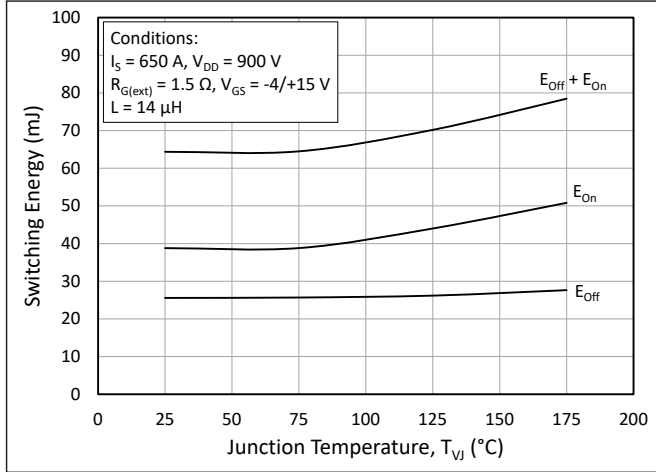


Figure 13. MOSFET Switching Energy vs. Junction Temperature

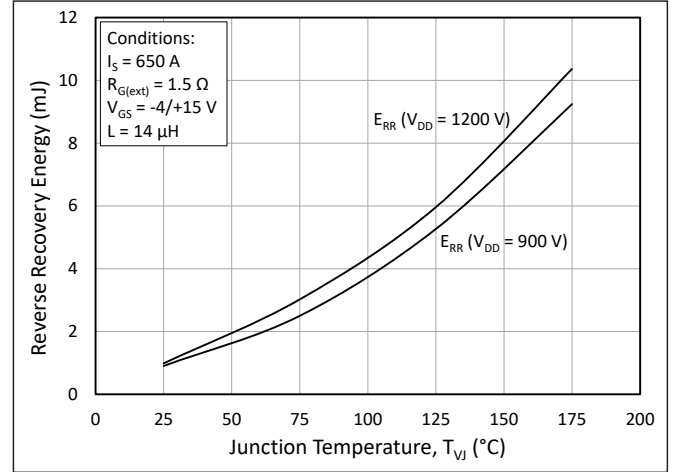


Figure 14. Reverse Recovery Energy vs. Junction Temperature

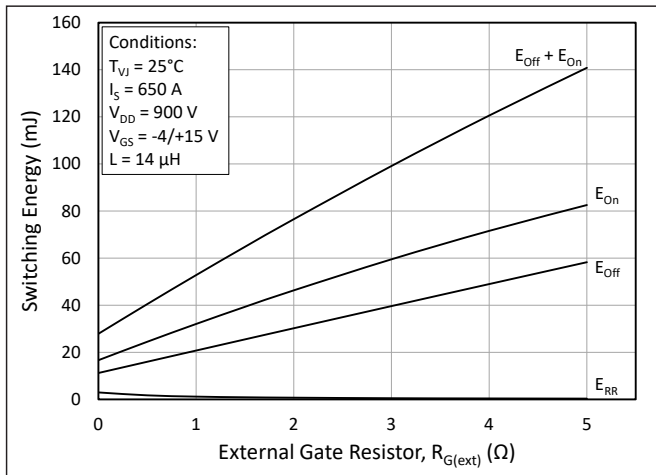


Figure 15. MOSFET Switching Energy vs. External Gate Resistance

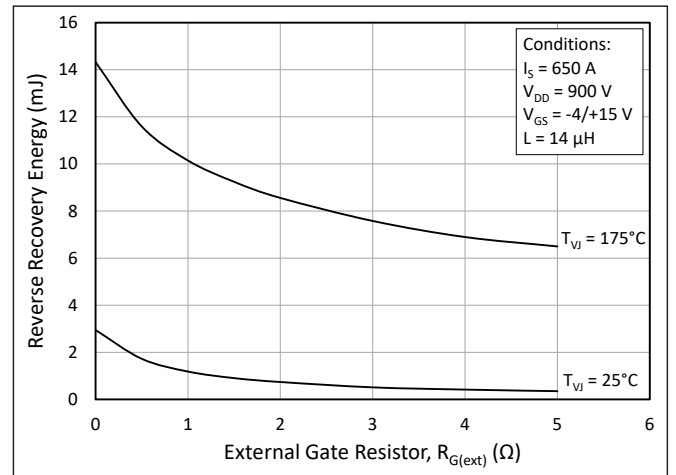


