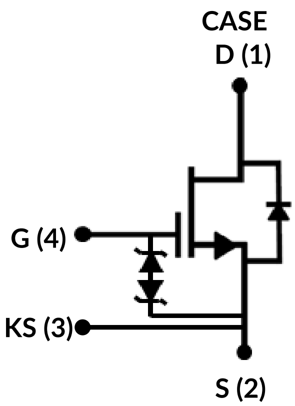
DATASHEET

UF3C120040K4S



Part Number	Package	Marking
UF3C120040K4S	TO-247-4L	UF3C120040K4S

1200V-35mΩ SiC Cascode

Rev. A, January 2019

Description

United Silicon Carbide's cascode products co-package its high-performance F3 SiC fast JFETs with a cascode optimized MOSFET to produce the only standard gate drive SiC device in the market today. This series exhibits very fast switching using a 4-terminal TO-247-package and the best reverse recovery characteristics of any device of similar ratings. These devices are excellent for switching inductive loads, and any application requiring standard gate drive.

Features

- Typical on-resistance $R_{DS(on),typ}$ of 35mΩ
- Maximum operating temperature of 175°C
- Excellent reverse recovery
- Low gate charge
- Low intrinsic capacitance
- ESD protected, HBM class 2
- TO-247-4L package for faster switching, clean gate waveforms

Typical applications

- 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}		1200	V
Gate-source voltage	V_{GS}	DC	-25 to +25	V
Continuous drain current [1]	I_D	T_C = 25°C	65	A
		T_C = 100°C	47	A
Pulsed drain current [2]	I_{DM}	T_C = 25°C	175	A
Single pulsed avalanche energy [3]	E_{AS}	L=15mH, I_{AS} =4.2A	132.3	mJ
Power dissipation	P_{tot}	T_C = 25°C	429	W
Maximum junction temperature	$T_{J,max}$		175	°C
Operating and storage temperature	T_J, T_{STG}		-55 to 175	°C
Max. lead temperature for soldering, 1/8" from case for 5 seconds	T_L		250	°C

1. Limited by $T_{J,max}$
2. Pulse width t_p limited by $T_{J,max}$
3. Starting T_J = 25°C

Thermal Characteristics

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Thermal resistance, junction-to-case	$R_{\theta JC}$			0.27	0.35	°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	1200			V
Total drain leakage current	I_{DSS}	V_{DS}=1200V, V_{GS}=0V, T_J=25°C		8	150	μA
		V_{DS}=1200V, V_{GS}=0V, T_J=175°C		35		
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=40A, T_J=25°C		35	45	mΩ
		V_{GS}=12V, I_D=40A, T_J=175°C		73		
Gate threshold voltage	$V_{G(th)}$	V_{DS}=5V, I_D=10mA	4	5	6	V
Gate resistance	R_G	f=1MHz, open drain		4.5		Ω

Typical Performance - Reverse Diode

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Diode continuous forward current [1]	I_S	T_C=25°C			65	A
Diode pulse current [2]	$I_{S,pulse}$	T_C=25°C			175	A
Forward voltage	V_{FSD}	V_{GS}=0V, I_F=20A, T_J=25°C		1.5	2	V
		V_{GS}=0V, I_F=20A, T_J=175°C		1.95		
Reverse recovery charge	Q_{rr}	V_R=800V, I_F=40A, V_{GS}=-5V, R_{G_EXT}=10Ω di/dt=2400A/μs, T_J=25°C		358		nC
Reverse recovery time	t_{rr}			25		ns
Reverse recovery charge	Q_{rr}	V_R=800V, I_F=40A, V_{GS}=-5V, R_{G_EXT}=10Ω di/dt=2400A/μs, T_J=150°C		259		nC
Reverse recovery time	t_{rr}			22		ns

