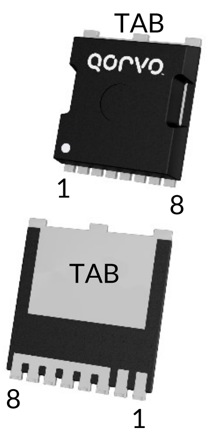
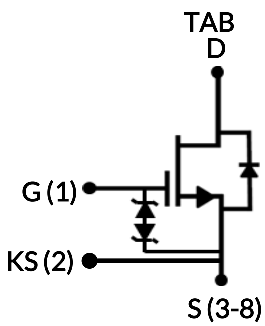
750V-5.4mΩ SiC FET

Rev. A, February 2023

DATASHEET

UJ4SC075005L8S





Part Number	Package	Marking
UJ4SC075005L8S	MO-229	UJ4SC075005

Description

The UJ4SC075005L8S is a 750V, 5.4mΩ 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 MO-229 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 $R_{DS(on)}$: 5.4mΩ (typ)
- Operating temperature: 175°C (max)
- Excellent reverse recovery: Q_{rr} = 440nC
- Low body diode V_{FSD}: 1.03V
- Low gate charge: Q_G =164nC
- Threshold voltage $V_{G(th)}$: 4.7V (typ) allowing 0 to 15V drive
- Low intrinsic capacitance
- ESD protected, HBM class 2
- MO-229 package for faster switching, clean gate waveforms

Typical applications

- Solid state relays and circuit-breakers
- Line rectification and active-bridge rectification circuits in AC/DC front-ends
- EV charging
- PV inverters
- Switch mode power supplies
- Power factor correction modules
- Motor drives
- Induction heating

Maximum Ratings

Parameter	Symbol	Test Conditions	Value	Units
Drain-source voltage	V_{DS}		750	V
Gate-source voltage	V_{GS}	DC	-20 to +20	V
		AC (f > 1Hz)	-25 to +25	V
Continuous drain current [1]	I_D	T_C < 144°C	120	A
Pulsed drain current [2]	I_{DM}	T_C = 25°C	588	A
Single pulsed avalanche energy [3]	E_{AS}	L=15mH, I_{AS} = 6.5A	316	mJ
Short circuit withstand time [4]	t_{SC}	V_{DS} = 400V, $T_{J(START)}$ = 175°C	5	µs
SiC FET dv/dt ruggedness	dv/dt	$V_{DS} \leq$ 500V	100	V/ns
Power dissipation	P_{tot}	T_C = 25°C	1153	W
Maximum junction temperature	$T_{J,max}$		175	°C
Operating and storage temperature	T_J, T_{STG}		-55 to 175	°C
Reflow soldering temperature	T_{solder}	reflow MSL 1	260	°C

1. Limited by bondwires
2. Pulse width t_p limited by $T_{J,max}$
3. Starting T_J = 25°C
4. Short circuit current is independent of the gate voltage V_{GS}>12V

Thermal Characteristics

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Thermal resistance, junction-to-case	$R_{\theta JC}$			0.10	0.13	°C/W

Electrical Characteristics (T_J = +25°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	750			V
Total drain leakage current	I_{DSS}	V_{DS}=750V, V_{GS}=0V, T_J=25°C		6	130	μA
		V_{DS}=750V, V_{GS}=0V, T_J=175°C		45		
Total gate leakage current	I_{GSS}	V_{DS}=0V, T_J=25°C, V_{GS}=-20V / +20V		6	20	μA
Drain-source on-resistance	$R_{DS(on)}$	V_{GS}=12V, I_D=80A, T_J=25°C		5.4	7.2	mΩ
		V_{GS}=12V, I_D=80A, T_J=125°C		9.3		
		V_{GS}=12V, I_D=80A, T_J=175°C		12.2		
Gate threshold voltage	$V_{G(th)}$	V_{DS}=5V, I_D=10mA	4	4.7	6	V
Gate resistance	R_G	f=1MHz, open drain		0.8	1.5	Ω

Typical Performance - Reverse Diode

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Diode continuous forward current [1]	I_S	T_C < 144°C			120	A
Diode pulse current [2]	$I_{S,pulse}$	T_C=25°C			588	A
Forward voltage	V_{FSD}	V_{GS}=0V, I_S=50A, T_J=25°C		1.03	1.16	V
		V_{GS}=0V, I_S=50A, T_J=175°C		1.06		
Reverse recovery charge	Q_{rr}	V_{DS}=400V, I_S=80A, V_{GS}=0V, R_G=20Ω di/dt=2800A/μs, T_J=25°C		440		nC
Reverse recovery time	t_{rr}			31		ns
Reverse recovery charge	Q_{rr}	V_{DS}=400V, I_S=80A, V_{GS}=0V, R_G=20Ω di/dt=2800A/μs, T_J=150°C		525		nC
Reverse recovery time	t_{rr}			37		ns