Figure 16. Reverse Recovery Energy vs. External Gate Resistance

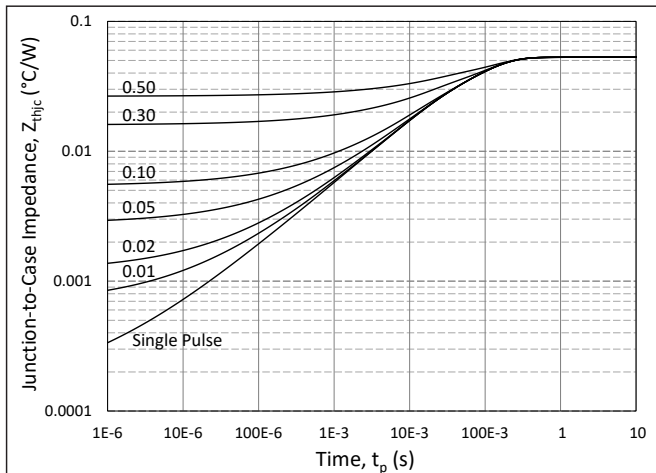


Figure 17. MOSFET Junction to Case Transient Thermal Impedance,  $Z_{thJC}$  (°C/W)

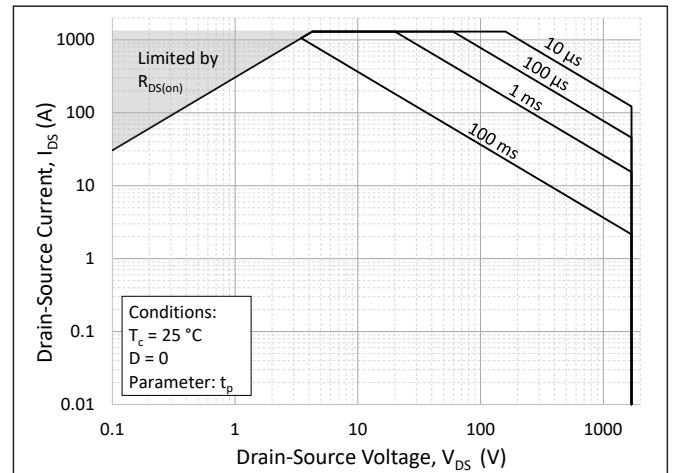


Figure 18. Forward Bias Safe Operating Area (FBSOA)



Typical Performance

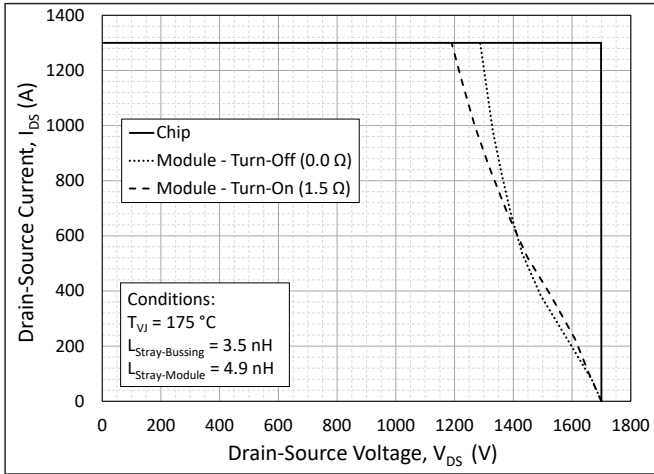


Figure 19. Reverse Bias Safe Operating Area (RBSOA)

