

Silicon Carbide (SiC) Cascode JFET – EliteSiC, Power N-Channel, TO247-4, 1200 V, 23 mohm

UF4SC120023K4S

Description

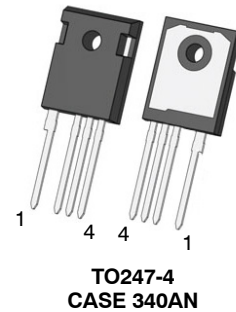
The UF4SC120023K4S is a 1200 V, 23 mΩ G4 SiC FET. It is based on a unique 'cascode' circuit configuration, in which a normally-on SiC JFET is co-packaged with a Si MOSFET to produce a normally-off SiC FET device. The device's standard gate-drive characteristics allows for a true "drop-in replacement" to Si IGBTs, Si FETs, SiC MOSFETs or Si superjunction devices. Available in the TO-247-4L package, 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

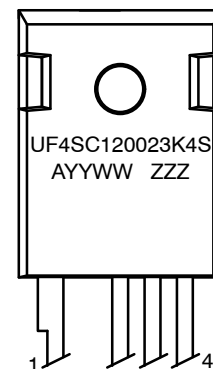
- On-resistance $R_{DS(on)}$: 23 mΩ (typ)
- Operating Temperature: 175 °C (max)
- Excellent Reverse Recovery: Q_{rr} = 341 nC
- Low Body Diode V_{FSD} : 1.2 V
- Low Gate Charge: Q_G = 37.8 nC
- Threshold Voltage $V_{G(th)}$: 4.8 V (typ) Allowing 0 to 15 V Drive
- Low Intrinsic Capacitance
- ESD Protected: HBM Class 2 and CDM Class C3
- TO-247-4L Package for Faster Switching, Clean Gate Waveforms
- This Device is Pb-Free, Halogen Free and is RoHS Compliant

Typical Applications

- EV Charging
- PV Inverters
- Switch Mode Power Supplies
- Power Factor Correction Modules
- Motor Drives
- Induction Heating

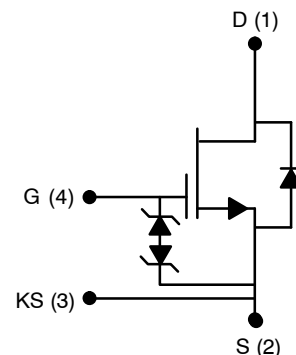


MARKING DIAGRAM



UF4SC120023K4S = Specific Device Code
A = Assembly Location
YY = Year
WW = Work Week
ZZZ = Lot Code

PIN CONNECTIONS



ORDERING INFORMATION

See detailed ordering and shipping information on page 8 of this data sheet.

UF4SC120023K4S

MAXIMUM RATINGS

Parameter	Symbol	Test Conditions	Value	Unit
Drain-source Voltage	V_{DS}		1200	V
Gate-source Voltage	V_{GS}	DC	-20 to +20	V
		AC ($f > 1$ Hz)	-25 to +25	
Continuous Drain Current (Note 1)	I_D	$T_C \leq 95^\circ\text{C}$	53	A
Pulsed Drain Current (Note 2)	I_{DM}	$T_C = 25^\circ\text{C}$	204	A
Single Pulsed Avalanche Energy (Note 3)	E_{AS}	$L = 15$ mH, $I_{AS} = 4.1$ A	126	mJ
SiC FET dv/dt Ruggedness	dv/dt	$V_{DS} \leq 800$ 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	$^\circ\text{C}$
Max. Lead Temperature for Soldering, 1/8" from Case for 5 seconds	T_L		250	$^\circ\text{C}$

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. Limited by bondwires.
2. Pulse width t_p limited by $T_{J, max}$.
3. Starting $T_J = 25^\circ\text{C}$.

THERMAL CHARACTERISTICS

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$		-	0.3	0.39	$^\circ\text{C/W}$

ELECTRICAL CHARACTERISTICS ($T_J = +25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
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TYPICAL PERFORMANCE – STATIC

Drain-source Breakdown Voltage	BV_{DS}	$V_{GS} = 0$ V, $I_D = 1$ mA	1200	-	-	V
Total Drain Leakage Current	I_{DSS}	$V_{DS} = 1200$ V, $V_{GS} = 0$ V, $T_J = 25^\circ\text{C}$	-	2	60	μA
		$V_{DS} = 1200$ V, $V_{GS} = 0$ V, $T_J = 175^\circ\text{C}$	-	20	-	
Total Gate Leakage Current	I_{GSS}	$V_{DS} = 0$ V, $T_J = 25^\circ\text{C}$, $V_{GS} = -20$ V / +20 V	-	6	20	μA
Drain-source On-resistance	$R_{DS(on)}$	$V_{GS} = 12$ V, $I_D = 40$ A, $T_J = 25^\circ\text{C}$	-	23	29	m Ω
		$V_{GS} = 12$ V, $I_D = 40$ A, $T_J = 125^\circ\text{C}$	-	42	-	
		$V_{GS} = 12$ V, $I_D = 40$ A, $T_J = 175^\circ\text{C}$	-	57	-	
Gate Threshold Voltage	$V_{G(th)}$	$V_{DS} = 5$ V, $I_D = 10$ mA	4	4.8	6	V
Gate Resistance	R_G	$f = 1$ MHz, open drain	-	4.5	-	Ω

