

# QORVO

## SiC JFET Division

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DATASHEET

# UF4SC120023B7S

## Silicon Carbide (SiC) Cascode JFET - EliteSiC, Power N-Channel, D<sup>2</sup>PAK-7L, 1200 V, 23 mohm

Rev. B, January 2025

### Description

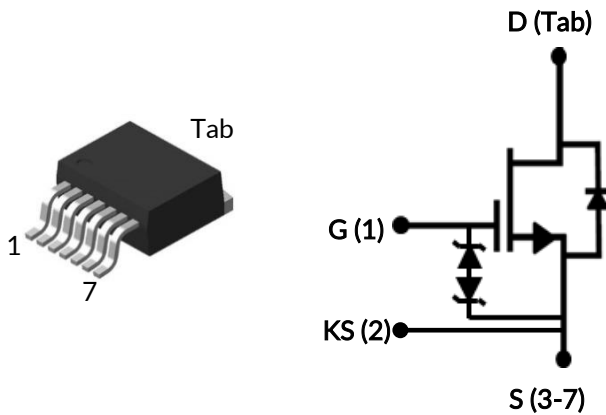
The UF4SC120023B7S is a 1200V, 23mΩ G4 SiC FET. It is based on a unique ‘cascode’ circuit configuration, in which a normally-on SiC JFET is co-packaged with a Si MOSFET to produce a normally-off SiC FET device. The device’s standard gate-drive characteristics allows use of off-the-shelf gate drivers hence requiring minimal re-design when replacing Si IGBTs, Si superjunction devices or SiC MOSFETs. Available in the space-saving D<sup>2</sup>PAK-7L package which enables automated assembly, this device exhibits ultra-low gate charge and exceptional reverse recovery characteristics, making it ideal for switching inductive loads and any application requiring standard gate drive.

### Features

- ◆ On-resistance  $R_{DS(on)}$ : 23mΩ (typ)
- ◆ Operating temperature: 175°C (max)
- ◆ Excellent reverse recovery:  $Q_{rr}$  = 243 nC
- ◆ Low body diode  $V_{FSD}$ : 1.2V
- ◆ Low gate charge:  $Q_G$  = 37.8nC
- ◆ Threshold voltage  $V_{G(th)}$ : 4.8V (typ) allowing 0 to 15V drive
- ◆ Low intrinsic capacitance
- ◆ ESD protected: HBM class 2 and CDM class C3
- ◆ D<sup>2</sup>PAK-7L package for faster switching, clean gate waveforms
- ◆ AECQ Qualified

### Typical applications

- ◆ EV charging
- ◆ PV inverters
- ◆ Switch mode power supplies
- ◆ Power factor correction modules
- ◆ Induction heating



Part Number	Package	Marking
UF4SC120023B7S	D <sup>2</sup> PAK-7L	UF4SC120023B7S



## Maximum Ratings

Parameter	Symbol	Test Conditions	Value	Units
Drain-source voltage	$V_{DS}$		1200	V
Gate-source voltage	$V_{GS}$	DC	-20 to +20	V
Continuous drain current <sup>1</sup>	$I_D$	$T_C = 25^\circ\text{C}$	72	A
		$T_C = 100^\circ\text{C}$	51	A
Pulsed drain current <sup>2</sup>	$I_{DM}$	$T_C = 25^\circ\text{C}$	204	A
Single pulsed avalanche energy <sup>3</sup>	$E_{AS}$	$L=15\text{mH}, I_{AS}=4.1\text{A}$	126	mJ
SiC FET dv/dt ruggedness	dv/dt	$V_{DS} \leq 800\text{V}$	150	V/ns
Power dissipation	$P_{tot}$	$T_C = 25^\circ\text{C}$	385	W
Maximum junction temperature	$T_{J,max}$		175	$^\circ\text{C}$
Operating and storage temperature	$T_J, T_{STG}$		-55 to 175	$^\circ\text{C}$
Reflow soldering Temperature	$T_{solder}$	reflow MSL 1	245	$^\circ\text{C}$

- Limited by  $T_{J,max}$
- Pulse width  $t_p$  limited by  $T_{J,max}$
- Starting  $T_J = 25^\circ\text{C}$

## Thermal Characteristics

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Thermal resistance, junction-to-case	$R_{\theta JC}$			0.3	0.39	$^\circ\text{C}/\text{W}$

## Electrical Characteristics ( $T_J = +25^\circ\text{C}$ unless otherwise specified)

### Typical Performance - Static

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Drain-source breakdown voltage	$BV_{DS}$	$V_{GS}=0V, I_D=1mA$	1200			V
Total drain leakage current	$I_{DSS}$	$V_{DS}=1200V,$ $V_{GS}=0V, T_J=25^\circ\text{C}$		2	60	$\mu\text{A}$
		$V_{DS}=1200V,$ $V_{GS}=0V, T_J=175^\circ\text{C}$		20		
Total gate leakage current	$I_{GSS}$	$V_{DS}=0V, T_J=25^\circ\text{C},$ $V_{GS}=-20V / +20V$		6	$\pm 20$	$\mu\text{A}$
Drain-source on-resistance	$R_{DS(on)}$	$V_{GS}=12V, I_D=40A,$ $T_J=25^\circ\text{C}$		23	30	m $\Omega$
		$V_{GS}=12V, I_D=40A,$ $T_J=125^\circ\text{C}$		42		
		$V_{GS}=12V, I_D=40A,$ $T_J=175^\circ\text{C}$		62		
Gate threshold voltage	$V_{G(th)}$	$V_{DS}=5V, I_D=10mA$	4	4.8	6	V
Gate resistance	$R_G$	f=1MHz, open drain		4.5		$\Omega$

### Typical Performance - Reverse Diode

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Diode continuous forward current <sup>1</sup>	$I_S$	$T_C = 25^\circ\text{C}$			72	A
Diode pulse current <sup>2</sup>	$I_{S,pulse}$	$T_C = 25^\circ\text{C}$			204	A
Forward voltage	$V_{FSD}$	$V_{GS}=0V, I_S=20A,$ $T_J=25^\circ\text{C}$		1.2	1.4	V
		$V_{GS}=0V, I_S=20A,$ $T_J=175^\circ\text{C}$		1.65		
Reverse recovery charge	$Q_{rr}$	$V_R=800V, I_S=40A,$ $V_{GS}=0V, R_G=50\Omega$		243		nC
Reverse recovery time	$t_{rr}$	di/dt=2000A/ $\mu\text{s},$ $T_J=25^\circ\text{C}$		26.8		ns
Reverse recovery charge	$Q_{rr}$	$V_R=800V, I_S=40A,$ $V_{GS}=0V, R_G=50\Omega$		264		nC
Reverse recovery time	$t_{rr}$	di/dt=2000A/ $\mu\text{s},$ $T_J=150^\circ\text{C}$		28.8		ns