Typical Performance - Dynamic

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Input capacitance	C_{iss}	V_{DS}=400V, V_{GS}=0V f=100kHz		8374		pF
Output capacitance	C_{oss}			362		
Reverse transfer capacitance	C_{rss}			4		
Effective output capacitance, energy related	$C_{oss(er)}$	V_{DS}=0V to 400V, V_{GS}=0V		475		pF
Effective output capacitance, time related	$C_{oss(tr)}$	V_{DS}=0V to 400V, V_{GS}=0V		950		pF
C_{OSS} stored energy	E_{oss}	V_{DS}=400V, V_{GS}=0V		38		μJ
Total gate charge	Q_G	V_{DS}=400V, I_D=80A, V_{GS} = 0V to 15V		164		nC
Gate-drain charge	Q_{GD}			24		
Gate-source charge	Q_{GS}			46		
Turn-on delay time	$t_{d(on)}$	Notes 5 and 6, V_{DS}=400V, I_D=80A, Gate Driver =0V to +15V, Turn-on $R_{G,EXT}$=1.5Ω, Turn-off $R_{G,EXT}$=5Ω, inductive Load, FWD: same device with V_{GS} = 0V and R_G = 5Ω, RC snubber: R_S=5Ω and C_S=680pF, T_J=25°C		35		ns
Rise time	t_r			39		
Turn-off delay time	$t_{d(off)}$			109		
Fall time	t_f			13		
Turn-on energy including R_S energy	E_{ON}			766		μJ
Turn-off energy including R_S energy	E_{OFF}			162		
Total switching energy	E_{TOTAL}			928		
Snubber R_S energy during turn-on	E_{RS_ON}			17.6		
Snubber R_S energy during turn-off	E_{RS_OFF}			7.2		
Turn-on delay time	$t_{d(on)}$	Notes 5 and 6, V_{DS}=400V, I_D=80A, Gate Driver =0V to +15V, Turn-on $R_{G,EXT}$=1.5Ω, Turn-off $R_{G,EXT}$=5Ω, inductive Load, FWD: same device with V_{GS} = 0V and R_G = 5Ω, RC snubber: R_S=5Ω and C_S=680pF, T_J=150°C		37		ns
Rise time	t_r			41		
Turn-off delay time	$t_{d(off)}$			114		
Fall time	t_f			13		
Turn-on energy including R_S energy	E_{ON}			808		μJ
Turn-off energy including R_S energy	E_{OFF}			187		
Total switching energy	E_{TOTAL}			995		
Snubber R_S energy during turn-on	E_{RS_ON}			18.3		
Snubber R_S energy during turn-off	E_{RS_OFF}			10.3		