TYPICAL PERFORMANCE – REVERSE DIODE

Diode Continuous Forward Current (Note 1)	I_S	$T_C \leq 95^\circ\text{C}$	-	-	53	A
Diode Pulse Current (Note 2)	$I_{S, pulse}$	$T_C = 25^\circ\text{C}$	-	-	204	A
Forward Voltage	V_{FSD}	$V_{GS} = 0$ V, $I_S = 20$ A, $T_J = 25^\circ\text{C}$	-	1.2	1.35	V
		$V_{GS} = 0$ V, $I_S = 20$ A, $T_J = 175^\circ\text{C}$	-	1.65	-	
Reverse Recovery Charge	Q_{rr}	$V_{DS} = 800$ V, $I_S = 40$ A, $V_{GS} = 0$ V, $R_G = 30$ Ω , di/dt = 2100 A/ μs , $T_J = 25^\circ\text{C}$	-	341	-	nC
Reverse Recovery Time	t_{rr}		-	27	-	ns
Reverse Recovery Charge	Q_{rr}	$V_{DS} = 800$ V, $I_S = 40$ A, $V_{GS} = 0$ V, $R_G = 30$ Ω , di/dt = 2100 A/ μs , $T_J = 150^\circ\text{C}$	-	374	-	nC
Reverse Recovery Time	t_{rr}		-	30	-	ns

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ELECTRICAL CHARACTERISTICS ($T_J = +25\text{ }^{\circ}\text{C}$ unless otherwise specified) (continued)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
TYPICAL PERFORMANCE – DYNAMIC						
Input Capacitance	C_{iss}	$V_{DS} = 800\text{ V}$, $V_{GS} = 0\text{ V}$, $f = 100\text{ kHz}$	–	1430	–	pF
Output Capacitance	C_{oss}		–	85	–	
Reverse Transfer Capacitance	C_{rss}		–	2	–	
Effective Output Capacitance, Energy Related	$C_{oss(er)}$	$V_{DS} = 0\text{ V to } 800\text{ V}$, $V_{GS} = 0\text{ V}$	–	108	–	pF
Effective Output Capacitance, Time Related	$C_{oss(tr)}$		–	200	–	
C_{oss} Stored Energy	E_{oss}	$V_{DS} = 800\text{ V}$, $V_{GS} = 0\text{ V}$	–	35	–	μJ
Total Gate Charge	Q_G	$V_{DS} = 800\text{ V}$, $I_D = 40\text{ A}$, $V_{GS} = 0\text{ V to } 15\text{ V}$	–	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 (Note 5) $V_{DS} = 800\text{ V}$, $I_D = 40\text{ A}$, Gate Driver = $0\text{ V to } +15\text{ V}$, $R_{G_ON} = 1\text{ }\Omega$, $R_{G_OFF} = 18\text{ }\Omega$ Inductive Load, FWD: same device with $V_{GS} = 0\text{ V}$ and $R_G = 18\text{ }\Omega$, Snubber: $R_s = 20\text{ }\Omega$, $C_s = 100\text{ pF}$, $T_J = 25\text{ }^{\circ}\text{C}$	–	10	–	ns
Rise Time	t_r		–	24	–	
Turn-off Delay Time	$t_{d(off)}$		–	72	–	
Fall Time	t_f		–	13.6	–	
Turn-on Energy Including R_S Energy	E_{ON}		–	599	–	μJ
Turn-off Energy Including R_S Energy	E_{OFF}		–	195	–	
Total Switching Energy	E_{TOTAL}		–	794	–	
Snubber R_S Energy During Turn-on	E_{RS_ON}		–	7	–	
Snubber R_S Energy During Turn-off	E_{RS_OFF}		–	10	–	
Turn-on Delay Time	$t_{d(on)}$	(Note 4) and (Note 5) $V_{DS} = 800\text{ V}$, $I_D = 40\text{ A}$, Gate Driver = $0\text{ V to } +15\text{ V}$, $R_{G_ON} = 1\text{ }\Omega$, $R_{G_OFF} = 18\text{ }\Omega$ Inductive Load, FWD: same device with $V_{GS} = 0\text{ V}$ and $R_G = 18\text{ }\Omega$, Snubber: $R_s = 20\text{ }\Omega$, $C_s = 100\text{ pF}$, $T_J = 150\text{ }^{\circ}\text{C}$	–	9.2	–	ns
Rise Time	t_r		–	26	–	
Turn-off Delay Time	$t_{d(off)}$		–	81	–	
Fall Time	t_f		–	14	–	
Turn-on Energy Including R_S Energy	E_{ON}		–	678	–	μJ
Turn-off Energy Including R_S Energy	E_{OFF}		–	239	–	
Total Switching Energy	E_{TOTAL}		–	917	–	
Snubber R_S Energy During Turn-on	E_{RS_ON}		–	6	–	
Snubber R_S Energy During Turn-off	E_{RS_OFF}		–	9	–	

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

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

5. All the switching energies (turn-on energy, turn-off energy and total energy) presented in this table include the device RC snubber energy losses.