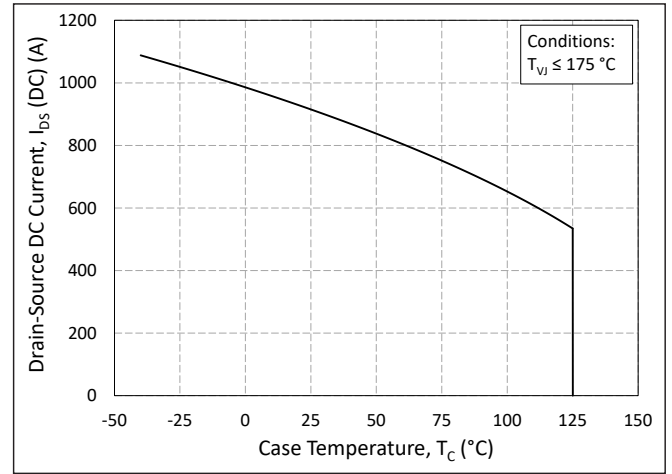


Figure 20. Continuous Drain Current Derating vs. Case Temperature

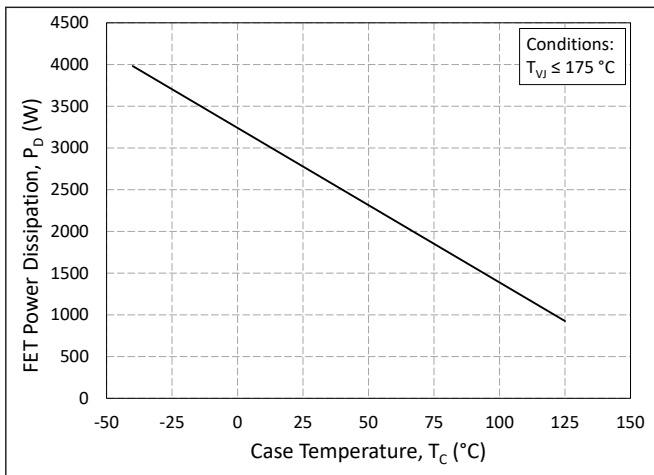


Figure 21. Maximum Power Dissipation Derating vs. Case Temperature

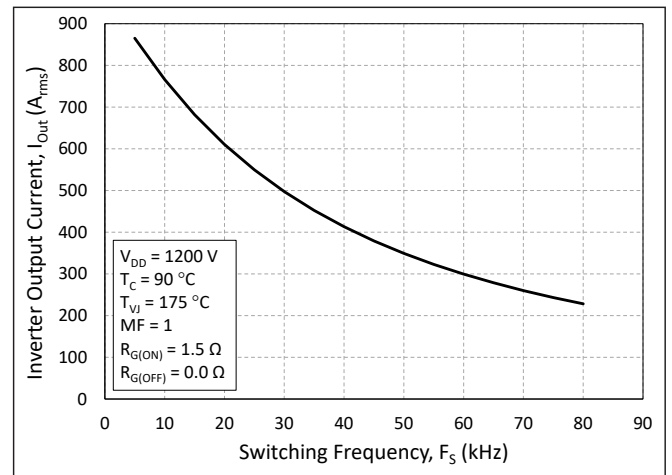


Figure 22. Typical Output Current Capability vs. Switching Frequency (Inverter Application)