## Typical Performance - Dynamic

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Input capacitance	$C_{iss}$	$V_{DS}=800V, V_{GS}=0V$ $f=100kHz$		1430		pF
Output capacitance	$C_{oss}$			85		
Reverse transfer capacitance	$C_{rss}$			2		
Effective output capacitance, energy related	$C_{oss(er)}$	$V_{DS}=0V$ to 800V, $V_{GS}=0V$		108		pF
Effective output capacitance, time related	$C_{oss(tr)}$	$V_{DS}=0V$ to 800V, $V_{GS}=0V$		200		pF
$C_{OSS}$ stored energy	$E_{oss}$	$V_{DS}=800V, V_{GS}=0V$		35		$\mu J$
Total gate charge	$Q_G$	$V_{DS}=800V, I_D=40A,$ $V_{GS} = 0V$ to 15V		37.8		nC
Gate-drain charge	$Q_{GD}$			8		
Gate-source charge	$Q_{GS}$			11.8		
Turn-on delay time	$t_{d(on)}$	Note 4 and 5, $V_{DS}=800V, I_D=40A,$ Gate Driver =0V to +15V,		23		ns
Rise time	$t_r$	$R_{G\_ON}=10\Omega, R_{G\_OFF}=20\Omega,$ inductive Load,		25		
Turn-off delay time	$t_{d(off)}$			64		
Fall time	$t_f$	FWD: same device with $V_{GS} = 0V$ and $R_G = 20\Omega,$ Snubber: $R_s=10\Omega,$ $C_s=100pF$ $T_J=25^\circ C$		10		
Turn-on energy including $R_s$ energy	$E_{ON}$	Note 4 and 5, $V_{DS}=800V, I_D=40A,$ Gate Driver =0V to +15V, $R_{G\_ON}=10\Omega, R_{G\_OFF}=20\Omega,$ inductive Load, FWD: same device with $V_{GS} = 0V$ and $R_G = 20\Omega,$ Snubber: $R_s=10\Omega,$ $C_s=100pF$ $T_J=25^\circ C$		719		mJ
Turn-off energy including $R_s$ energy	$E_{OFF}$			95		
Total switching energy	$E_{TOTAL}$			814		
Snubber $R_s$ energy during turn-on	$E_{RS\_ON}$			8		
Snubber $R_s$ energy during turn-off	$E_{RS\_OFF}$			15		
Turn-on delay time	$t_{d(on)}$		Note 4 and 5, $V_{DS}=800V, I_D=40A,$ Gate Driver =0V to +15V, $R_{G\_ON}=10\Omega, R_{G\_OFF}=20\Omega,$ inductive Load,		21	
Rise time	$t_r$	FWD: same device with $V_{GS} = 0V$ and $R_G = 20\Omega,$ Snubber: $R_s=10\Omega,$ $C_s=100pF$ $T_J=150^\circ C$		27		
Turn-off delay time	$t_{d(off)}$			63		
Fall time	$t_f$		10			
Turn-on energy including $R_s$ energy	$E_{ON}$	Note 4 and 5, $V_{DS}=800V, I_D=40A,$ Gate Driver =0V to +15V, $R_{G\_ON}=10\Omega, R_{G\_OFF}=20\Omega,$ inductive Load, FWD: same device with $V_{GS} = 0V$ and $R_G = 20\Omega,$ Snubber: $R_s=10\Omega,$ $C_s=100pF$ $T_J=150^\circ C$		781		$\mu J$
Turn-off energy including $R_s$ energy	$E_{OFF}$			111		
Total switching energy	$E_{TOTAL}$			892		
Snubber $R_s$ energy during turn-on	$E_{RS\_ON}$			11		
Snubber $R_s$ energy during turn-off	$E_{RS\_OFF}$			15		

4. Measured with the switching test circuit in Figure 26.

5. In this datasheet, all the switching energies (turn-on energy, turn-off energy and total energy) presented in the tables and Figures include the device RC snubber energy losses.

Typical Performance Diagrams

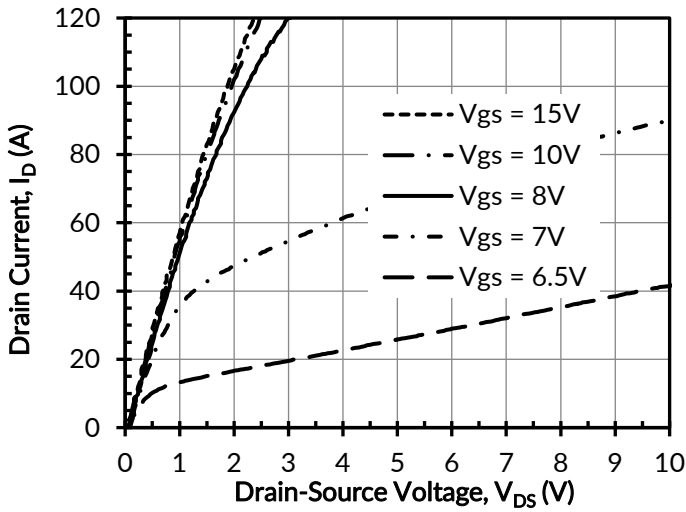


Figure 1. Typical output characteristics at  $T_j = -55^\circ\text{C}$ ,  $t_p < 250\mu\text{s}$

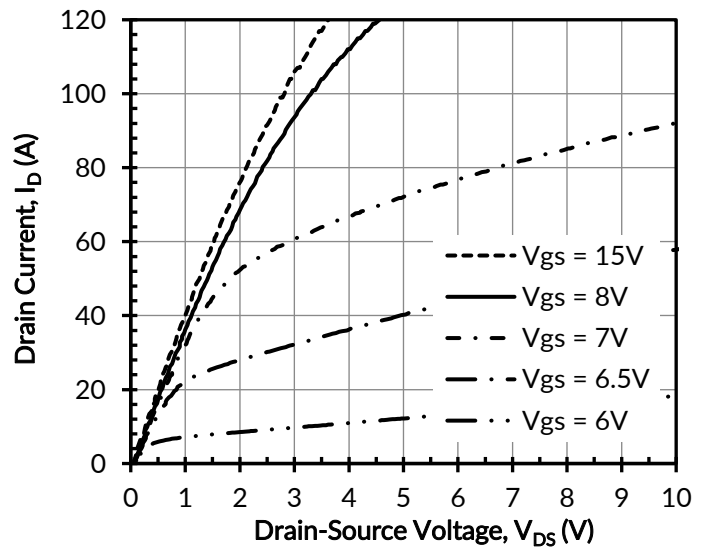


Figure 2. Typical output characteristics at  $T_j = 25^\circ\text{C}$ ,  $t_p < 250\mu\text{s}$

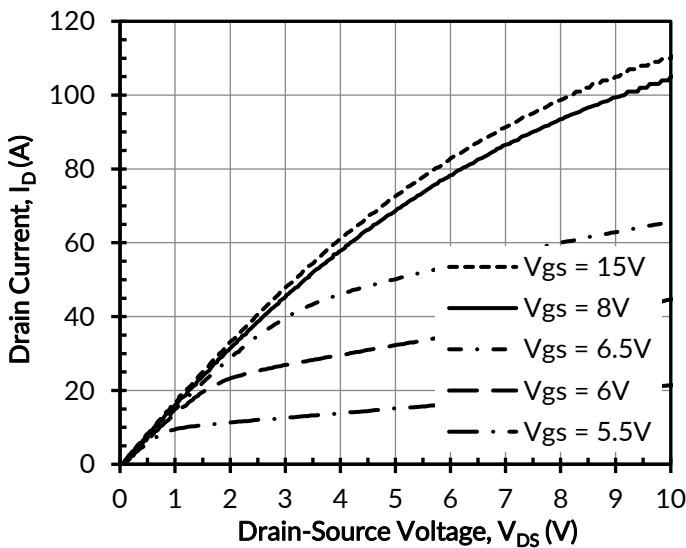


Figure 3. Typical output characteristics at  $T_j = 175^\circ\text{C}$ ,  $t_p < 250\mu\text{s}$