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

6. 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

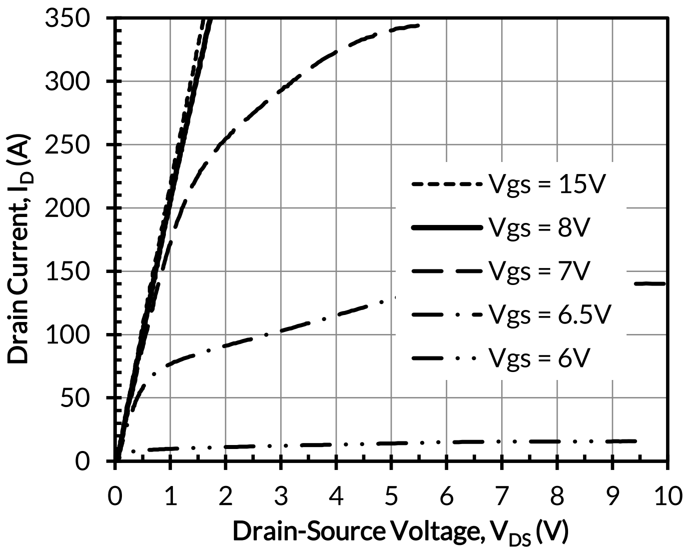


Figure 1. Typical output characteristics at T_J = - 55°C, tp < 250µs

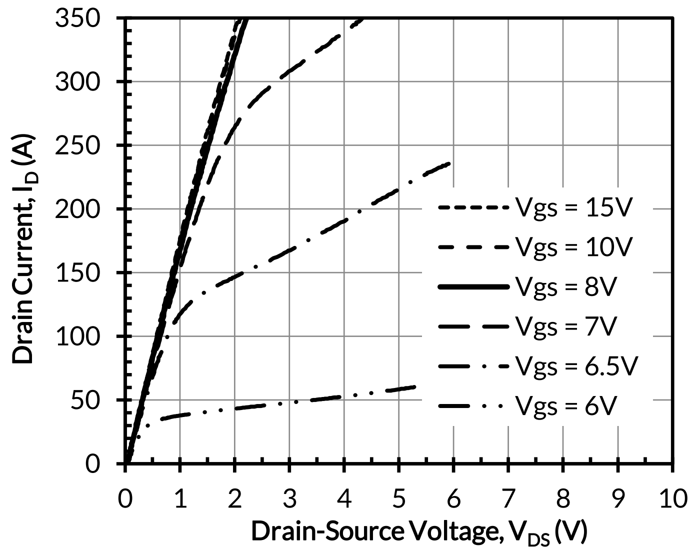


Figure 2. Typical output characteristics at T_J = 25°C, tp < 250µs

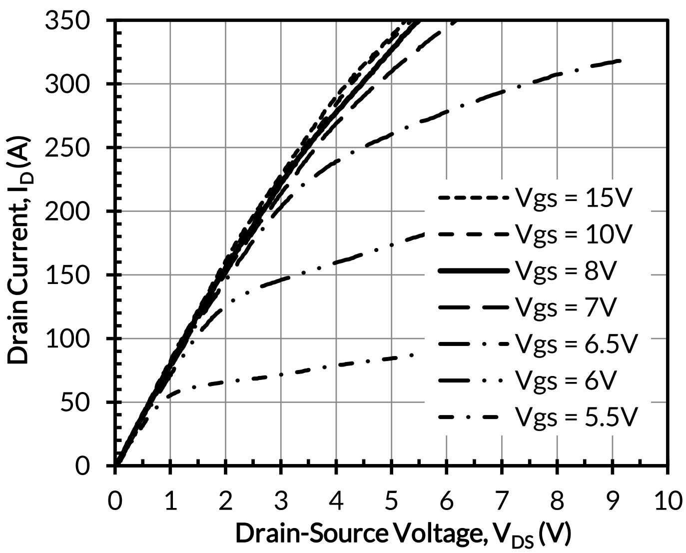


Figure 3. Typical output characteristics at T_J = 175°C, tp < 250µs

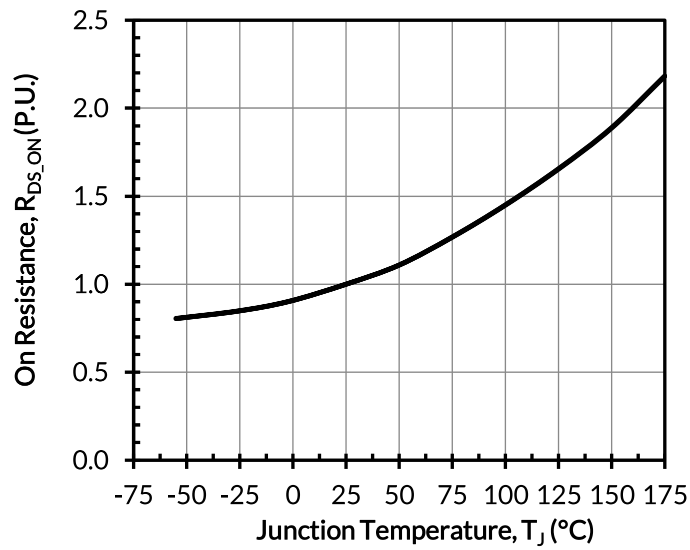


Figure 4. Normalized on-resistance vs. temperature at V_{GS} = 12V and I_D = 80A

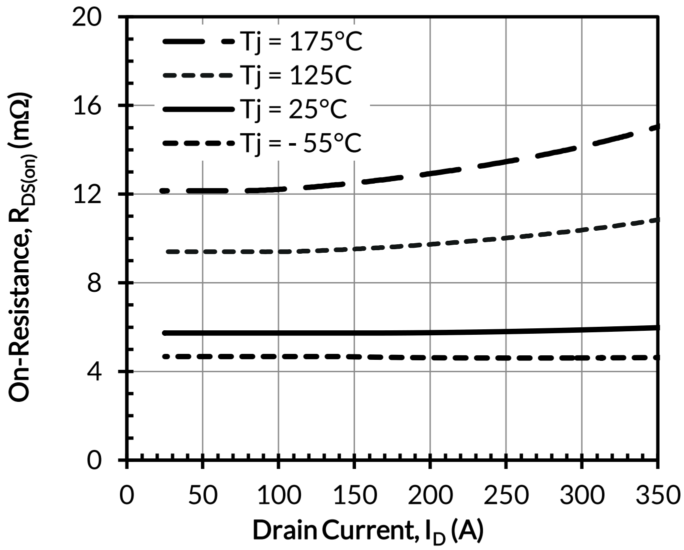


Figure 5. Typical drain-source on-resistances at V_{GS} = 12V

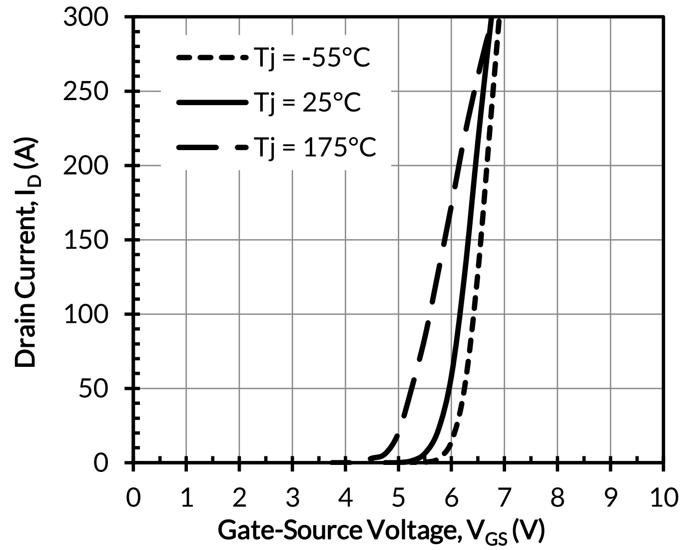


Figure 6. Typical transfer characteristics at V_{DS} = 5V

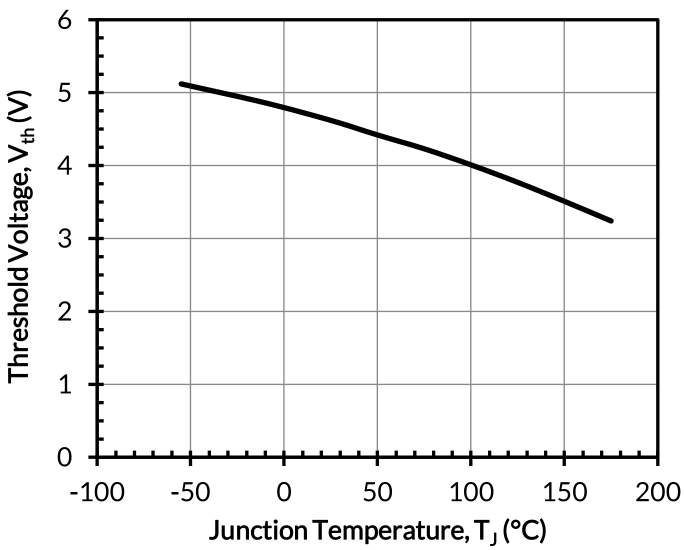


Figure 7. Threshold voltage vs. junction temperature at V_{DS} = 5V and I_D = 10mA

