

# Silicon Carbide (SiC) Cascode JFET – EliteSiC, Power N-Channel, D2PAK-3, 650 V, 42 mohm

## UF3C065040B3

### Description

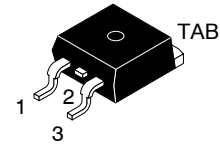
This SiC FET device is based on a unique ‘cascode’ circuit configuration, in which a normally-on SiC JFET is co-packaged with a Si MOSFET to produce a normally-off SiC FET device. The device’s standard gate-drive characteristics allows for a true “drop-in replacement” to Si IGBTs, Si FETs, SiC MOSFETs or Si superjunction devices. Available in the D<sup>2</sup>PAK-3 package, this device exhibits ultra-low gate charge and exceptional reverse recovery characteristics, making it ideal for switching inductive loads when used with recommended RC-snubbers, and any application requiring standard gate drive.

### Features

- Typical On-resistance  $R_{DS(on),typ}$  of 42 mΩ
- Maximum Operating Temperature of 175°C
- Excellent Reverse Recovery
- Low Gate Charge
- Low Intrinsic Capacitance
- ESD Protected, HBM Class 2
- Very Low Switching Losses (Required RC-snubber Loss Negligible under Typical Operating Conditions)
- This Device is Halogen Free and RoHS Compliant with Exemption 7a, Pb-Free 2LI (on second level interconnection)

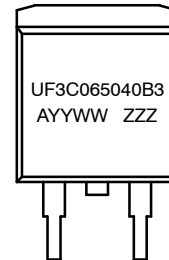
### Typical Applications

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



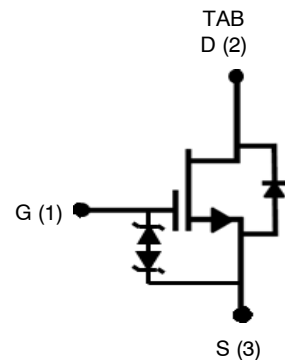
D<sup>2</sup>PAK-3 (TO-263, 3-LEAD)  
 CASE 418AJ

### MARKING DIAGRAM



UF3C065040B3 = Specific Device Number  
 A = Assembly Location  
 YY = Year  
 WW = Work Week  
 ZZZ = Lot ID

### PIN CONNECTIONS



### ORDERING INFORMATION

See detailed ordering and shipping information on page 9 of this data sheet.

# UF3C065040B3

## MAXIMUM RATINGS

Parameter	Symbol	Test Conditions	Value	Unit
Drain-source Voltage	$V_{DS}$		650	V
Gate-source Voltage	$V_{GS}$	DC	-25 to +25	V
Continuous Drain Current (Note 1)	$I_D$	$T_C = 25\text{ }^\circ\text{C}$	41	A
		$T_C = 100\text{ }^\circ\text{C}$	30	
Pulsed Drain Current (Note 2)	$I_{DM}$	$T_C = 25\text{ }^\circ\text{C}$	125	A
Single Pulsed Avalanche Energy (Note 3)	$E_{AS}$	$L = 15\text{ mH}$ , $I_{AS} = 3.19\text{ A}$	76	mJ
Power Dissipation	$P_{tot}$	$T_C = 25\text{ }^\circ\text{C}$	176	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	$^\circ\text{C}$

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.

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

## THERMAL CHARACTERISTICS

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$		-	0.65	0.85	$^\circ\text{C/W}$

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

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

Drain-source Breakdown Voltage	$BV_{DS}$	$V_{GS} = 0\text{ V}$ , $I_D = 1\text{ mA}$	650	-	-	V	
Total Drain Leakage Current	$I_{DSS}$	$V_{DS} = 650\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 25\text{ }^\circ\text{C}$	-	0.7	150	$\mu\text{A}$	
		$V_{DS} = 650\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 175\text{ }^\circ\text{C}$	-	10	-		
Total Gate Leakage Current	$I_{GSS}$	$V_{DS} = 0\text{ V}$ , $V_{GS} = -20\text{ V} / +20\text{ V}$	-	6	$\pm 20$	$\mu\text{A}$	
Drain-source On-resistance	$R_{DS(on)}$	$V_{GS} = 12\text{ V}$ , $I_D = 30\text{ A}$	$T_J = 25\text{ }^\circ\text{C}$	-	42	52	m $\Omega$
			$T_J = 125\text{ }^\circ\text{C}$	-	59	-	
			$T_J = 175\text{ }^\circ\text{C}$	-	78	-	
Gate Threshold Voltage	$V_{G(th)}$	$V_{DS} = 5\text{ V}$ , $I_D = 10\text{ mA}$	4	5	6	V	
Gate Resistance	$R_G$	$f = 1\text{ MHz}$ , open drain	-	4.5	-	$\Omega$	

### TYPICAL PERFORMANCE – REVERSE DIODE

Diode Continuous Forward Current (Note 1)	$I_S$	$T_C = 25\text{ }^\circ\text{C}$	-	-	41	A
Diode Pulse Current (Note 2)	$I_{S,pulse}$	$T_C = 25\text{ }^\circ\text{C}$	-	-	125	A
Forward Voltage	$V_{FSD}$	$V_{GS} = 0\text{ V}$ , $I_S = 20\text{ A}$ , $T_J = 25\text{ }^\circ\text{C}$	-	1.5	1.75	V
		$V_{GS} = 0\text{ V}$ , $I_S = 20\text{ A}$ , $T_J = 175\text{ }^\circ\text{C}$	-	1.8	-	
Reverse Recovery Charge	$Q_{rr}$	$V_{DS} = 400\text{ V}$ , $I_S = 30\text{ A}$ , $V_{GS} = -5\text{ V}$ , $R_{G\_EXT} = 22\text{ }^\circ\Omega$ , $di/dt = 1600\text{ A}/\mu\text{s}$ , $T_J = 25\text{ }^\circ\text{C}$	-	138	-	nC
Reverse Recovery Time	$t_{rr}$		-	26	-	ns
Reverse Recovery Charge	$Q_{rr}$	$V_{DS} = 400\text{ V}$ , $I_S = 30\text{ A}$ , $V_{GS} = -5\text{ V}$ , $R_{G\_EXT} = 22\text{ }^\circ\Omega$ , $di/dt = 1600\text{ A}/\mu\text{s}$ , $T_J = 150\text{ }^\circ\text{C}$	-	137	-	nC
Reverse Recovery Time	$t_{rr}$		-	26	-	ns