Typical Performance - Dynamic

Parameter	Symbol	Test Conditions	Value			Units
			Min	Typ	Max	
Input capacitance	C_{iss}	V_{DS}=100V, V_{GS}=0V f=100kHz		1500		pF
Output capacitance	C_{oss}			210		
Reverse transfer capacitance	C_{rss}			1.7		
Effective output capacitance, energy related	$C_{oss(er)}$	V_{DS}=0V to 800V, V_{GS}=0V		112		pF
Effective output capacitance, time related	$C_{oss(tr)}$	V_{DS}=0V to 800V, V_{GS}=0V		280		pF
C_{OSS} stored energy	E_{oss}	V_{DS}=800V, V_{GS}=0V		35.6		μJ
Total gate charge	Q_G	V_{DS}=800V, I_D=40A, V_{GS} = -5V to 12V		43		nC
Gate-drain charge	Q_{GD}			11		
Gate-source charge	Q_{GS}			19		
Turn-on delay time	$t_{d(on)}$	V_{DS}=800V, I_D=40A, Gate Driver =-5V to +12V, Turn-on $R_{G,EXT}$=8.5Ω, Turn-off $R_{G,EXT}$=20Ω Inductive Load, FWD: same device with V_{GS} = -5V, R_G = 10Ω, T_J=25°C		24		ns
Rise time	t_r			27		
Turn-off delay time	$t_{d(off)}$			50		
Fall time	t_f			10		
Turn-on energy	E_{ON}			780		μJ
Turn-off energy	E_{OFF}			195		
Total switching energy	E_{TOTAL}			975		
Turn-on delay time	$t_{d(on)}$	V_{DS}=800V, I_D=40A, Gate Driver =-5V to +12V, Turn-on $R_{G,EXT}$=8.5Ω, Turn-off $R_{G,EXT}$=20Ω Inductive Load, FWD: same device with V_{GS} = -5V, R_G = 10Ω, T_J=150°C		23		ns
Rise time	t_r			24		
Turn-off delay time	$t_{d(off)}$			50		
Fall time	t_f			9		
Turn-on energy	E_{ON}			668		μJ
Turn-off energy	E_{OFF}			134		
Total switching energy	E_{TOTAL}			802		