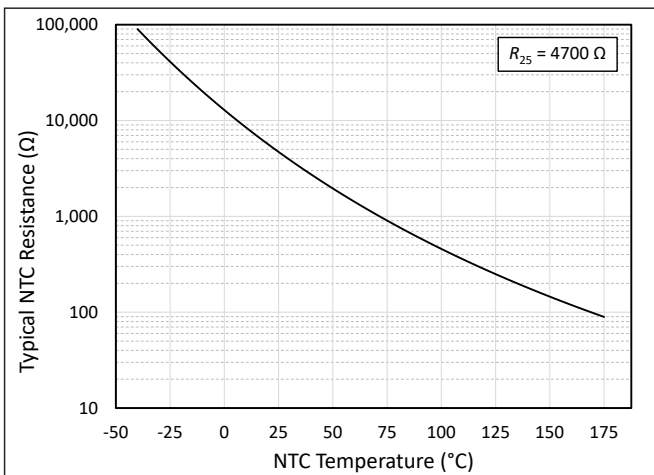


Figure 23. NTC Resistance vs. NTC Temperature



Timing Characteristics

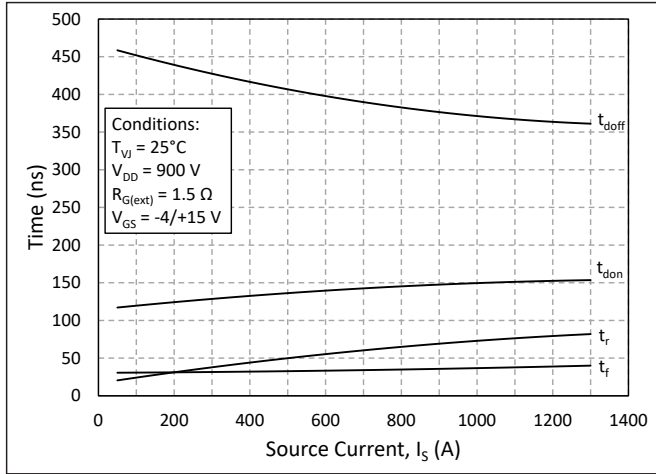


Figure 24. Timing vs. Source Current

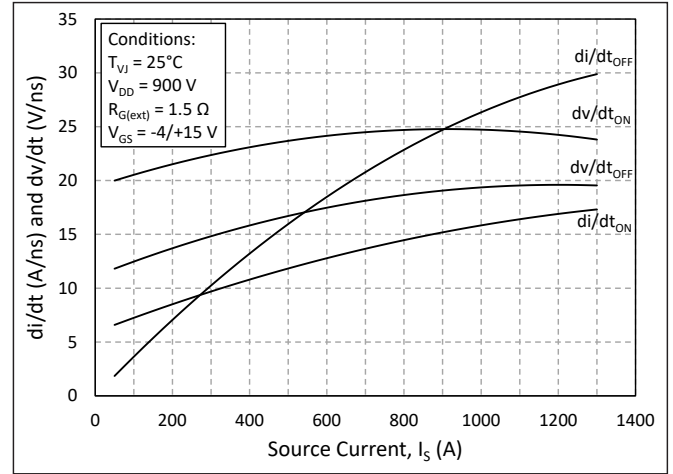


Figure 25. dv/dt and di/dt vs. Source Current

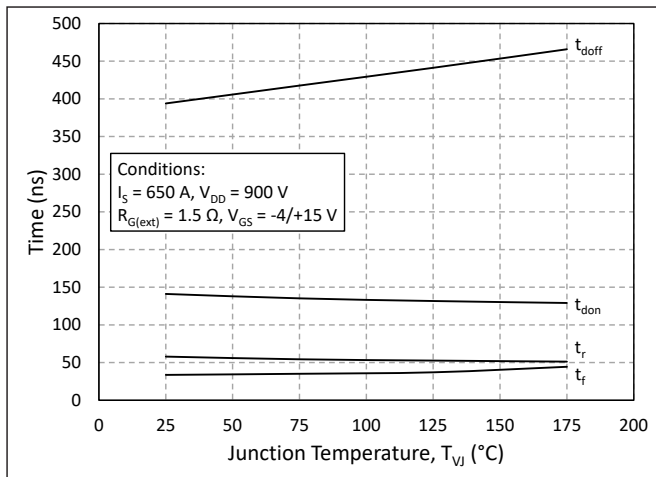