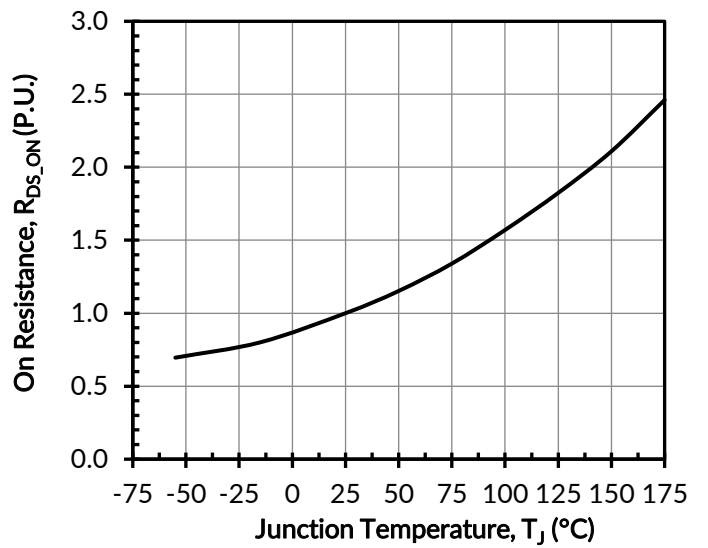


Figure 4. Normalized on-resistance vs. temperature at  $V_{GS} = 12\text{V}$  and  $I_D = 40\text{A}$

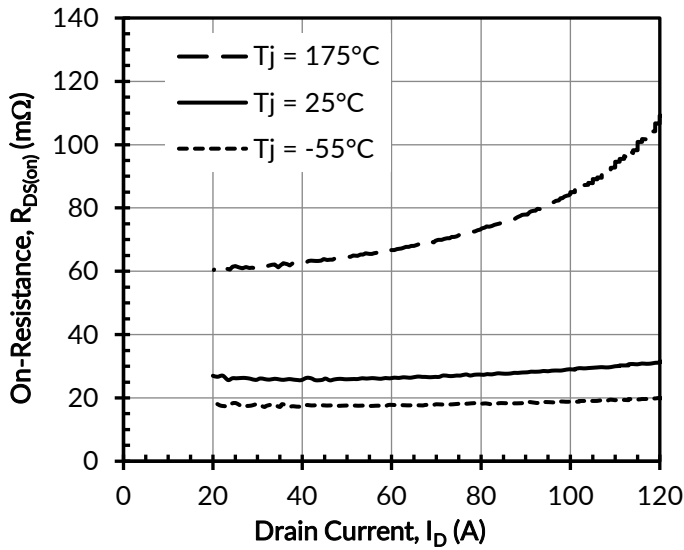


Figure 5. Typical drain-source on-resistances at  $V_{GS} = 12V$

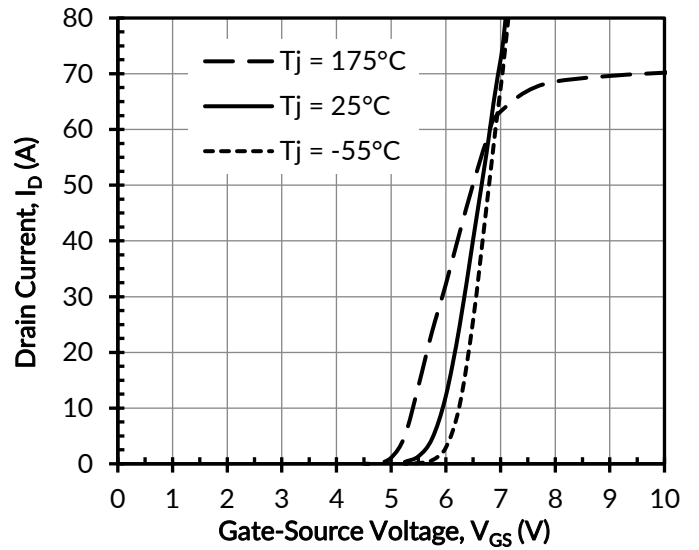


Figure 6. Typical transfer characteristics at  $V_{DS} = 5V$

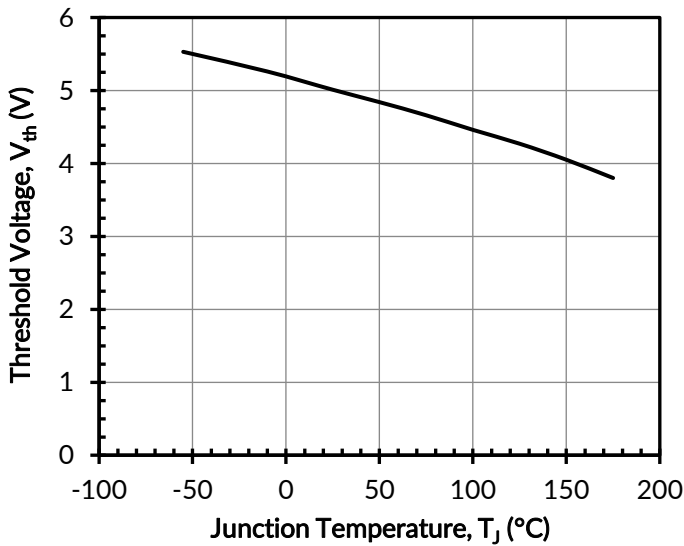


Figure 7. Threshold voltage vs. junction temperature at  $V_{DS} = 5V$  and  $I_D = 10mA$