# UF3C065040B3

## ELECTRICAL CHARACTERISTICS (T<sub>J</sub> = +25 °C unless otherwise specified) (continued)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit	
<b>TYPICAL PERFORMANCE – DYNAMIC</b>							
Input Capacitance	C <sub>iss</sub>	V <sub>DS</sub> = 100 V, V <sub>GS</sub> = 0 V, f = 100 kHz	–	1500	–	pF	
Output Capacitance	C <sub>OSS</sub>		–	200	–		
Reverse Transfer Capacitance	C <sub>rss</sub>		–	2.2	–		
Effective Output Capacitance, Energy Related	C <sub>OSS(er)</sub>	V <sub>DS</sub> = 0 V to 400 V, V <sub>GS</sub> = 0 V	–	146	–	pF	
Effective Output Capacitance, Time Related	C <sub>OSS(tr)</sub>		–	325	–		
C <sub>OSS</sub> Stored Energy	E <sub>OSS</sub>	V <sub>DS</sub> = 400 V, V <sub>GS</sub> = 0 V	–	11.7	–	μJ	
Total Gate Charge	Q <sub>G</sub>	V <sub>DS</sub> = 400 V, I <sub>D</sub> = 30 A, V <sub>GS</sub> = -5 V to 15 V	–	51	–	nC	
Gate-drain Charge	Q <sub>GD</sub>		–	11	–		
Gate-source Charge	Q <sub>GS</sub>		–	19	–		
Turn-on Delay Time	t <sub>d(on)</sub>	V <sub>DS</sub> = 400 V, I <sub>D</sub> = 30 A, Gate Driver = -5 V to +15 V, Turn-on R <sub>G,EXT</sub> = 1.8 Ω, Turn-off R <sub>G,EXT</sub> = 22 Ω, Inductive Load, FWD: same device with V <sub>GS</sub> = -5 V and R <sub>G</sub> = 22 Ω, RC snubber: R <sub>S</sub> = 5 Ω and C <sub>S</sub> = 150 pF, T <sub>J</sub> = 25 °C	–	34	–	ns	
Rise Time	t <sub>r</sub>		–	15	–		
Turn-off Delay Time	t <sub>d(off)</sub>		–	57	–		
Fall Time	t <sub>f</sub>		–	12	–		
Turn-on Energy including R <sub>S</sub> Energy (Note 4)	E <sub>ON</sub>		V <sub>DS</sub> = 400 V, I <sub>D</sub> = 30 A, Gate Driver = -5 V to +15 V, Turn-on R <sub>G,EXT</sub> = 1.8 Ω, Turn-off R <sub>G,EXT</sub> = 22 Ω, Inductive Load, FWD: same device with V <sub>GS</sub> = -5 V and R <sub>G</sub> = 22 Ω, RC snubber: R <sub>S</sub> = 5 Ω and C <sub>S</sub> = 150 pF, T <sub>J</sub> = 25 °C	–	327	–	μJ
Turn-off Energy including R <sub>S</sub> Energy (Note 4)	E <sub>OFF</sub>			–	65	–	
Total Switching Energy including R <sub>S</sub> Energy (Note 4)	E <sub>TOTAL</sub>			–	392	–	
Snubber R <sub>S</sub> Energy during Turn-on	E <sub>RS_ON</sub>			–	1.5	–	
Snubber R <sub>S</sub> Energy during Turn-off	E <sub>RS_OFF</sub>			–	3	–	
Turn-on Delay Time	t <sub>d(on)</sub>			V <sub>DS</sub> = 400 V, I <sub>D</sub> = 30 A, Gate Driver = -5 V to +15 V, Turn-on R <sub>G,EXT</sub> = 1.8 Ω, Turn-off R <sub>G,EXT</sub> = 22 Ω, Inductive Load, FWD: same device with V <sub>GS</sub> = -5 V and R <sub>G</sub> = 22 Ω, RC snubber: R <sub>S</sub> = 5 Ω and C <sub>S</sub> = 150 pF, T <sub>J</sub> = 150 °C	–	33	
Rise Time	t <sub>r</sub>	–			15	–	
Turn-off Delay Time	t <sub>d(off)</sub>	–			58	–	
Fall Time	t <sub>f</sub>	–			13	–	
Turn-on Energy including R <sub>S</sub> Energy (Note 4)	E <sub>ON</sub>	V <sub>DS</sub> = 400 V, I <sub>D</sub> = 30 A, Gate Driver = -5 V to +15 V, Turn-on R <sub>G,EXT</sub> = 1.8 Ω, Turn-off R <sub>G,EXT</sub> = 22 Ω, Inductive Load, FWD: same device with V <sub>GS</sub> = -5 V and R <sub>G</sub> = 22 Ω, RC snubber: R <sub>S</sub> = 5 Ω and C <sub>S</sub> = 150 pF, T <sub>J</sub> = 150 °C			–	314	–
Turn-off Energy including R <sub>S</sub> Energy (Note 4)	E <sub>OFF</sub>		–		66	–	
Total Switching Energy including R <sub>S</sub> Energy (Note 4)	E <sub>TOTAL</sub>		–		380	–	
Snubber R <sub>S</sub> Energy during Turn-on	E <sub>RS_ON</sub>		–		1.5	–	
Snubber R <sub>S</sub> Energy during Turn-off	E <sub>RS_OFF</sub>		–		2.9	–	

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. The switching performance are evaluated with a RC snubber circuit as shown in Figure 29.

