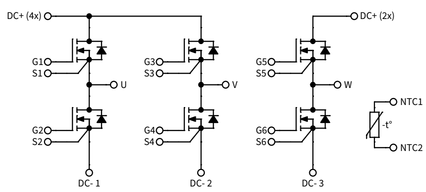
CCB016M12GM3, CCB016M12GM3T

1200 V, 16 mΩ, Silicon Carbide, Six-Pack Module

V_{DS}	1200 V
$R_{DS(on)}$	16 mΩ

Technical Features

- Ultra-Low Loss
- High Frequency Operation
- Zero Turn-Off Tail Current from MOSFET
- Normally-Off, Fail-Safe Device Operation
- Optional Pre-Applied Thermal Interface Material



Typical Applications

- DC-DC Converters
- 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	Test Conditions	Note
Drain-Source Voltage	V_{DS}			1200	V		
Maximum Gate-Source Voltage	$V_{GS(max)}$	-10		+23		Transient	Fig. 33 Note 1
Operational Gate-Source Voltage	$V_{GS(op)}$		-4/15			Static	
DC Continuous Drain Current (T_{VJ} ≤ 150 °C)	I_D			50	A	V_{GS} = 15 V, T_{HS} = 50 °C, T_{VJ} ≤ 150 °C	Notes 2,3,4 Fig. 20
DC Continuous Drain Current (T_{VJ} ≤ 175 °C)				50		V_{GS} = 15 V, T_{HS} = 50 °C, T_{VJ} ≤ 175 °C	
DC Source-Drain Current (Body Diode)	$I_{SD\ BD}$		41			V_{GS} = -4 V, T_{HS} = 50 °C, T_{VJ} ≤ 175 °C	
Pulsed Drain Current	$I_{D\ (pulsed)}$			100		t_{Pmax} limited by T_{VJmax} V_{GS} = 15 V, T_{HS} = 50 °C	
Power Dissipation	P_D		170		W	T_{HS} = 50 °C, T_{VJ} ≤ 175 °C	Note 5 Fig. 21
Virtual Junction Temperature	$T_{VJ(op)}$	-40		150	°C	Operation	
		-40		175		Intermittent with Reduced Life	

Note (1): Recommended turn-on gate voltage is 15 V with ±5% regulation tolerance,. Not for use in linear region.
Note (2): DC continuous drain current limit imposed by package.
Note (3): Continuous DC operational limit set by DC+ and DC- pins. See Figure 22 for implementable AC current.
Note (4): Verified by design.
Note (5): $P_D = (T_{VJ} - T_{HS})/R_{TH(JH,typ)}$

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MOSFET Characteristics (Per Position) (T_{VJ} = 25 °C unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Note
Drain-Source Breakdown Voltage	$V_{(BR)DSS}$	1200			V	V_{GS} = 0 V, T_{VJ} = -40 °C	
Gate Threshold Voltage	$V_{GS(th)}$	1.8	2.5	3.9	V	V_{DS} = V_{GS}, I_D = 23 mA	
			2.1		V	V_{DS} = V_{GS}, I_D = 23 mA, T_{VJ} = 150 °C	
Zero Gate Voltage Drain Current	I_{DSS}		2	200	µA	V_{GS} = 0 V, V_{DS} = 1200 V	
Gate-Source Leakage Current	I_{GSS}		20	500	nA	V_{GS} = 15 V, V_{DS} = 0 V	
Drain-Source On-State Resistance (Devices Only)	$R_{DS(on)}$		16.0	22.1	mΩ	V_{GS} = 15 V, I_D = 50 A	Fig. 2 Fig. 3
			25.6			V_{GS} = 15 V, I_D = 50 A, T_{VJ} = 150 °C	
			28.8			V_{GS} = 15 V, I_D = 50 A, T_{VJ} = 175 °C	
Transconductance	g_{fs}		42		S	V_{DS} = 20 V, I_D = 50 A	Fig. 4
			40			V_{DS} = 20 V, I_D = 50 A, T_{VJ} = 150 °C	
Turn-On Switching Energy, T_{VJ} = 25 °C T_{VJ} = 125 °C T_{VJ} = 150 °C	E_{On}		1.6 1.7 1.8		mJ	V_{DD} = 600 V, I_D = 60 A, V_{GS} = -4 V/15 V, $R_{G(OFF)}$ = 0.0 Ω, $R_{G(ON)}$ = 3.0 Ω, L = 22.7 µH	Fig. 11 Fig. 13
Turn-Off Switching Energy, T_{VJ} = 25 °C T_{VJ} = 125 °C T_{VJ} = 150 °C	E_{Off}		0.2 0.2 0.2				
Internal Gate Resistance	$R_{G(int)}$		2.35		Ω	f = 100 kHz, V_{AC} = 25 mV	
Input Capacitance	C_{iss}		6.7		nF	V_{GS} = 0 V, V_{DS} = 1000 V, V_{AC} = 25 mV, f = 100 kHz	Fig. 9
Output Capacitance	C_{oss}		258		pF		
Reverse Transfer Capacitance	C_{rss}		16				
Gate to Source Charge	Q_{GS}		80		nC	V_{DS} = 800 V, V_{GS} = -4 V/15 V, I_D = 40 A, Per IEC60747-8-4 pg 21	
Gate to Drain Charge	Q_{GD}		68				
Total Gate Charge	Q_G		236				
FET Thermal Resistance, Junction to Heatsink	$R_{th\ JHS}$		0.725		°C/W	Measured with Pre-Applied TIM	Fig. 17

Diode Characteristics (Per Position) (T_{VJ} = 25 °C unless otherwise specified)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Notes
Body Diode Forward Voltage	V_{SD}		4.5		V	V_{GS} = -4 V, I_{SD} = 50 A	Fig. 7
			4.1			V_{GS} = -4 V, I_{SD} = 50 A, T_{VJ} = 150 °C	
Reverse Recovery Time	t_{RR}		22		ns	V_{GS} = -4 V, I_{SD} = 60 A, V_R = 600 V, di/dt = 14.4 A/ns, T_{VJ} = 150 °C	Fig. 32
Reverse Recovery Charge	Q_{RR}		2.3		µC		
Peak Reverse Recovery Current	I_{RRM}		167		A		
Reverse Recovery Energy, T_{VJ} = 25 °C T_{VJ} = 125 °C T_{VJ} = 150 °C	E_{RR}		0.13 0.32 0.42		mJ	V_{DD} = 600 V, I_D = 60 A, V_{GS} = -4 V/15 V, $R_{G(EXT)}$ = 3.0 Ω, L =22.7 µH	Fig. 14