TYPICAL PERFORMANCE DIAGRAMS

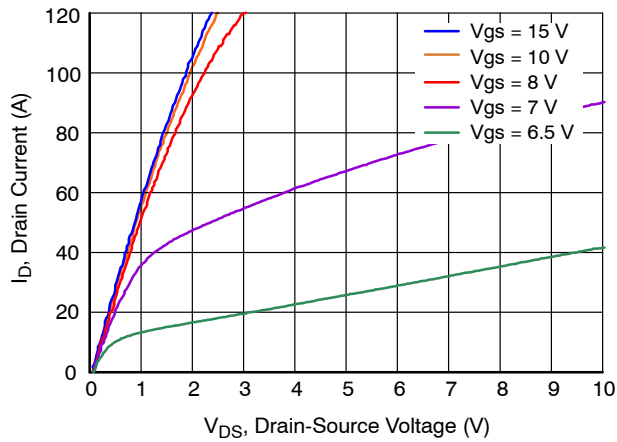


Figure 1. Typical Output Characteristics at $T_J = -55^\circ\text{C}$

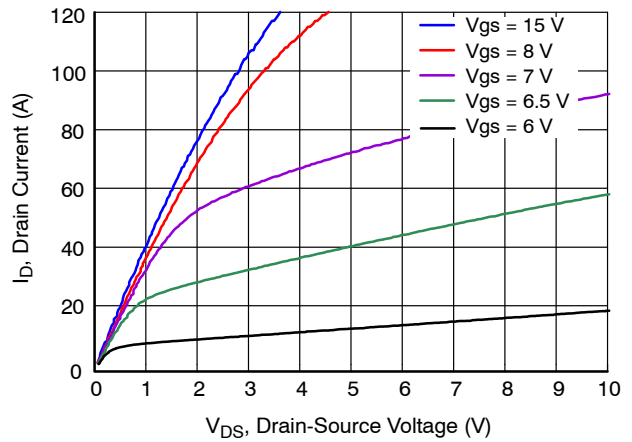


Figure 2. Typical Output Characteristics at $T_J = 25^\circ\text{C}$

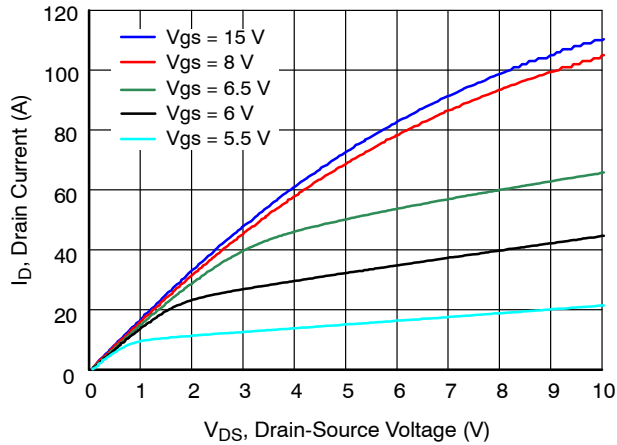


Figure 3. Typical Output Characteristics at $T_J = 175^\circ\text{C}$, $t_p < 250\ \mu\text{s}$

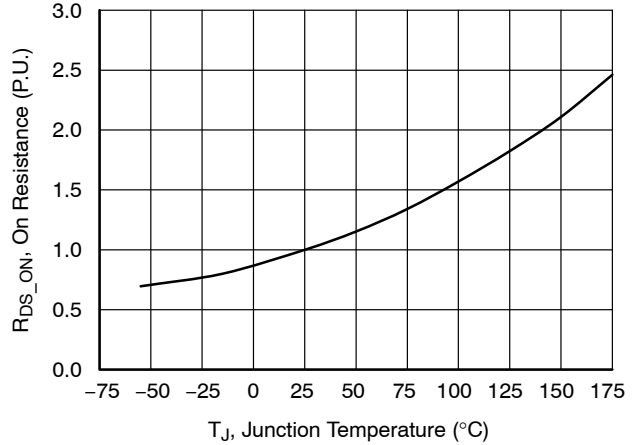


Figure 4. Normalized On-Resistance vs. Temperature at $V_{GS} = 12\text{ V}$ and $I_D = 40\text{ A}$

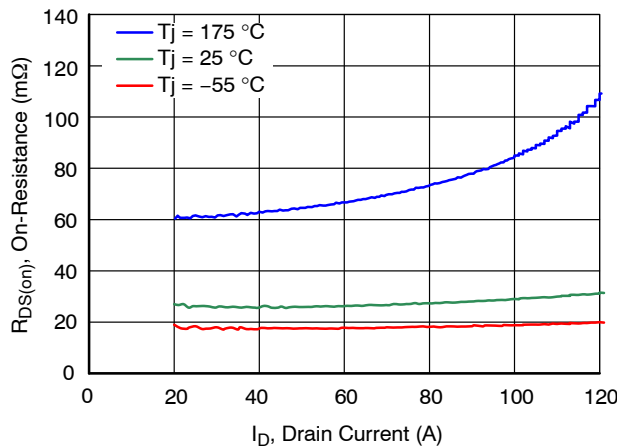


Figure 5. Typical Drain-Source On-Resistances at $V_{GS} = 12\text{ V}$

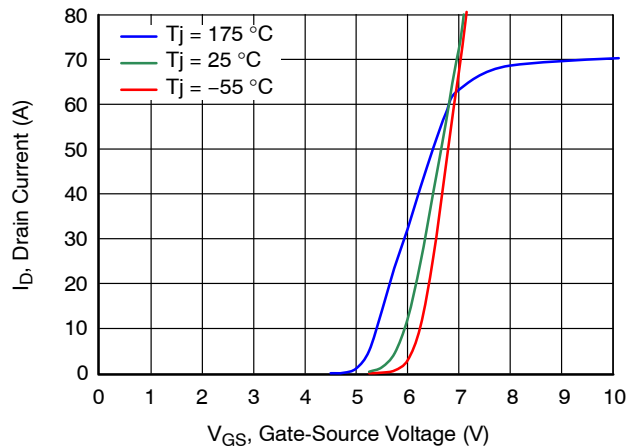


Figure 6. Typical Transfer Characteristics at $V_{DS} = 5\text{ V}$

TYPICAL PERFORMANCE DIAGRAMS (CONTINUED)