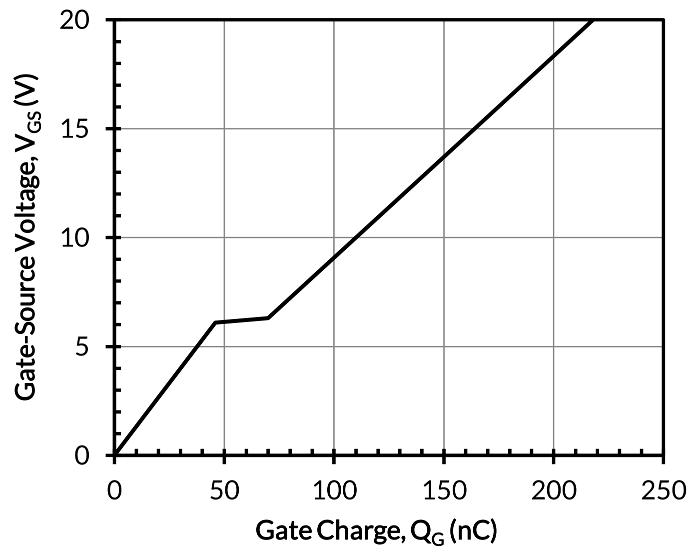


Figure 8. Typical gate charge at V_{DS} = 400V and I_D = 80A

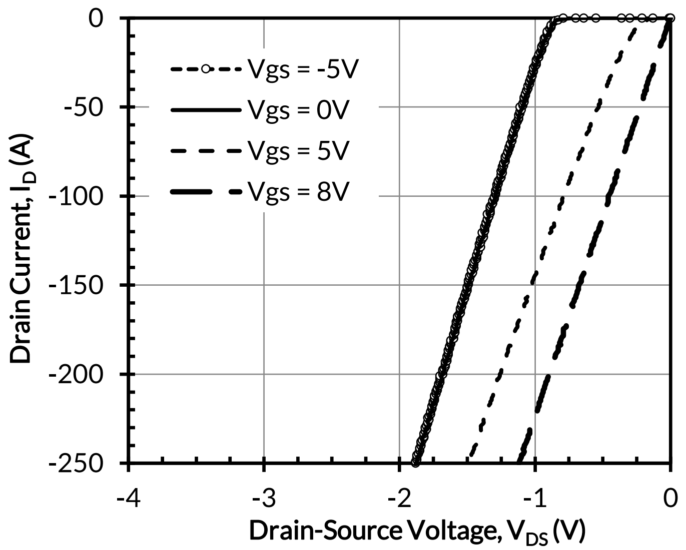


Figure 9. 3rd quadrant characteristics at T_J = -55°C

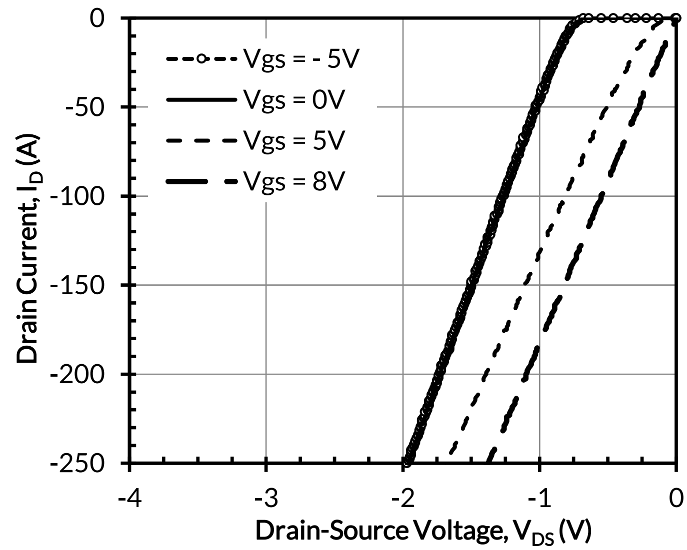


Figure 10. 3rd quadrant characteristics at T_J = 25°C

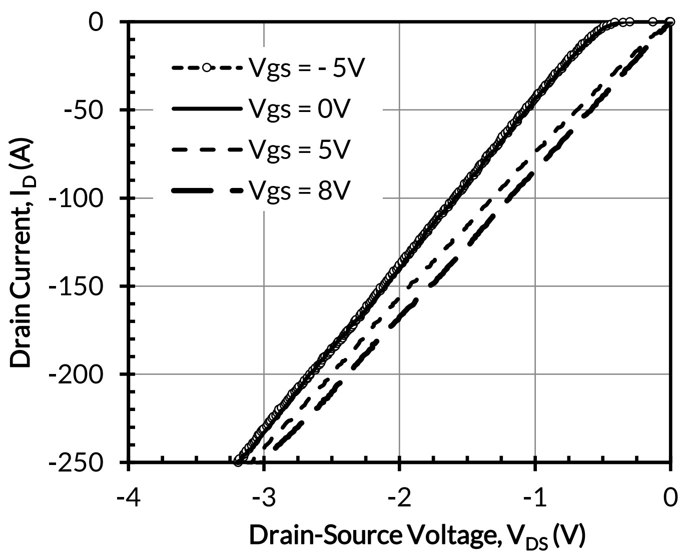