Module Physical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions
Package Resistance, M1, M3, M5 (High-Side)	R_{HS}		1.01		mΩ	T_{HS} = 125°C, I_D = 75 A, Note 6
Package Resistance, M2, M4, M6 (Low-Side)	R_{LS}		1.51		mΩ	T_{HS} = 125°C, I_D = 75 A, Note 6
Stray Inductance	L_{Stray}		20		nH	Between DC- and DC+, f = 10 MHz
Case Temperature	T_C	-40		125	°C	
Mounting Torque	M_S		2.0	2.3	N-m	M4 bolts
Weight	W		39		g	
Case Isolation Voltage	V_{isol}	3			kV	AC, 50 Hz, 1 minute
Comparative Tracking Index	CTI	200				
Clearance Distance			5.0		mm	Terminal to Terminal
			10.0		mm	Terminal to Heatsink
Creepage Distance			6.3		mm	Terminal to Terminal
			11.5		mm	Terminal to Heatsink

Note (6): Total Effective Resistance (Per Switch Position) = MOSFET $R_{DS(on)}$ + Switch Position Package Resistance

NTC Thermistor Characterization

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions
Rated Resistance	R_{NTC}		5.0		kΩ	T_{NTC} = 25°C
Resistance Tolerance at 25 °C	ΔR/R	-5		5	%	
Beta Value (T_2 = 50 °C)	$\beta_{25/50}$		3380		K	
Beta Value (T_2 = 80 °C)	$\beta_{25/80}$		3468		K	
Beta Value (T_2 = 100 °C)	$\beta_{25/100}$		3523		K	
Power Dissipation	P_{Max}			10	mW	T_{NTC} = 25°C

Typical Performance

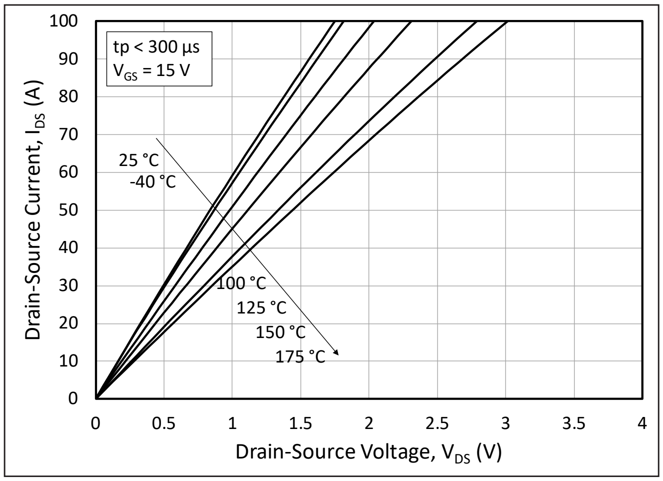


Figure 1. Output Characteristics for Various Junction Temperatures

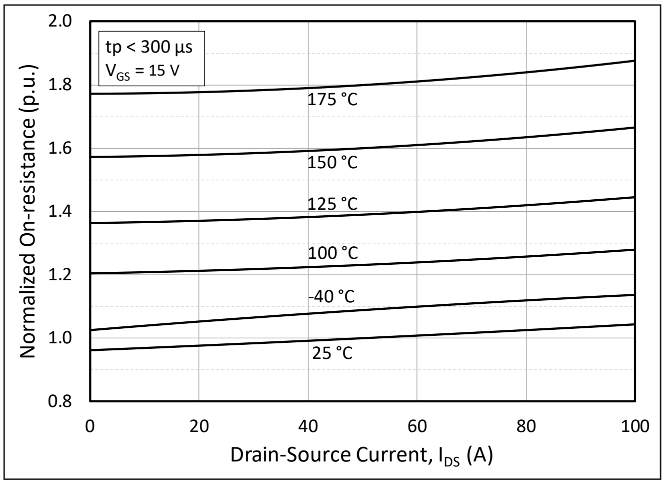


Figure 2. Normalized On-State Resistance vs. Drain Current for Various Junction Temperatures