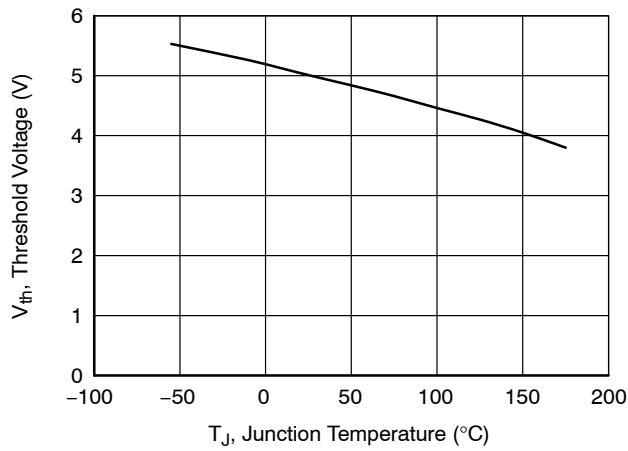


Figure 7. Threshold Voltage vs. Junction Temperature at $V_{DS} = 5 \text{ V}$ and $I_D = 10 \text{ mA}$

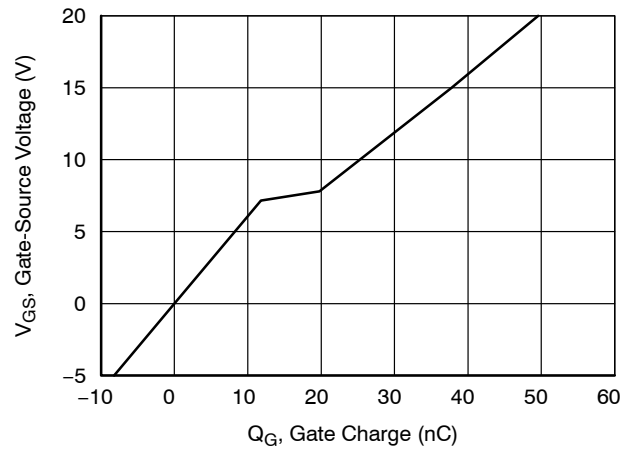


Figure 8. Typical Gate Charge at $V_{DS} = 800 \text{ V}$ and $I_D = 40 \text{ A}$

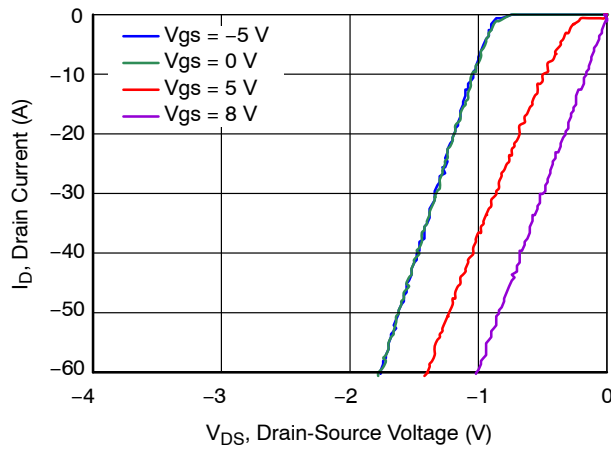


Figure 9. 3rd Quadrant Characteristics at $T_J = -55 \text{ }^{\circ}\text{C}$

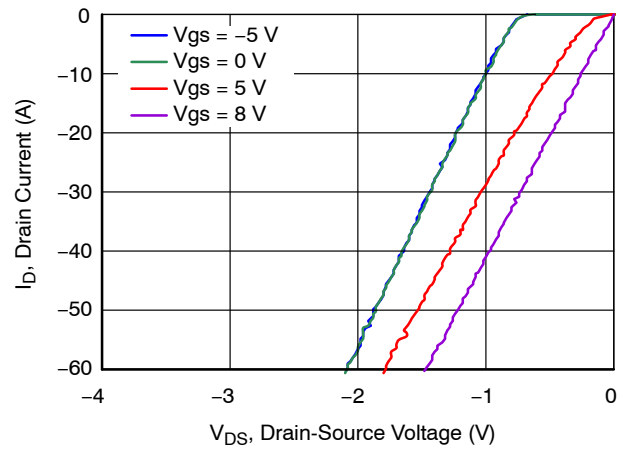


Figure 10. 3rd Quadrant Characteristics at $T_J = 25 \text{ }^{\circ}\text{C}$

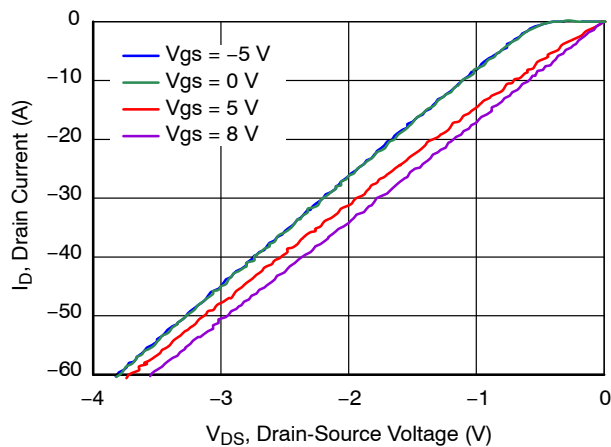


Figure 11. 3rd Quadrant Characteristics at $T_J = 175 \text{ }^{\circ}\text{C}$

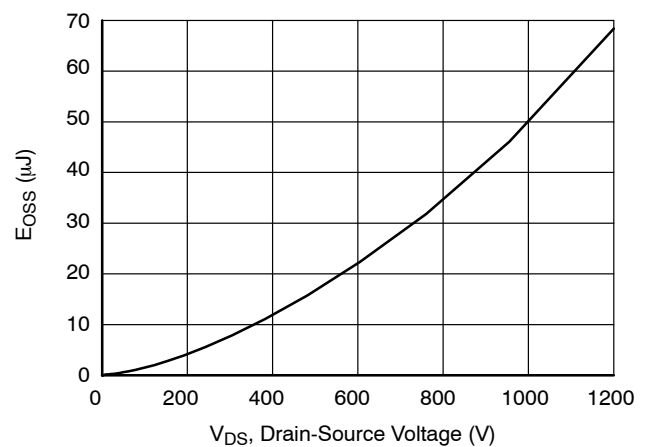


Figure 12. Typical Stored Energy in C_{OSS} at $V_{GS} = 0 \text{ V}$

TYPICAL PERFORMANCE DIAGRAMS (CONTINUED)