Figure 11. 3rd quadrant characteristics at T_J = 175°C

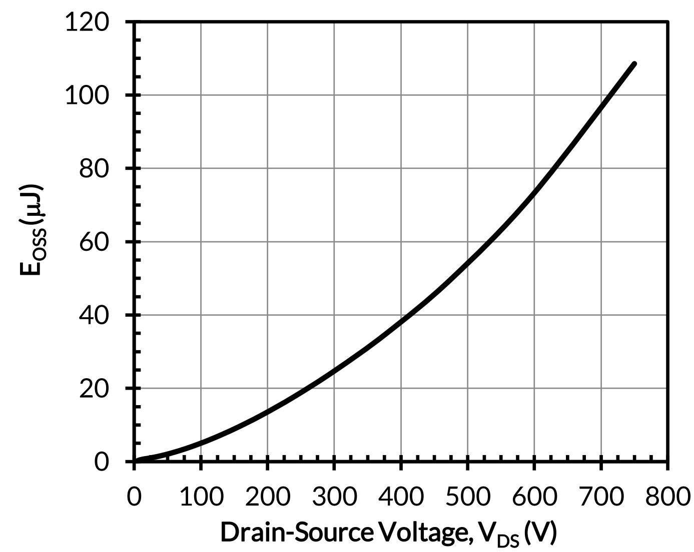


Figure 12. Typical stored energy in C_{OSS} at V_{GS} = 0V

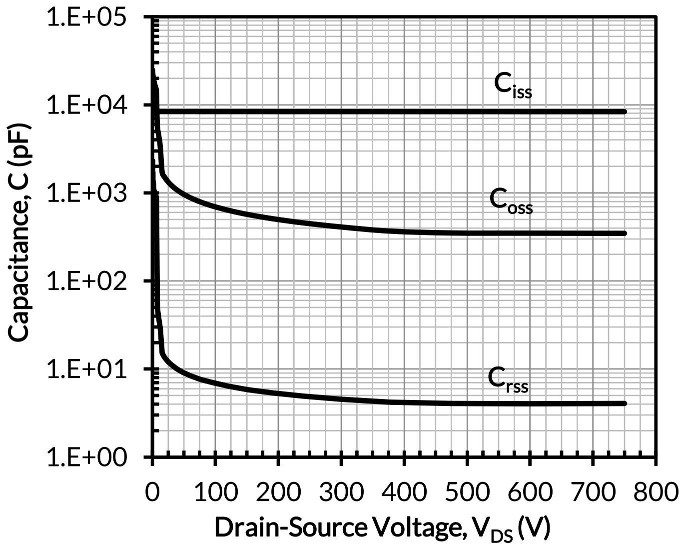


Figure 13. Typical capacitances at f = 100kHz and V_{GS} = 0V

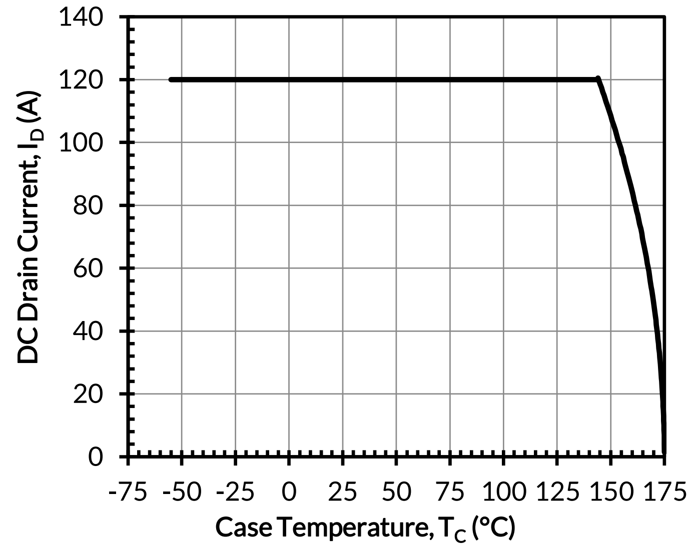