Typical Performance Diagrams

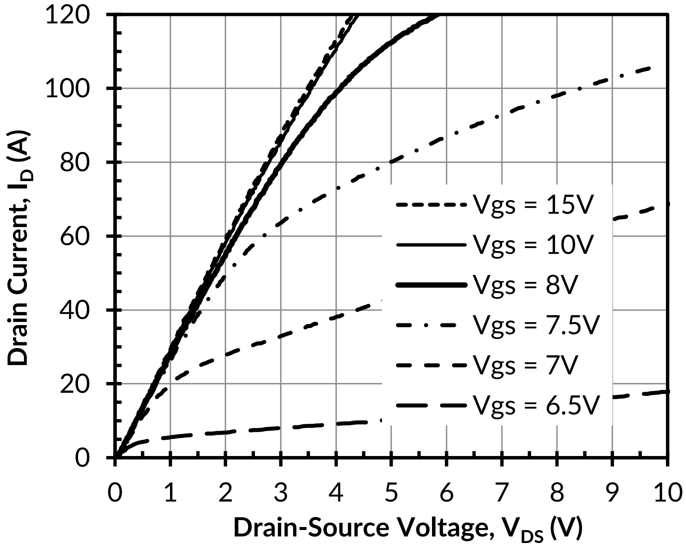


Figure 1. Typical output characteristics at T_J = -55°C, tp < 250μs

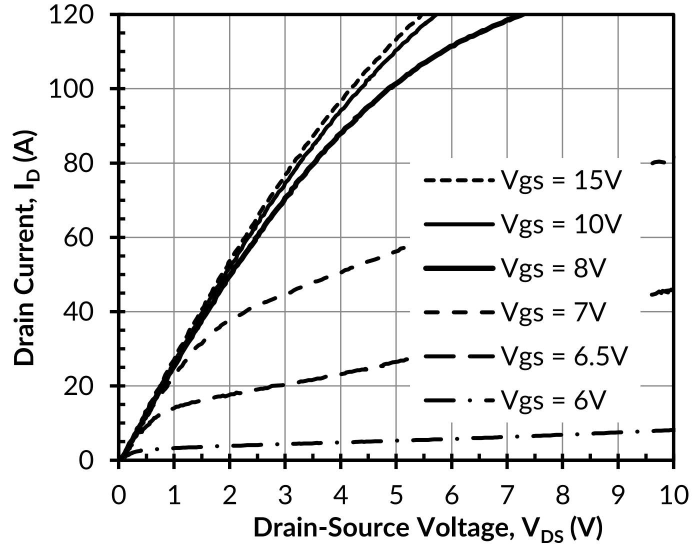


Figure 2. Typical output characteristics at T_J = 25°C, tp < 250μs

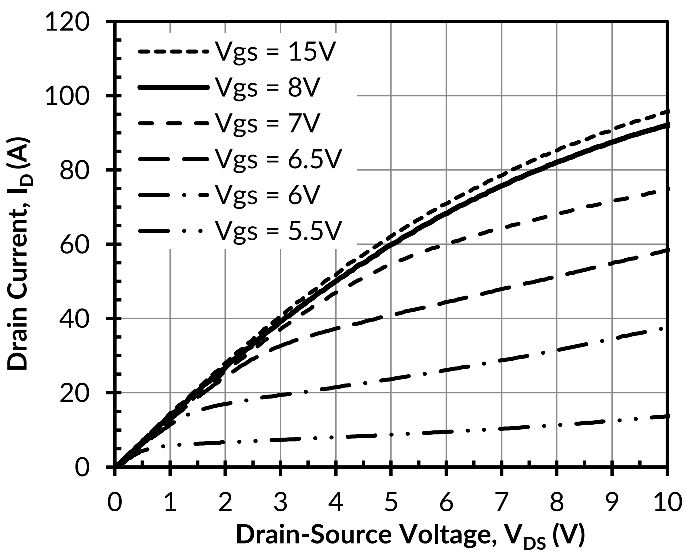


Figure 3. Typical output characteristics at T_J = 175°C, tp < 250μs

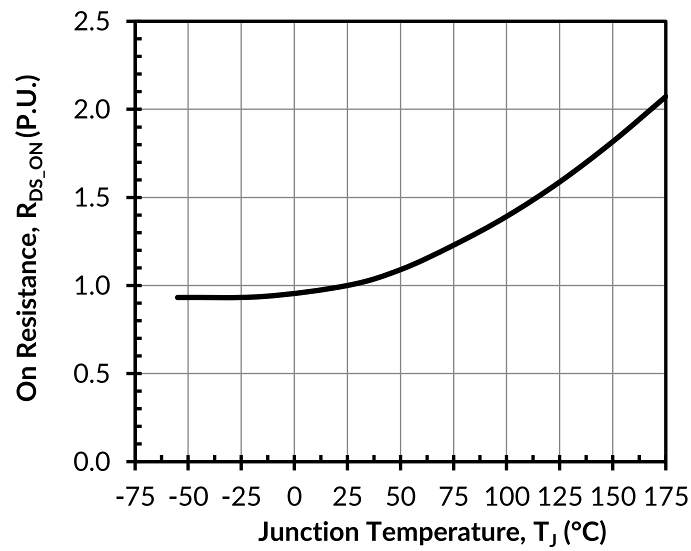