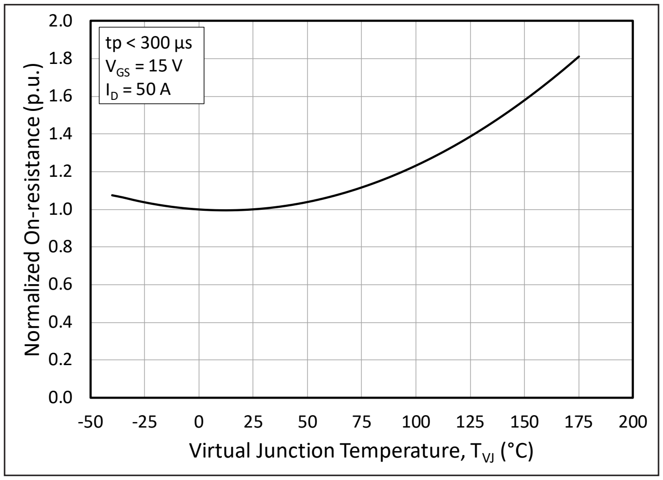


Figure 3. Normalized On-State Resistance vs. Junction Temperature

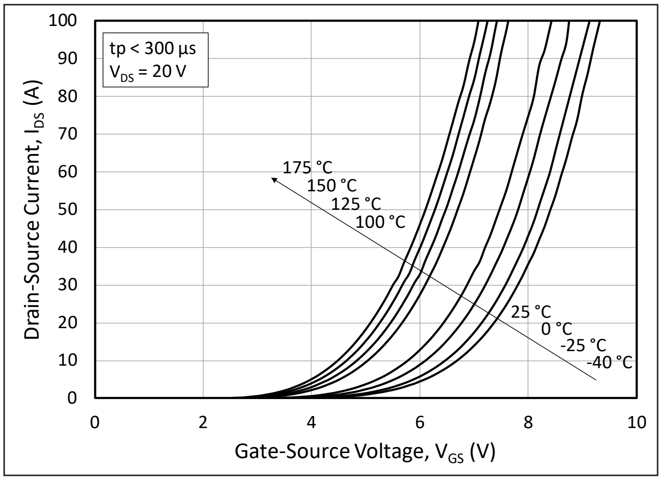


Figure 4. Transfer Characteristic for Various Junction Temperatures

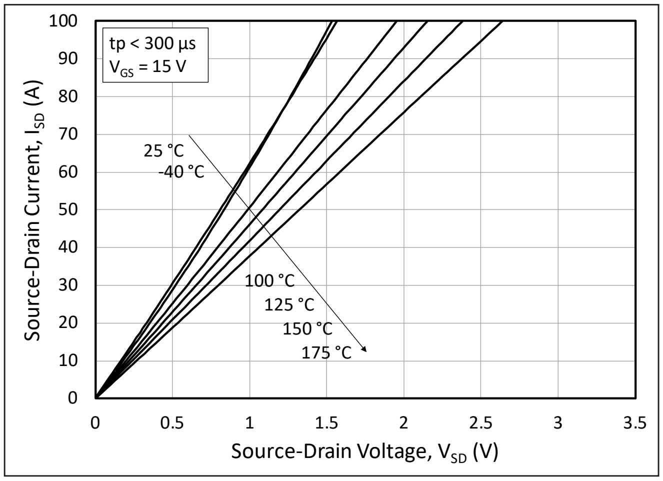


Figure 5. 3rd Quadrant Characteristic vs. Junction Temperatures at V_{GS} = 15 V

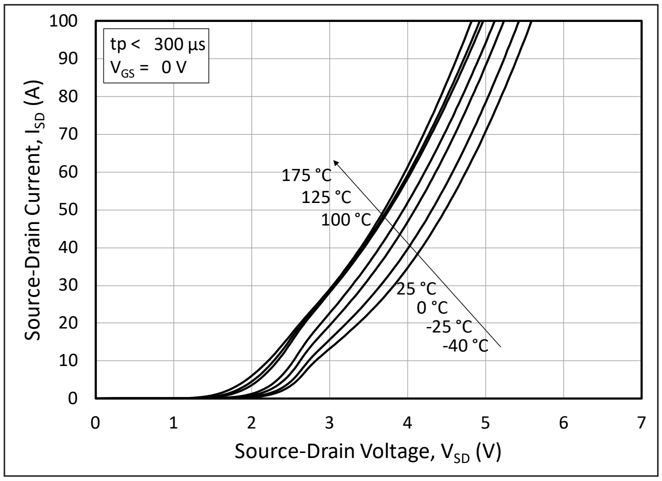


Figure 6. 3rd Quadrant Characteristic vs. Junction Temperatures at V_{GS} = 0 V

Typical Performance

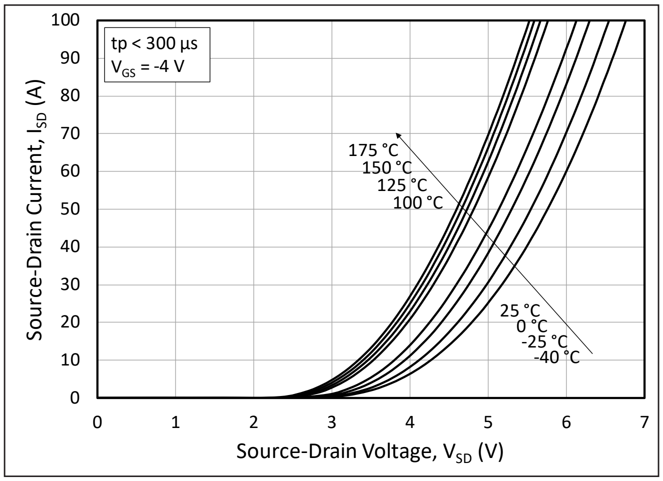


Figure 7. 3rd Quadrant Characteristic vs. Junction Temperatures at V_{GS} = -4 V (Body Diode)

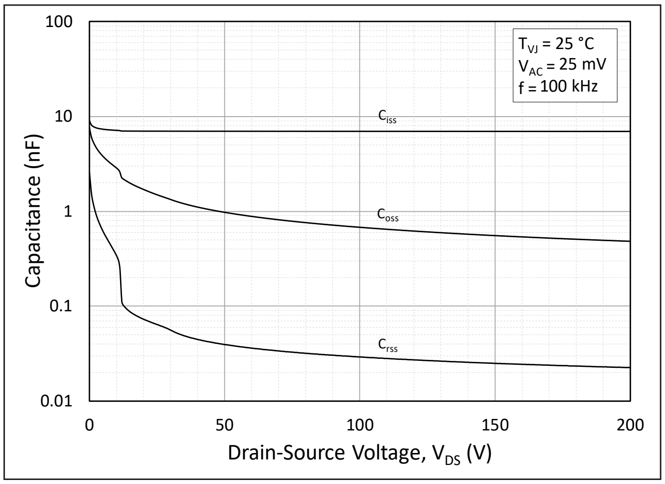


Figure 8. Typical Capacitances vs. Drain to Source Voltage (0 - 200 V)

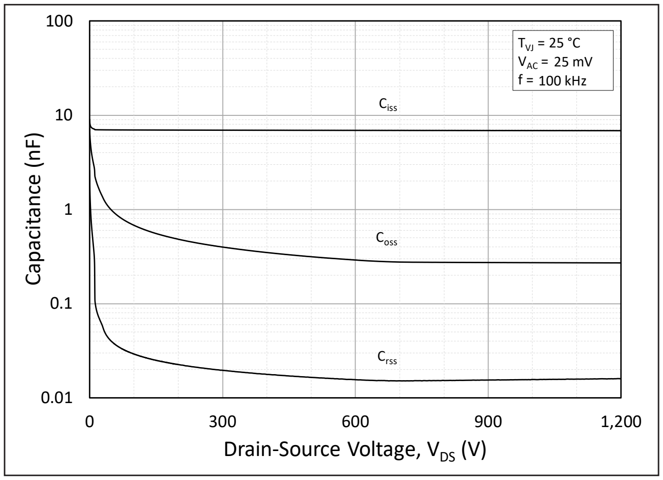


Figure 9. Typical Capacitances vs. Drain to Source Voltage (0 - 1200 V)