TYPICAL PERFORMANCE DIAGRAMS

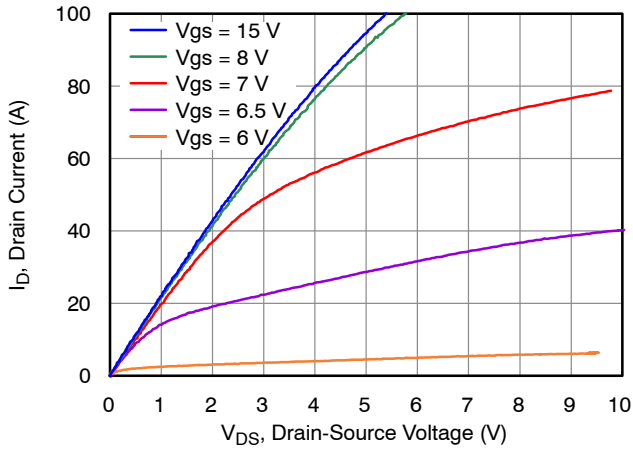


Figure 1. Typical Output Characteristics at  $T_J = -55\text{ }^\circ\text{C}$ ,  $t_p < 250\text{ }\mu\text{s}$

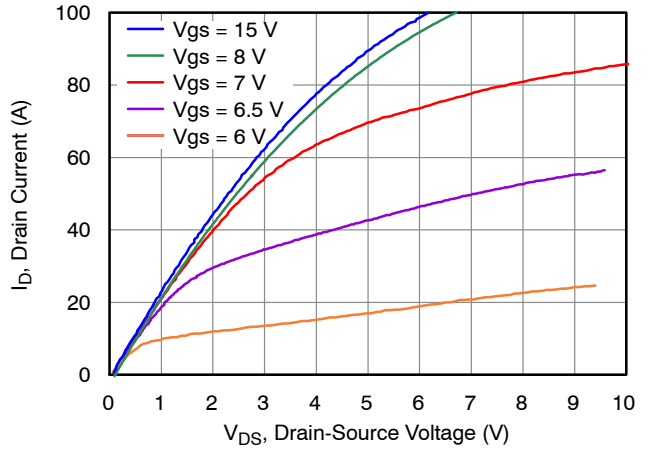


Figure 2. Typical Output Characteristics at  $T_J = 25\text{ }^\circ\text{C}$ ,  $t_p < 250\text{ }\mu\text{s}$

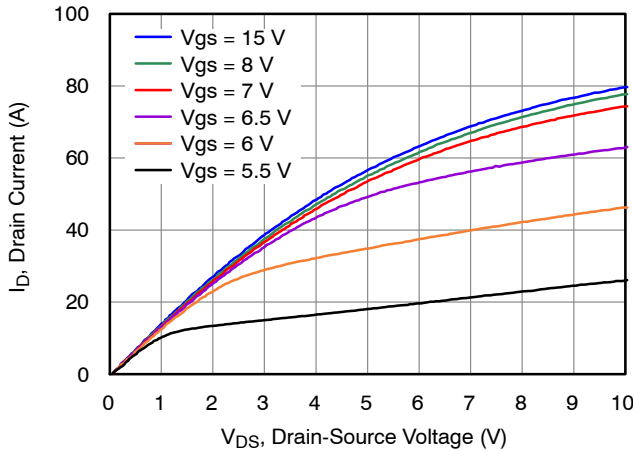


Figure 3. Typical Output Characteristics at  $T_J = 175\text{ }^\circ\text{C}$ ,  $t_p < 250\text{ }\mu\text{s}$

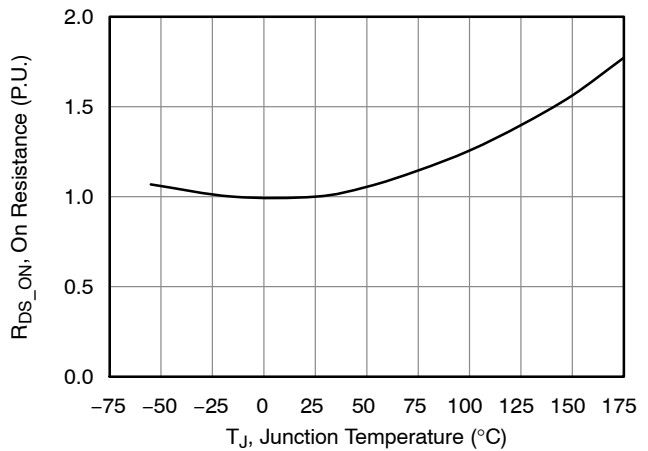


Figure 4. Normalized On-Resistance vs. Temperature at  $V_{GS} = 12\text{ V}$  and  $I_D = 30\text{ A}$

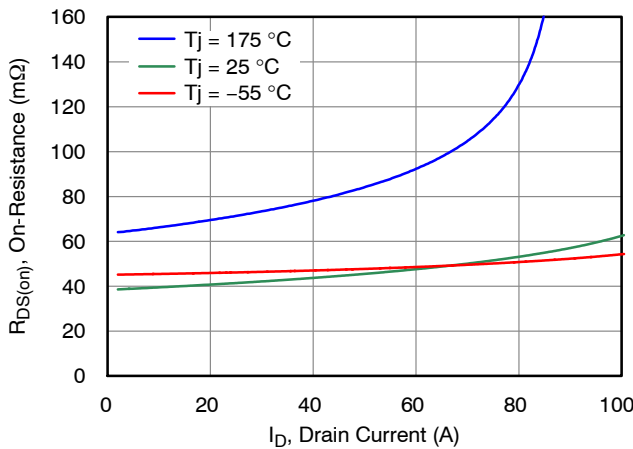


Figure 5. Typical Drain-Source On-Resistances at  $V_{GS} = 12\text{ V}$

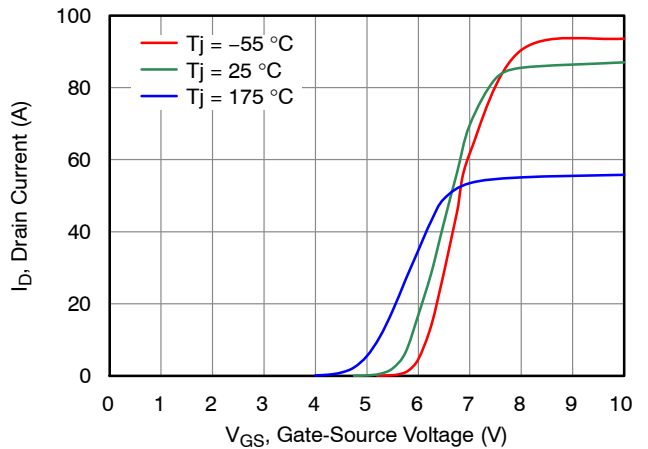


Figure 6. Typical Transfer Characteristics at  $V_{DS} = 5\text{ V}$

TYPICAL PERFORMANCE DIAGRAMS (CONTINUED)