Figure 14. DC drain current derating

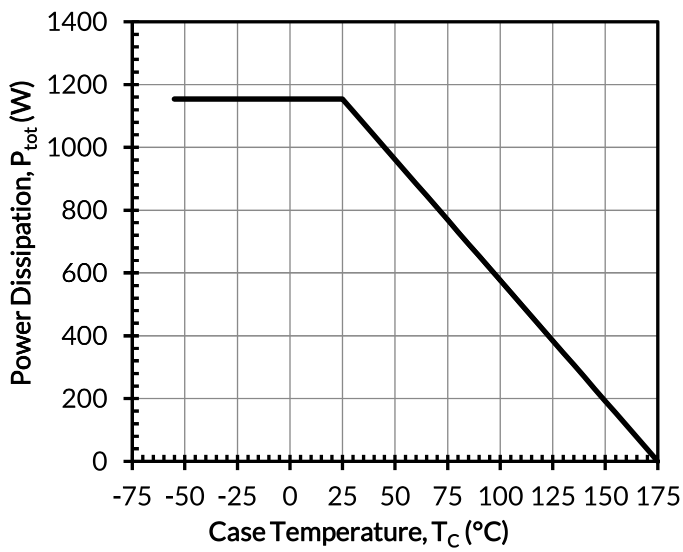


Figure 15. Total power dissipation

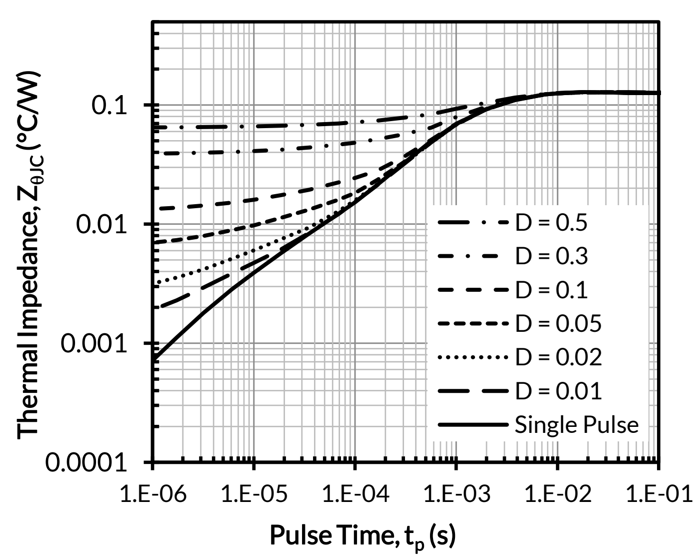
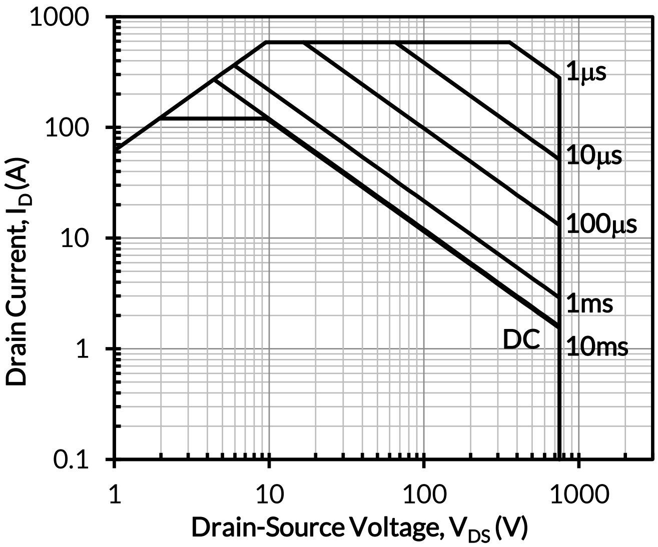


Figure 16. Maximum transient thermal impedance



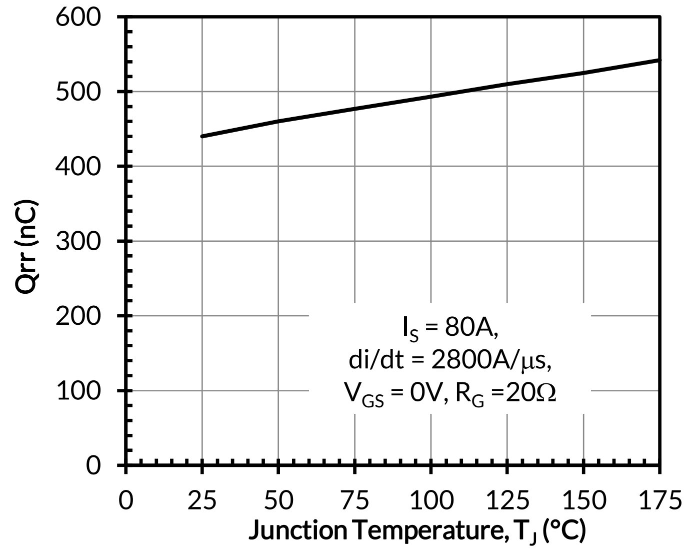
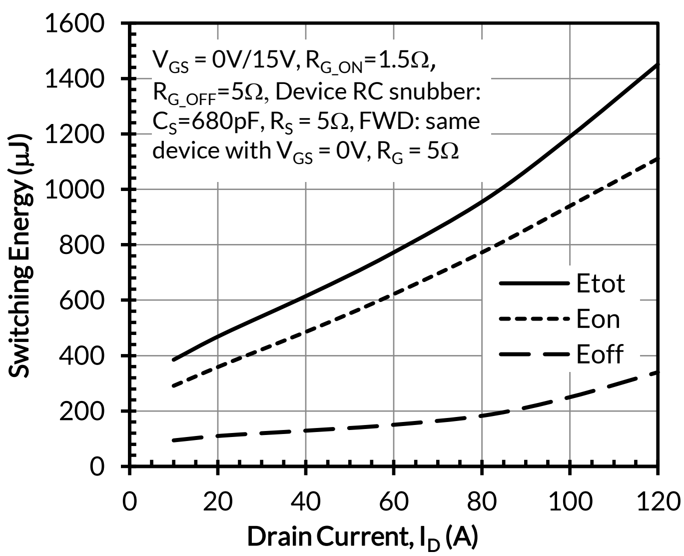