Figure 4. Normalized on-resistance vs. temperature at V_{GS} = 12V and I_D = 40A

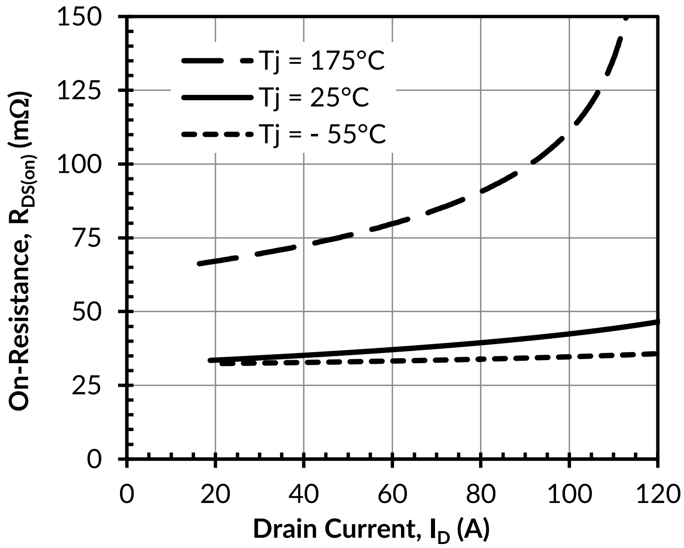


Figure 5. Typical drain-source on-resistances at V_{GS} = 12V

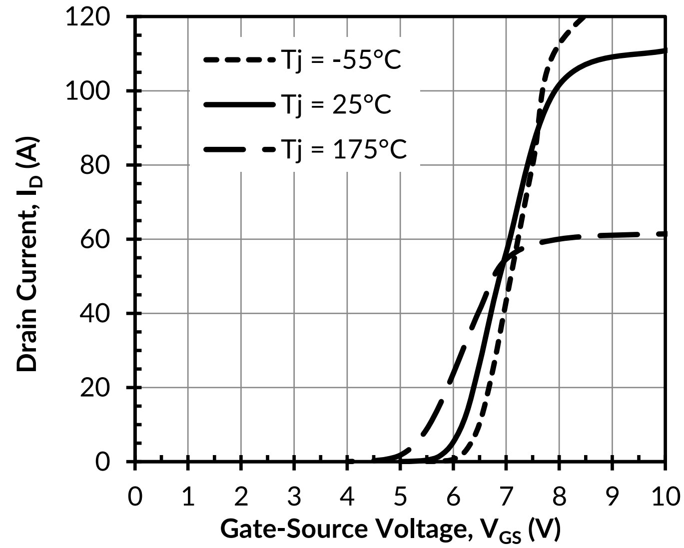


Figure 6. Typical transfer characteristics at V_{DS} = 5V

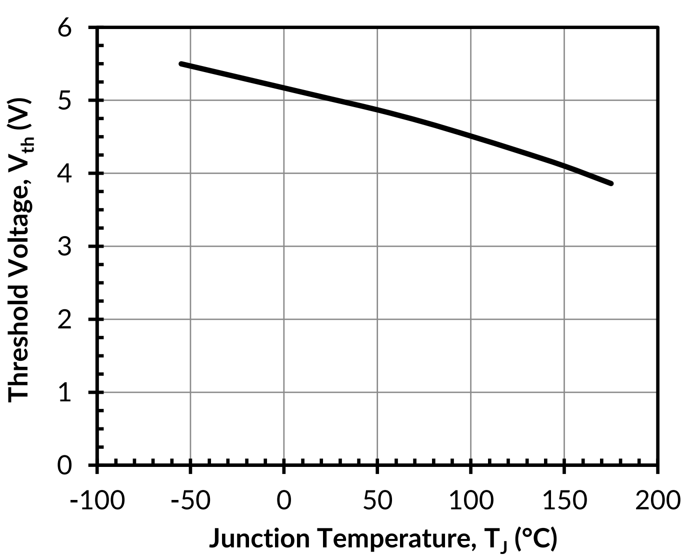


Figure 7. Threshold voltage vs. junction temperature at V_{DS} = 5V and I_D = 10mA