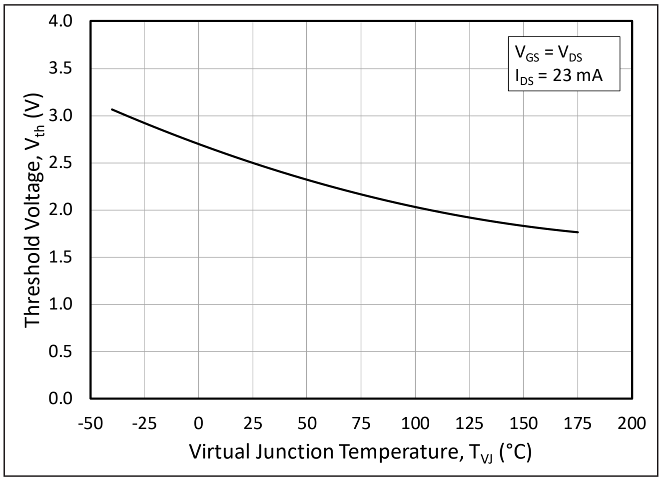


Figure 10. Threshold Voltage vs. Junction Temperature

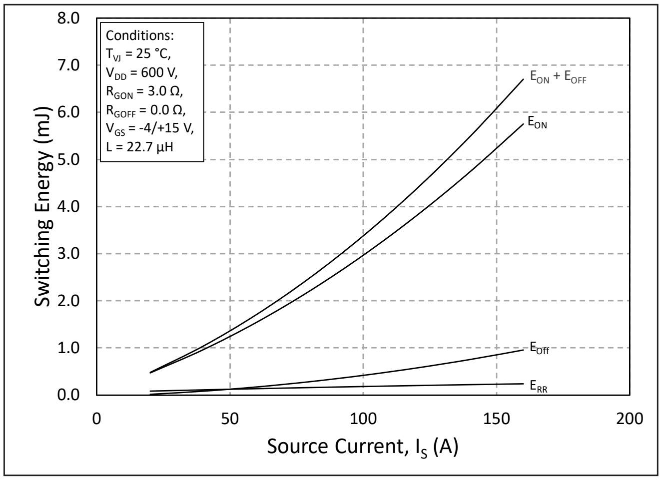


Figure 11. Switching Energy vs. Drain Current (V_{DD} = 600 V)

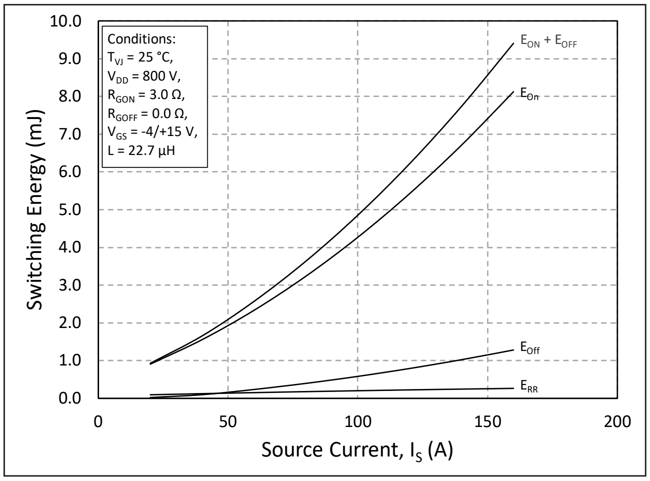


Figure 12. Switching Energy vs. Drain Current (V_{DD} = 800 V)