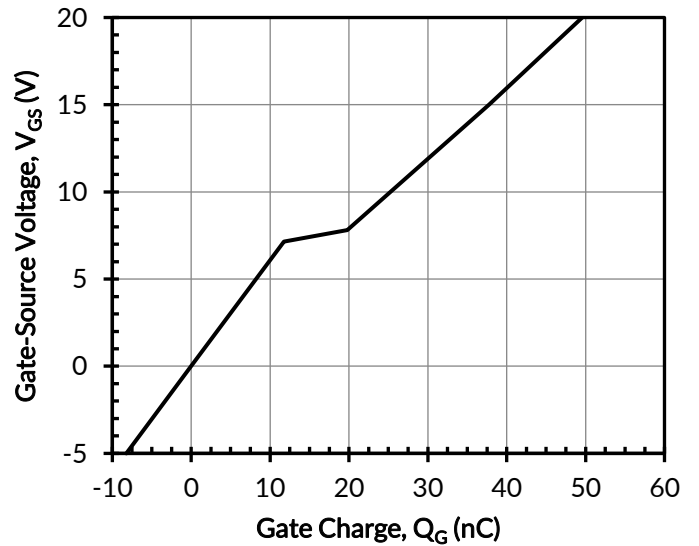


Figure 8. Typical gate charge at  $V_{DS} = 800V$   $I_D = 40A$

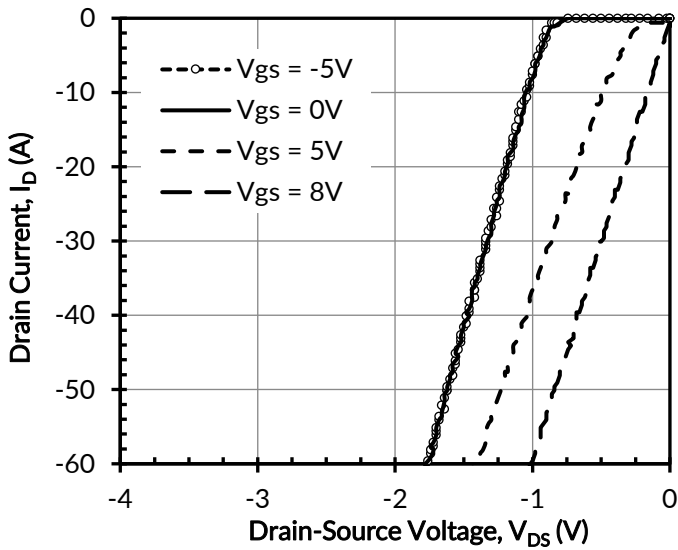


Figure 9. 3rd quadrant characteristics at  $T_j = -55^\circ\text{C}$

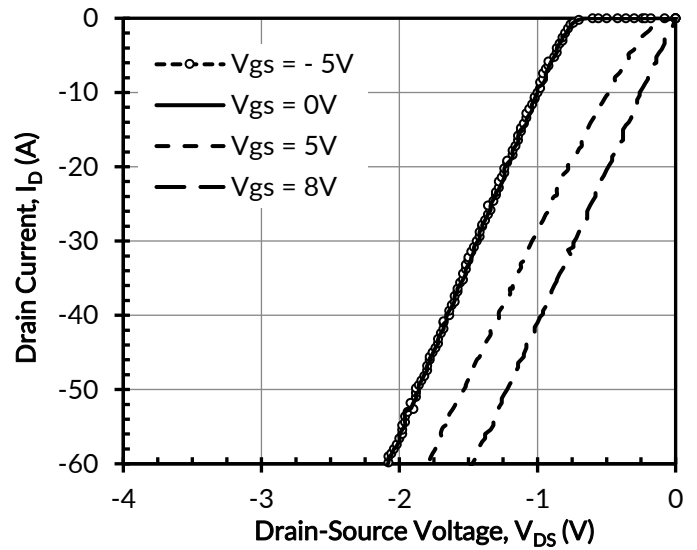


Figure 10. 3rd quadrant characteristics at  $T_j = 25^\circ\text{C}$

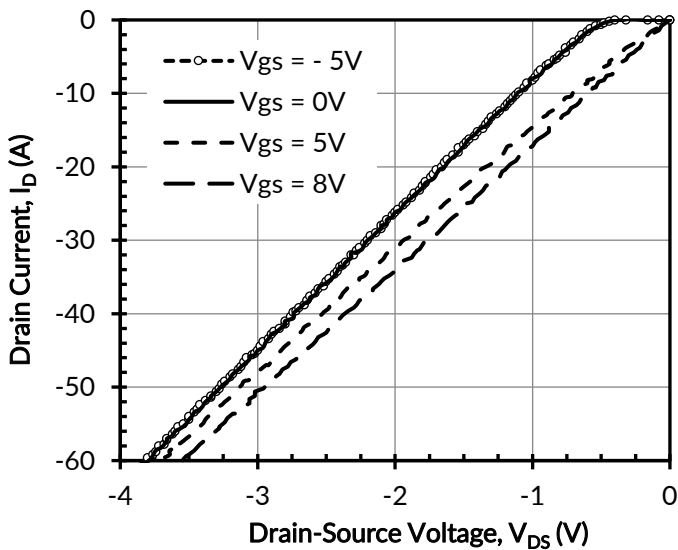


Figure 11. 3rd quadrant characteristics at  $T_j = 175^\circ\text{C}$

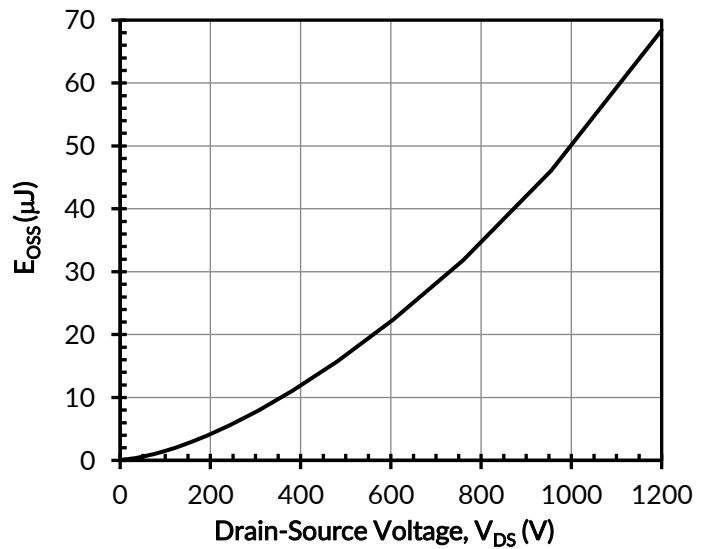


Figure 12. Typical stored energy in  $C_{OSS}$  at  $V_{GS} = 0\text{V}$



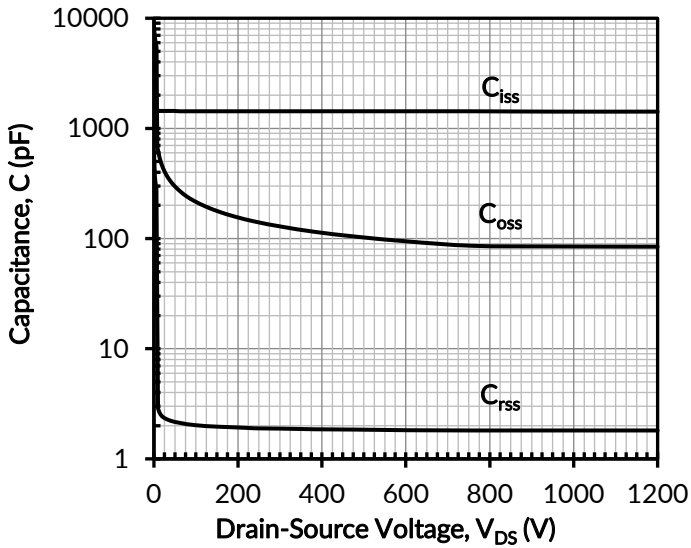


Figure 13. Typical capacitances at  $f = 100\text{kHz}$  and  $V_{GS} = 0\text{V}$