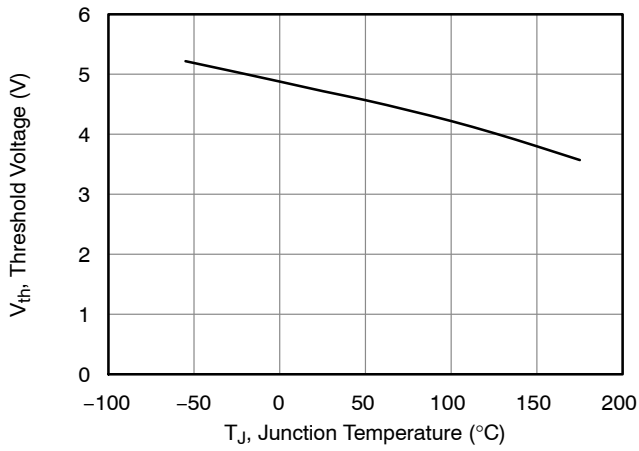


Figure 7. Threshold Voltage vs. Junction Temperature at  $V_{DS} = 5\text{ V}$  and  $I_D = 10\text{ mA}$

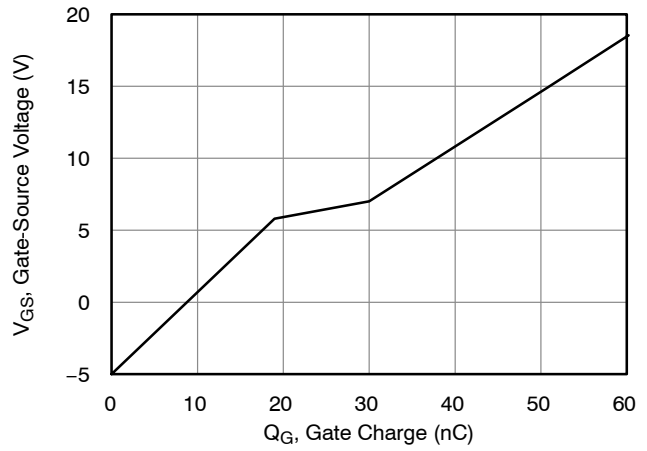


Figure 8. Typical Gate Charge at  $V_{DS} = 400\text{ V}$  and  $I_D = 30\text{ A}$

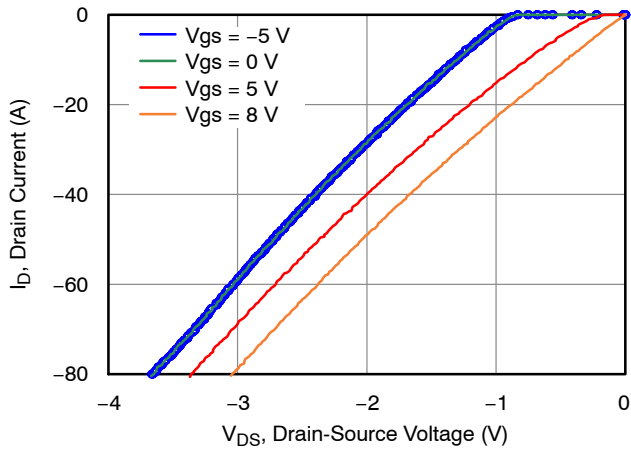


Figure 9. 3<sup>rd</sup> Quadrant Characteristics at  $T_J = -55\text{ °C}$

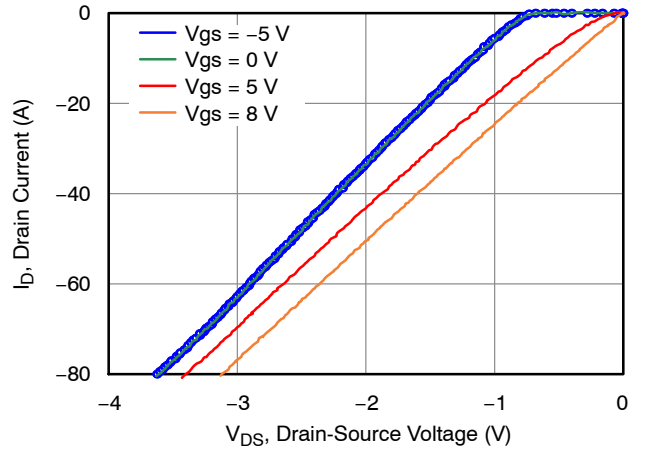


Figure 10. 3<sup>rd</sup> Quadrant Characteristics at  $T_J = 25\text{ °C}$

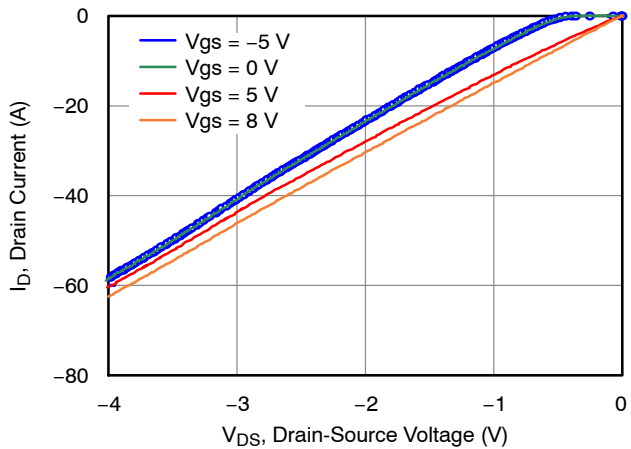


Figure 11. 3<sup>rd</sup> Quadrant Characteristics at  $T_J = 175\text{ °C}$

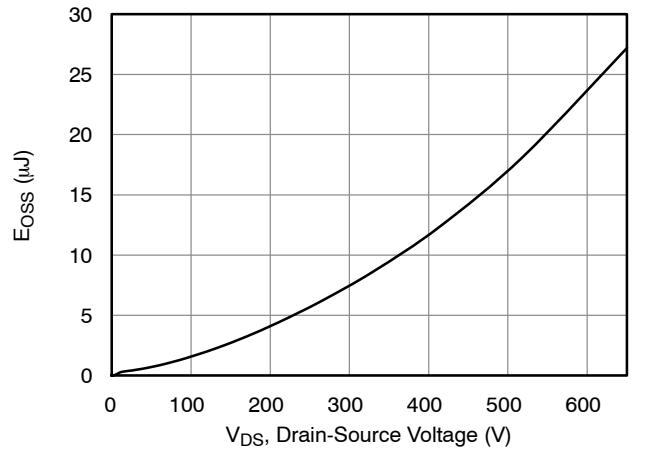


Figure 12. Typical Stored Energy in  $C_{OSS}$  at  $V_{GS} = 0\text{ V}$

TYPICAL PERFORMANCE DIAGRAMS (CONTINUED)