Typical Performance

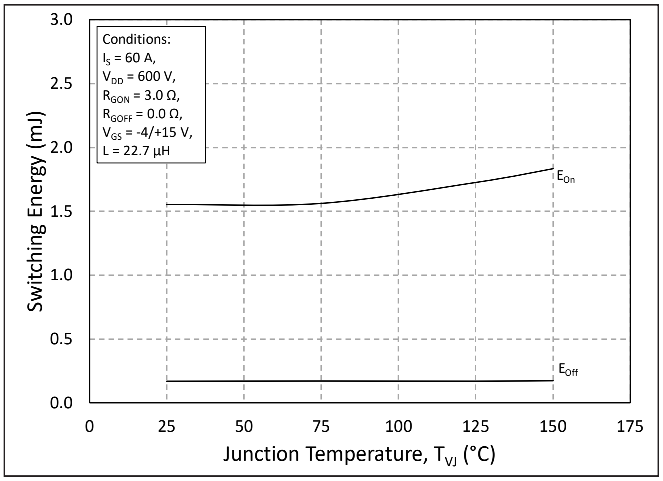


Figure 13. MOSFET Switching Energy vs. Junction Temperature

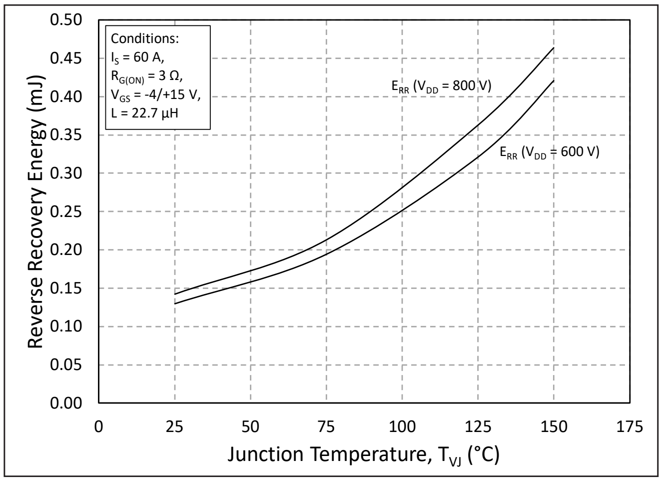


Figure 14. Reverse Recovery Energy vs. Junction Temperature

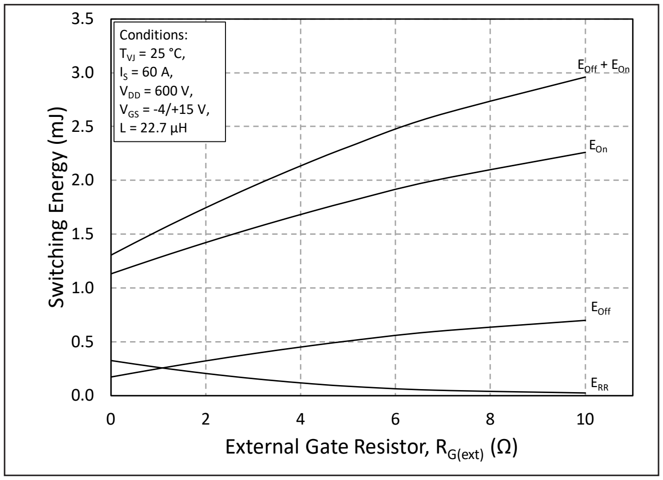


Figure 15. MOSFET Switching Energy vs. External Gate Resistance

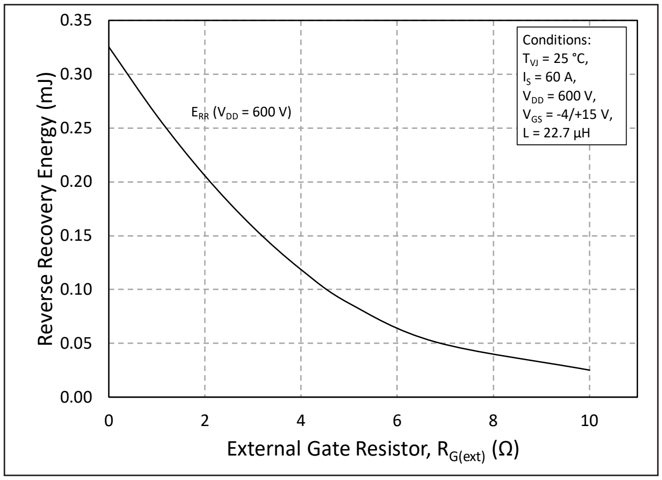


Figure 16. Reverse Recovery Energy vs. External Gate Resistance

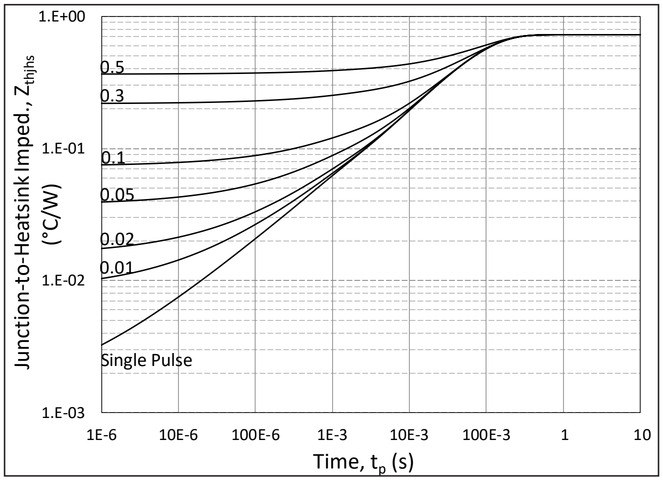


Figure 17. MOSFET Junction to Heatsink Transient Thermal Impedance, $Z_{th\ JHS}$ (°C/W)