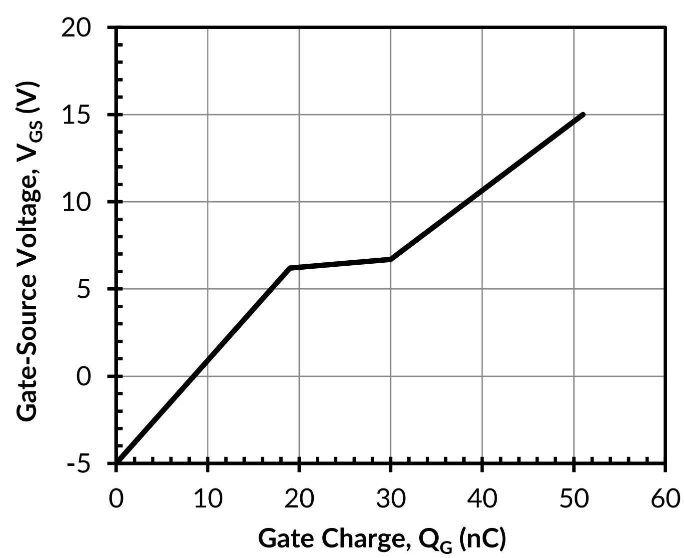


Figure 8. Typical gate charge at V_{DS} = 800V and I_D = 40A

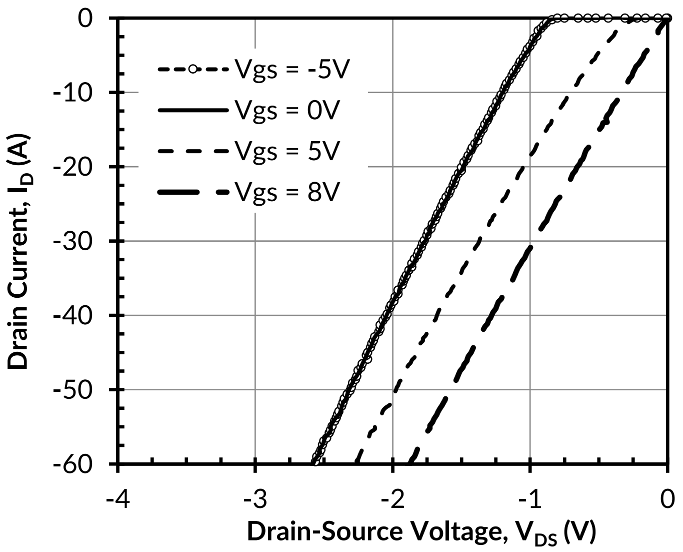


Figure 9. 3rd quadrant characteristics at T_J = -55°C

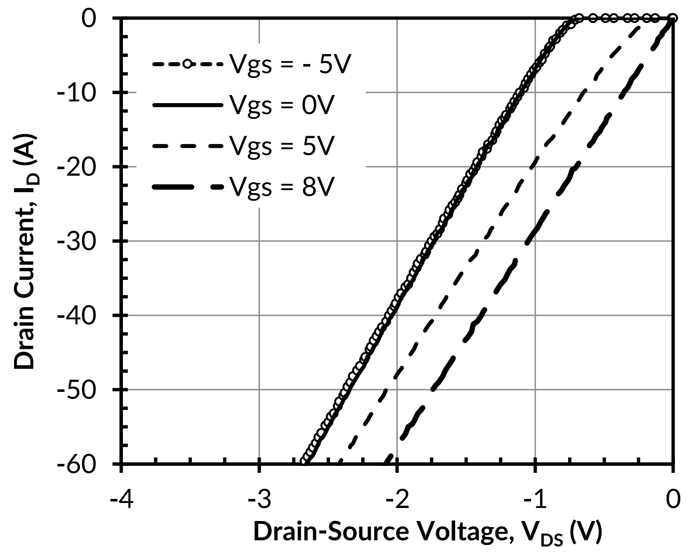


Figure 10. 3rd quadrant characteristics at T_J = 25°C

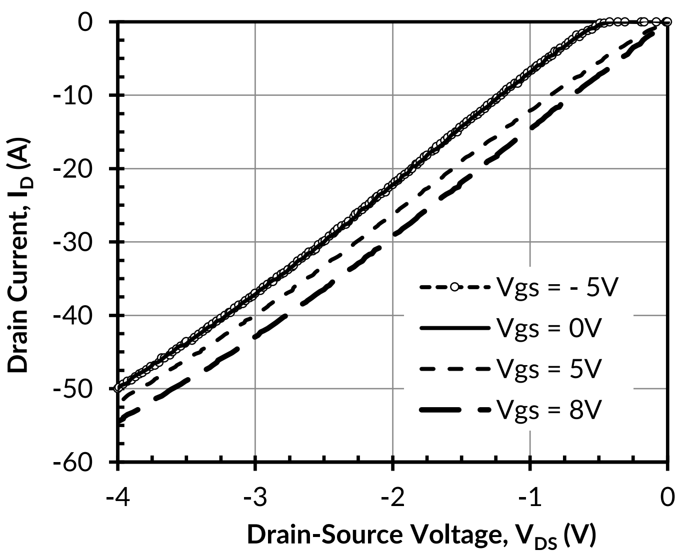


Figure 11. 3rd quadrant characteristics at T_J = 175°C

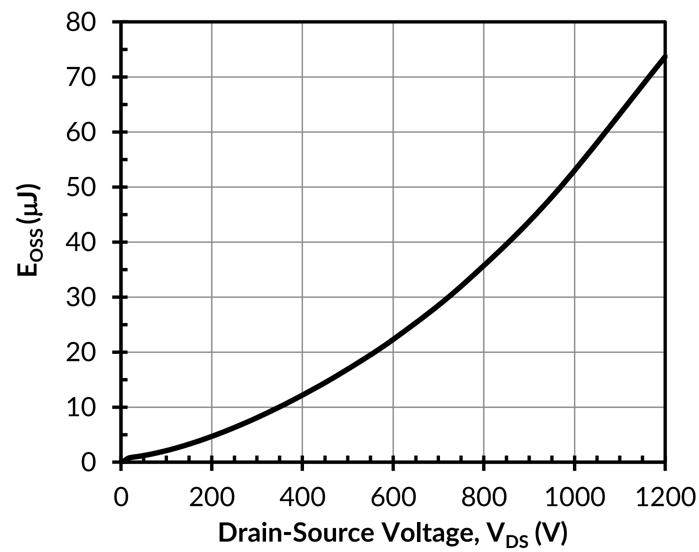


Figure 12. Typical stored energy in C_{OSS} at V_{GS} = 0V