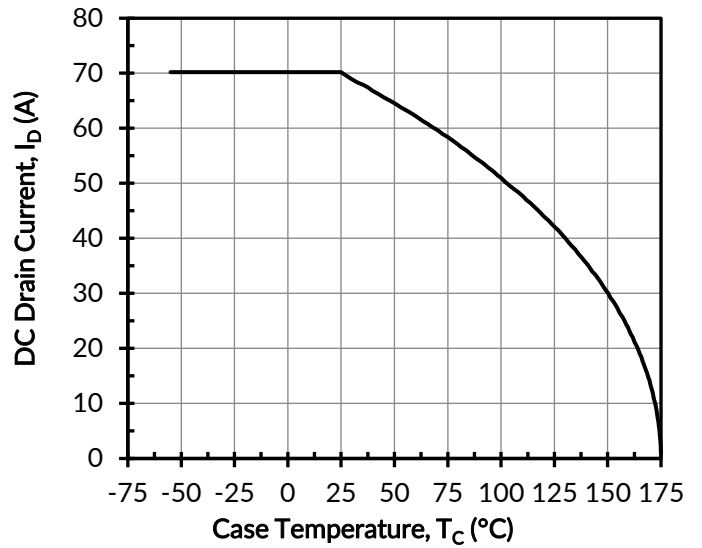


Figure 14. DC drain current derating

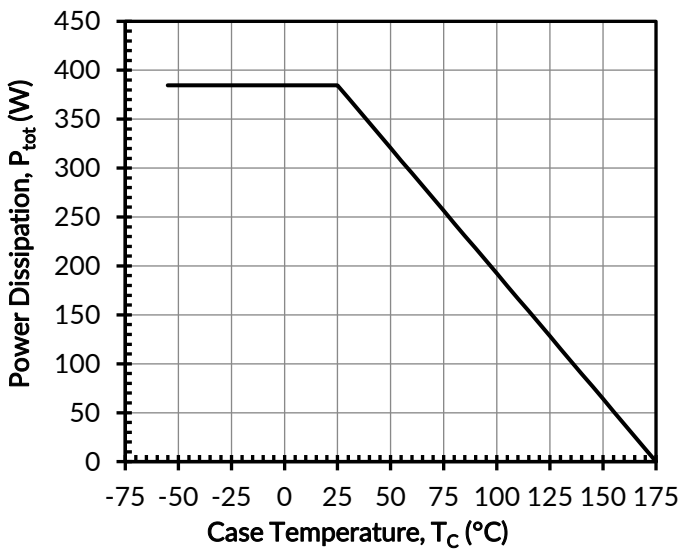


Figure 15. Total power dissipation

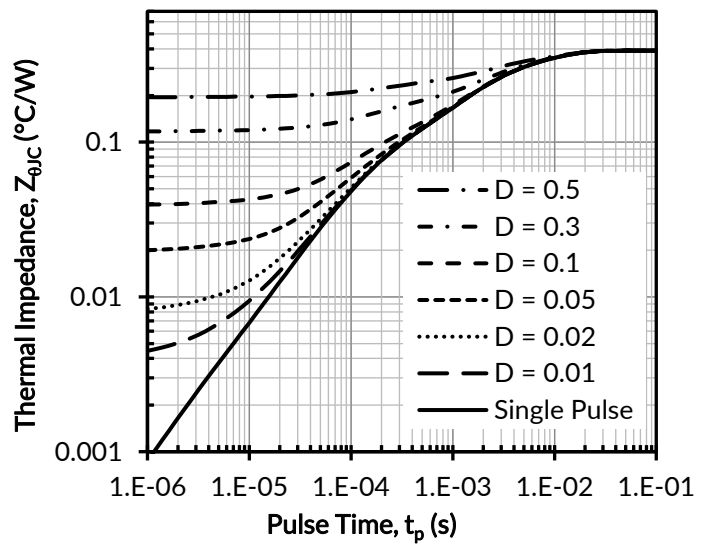


Figure 16. Maximum transient thermal impedance

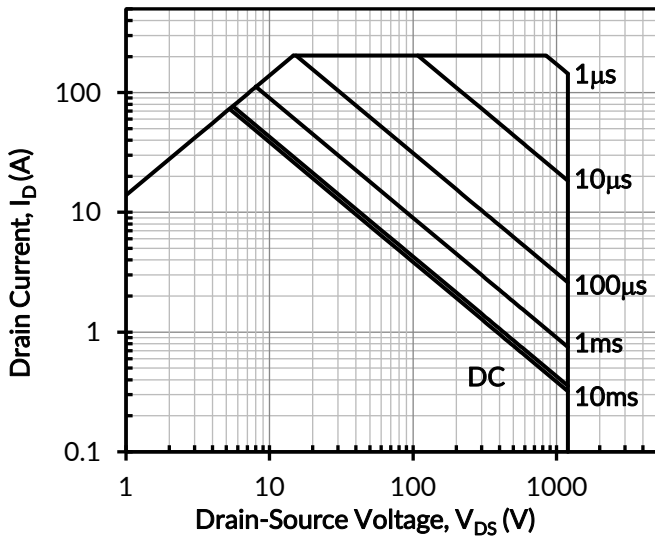


Figure 17. Safe operation area at  $T_C = 25^\circ\text{C}$ ,  $D = 0$ , Parameter  $t_p$

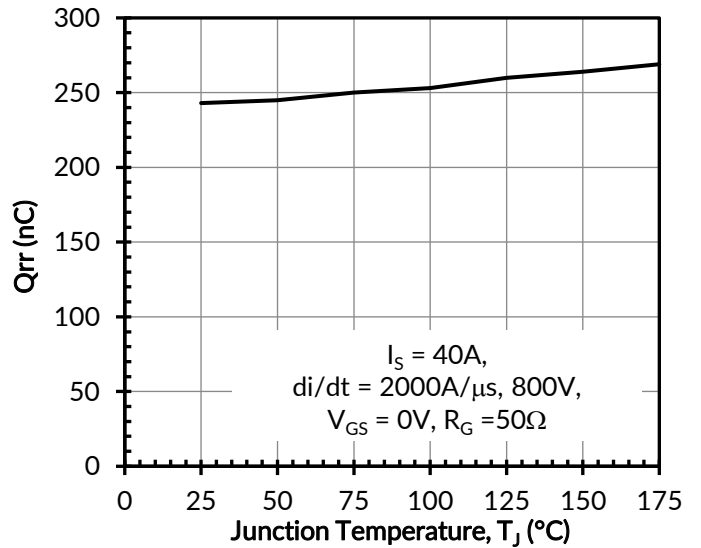


Figure 18. Reverse recovery charge  $Q_{rr}$  vs. junction temperature at  $V_{DS} = 800\text{V}$

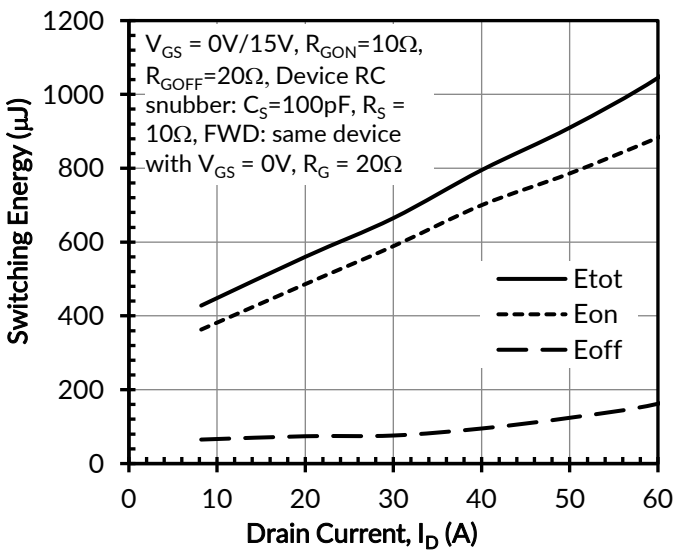


Figure 19. Clamped inductive switching energy vs. drain current at  $V_{DS} = 800\text{V}$  and  $T_J = 25^\circ\text{C}$