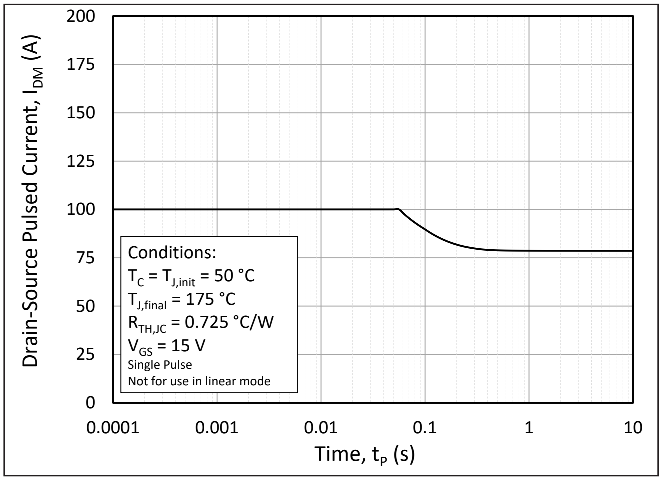


Figure 18. Pulse Current Safe Operating Area

Typical Performance

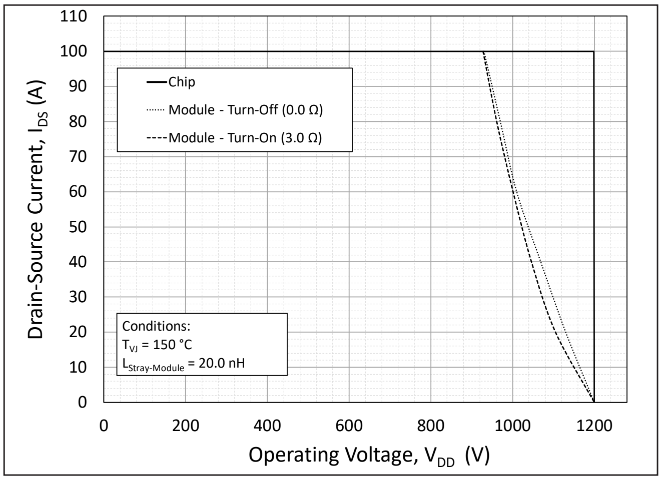


Figure 19. Switching Safe Operating Area

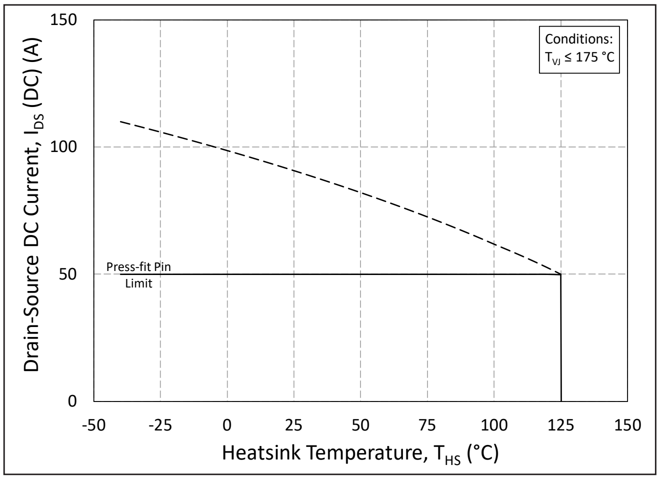


Figure 20. Continuous Drain Current Derating vs. Heatsink Temperature

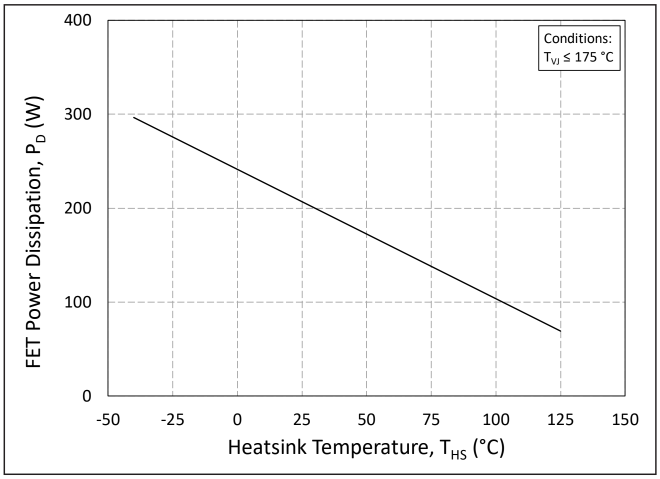


Figure 21. Maximum Power Dissipation Derating vs. Heatsink Temperature

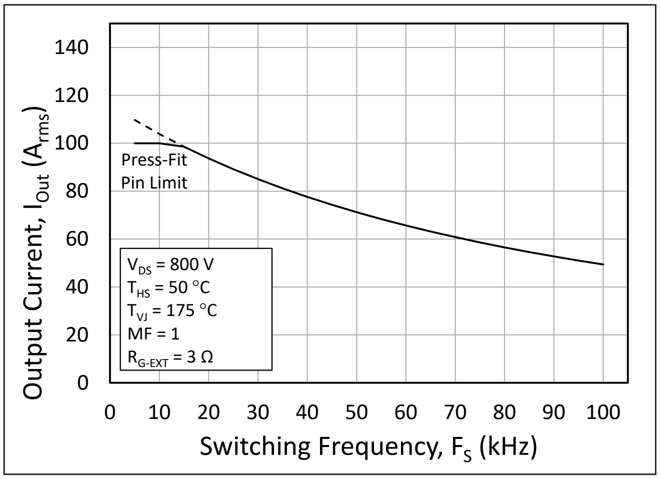


Figure 22. Typical Output Current Capability vs. Switching Frequency (Inverter Application)

