







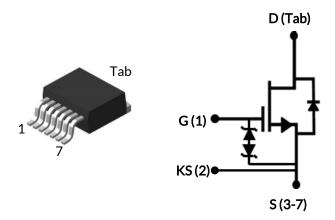








# UF3C065080B7S



Part Number	Package	Marking
UF3C065080B7S	D <sup>2</sup> PAK-7L	UF3C065080B7S







### 650V-85mΩ SiC FET

Rev. B, May 2023

### Description

This SiC FET device 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  $D^2PAK\text{-}7L$  package, this device exhibits ultralow 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<sub>DS(on)</sub>: 85mΩ (typ)
- Operating temperature: 175°C (max)
- Excellent reverse recovery: Q<sub>rr</sub> = 69nC
- ◆ Low body diode V<sub>FSD</sub>: 1.54V
- Low gate charge: Q<sub>G</sub> = 23nC
- Threshold voltage V<sub>G(th)</sub>: 4.8V (typ) allowing 0 to 15V drive
- Package creepage and clearance distance > 6.1mm
- Kelvin source pin for optimized switching performance
- ESD protected, HBM class 2

### Typical applications

Any controlled environment such as

- ◆ Telecom and Server Power
- Industrial power supplies
- Power factor correction modules
- Motor drives
- Induction heating















### **Maximum Ratings**

Parameter	Symbol	Test Conditions	Value	Units
Drain-source voltage	$V_{DS}$		650	V
Gate-source voltage	$V_{GS}$	DC	-25 to +25	V
Continuous drain current <sup>1</sup>	I <sub>D</sub>	T <sub>C</sub> = 25°C	27	Α
Continuous drain current		T <sub>C</sub> = 100°C	20	Α
Pulsed drain current <sup>2</sup>	I <sub>DM</sub>	T <sub>C</sub> = 25°C	65	А
Single pulsed avalanche energy <sup>3</sup>	E <sub>AS</sub>	L=15mH, I <sub>AS</sub> =2.1A	33	mJ
Power dissipation	P <sub>tot</sub>	T <sub>C</sub> = 25°C	136.4	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 <sub>solder</sub>	reflow MSL 3	245	°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	Тур	Max	Offics
Thermal resistance, junction-to-case	$R_{ heta$ JC			0.83	1.1	°C/W













### Electrical Characteristics (T<sub>J</sub> = +25°C unless otherwise specified)

### **Typical Performance - Static**

Parameter	Symbol	Test Conditions		Units		
			Min	Тур	Max	Units
Drain-source breakdown voltage	$BV_DS$	$V_{GS}$ =0V, $I_D$ =1mA	650			V
Total drain leakage current	I <sub>DSS</sub>	V <sub>DS</sub> =650V, V <sub>GS</sub> =0V, T <sub>J</sub> =25°C		1.3	100	- μΑ
		V <sub>DS</sub> =650V, V <sub>GS</sub> =0V, T <sub>J</sub> =175°C		10		
Total gate leakage current	I <sub>GSS</sub>	V <sub>DS</sub> =0V, T <sub>J</sub> =25°C, V <sub>GS</sub> =-20V / +20V		6	±20	μА
Drain-source on-resistance	R <sub>DS(on)</sub>	$V_{GS}$ =12V, $I_{D}$ =20A, $T_{J}$ =25°C		85	105	
		$V_{GS}$ =12V, $I_{D}$ =20A, $T_{J}$ =125°C		116		mΩ
		$V_{GS}$ =12V, $I_{D}$ =20A, $T_{J}$ =175°C		146		
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		4.2		Ω