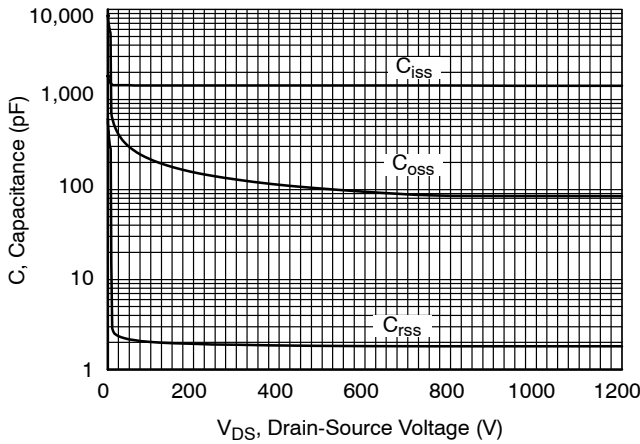


Figure 13. Typical Capacitances at $f = 100 \text{ kHz}$ and $V_{GS} = 0 \text{ V}$

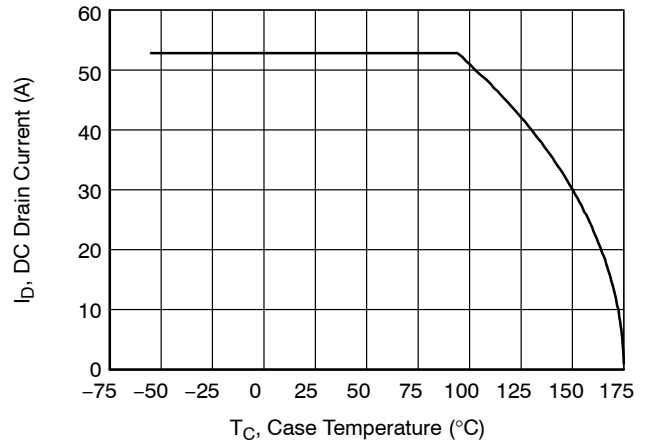


Figure 14. DC Drain Current Derating

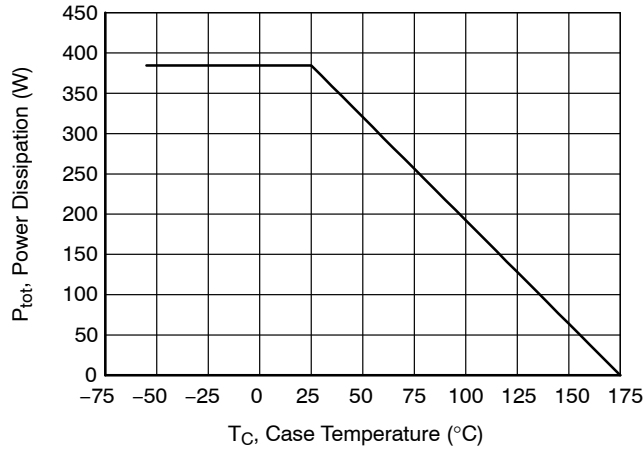


Figure 15. Total Power Dissipation

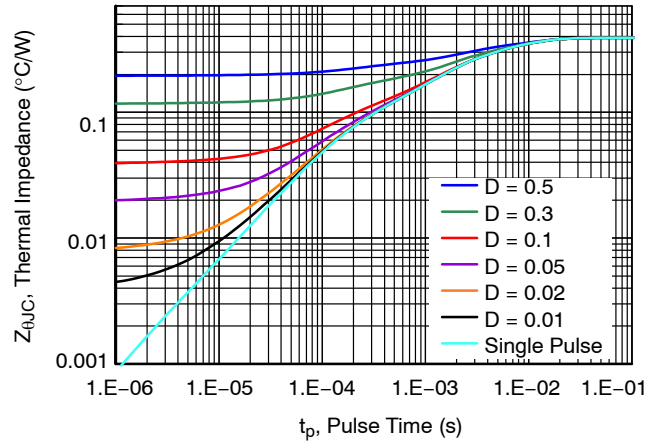


Figure 16. Maximum Transient Thermal Impedance

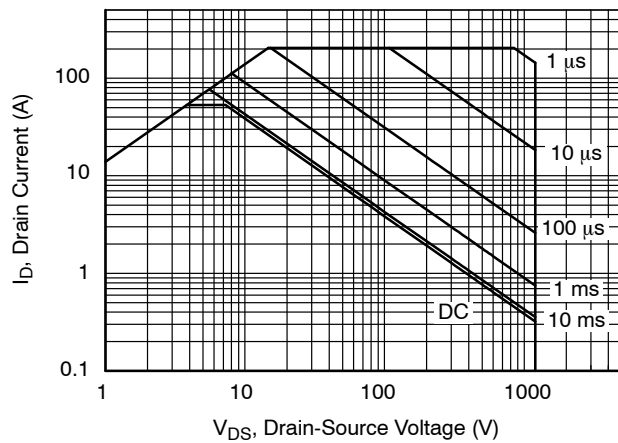


Figure 17. Safe Operation Area at $T_C = 25^\circ\text{C}$, $D = 0$, Parameter t_p