Figure 17. Safe operation area at T_C = 25°C, D = 0, Parameter t_p

Figure 18. Reverse recovery charge Qrr vs. junction temperature at V_{DS} = 400V



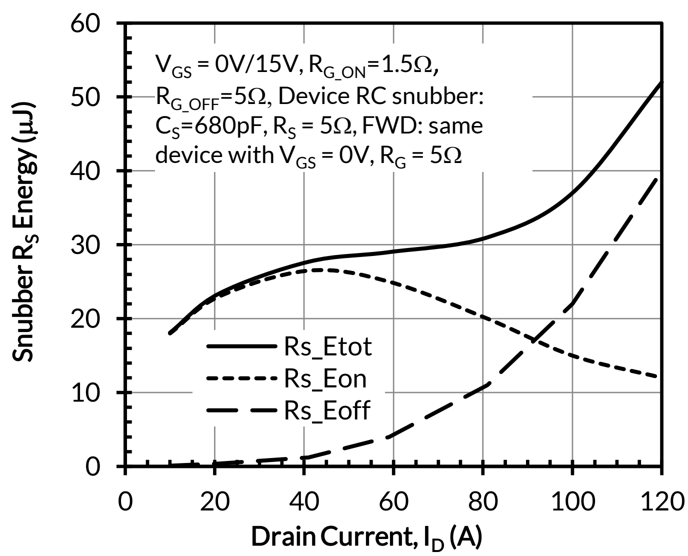


Figure 19. Clamped inductive switching energy vs. drain current at V_{DS} = 400V and T_J = 25°C

Figure 20. RC snubber energy loss vs. drain current at V_{DS} = 400V and T_J = 25°C

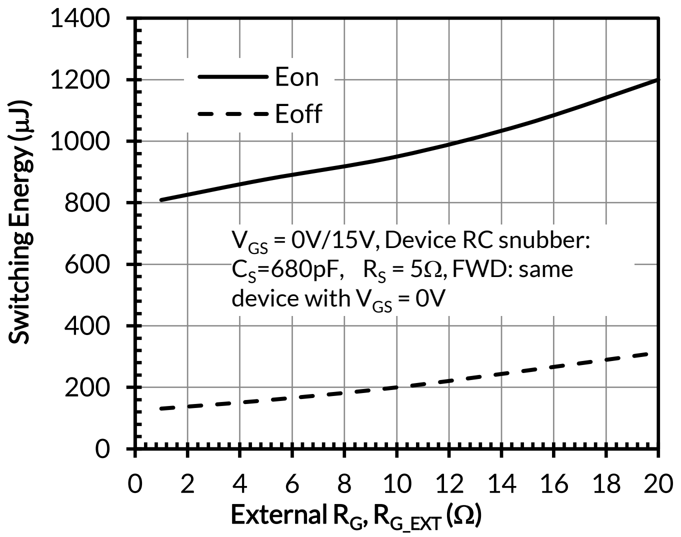


Figure 21. Clamped inductive switching energies vs. $R_{G,EXT}$ at V_{DS} = 400V, I_D = 80A, and T_J = 25°C

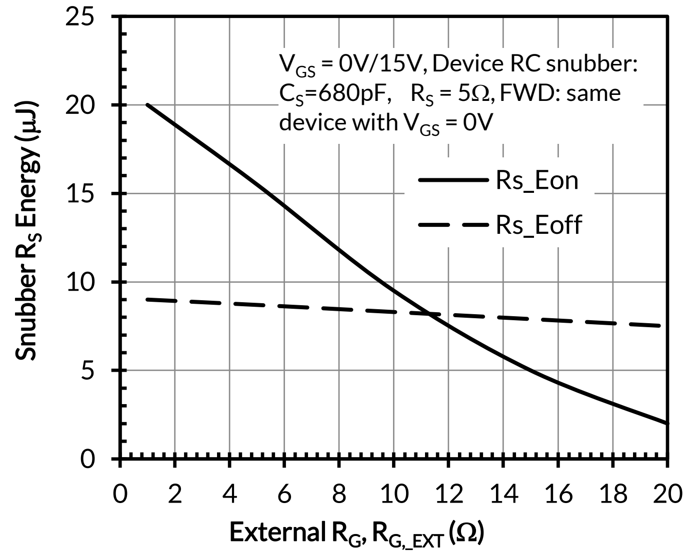


Figure 22. RC snubber energy losses vs. $R_{G,EXT}$ at V_{DS} = 400V, I_D = 80A, and T_J = 25°C