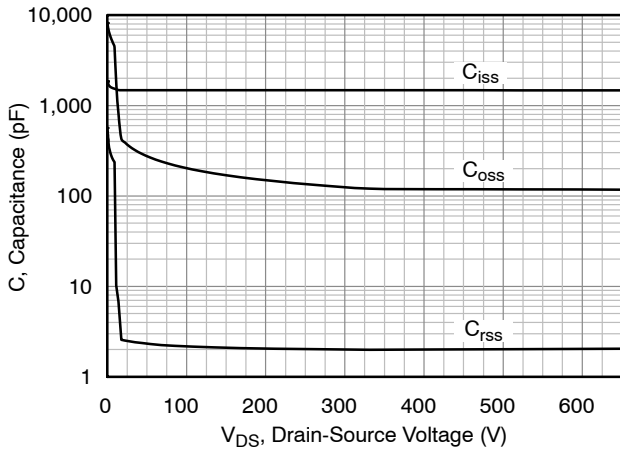


Figure 13. Typical Capacitances at  $f = 100 \text{ kHz}$  and  $V_{GS} = 0 \text{ V}$

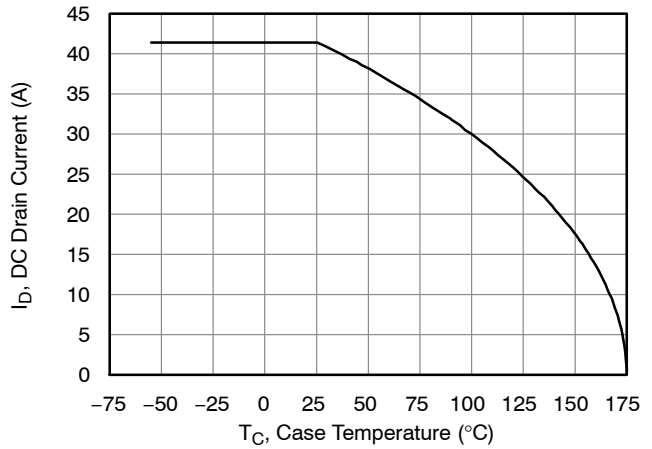


Figure 14. DC Drain Current Derating

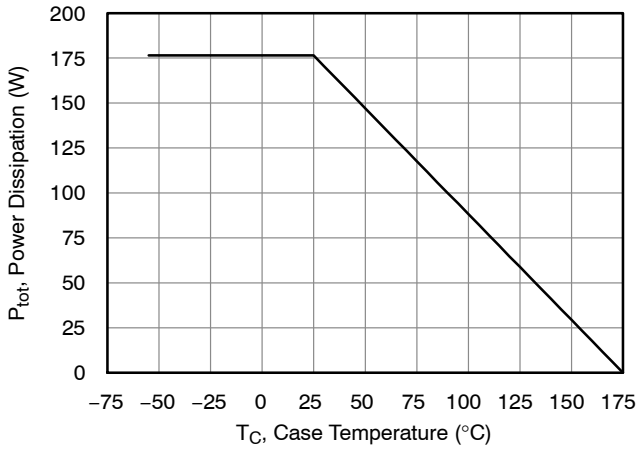


Figure 15. Total Power Dissipation

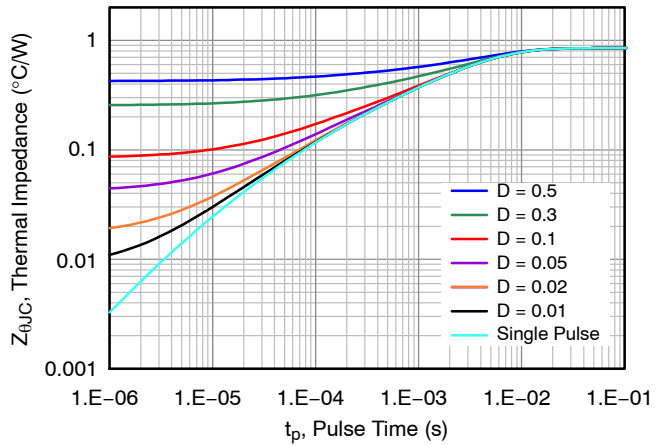


Figure 16. Maximum Transient Thermal Impedance

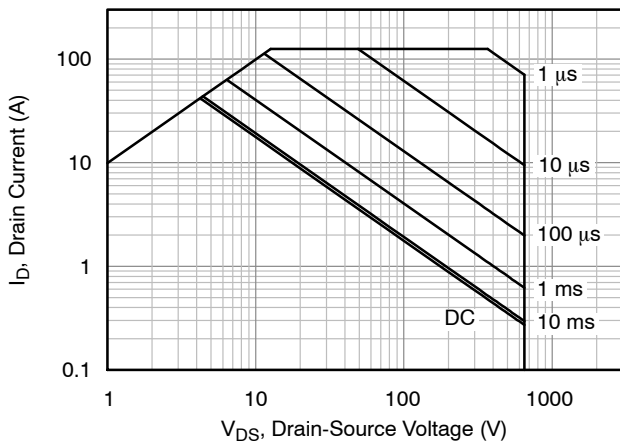


Figure 17. Safe Operation Area at  $T_C = 25 \text{ }^\circ\text{C}$ ,  $D = 0$ , Parameter  $t_p$

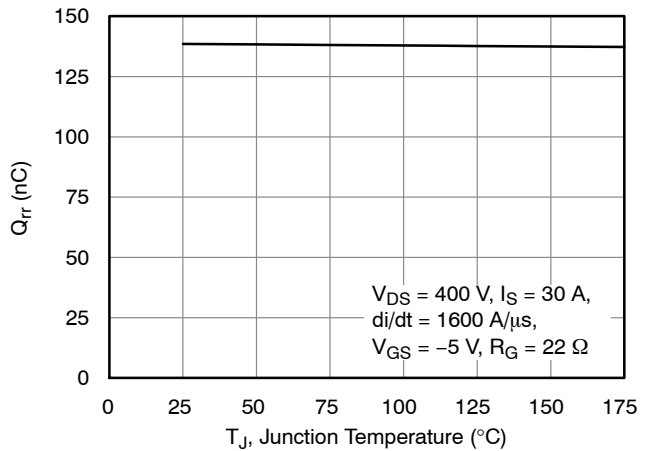


Figure 18. Reverse Recovery Charge  $Q_{rr}$  vs. Junction Temperature

TYPICAL PERFORMANCE DIAGRAMS (CONTINUED)