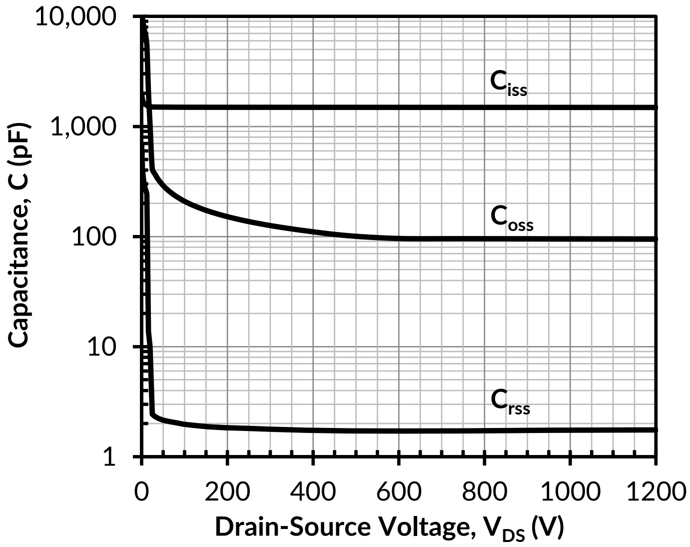


Figure 13. Typical capacitances at f = 100kHz and V_{GS} = 0V

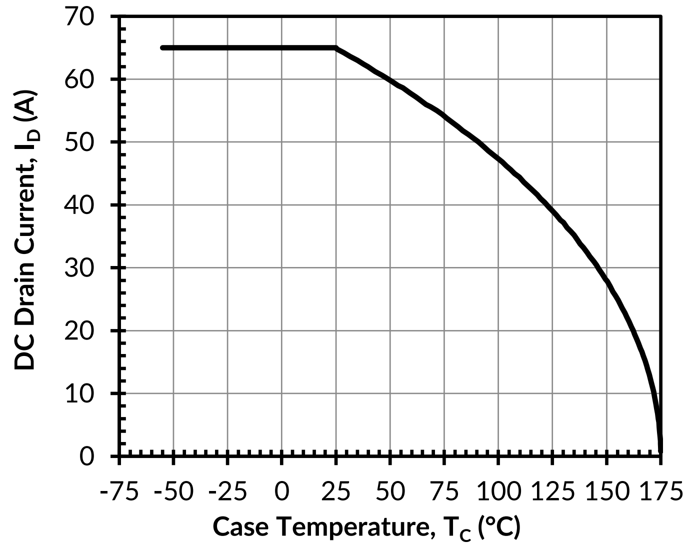


Figure 14. DC drain current derating

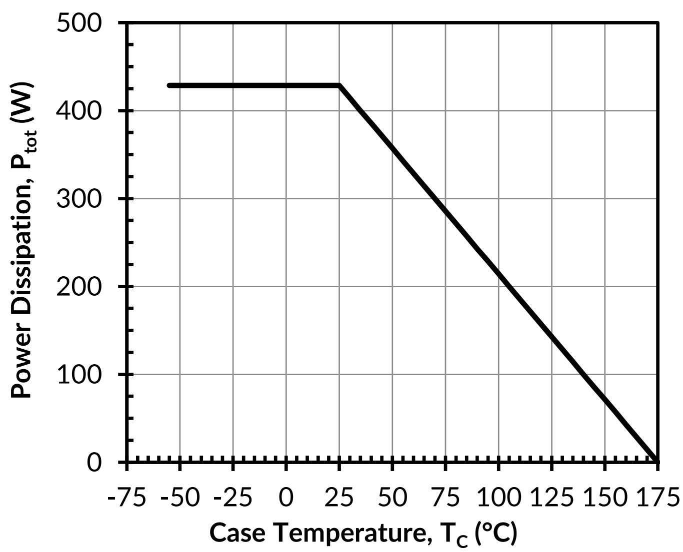


Figure 15. Total power dissipation

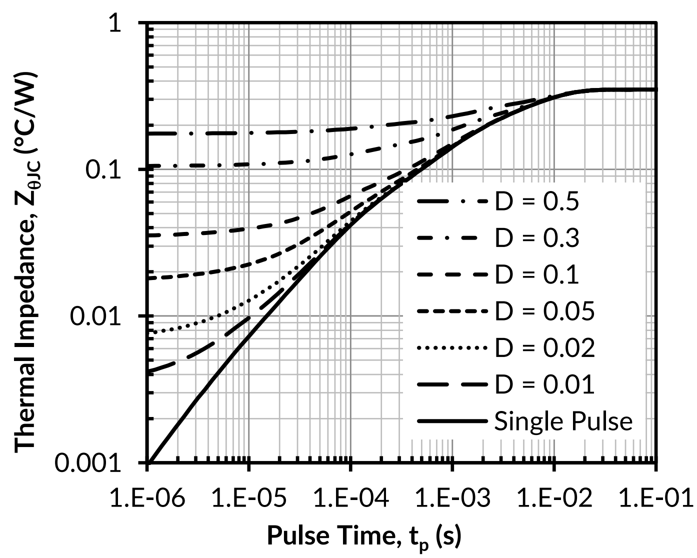


Figure 16. Maximum transient thermal impedance

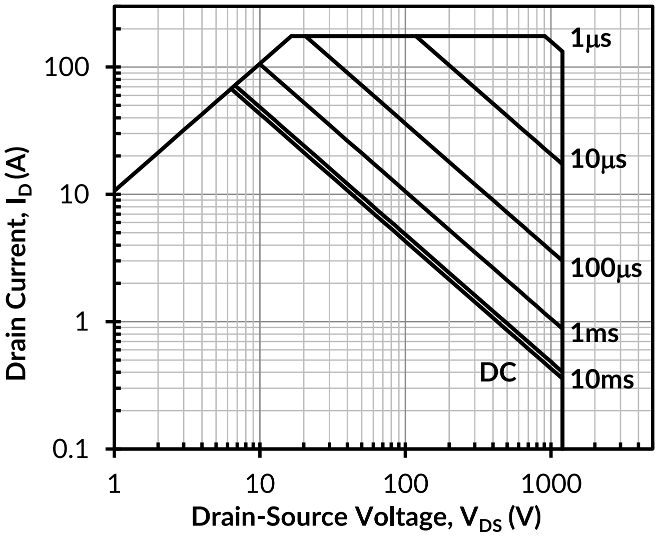


Figure 17. Safe operation area at T_C = 25°C, D = 0, Parameter t_p

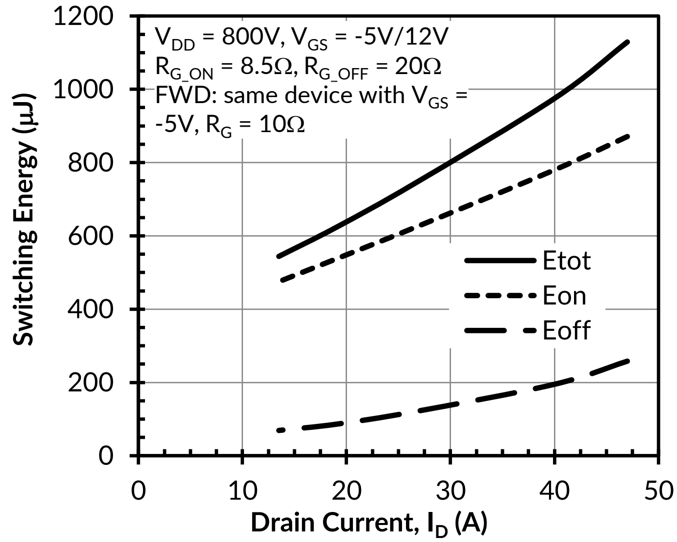