### Typical Performance - Reverse Diode

Parameter	Symbol	Test Conditions		Limita		
			Min	Тур	Max	- Units
Diode continuous forward current <sup>1</sup>	I <sub>S</sub>	T <sub>C</sub> =25°C			27	Α
Diode pulse current <sup>2</sup>	I <sub>S,pulse</sub>	T <sub>C</sub> =25°C			65	Α
Forward voltage	$V_{FSD}$	V <sub>GS</sub> =0V, I <sub>S</sub> =10A, T <sub>J</sub> =25°C		1.54	2	V
		V <sub>GS</sub> =0V, I <sub>S</sub> =10A, T <sub>J</sub> =175°C		1.85		
Reverse recovery charge	Q <sub>rr</sub>	$V_R$ =400V, $I_S$ =20A, $V_{GS}$ =-5V, $R_{G_EXT}$ =22 $\Omega$		69		nC
Reverse recovery time	t <sub>rr</sub>	di/dt=2000A/μs, T <sub>J</sub> =25°C		21		ns
Reverse recovery charge	Q <sub>rr</sub>	$V_R$ =400V, $I_S$ =20A, $V_{GS}$ =-5V, $R_{G\_EXT}$ =22 $\Omega$		66		nC
Reverse recovery time	t <sub>rr</sub>	di/dt=2000A/μs, Τ <sub>J</sub> =150°C		19		ns













### Typical Performance - Dynamic

Parameter	Symbol	Test Conditions	Value			Units
			Min	Тур	Max	Units
Input capacitance	C <sub>iss</sub>	V <sub>DS</sub> =100V, V <sub>GS</sub> =0V		760		
Output capacitance	C <sub>oss</sub>	f=100kHz		98		pF
Reverse transfer capacitance	$C_{rss}$	1-100KHZ		1		
Effective output capacitance, energy related	C <sub>oss(er)</sub>	$V_{DS}$ =0V to 400V, $V_{GS}$ =0V		71		pF
Effective output capacitance, time related	C <sub>oss(tr)</sub>	$V_{DS}$ =0V to 400V, $V_{GS}$ =0V		150		pF
C <sub>OSS</sub> stored energy	E <sub>oss</sub>	$V_{DS}$ =400V, $V_{GS}$ =0V		5.7		μJ
Total gate charge	$Q_{G}$	- V <sub>DS</sub> =400V, I <sub>D</sub> =20A,		23		nC
Gate-drain charge	$Q_{GD}$	$V_{DS} = -5V \text{ to } 12V$		5		
Gate-source charge	$Q_{GS}$	V <sub>GS</sub> - 3V to 12V		11		
Turn-on delay time	t <sub>d(on)</sub>	V <sub>DS</sub> =400V, I <sub>D</sub> =20A, Gate		30		ns 
Rise time	t <sub>r</sub>	Driver =-5V to +12V,		8		
Turn-off delay time	t <sub>d(off)</sub>	$Turn-on R_{G,EXT}=8.5\Omega,$ $Turn-off R_{G,EXT}=22\Omega$ $Inductive Load,$ $FWD: same device with$ $V_{GS}=-5V, R_{G}=22\Omega,$ $T_{J}=25^{\circ}C$		25		
Fall time	t <sub>f</sub>			7		
Turn-on energy	E <sub>ON</sub>			163		
Turn-off energy	E <sub>OFF</sub>			29		
Total switching energy	E <sub>TOTAL</sub>			192		
Turn-on delay time	t <sub>d(on)</sub>	$V_{DS} = 400V, I_D = 20A, Gate \\ Driver = -5V to + 12V, \\ Turn-on R_{G,EXT} = 8.5\Omega, \\ Turn-off R_{G,EXT} = 22\Omega \\ Inductive Load, \\ FWD: same device with \\ V_{GS} = -5V, R_G = 22\Omega, \\ T_J = 150°C$		27		
Rise time	t <sub>r</sub>			7		
Turn-off delay time	t <sub>d(off)</sub>			26		ns
Fall time	t <sub>f</sub>			6		
Turn-on energy	E <sub>ON</sub>			144		
Turn-off energy	E <sub>OFF</sub>			26		μЈ
Total switching energy	E <sub>TOTAL</sub>			170		





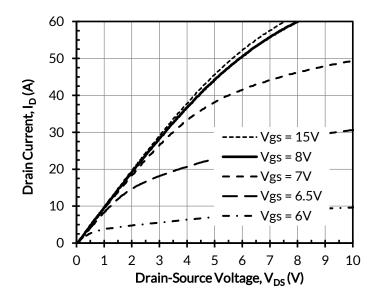








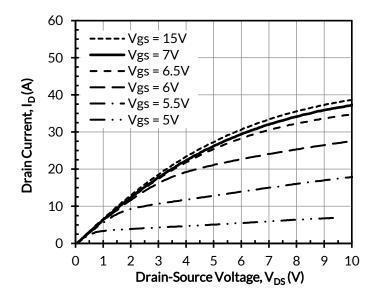




60 50 Drain Current, I<sub>D</sub> (A) 40 30 Vgs = 8V 20 **-** Vgs = 7V Vgs = 6.5V 10 Vgs = 6V 10 0 1 2 Drain-Source Voltage, V<sub>DS</sub> (V)