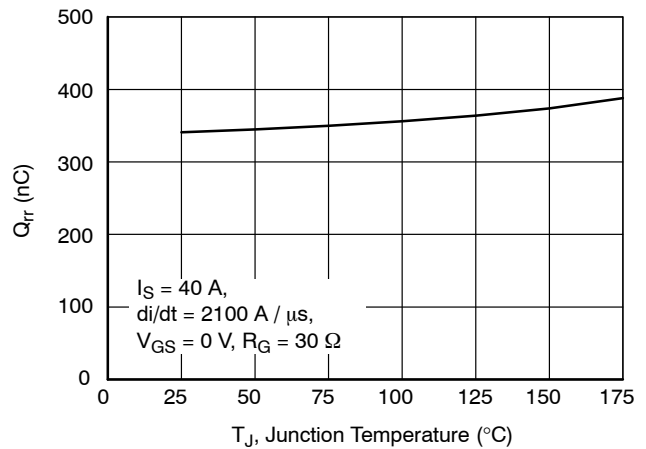


Figure 18. Reverse Recovery Charge Q_{rr} vs. Junction Temperature at $V_{DS} = 800 \text{ V}$

TYPICAL PERFORMANCE DIAGRAMS (CONTINUED)

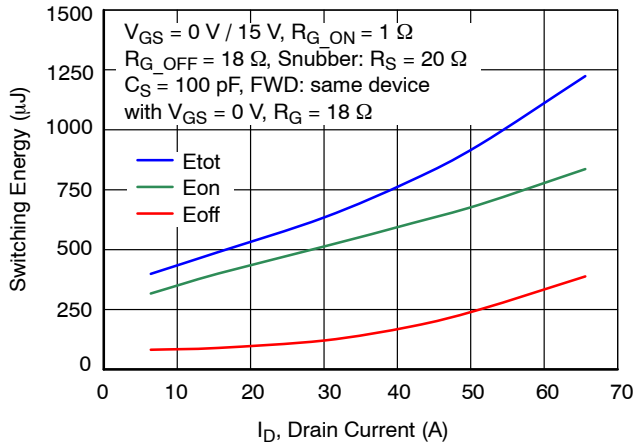


Figure 19. Clamped Inductive Switching Energies vs. Drain Current at $V_{DS} = 800$ V and $T_J = 25$ °C

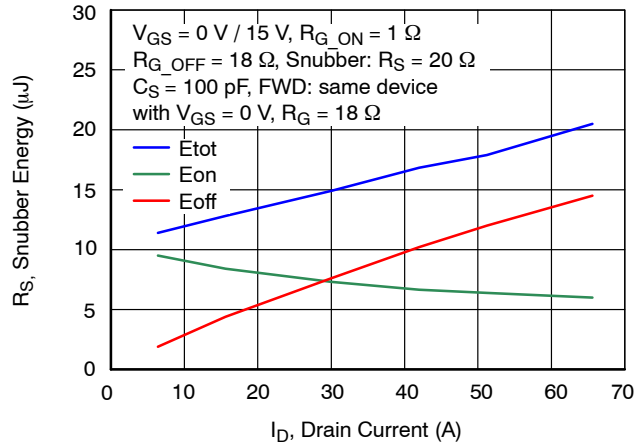


Figure 20. RC Snubber Energy Losses vs. Drain Current at $V_{DS} = 800$ V and $T_J = 25$ °C

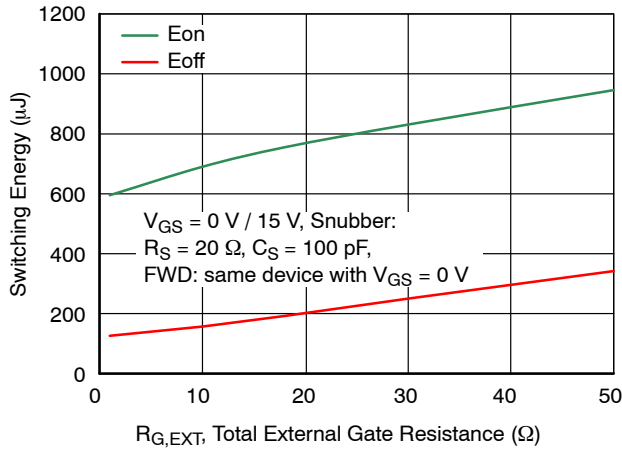


Figure 21. Clamped Inductive Switching Energies vs. $R_{G,EXT}$ at $V_{DS} = 800$ V, $I_D = 40$ A, and $T_J = 25$ °C

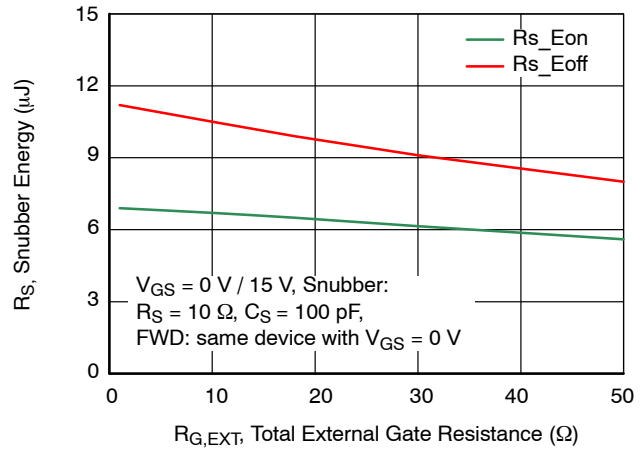


Figure 22. RC Snubber Energy Losses vs. $R_{G,EXT}$ at $V_{DS} = 800$ V, $I_D = 40$ A, and $T_J = 25$ °C