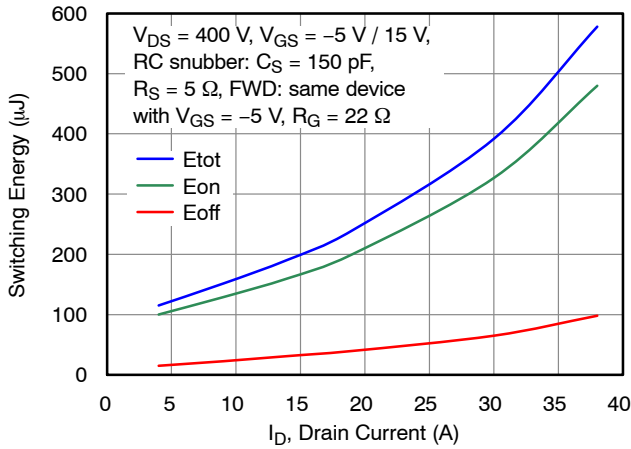


Figure 19. Clamped Inductive Switching Energy vs. Drain Current at  $T_J = 25\text{ }^\circ\text{C}$ , Turn-on  $R_{G\_EXT} = 1.8\text{ }\Omega$  and Turn-off  $R_{G\_EXT} = 22\text{ }\Omega$

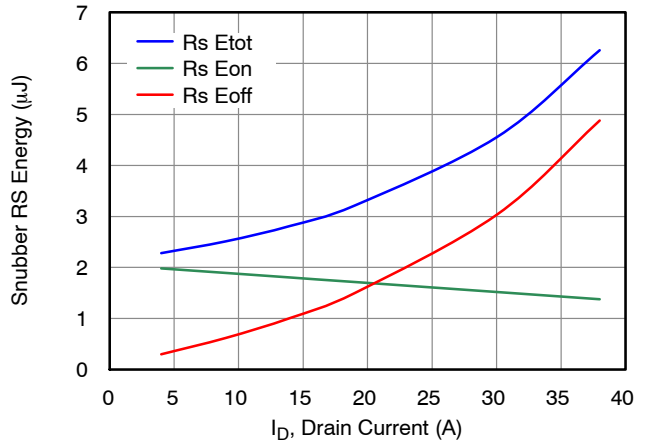


Figure 20. RC Snubber Energy Loss vs. Drain Current at the Test Conditions shown in Figure 19

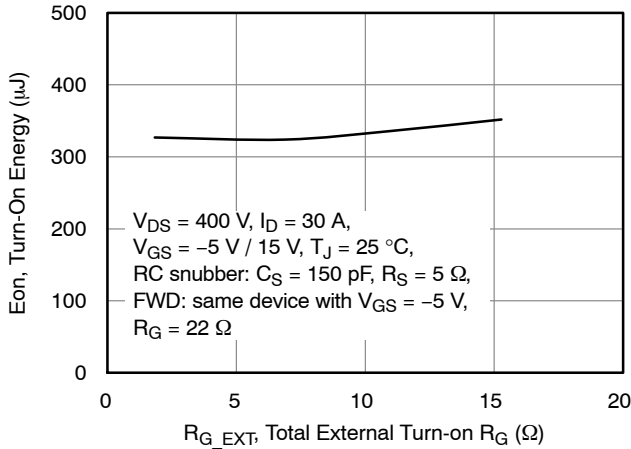


Figure 21. Clamped Inductive Switching Turn-On Energy including RC Snubber Energy Loss as a Function of Total External Turn-on Gate Resistor  $R_{G\_EXT}$

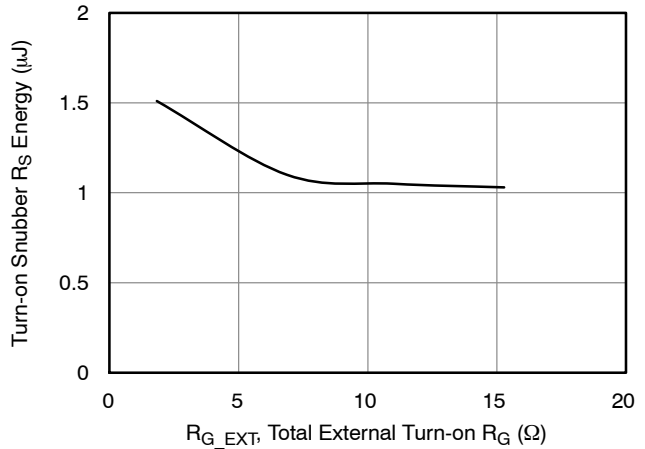


Figure 22. RC Snubber Energy Loss as a Function of Total External Turn-on Gate Resistor  $R_{G\_EXT}$  at the Test Conditions shown in Figure 21

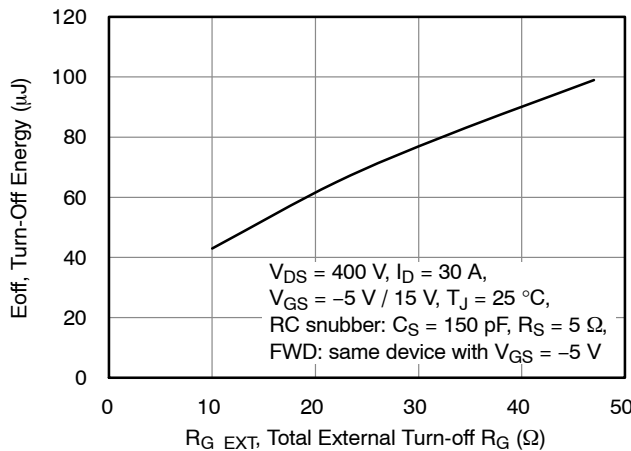


Figure 23. Clamped Inductive Switching Turn-Off Energy including RC Snubber Energy Loss as a Function of Total External Turn-off Gate Resistor  $R_{G\_EXT}$