Figure 26. Timing vs. Junction Temperature

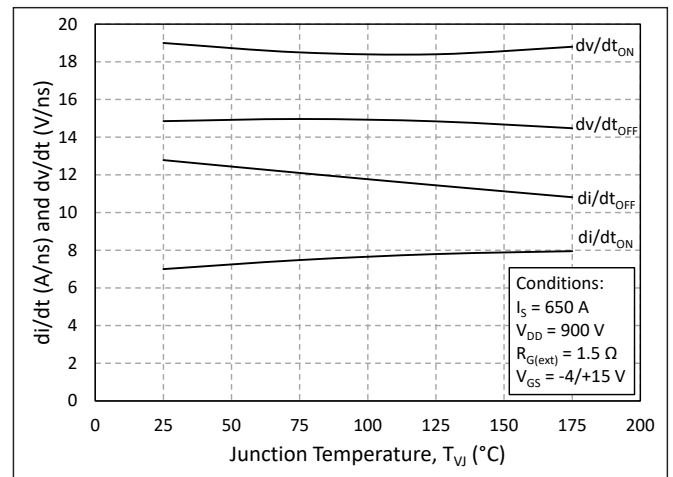


Figure 27. dv/dt and di/dt vs. Junction Temperature

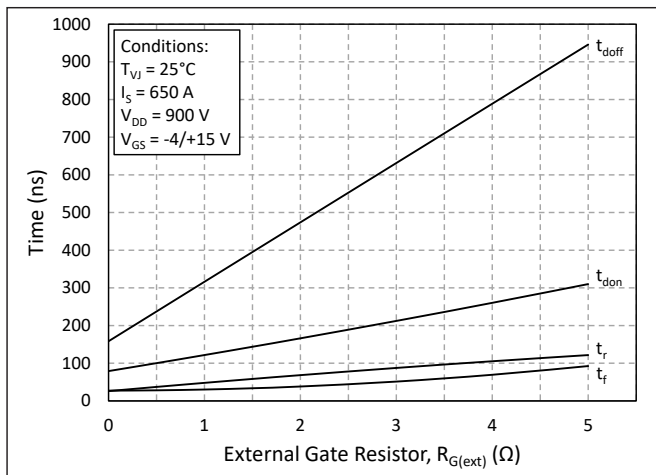


Figure 28. Timing vs. External Gate Resistance

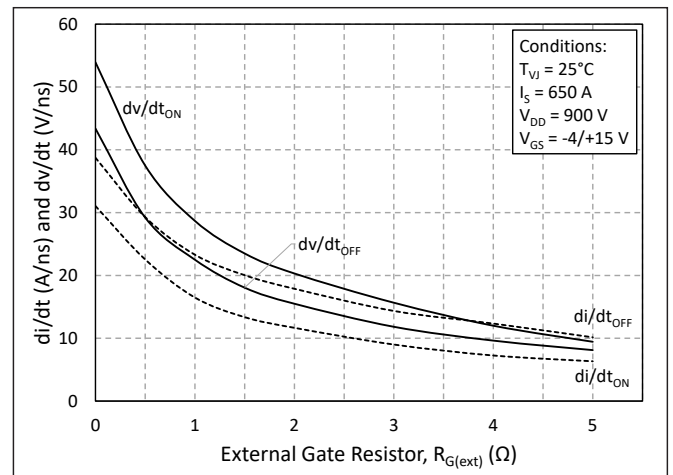
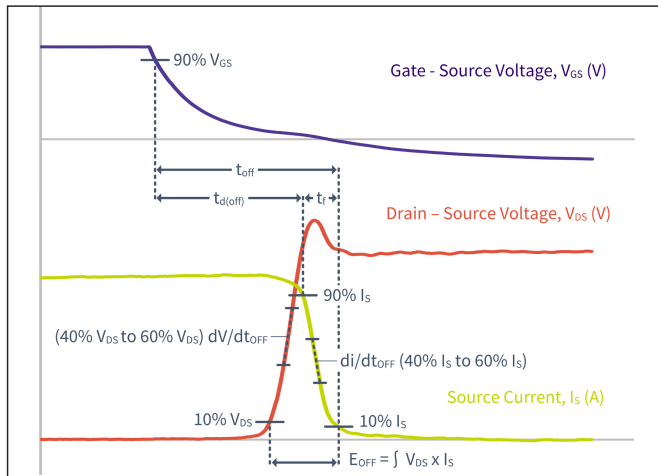