Figure 18. Clamped inductive switching energy vs. drain current at T_J = 25°C

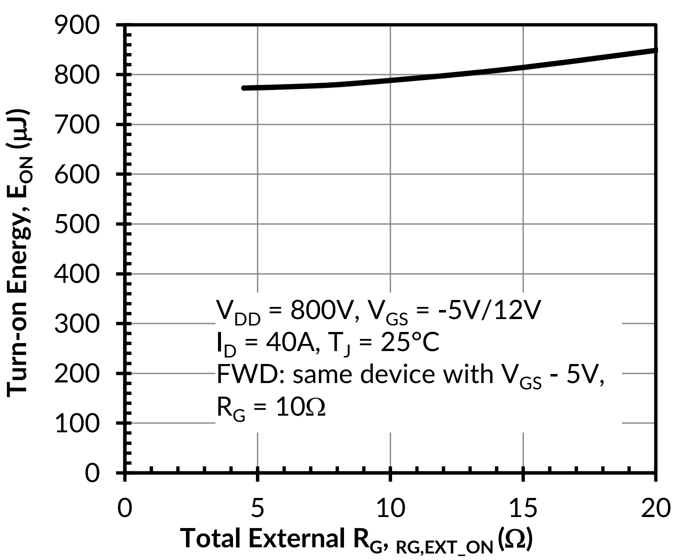


Figure 19. Clamped inductive switching turn-on energy vs. R_{G,EXT_ON}

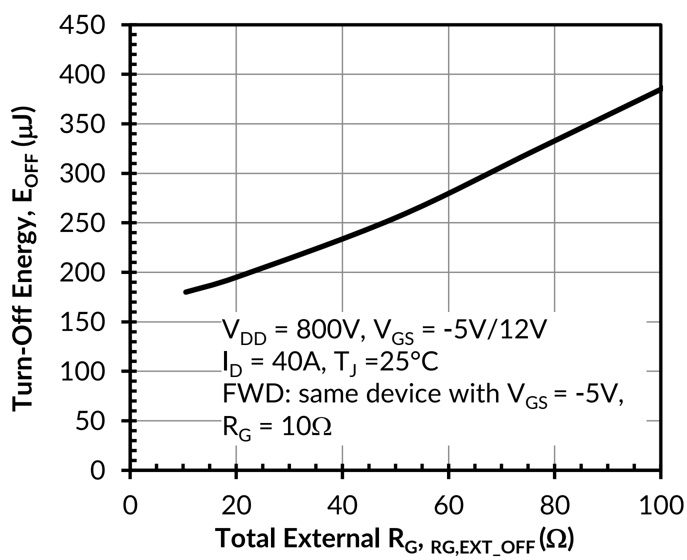


Figure 20. Clamped inductive switching turn-off energy vs. R_{G,EXT_OFF}

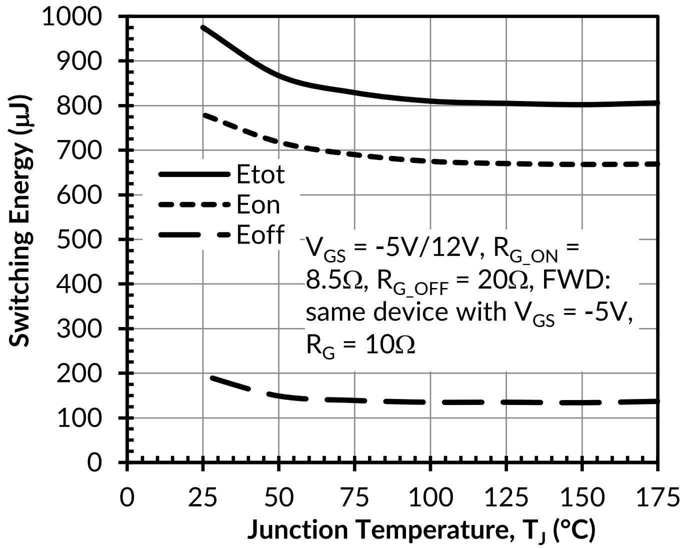


Figure 21. Clamped inductive switching energy vs. junction temperature at V_{DS} = 800V and I_D = 40A

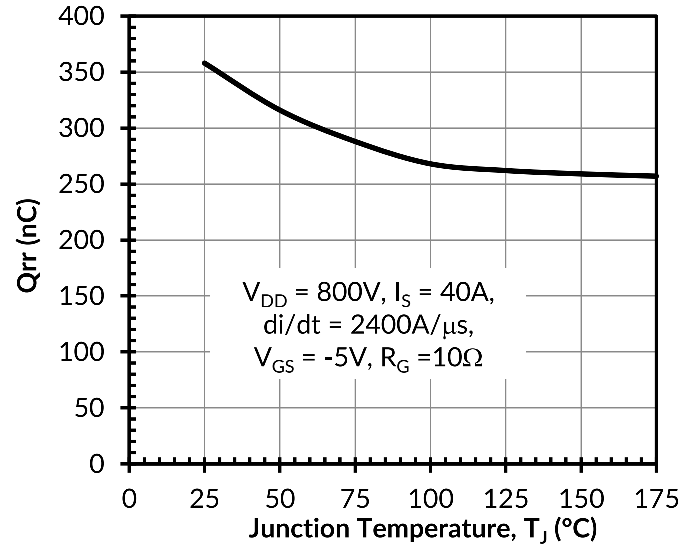


Figure 22. Reverse recovery charge Qrr vs. junction temperature

Applications Information

SiC cascodes 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 (Qrr) leading to low conduction and switching losses. The SiC cascodes 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 cascode is working in the diode mode in order to achieve the optimum reverse recovery performance. For more information on cascode operation, see www.unitedsic.com.

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