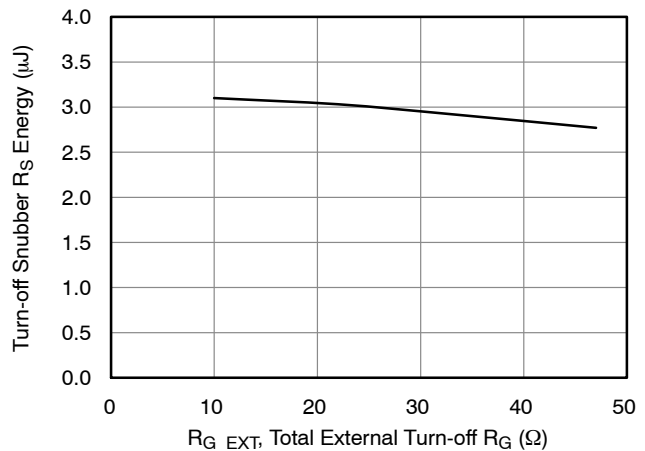


Figure 24. RC Snubber Energy Loss as a Function of Total External Turn-off Gate Resistor  $R_{G\_EXT}$  at the Test Conditions shown in Figure 23

TYPICAL PERFORMANCE DIAGRAMS (CONTINUED)

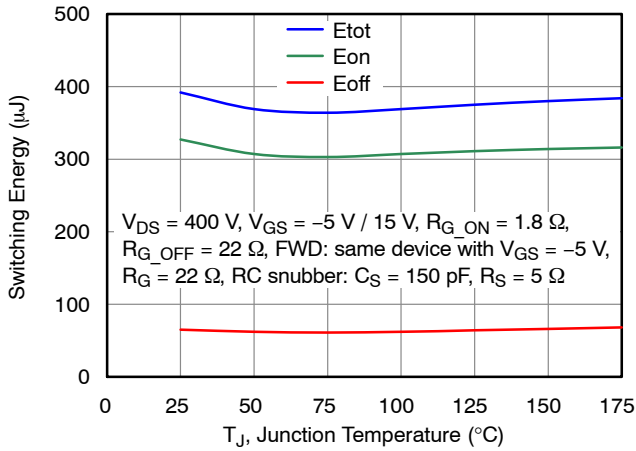


Figure 25. Clamped Inductive Switching Energy including RC Snubber Energy Loss as a Function of Junction Temperature at  $I_D = 30\text{ A}$

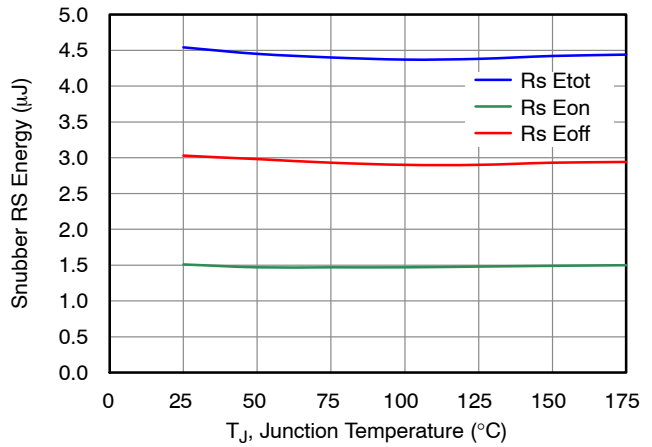


Figure 26. RC Snubber Energy Loss as a Function of Junction Temperature at the Test Conditions shown in Figure 25

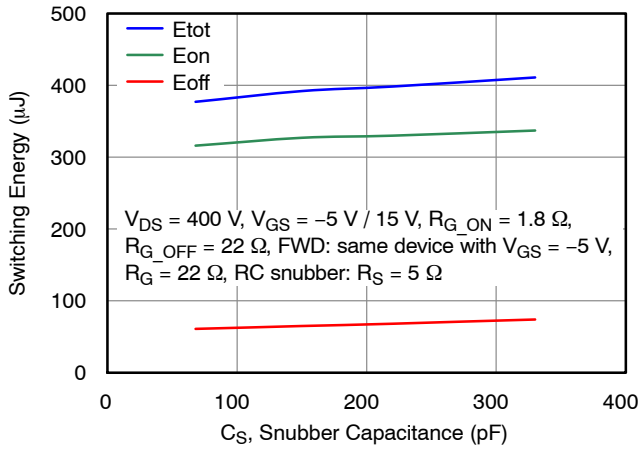


Figure 27. Clamped Inductive Switching Energy including RC Snubber Energy Loss as a Function of Snubber Capacitance at  $I_D = 30\text{ A}$  and  $T_J = 25\text{ °C}$

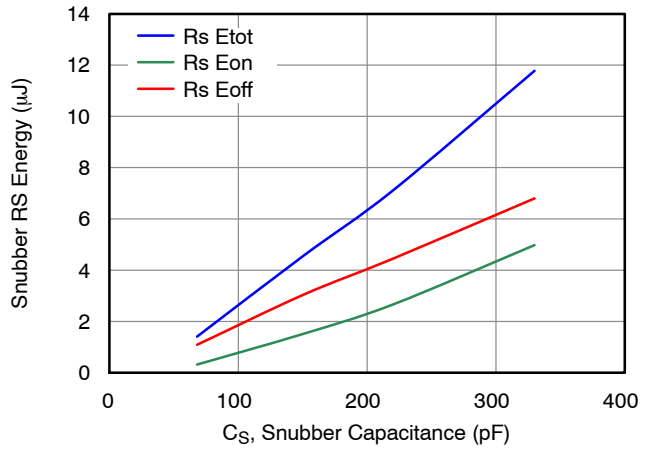


Figure 28. RC Snubber Energy Loss as a Function of Snubber Capacitance at the Test Conditions shown in Figure 27

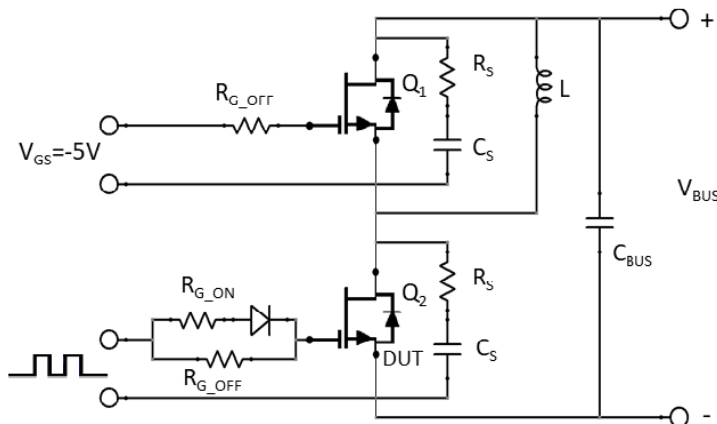


Figure 29. Clamped Inductive Load Switching Test Circuit. An RC Snubber ( $R_S = 5\text{ }\Omega$  and  $C_S = 150\text{ pF}$ ) is required to Improve the Turn-off Waveforms.