Figure 29. dv/dt and di/dt vs. External Gate Resistance

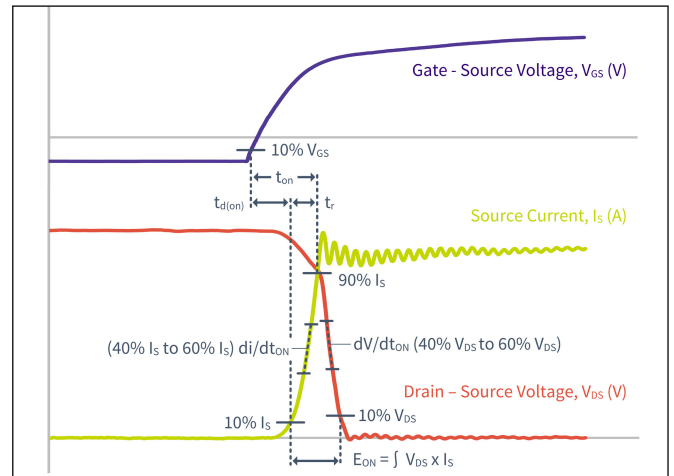




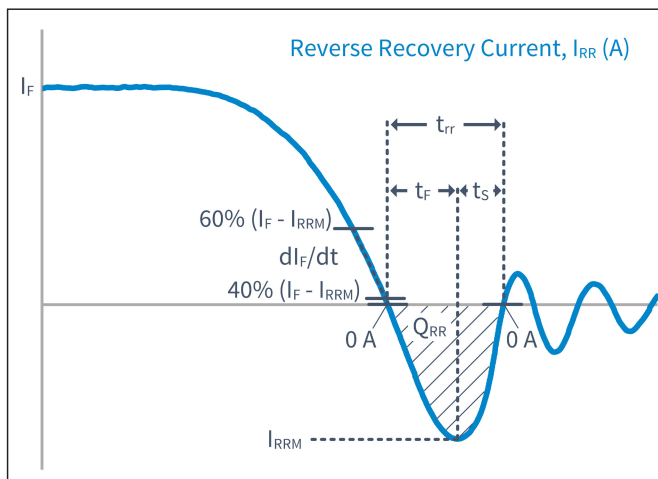
**Definitions**



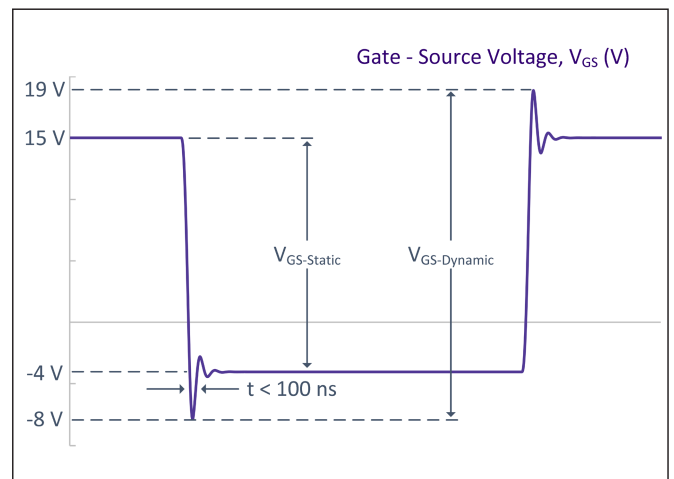
**Figure 30. Turn-off Transient Definitions**



**Figure 31. Turn-on Transient Definitions**



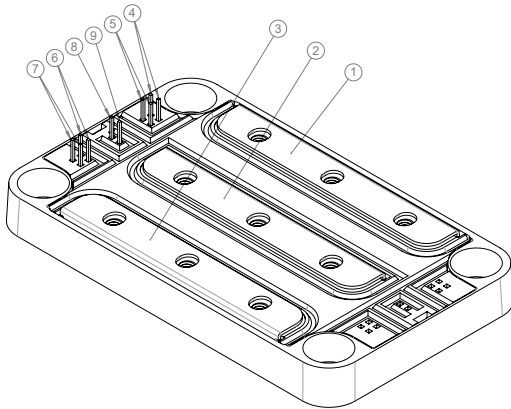
**Figure 32. Reverse Recovery Definitions**



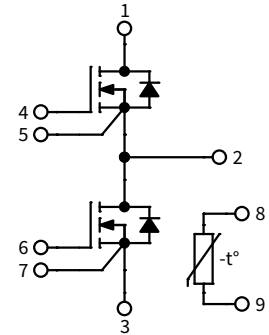
**Figure 33.  $V_{GS}$  Transient Definitions**