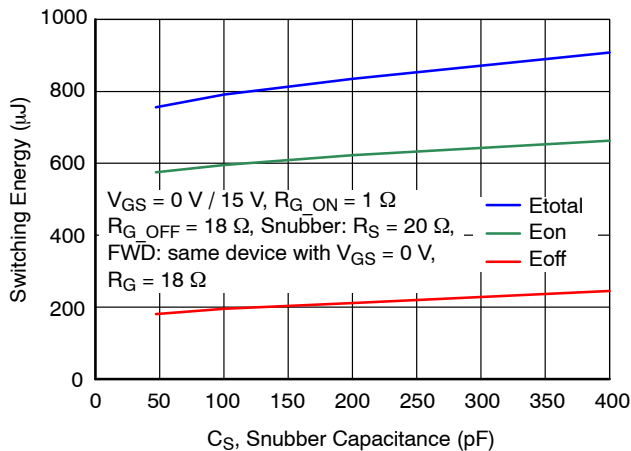


Figure 23. Clamped Inductive Switching Energies vs. Snubber Capacitance C_S at $V_{DS} = 800$ V, $I_D = 40$ A, and $T_J = 25$ °C

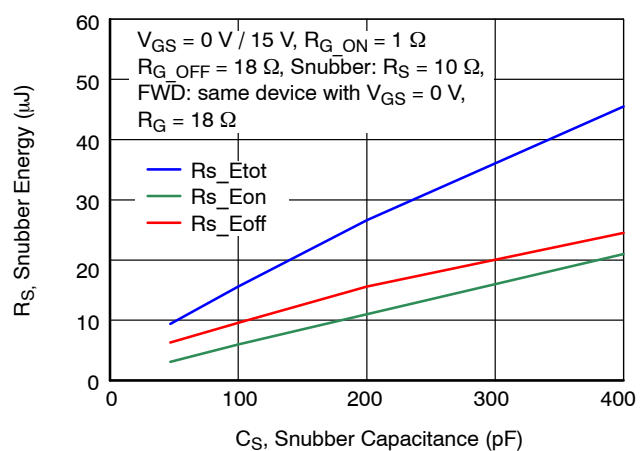


Figure 24. RC Snubber Energy Losses vs. Snubber Capacitance C_S at $V_{DS} = 800$ V, $I_D = 40$ A, and $T_J = 25$ °C

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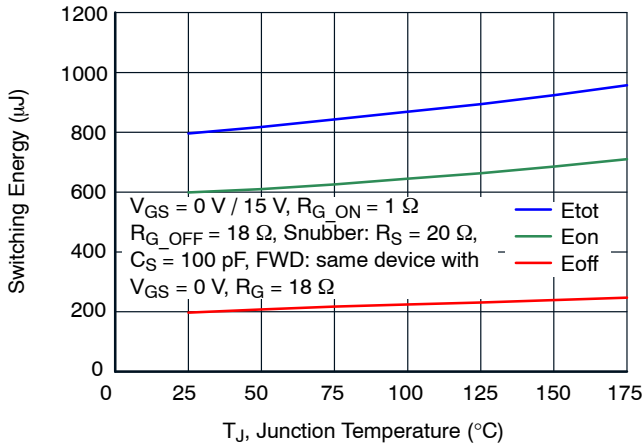


Figure 25. Clamped Inductive Switching Energy vs. Junction Temperature at $V_{DS} = 800$ V and $I_D = 40$ A

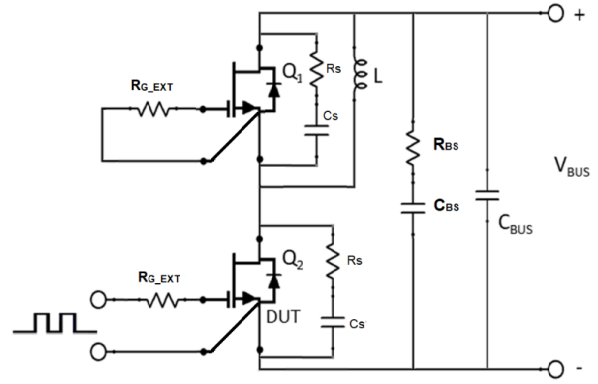


Figure 26. Schematic of the Half-Bridge Mode Switching Test Circuit. Note, a Bus RC Snubber ($R_{BS} = 5 \Omega$, $C_{BS} = 100$ nF) is Used to Reduce the Power Loop High Frequency Oscillations.

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.onsemi.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 **onsemi** website at www.onsemi.com.

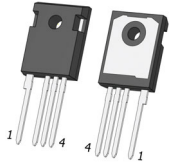
ORDERING INFORMATION

Part Number	Marking	Package	Shipping
UF4SC120023K4S	UF4SC120023K4S	TO247-4	600 Units / Tube