# UF3C065040B3

## 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

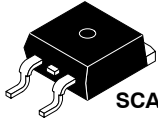
working in the diode mode in order to achieve the optimum reverse recovery performance. For more information on SiC FET operation, see [www.onsemi.com](http://www.onsemi.com).

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](http://www.onsemi.com).

## ORDERING INFORMATION

Part Number	Marking	Package	Shipping†
UF3C065040B3	UF3C065040B3	D <sup>2</sup> PAK-3 (TO-263, 3-LEAD)	800 units / Tape and Reel

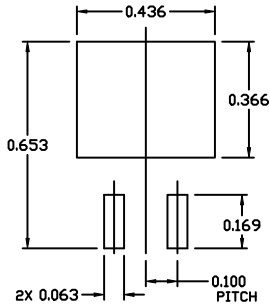
†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.



SCALE 1:1

D<sup>2</sup>PAK-3 (TO-263, 3-LEAD)  
CASE 418AJ  
ISSUE F

DATE 11 MAR 2021



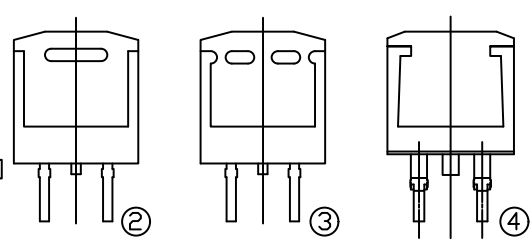
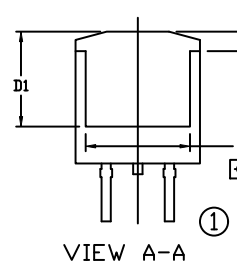
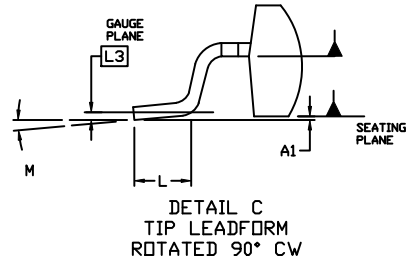
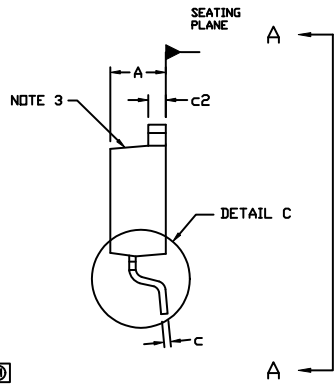
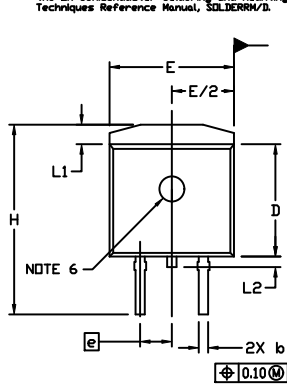
RECOMMENDED  
MOUNTING FOOTPRINT

For additional information on our Pb-free strategy and soldering details, please download the IN Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERM/D.

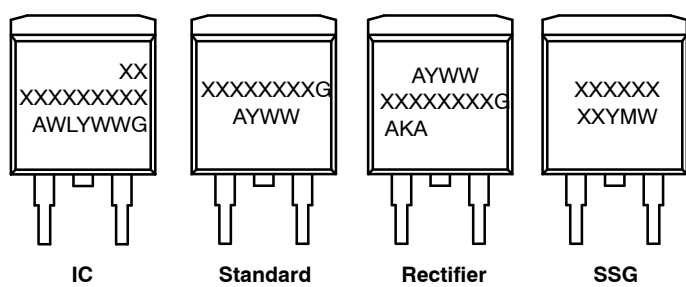
NOTES:

- DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.
- CONTROLLING DIMENSION: INCHES
- CHAMFER OPTIONAL.
- DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH. MOLD FLASH SHALL NOT EXCEED 0.005 PER SIDE. THESE DIMENSIONS ARE MEASURED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY AT DATUM H.
- THERMAL PAD CONTOUR IS OPTIONAL WITHIN DIMENSIONS E, L1, D1, AND E1.
- OPTIONAL MOLD FEATURE.
- ①, ② ... OPTIONAL CONSTRUCTION FEATURE CALL OUTS.

DIM	INCHES		MILLIMETERS	
	MIN.	MAX.	MIN.	MAX.
A	0.160	0.190	4.06	4.83
A1	0.000	0.010	0.00	0.25
b	0.020	0.039	0.51	0.99
c	0.012	0.029	0.30	0.74
c2	0.045	0.065	1.14	1.65
D	0.330	0.380	8.38	9.65
D1	0.260	---	6.60	---
E	0.380	0.420	9.65	10.67
E1	0.245	---	6.22	---
e	0.100 BSC	---	2.54 BSC	---
H	0.575	0.625	14.60	15.88
L	0.070	0.110	1.78	2.79
L1	---	0.066	---	1.68
L2	---	0.070	---	1.78
L3	0.010 BSC	---	0.25 BSC	---
M	0°	8°	0°	8°



GENERIC MARKING DIAGRAMS\*



XXXXXX = Specific Device Code  
 A = Assembly Location  
 WL = Wafer Lot  
 Y = Year  
 WW = Work Week  
 W = Week Code (SSG)  
 M = Month Code (SSG)  
 G = Pb-Free Package  
 AKA = Polarity Indicator

\*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

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DESCRIPTION:	D <sup>2</sup> PAK-3 (TO-263, 3-LEAD)	PAGE 1 OF 1

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