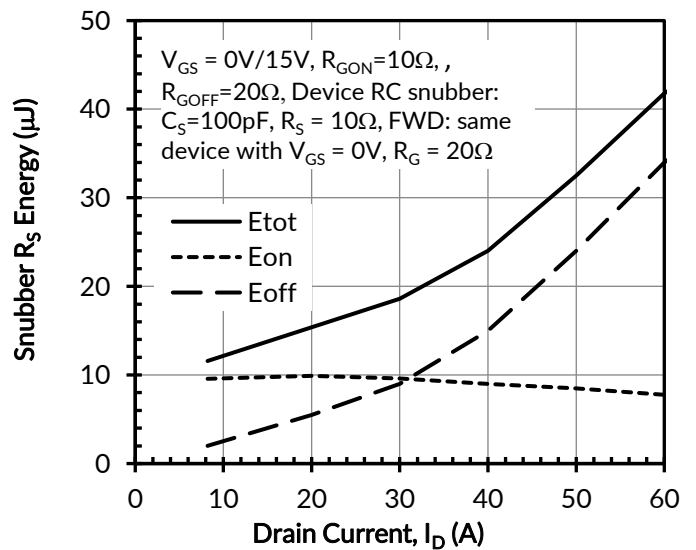


Figure 20. RC snubber energy loss vs. drain current at  $V_{DS} = 800\text{V}$  and  $T_J = 25^\circ\text{C}$

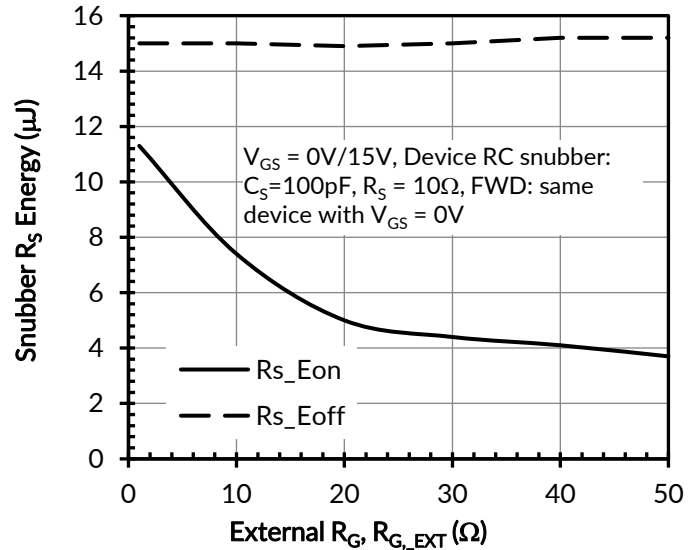
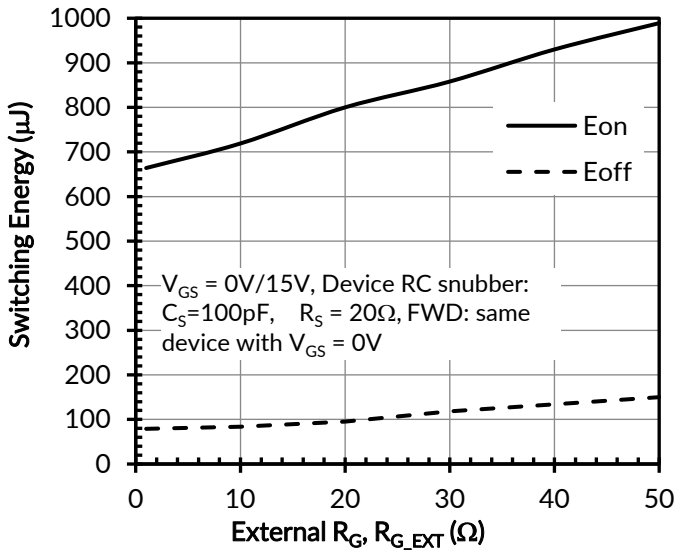


Figure 21. Clamped inductive switching energies vs.  $R_{G\_EXT}$  at  $V_{DS} = 800V$ ,  $I_D = 40A$ , and  $T_J = 25^\circ C$

Figure 22. RC snubber energy loss vs.  $R_{G\_EXT}$  at  $V_{DS} = 800V$ ,  $I_D = 40A$ , and  $T_J = 25^\circ C$

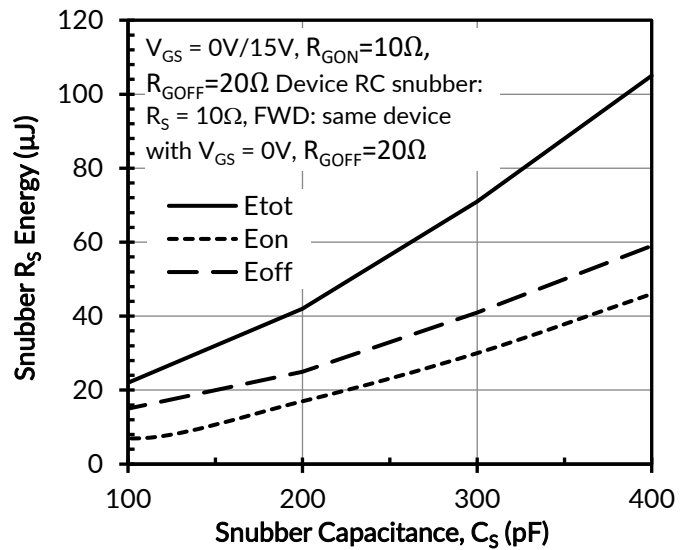
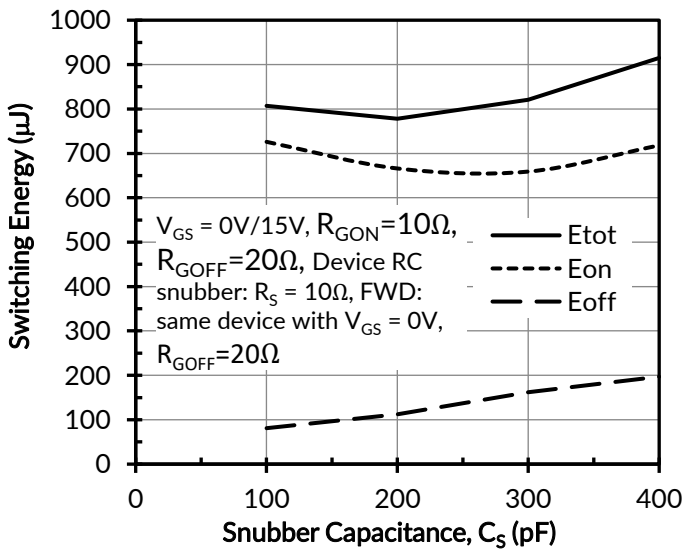