Figure 1. Typical output characteristics at  $T_J = -55$ °C, tp < 250 $\mu$ s

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



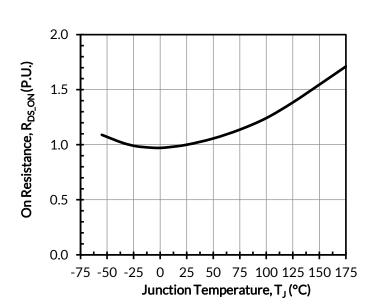


Figure 3. Typical output characteristics at  $T_J$  = 175°C, tp < 250 $\mu$ s

Figure 4. Normalized on-resistance vs. temperature at  $V_{GS}$  = 12V and  $I_{D}$  = 20A





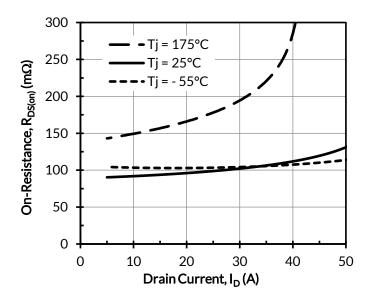








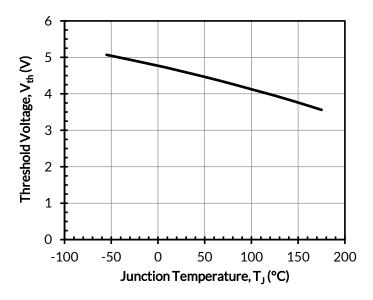




40 Tj = -55°C Tj = 25°C 30 **-** Tj = 175°C Drain Current, I<sub>D</sub> (A) 20 10 0 3 4 5 7 8 9 0 1 2 6 10 Gate-Source Voltage,  $V_{GS}(V)$ 

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

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



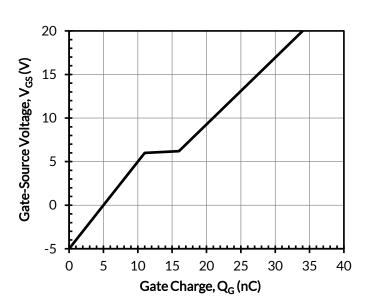


Figure 7. Threshold voltage vs. junction temperature at  $V_{DS}$  = 5V and  $I_D$  = 10mA

Figure 8. Typical gate charge at  $V_{DS}$  = 400V and  $I_{D}$  = 20A













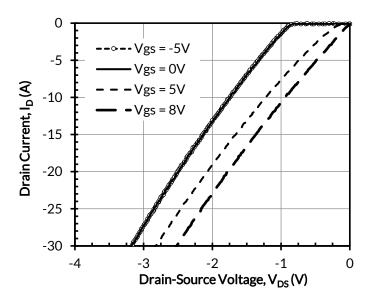
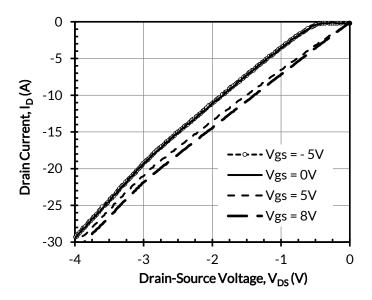