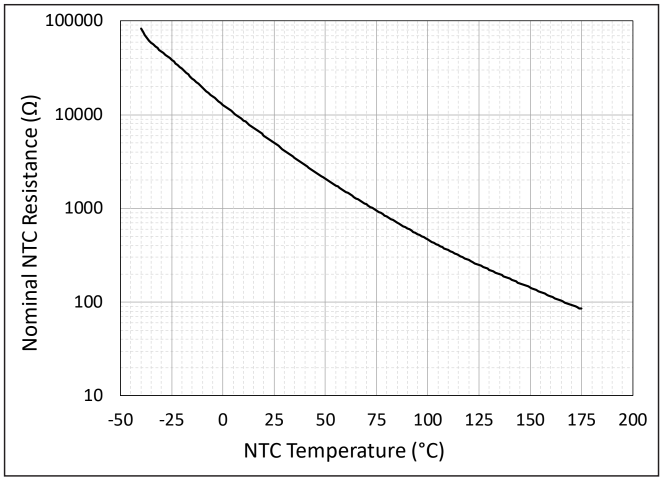


Figure 23. Nominal NTC Resistance vs. NTC Temperature

Timing Characteristics

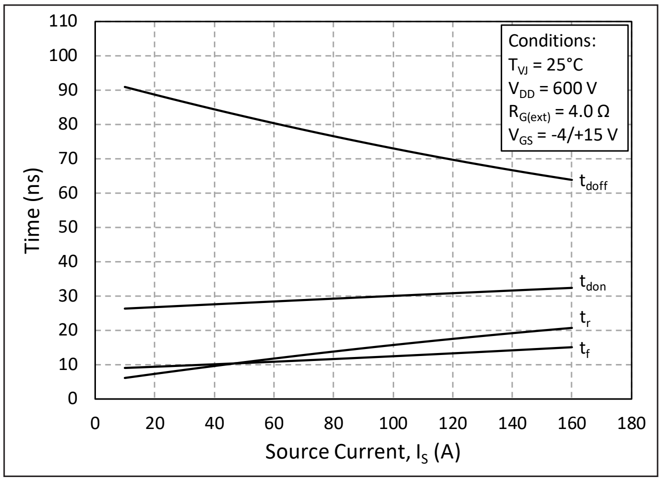


Figure 24. Timing vs. Source Current

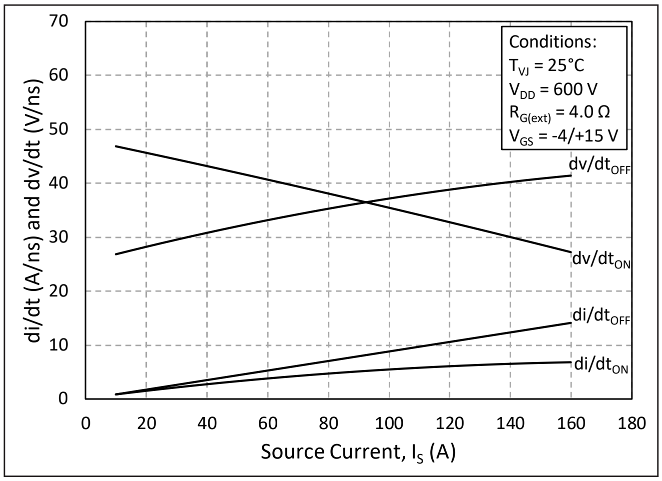


Figure 25. dv/dt and di/dt vs. Source Current

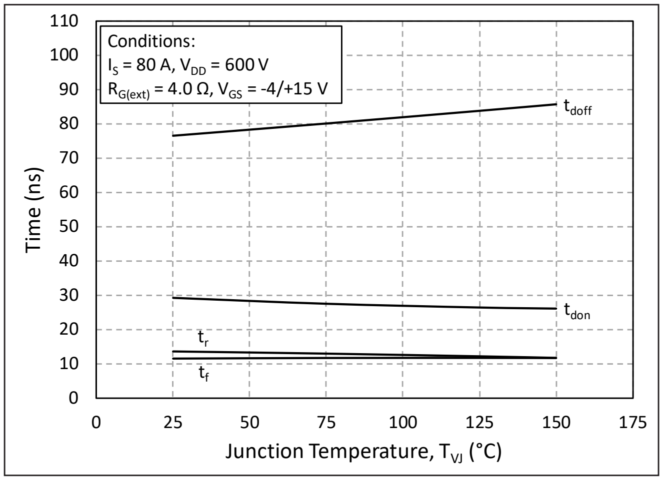


Figure 26. Timing vs. Junction Temperature

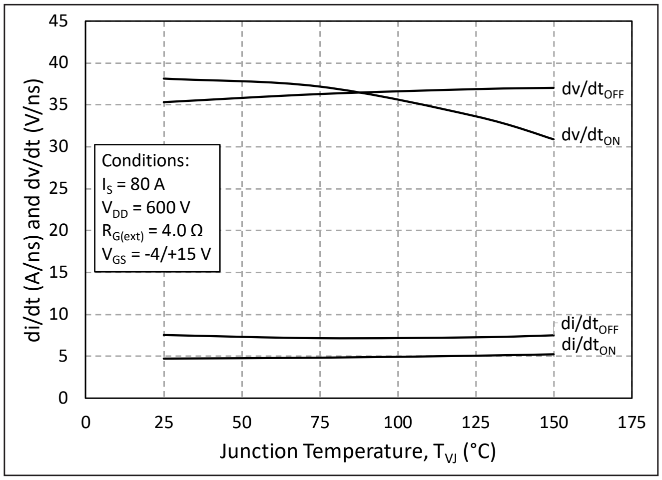


Figure 27. dv/dt and di/dt vs. Junction Temperature

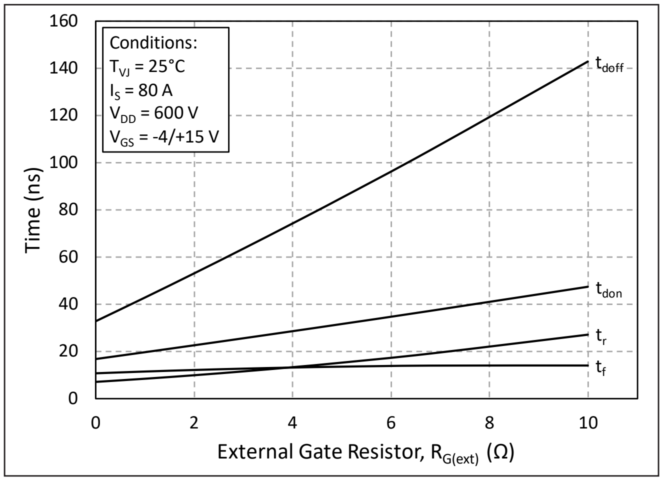


Figure 28. Timing vs. External Gate Resistance

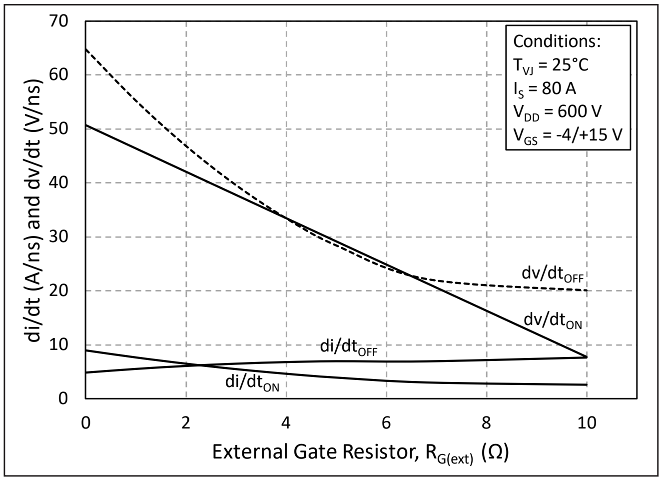


Figure 29. dv/dt and di/dt vs. External Gate Resistance

Definitions

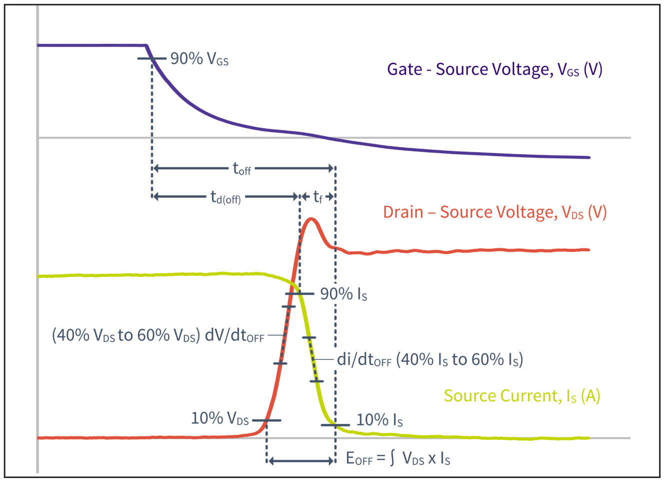


Figure 30. Turn-off Transient Definitions

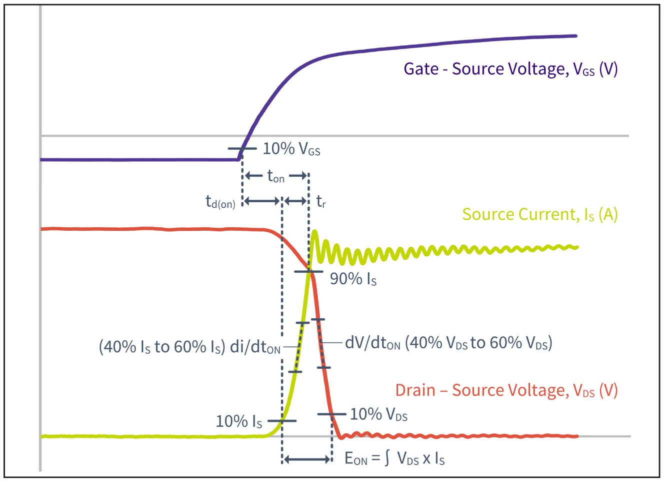


Figure 31. Turn-on Transient Definitions

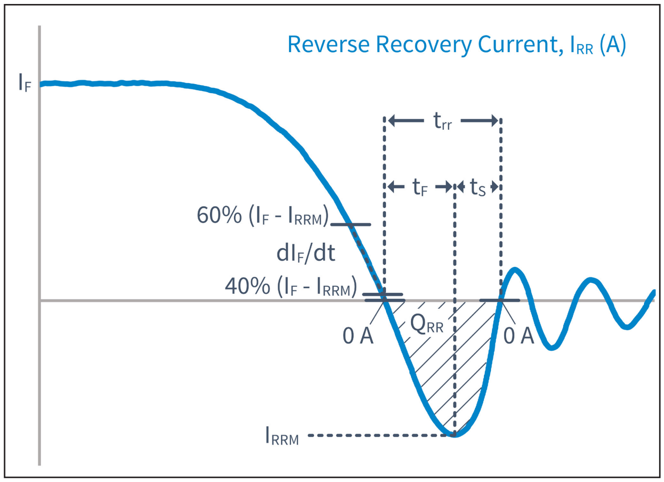


Figure 32. Reverse Recovery Definitions

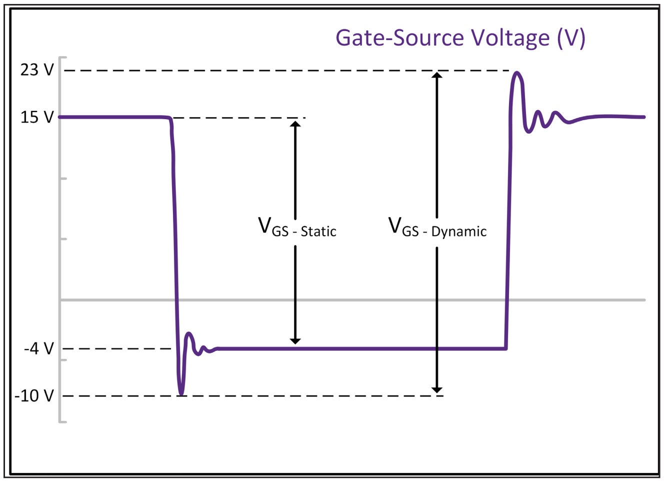
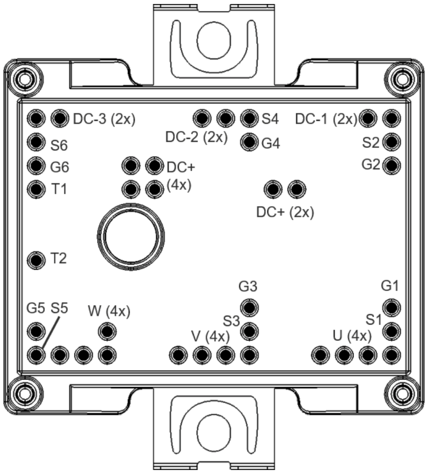
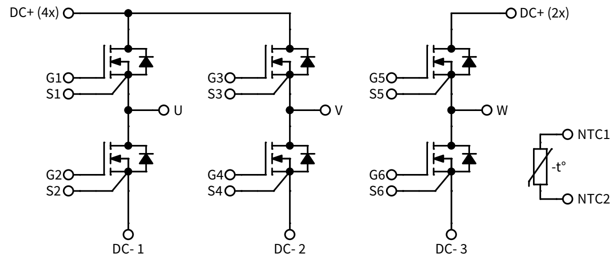


Figure 33. V_{GS} Transient Definitions

Note (7): The CGD1700HB2M-UNA, which features the UCC21710 gate driver IC, was used to evaluate dynamic performance. The typical driver high-state output resistance of 2.5 Ω and low-state output resistance of 0.3 Ω are not included in the $R_{G(ext)}$ values on this datasheet.

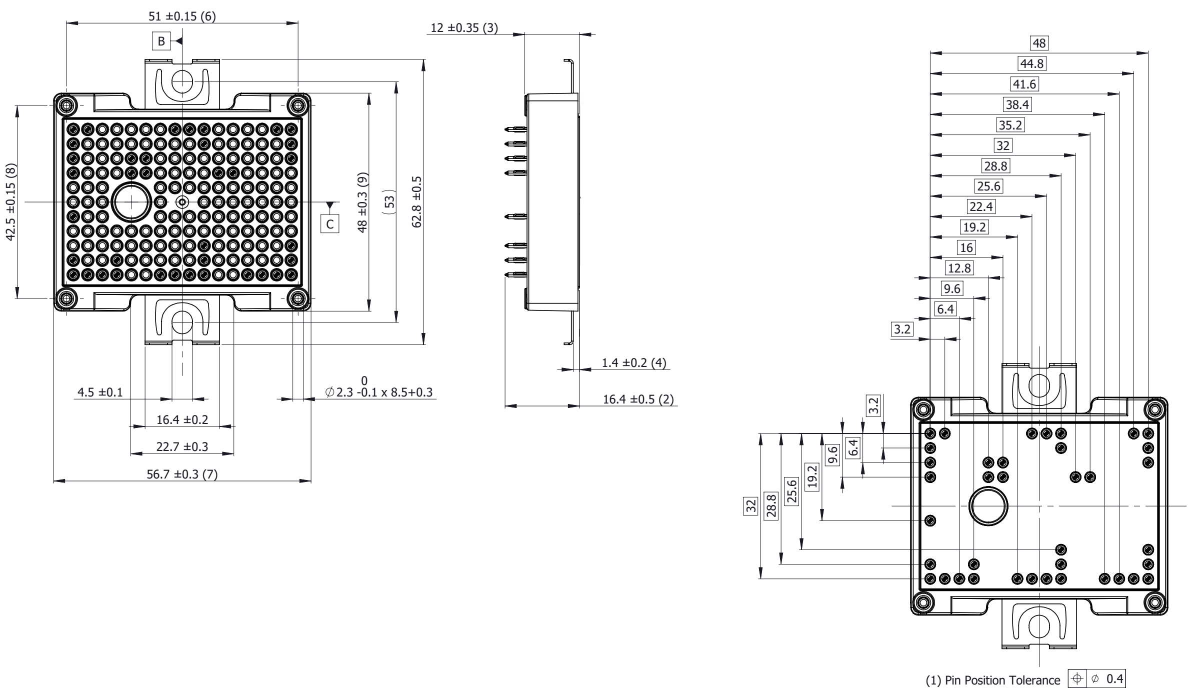
Pinout





DC+ pins must be connected externally at the PCB level.

Package Dimension (mm)



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Product Ordering Code