Figure 23. Clamped inductive switching energies vs. snubber capacitance  $C_S$  at  $V_{DS} = 800V$ ,  $I_D = 40A$ , and  $T_J = 25^\circ C$

Figure 24. RC snubber energy losses vs. snubber capacitance  $C_S$  at  $V_{DS} = 800V$ ,  $I_D = 40A$ , and  $T_J = 25^\circ C$

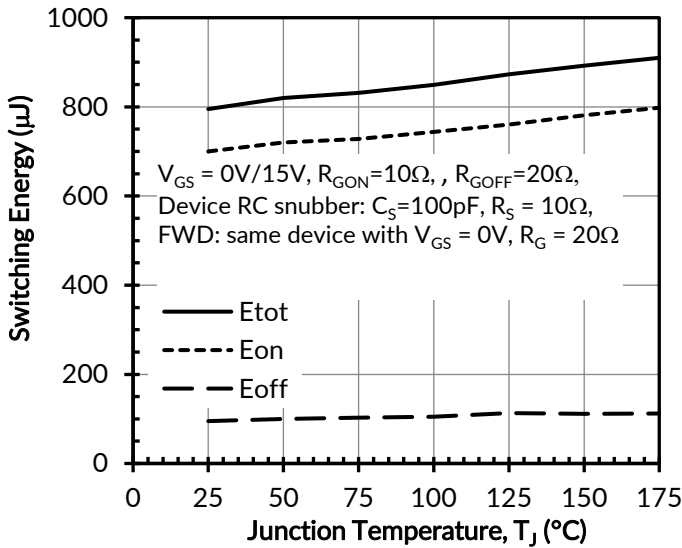


Figure 25. Clamped inductive switching energy vs. junction temperature at  $V_{DS} = 800V$  and  $I_D = 40A$

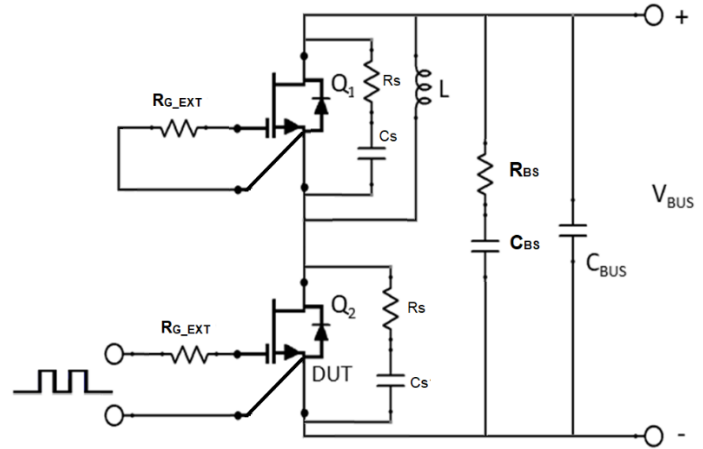


Figure 26. Schematic of the half-bridge mode switching test circuit with device RC snubbers ( $R_S = 10\Omega$ ,  $C_S = 100pF$ ) and a bus RC snubber ( $R_{BS} = 2.5\Omega$ ,  $C_{BS} = 100nF$ ).

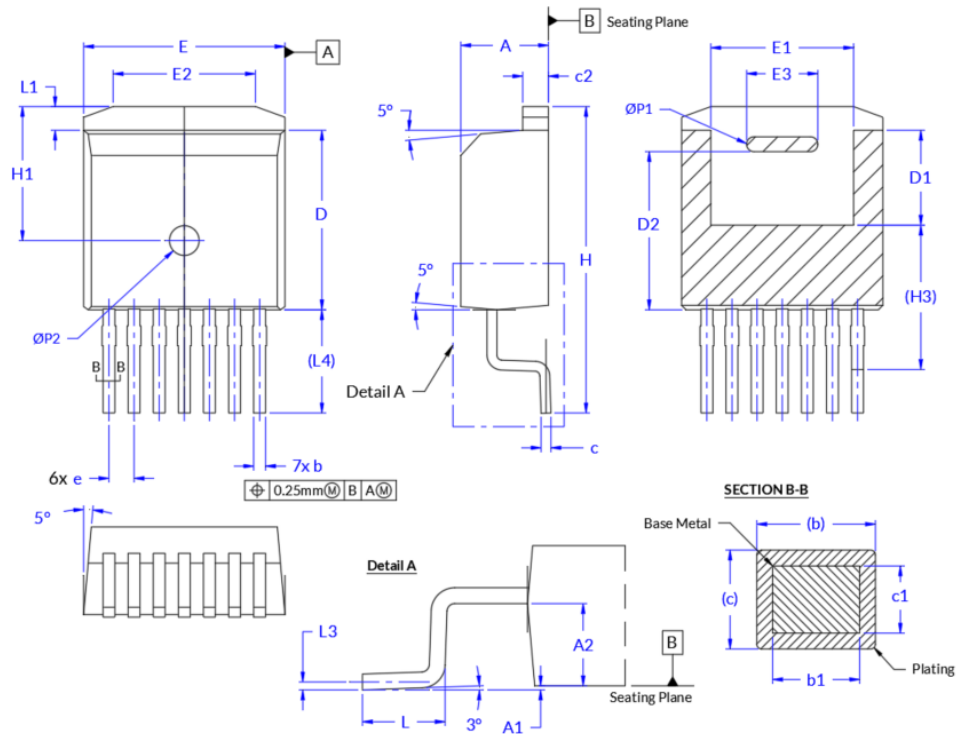
## Applications Information

SiC FETs are enhancement-mode power switches formed by a high-voltage SiC depletion-mode JFET and a low-voltage silicon MOSFET connected in series. The silicon MOSFET serves as the control unit while the SiC JFET provides high voltage blocking in the off state. This combination of devices in a single package provides compatibility with standard gate drivers and offers superior performance in terms of low on-resistance ( $R_{DS(on)}$ ), output capacitance ( $C_{oss}$ ), gate charge ( $Q_G$ ), and reverse recovery charge ( $Q_{rr}$ ) leading to low conduction and switching losses. The SiC FETs also provide excellent reverse conduction capability eliminating the need for an external anti-parallel diode. Like other high performance power switches, proper PCB layout design to minimize circuit parasitics is strongly recommended due to the high  $dv/dt$  and  $di/dt$  rates. An external gate resistor is recommended when the FET is working in the diode mode in order to achieve the optimum reverse recovery performance. For more information on SiC FET operation, see [www.unitedsic.com](http://www.unitedsic.com).