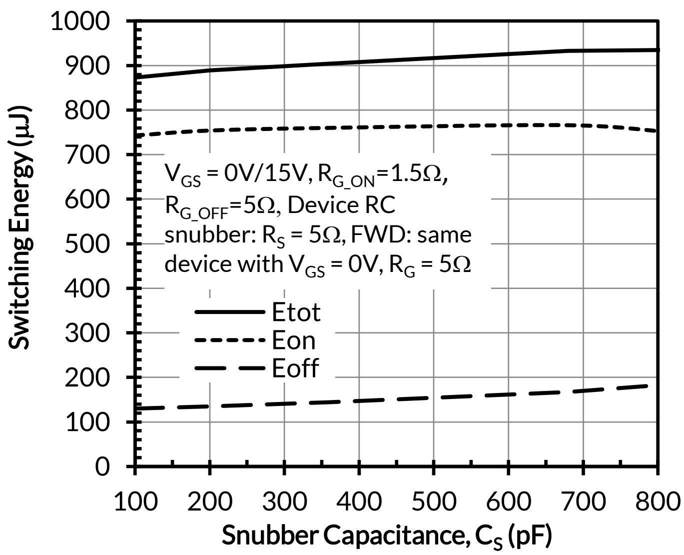


Figure 23. Clamped inductive switching energies vs. snubber capacitance C_S at V_{DS} = 400V, I_D = 80A, and T_J = 25°C

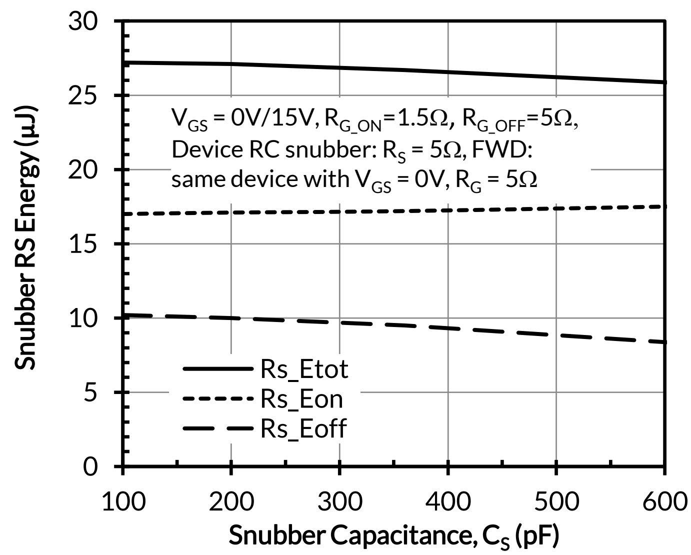


Figure 24. RC snubber energy losses vs. snubber capacitance C_S at V_{DS} = 400V, I_D = 80A, and T_J = 25°C

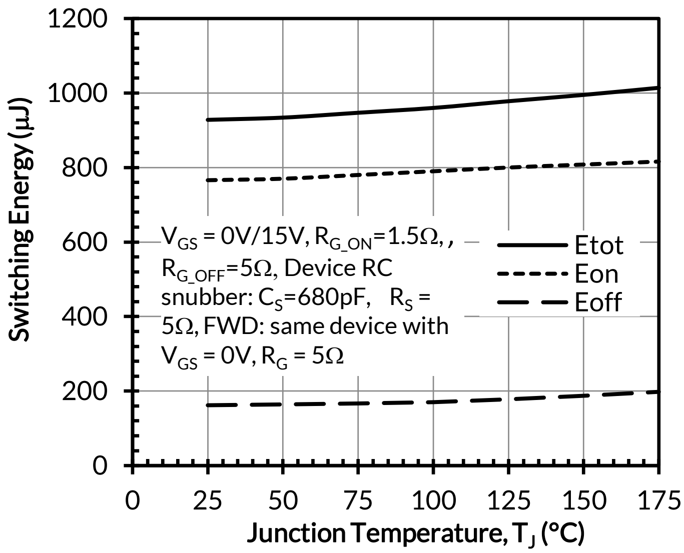


Figure 25. Clamped inductive switching energy vs. junction temperature at V_{DS} =400V and I_D = 80A

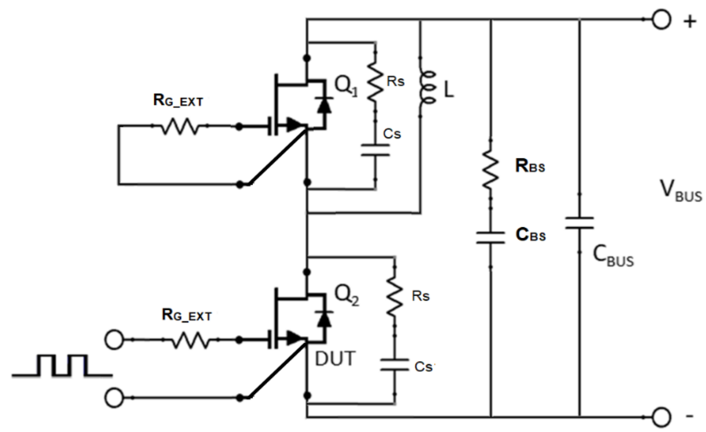


Figure 26. Schematic of the half-bridge mode switching test circuit. Note, a device snubber (Rs =5Ω, Cs = 680pF) and bus RC snubber (R_{BS} = 1Ω, C_{BS}=100nF) is used to reduce the power loop high frequency oscillations.

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.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

Important notice