Part Number	Description
CCB016M12GM3	Without Pre-Applied Phase Change Thermal Interface Material
CCB016M12GM3T	With Pre-Applied Phase Change Thermal Interface Material

Supporting Links & Tools

Simulation Tools & Support

- All LTSpice Models
- All PLECS Models
- SpeedFit 2.0 Design Simulator™
- Technical Support Forum

Compatible Evaluation Hardware

- EVAL-ADUM4146WHB1Z: Analog Devices® Gate Driver Board
- UCC21710QDWEVM-054: Texas Instruments® Gate Driver Board
- Si823H-AxWA-KIT: Skyworks® Gate Driver Board
- ACPL-355JC: Broadcom® Gate Driver Board
- CGD1700HB2M-UNA: Wolfspeed Gate Driver Board
- CGD12HB00D: Differential Transceiver Daughter Board Companion Tool for Differential Gate Drivers

Application Notes

- PRD-02302: Wolfpack Mounting Instructions and PCB Requirements
- PRD-06379: Environmental Considerations for Power Electronics
- PRD-07845: Power Module Baseplate Capacitance and Electromagnetic Compatibility
- PRD-07933: Wolfspeed Power Module Thermal Interface Material Application User Guide
- PRD-07968: Wolfspeed WolfPACK™ Dynamic Performance
- PRD-08376: Thermal Characterization Methods and Applications
- PRD-08710: Measuring Stray Inductance in Power Electronics Systems

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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 Wolfspeed representative or from the Product Documentation sections of www.wolfspeed.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 Wolfspeed 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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