A snubber circuit with a small  $R_{(G)}$ , or gate resistor, provides better EMI suppression with higher efficiency compared to using a high  $R_{(G)}$  value. There is no extra gate delay time when using the snubber circuitry, and a small  $R_{(G)}$  will better control both the turn-off  $V_{(DS)}$  peak spike and ringing duration, while a high  $R_{(G)}$  will damp the peak spike but result in a longer delay time. In addition, the total switching loss when using a snubber circuit is less than using high  $R_{(G)}$ , while greatly reducing  $E_{(OFF)}$  from mid-to-full load range with only a small increase in  $E_{(ON)}$ . Efficiency will therefore improve with higher load current. For more information on how a snubber circuit will improve overall system performance, visit the UnitedSiC website at [www.unitedsic.com](http://www.unitedsic.com)

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**PACKAGE OUTLINE**


SYM	7L-D2PAK			
	MM		MIN	MAX
A	4.30	4.56	.169	.180
A1	0.00	0.25	.000	.010
A2	2.45	2.75	.096	.108
b	0.50	0.70	.020	.028
b1	0.50	-	.020	-
c	0.40	0.60	.016	.024
c1	0.40	-	.016	-
c2	1.20	1.40	.047	.055
D	8.93	9.23	.352	.363
D1	4.65	4.95	.183	.195
D2	7.90	8.10	.311	.319
e	1.27 BSC		.050 BSC	
E	10.08	10.28	.397	.405
E1	6.82	7.62	.269	.300
E2	6.50	8.60	.256	.339
E3	3.50	3.70	.138	.146
H	15.00	16.00	.591	.630
H1	6.68	6.88	.263	.271
H3	7.3 REF.		.287 REF	
L	1.90	2.50	.075	.098
L1	0.98	1.42	.039	.056
L3	0.25 BSC		.0098 BSC	
L4	5.22 REF		.205 REF	
ØP1	0.65	0.85	.026	.033
ØP2	1.40	1.60	.055	.063

**Notes:**

1. GENERAL TOLERANCE:  $\pm 0.1$  unless otherwise specified
2. CONTROLLING DIMENSION: **MILLIMETERS**
3. PACKAGE BODY SIDES EXCLUDE MOLD FLASH AND GATE BURRS.
4. DIMENSION L IS MEASURED IN GAUGE LINE.
5. CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.
6. DIMENSION c1 AND b1 APPLIES TO BASE METAL ONLY

**PART MARKING**

G3, 650V / 1200V variant

UF3C: > 40 mOhm

UF3SC: ≤ 40 mOhm

G3, 1700V variant

UF3N: 400 mOhm

G4, 750V variant

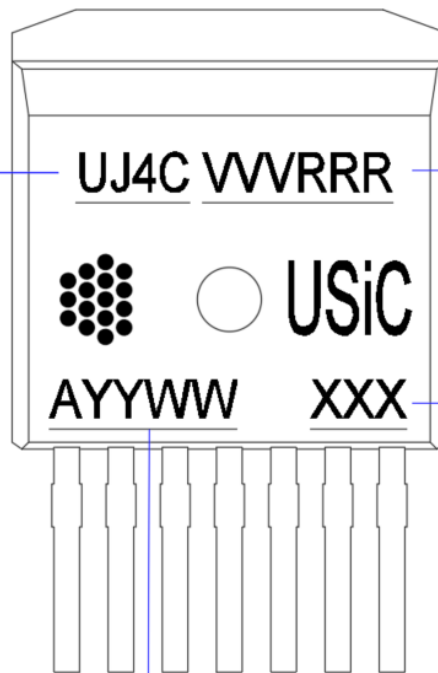
UJ4C: ≥ 23 mOhm

UJ4SC: < 23 mOhm

G4, 1200V variant

UF4C: > 30 mOhm

UF4SC: ≤ 30 mOhm



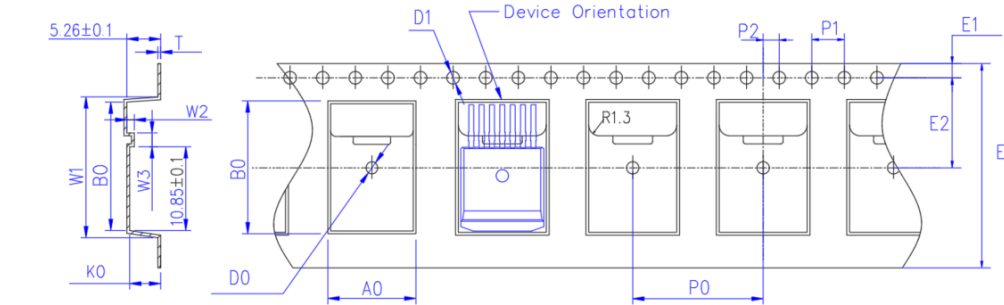
VVV : Voltage Rating  
 RRR : Resistance Rating

Lot Code

A: Assembly Site  
 YY: Year Code  
 WW: Week code

**PACKING TYPE**

*Carrier Tape*

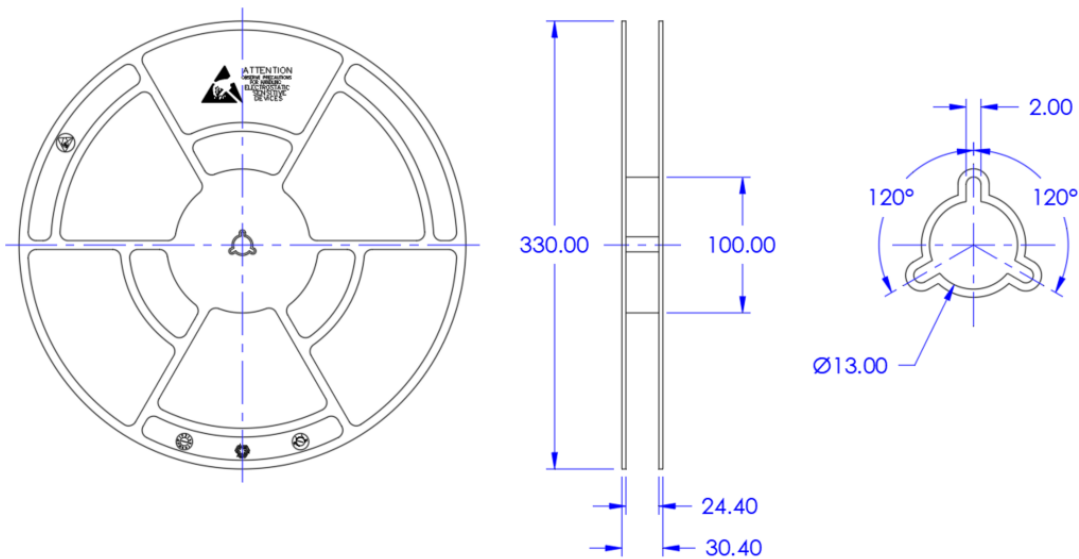


UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
D2PAK (24 mm)	10.80 ±0.10	16.30 ±0.10	4.70 ±0.10	1.50 ±0.10	1.50 $\begin{smallmatrix} +0.1 \\ -0 \end{smallmatrix}$	24.00 ±0.30	1.75 ±0.10	11.50 ±0.10	16.00 ±0.10	4.00 ±0.10	2.00 ±0.10	0.35 ±0.10

Exterior size	
Spec 1	W1 16.9±0.1
	W2 1.3±0.1
	W3 1.0±0.1
Spec 2	W1 17.2±0.1 (a)
	W2 1.8±0.1 (b)
	W3 0.85±0.1 (c)

*Reel*



All dimensions in millimeters  
 Anti-Static Tape and Reel (T&R)  
 Quantity per Reel: 800 units





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**REVISION HISTORY**

Revision	Create Date (mm/dd/yyyy)	Description of Change	Initiator of Change
C	11/06/2023	Updated to Qorvo template Updated Package outline drawing based latest drawing revision	Glenn Galang
D	05/21/2024	Added illustration of device orientation on carrier tape (page 3)	Glenn Galang

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