UF4SC120023K4S

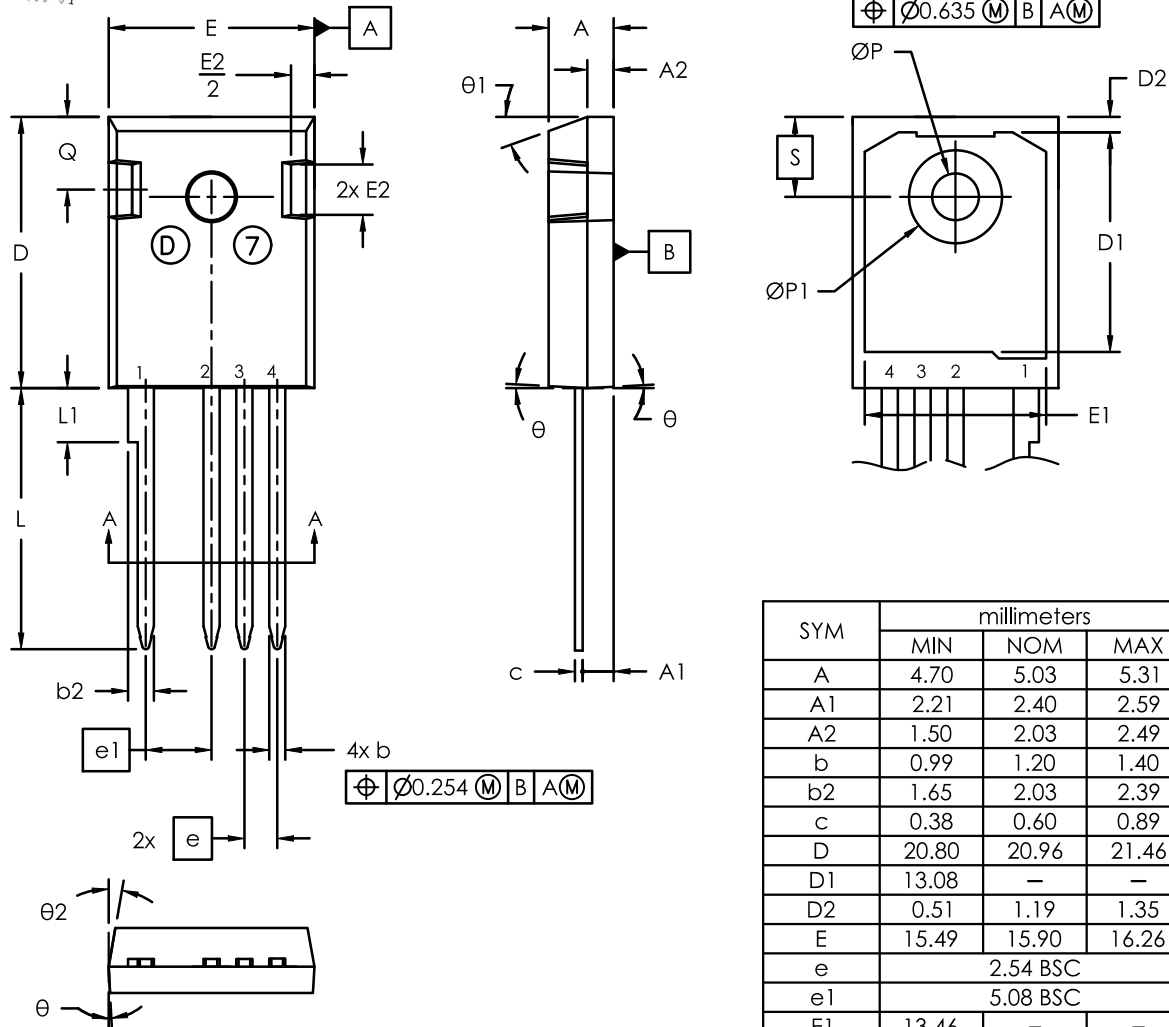
REVISION HISTORY

Revision	Description of Changes	Date
B	Acquired the original Qorvo JFET Division Data Sheet and updated the main document title to comply with onsemi standards for SiC products.	1/15/2025
2	Converted the Data Sheet to onsemi format.	06/25/2025



TO247-4 15.90x20.96x5.03, 5.44P
CASE 340AN
ISSUE E

DATE 20 JUN 2025



NOTE:

1. Dimensioning and tolerancing as per ASME Y14.5 - 2018
2. Controlling dimension : millimeters
3. Package Outline in compliance with JEDEC standard var. AD.
4. Dimensions D & E does not include mold flash.
5. ØP to have max draft angle of 1.7° to the top with max. hole diameter of 3.91mm.
5. Through Hole diameter value = End Hole diameter
6. PCB Through Hole pattern as per IPC-2221/IPC-2222

SYM	millimeters		
	MIN	NOM	MAX
A	4.70	5.03	5.31
A1	2.21	2.40	2.59
A2	1.50	2.03	2.49
b	0.99	1.20	1.40
b2	1.65	2.03	2.39
c	0.38	0.60	0.89
D	20.80	20.96	21.46
D1	13.08	—	—
D2	0.51	1.19	1.35
E	15.49	15.90	16.26
e	2.54 BSC		
e1	5.08 BSC		
E1	13.46	—	—
E2	3.43	3.89	5.20
L	19.81	20.17	20.32
L1	—	—	4.50
ØP	3.40	3.60	3.80
ØP1	7.06	7.19	7.39
Q	5.38	5.62	6.20
S	6.17 BSC		
θ	3°		
θ1	20°		
θ2	10°		

DOCUMENT NUMBER: 98AON86067F

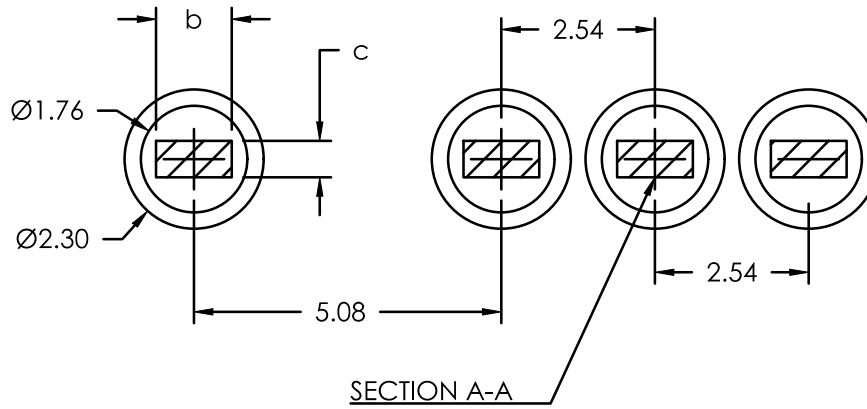
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DESCRIPTION: TO247-4 15.90x20.96x5.03, 5.44P

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RECOMMENDED PCB THROUGH HOLE



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