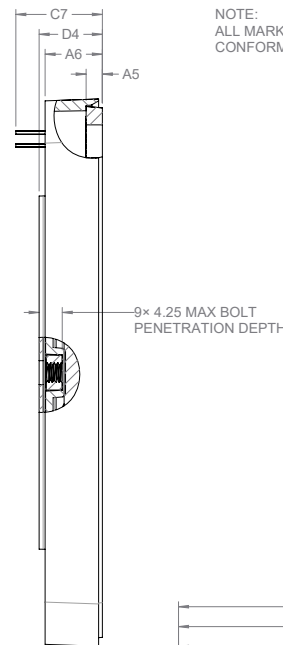
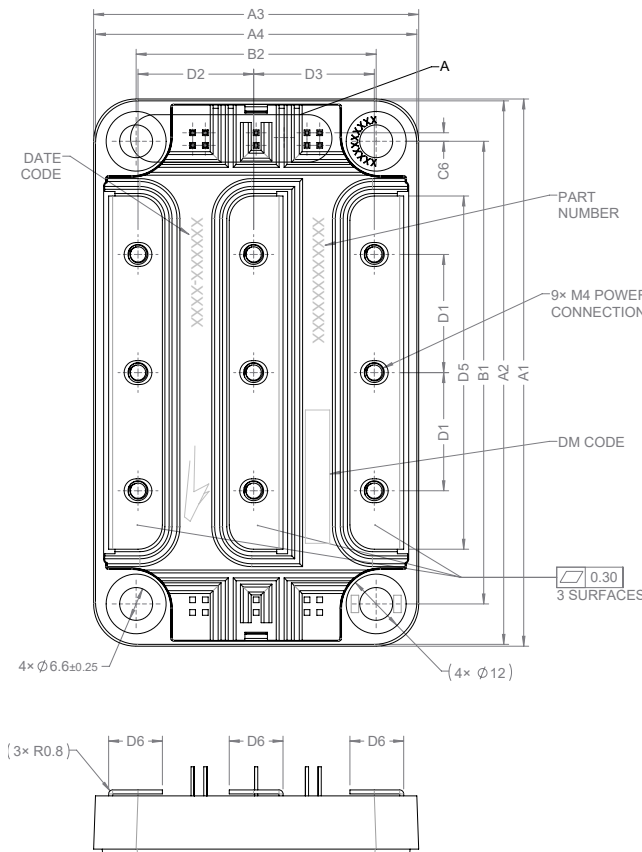
### Schematic and Pin Out



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

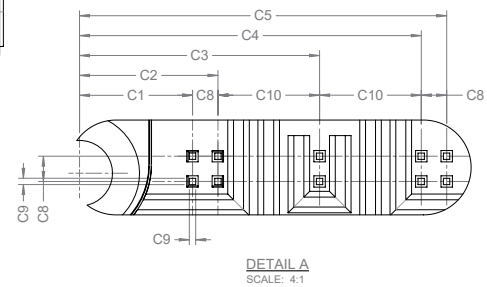


### Package Dimension (mm)



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





## Supporting Links & Tools

### Evaluation Tools & Support

- [CAB650M17HM3 PLECS Model](#)
- [SpeedFit 2.0 Design Simulator™](#)
- [Technical Support Forum](#)
- [Dynamic Characterization Evaluation Tool for the High Performance 62mm \(HM\) 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: 62mm 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](#)



## Notes & Disclaimer

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This product has not been designed or tested for use in, and is not intended for use in, applications in which failure of the product would reasonably be expected to cause death, personal injury, or property damage, including but not limited to equipment implanted into the human body, life-support machines, cardiac defibrillators, and similar emergency medical equipment, aircraft navigation, communication, and control systems, aircraft power and propulsion systems, air traffic control systems, and equipment used in the planning, construction, maintenance, or operation of nuclear facilities.

### **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 your Cree representative to ensure you get the most up-to-date REACH SVHC Declaration. REACH banned substance information (REACH Article 67) is also available upon request.

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