Figure 9. 3rd quadrant characteristics at  $T_J = -55$ °C

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



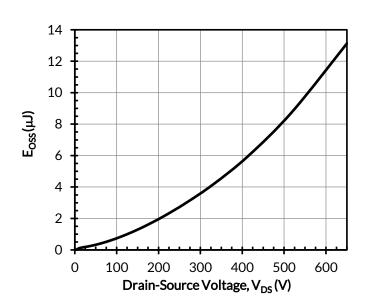


Figure 11. 3rd quadrant characteristics at  $T_J = 175$ °C

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





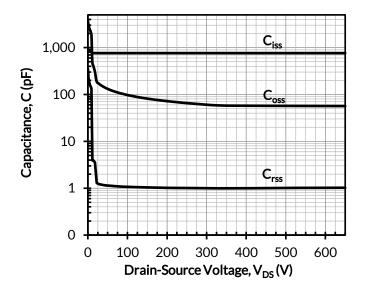








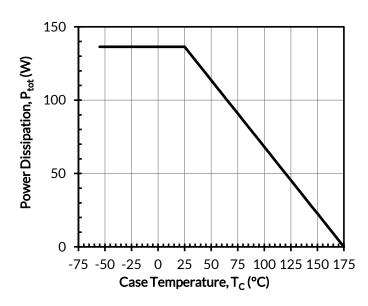




30 25 DC Drain Current, I<sub>D</sub> (A) 20 15 10 5 -75 -50 -25 0 25 50 75 100 125 150 175 Case Temperature, T<sub>C</sub> (°C)

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

Figure 14. DC drain current derating



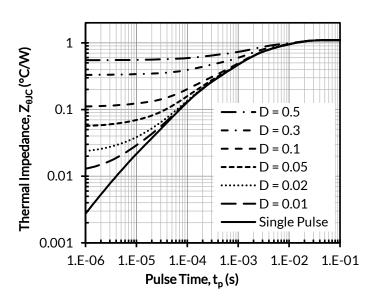


Figure 15. Total power dissipation

Figure 16. Maximum transient thermal impedance













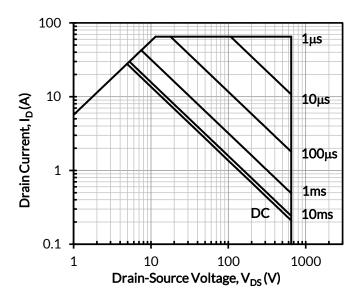


Figure 17. Safe operation area at  $T_C$  = 25°C, D = 0, Parameter  $t_p$ 

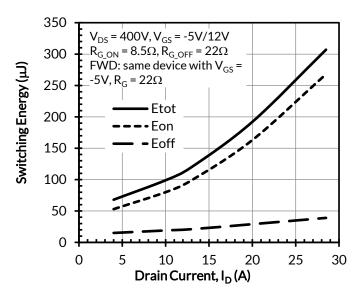


Figure 18. Clamped inductive switching energy vs. drain current at  $T_1 = 25$ °C

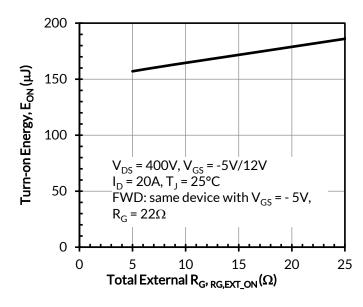


Figure 19. Clamped inductive switching turn-on energy vs.  $R_{G,EXT\_ON}$ 

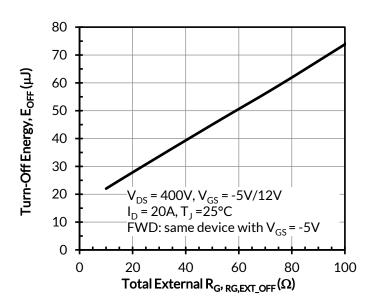


Figure 20. Clamped inductive switching turn-off energy vs.  $R_{G,\text{EXT OFF}}$ 



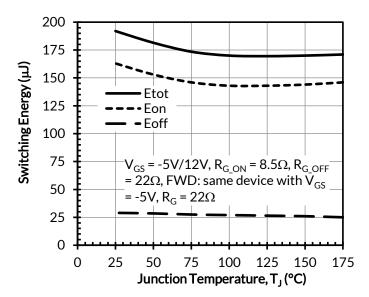












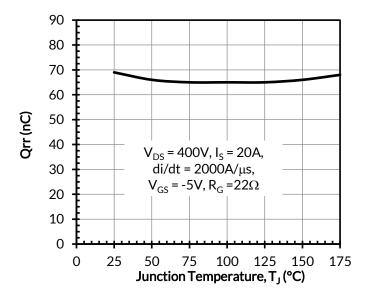


Figure 21. Clamped inductive switching energy vs. junction temperature at  $V_{DS} = 400V$  and  $I_D = 20A$ 

Figure 22. Reverse recovery charge Qrr vs. junction temperature

#### **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













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