

## Insulated Gate Bipolar Transistor (Warp 2 Speed IGBT), 90 A


**SOT-227**
**FEATURES**

- NPT warp 2 speed IGBT technology with positive temperature coefficient
- Square RBSOA
- HEXFRED® antiparallel diodes with ultrasoft reverse recovery
- Fully isolated package
- Very low internal inductance ( $\leq 5$  nH typical)
- Industry standard outline
- Material categorization: For definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS  
COMPLIANT**

PRODUCT SUMMARY	
$V_{CES}$	600 V
$I_C$ DC	90 A at 90 °C
$V_{CE(on)}$ typical at 100 A, 25 °C	2.40 V
$I_F$ DC	108 A at 90 °C

**BENEFITS**

- Designed for increased operating efficiency in power conversion: UPS, SMPS, welding, induction heating
- Easy to assemble and parallel
- Direct mounting to heatsink
- Plug-in compatible with other SOT-227 packages
- Higher switching frequency up to 150 kHz
- Lower conduction losses and switching losses
- Low EMI, requires less snubbing

ABSOLUTE MAXIMUM RATINGS				
PARAMETER	SYMBOL	TEST CONDITIONS	MAX.	UNITS
Collector to emitter voltage	$V_{CES}$		600	V
Continuous collector current	$I_C$	$T_C = 25\text{ °C}$	147	A
		$T_C = 90\text{ °C}$	90	
Pulsed collector current	$I_{CM}$		300	
Clamped inductive load current	$I_{LM}$		300	
Diode continuous forward current	$I_F$	$T_C = 25\text{ °C}$	180	
		$T_C = 90\text{ °C}$	108	
Gate-to-emitter voltage	$V_{GE}$		$\pm 20$	V
Power dissipation, IGBT	$P_D$	$T_C = 25\text{ °C}$	625	W
		$T_C = 90\text{ °C}$	300	
Power dissipation, diode	$P_D$	$T_C = 25\text{ °C}$	379	
		$T_C = 90\text{ °C}$	182	
Isolation voltage	$V_{ISOL}$	Any terminal to case, $t = 1$ min	2500	V



<b>ELECTRICAL SPECIFICATIONS</b> ( $T_J = 25\text{ }^\circ\text{C}$ unless otherwise specified)						
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Collector to emitter breakdown voltage	$V_{BR(CES)}$	$V_{GE} = 0\text{ V}, I_C = 250\text{ }\mu\text{A}$	600	-	-	V
Collector to emitter voltage	$V_{CE(on)}$	$V_{GE} = 15\text{ V}, I_C = 100\text{ A}$	-	2.4	2.8	
		$V_{GE} = 15\text{ V}, I_C = 100\text{ A}, T_J = 125\text{ }^\circ\text{C}$	-	3	3.4	
		$V_{GE} = 15\text{ V}, I_C = 100\text{ A}, T_J = 150\text{ }^\circ\text{C}$	-	3.3	-	
Gate threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}, I_C = 250\text{ }\mu\text{A}$	3	3.9	5.0	
		$V_{CE} = V_{GE}, I_C = 250\text{ }\mu\text{A}, T_J = 125\text{ }^\circ\text{C}$	-	2.5	-	
Temperature coefficient of threshold voltage	$\Delta V_{GE(th)}/\Delta T_J$	$V_{CE} = V_{GE}, I_C = 1\text{ mA}$ (25 °C to 125 °C)	-	- 10	-	mV/°C
Collector to emitter leakage current	$I_{CES}$	$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}$	-	7	100	$\mu\text{A}$
		$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	1.5	6.0	mA
		$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	6	10	
Forward voltage drop, diode	$V_{FM}$	$I_C = 100\text{ A}, V_{GE} = 0\text{ V}$	-	1.6	2.1	V
		$I_C = 100\text{ A}, V_{GE} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	1.56	2.0	
		$I_C = 100\text{ A}, V_{GE} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	1.53	-	
Gate to emitter leakage current	$I_{GES}$	$V_{GE} = \pm 20\text{ V}$	-	-	$\pm 200$	nA

<b>SWITCHING CHARACTERISTICS</b> ( $T_J = 25\text{ }^\circ\text{C}$ unless otherwise specified)								
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS		
Total gate charge (turn-on)	$Q_g$	$I_C = 100\text{ A}, V_{CC} = 480\text{ V}, V_{GE} = 15\text{ V}$	-	460	690	nC		
Gate to emitter charge (turn-on)	$Q_{ge}$		-	160	250			
Gate to collector charge (turn-on)	$Q_{gc}$		-	70	130			
Turn-on switching loss	$E_{on}$	$I_C = 100\text{ A}, V_{CC} = 360\text{ V}, V_{GE} = 15\text{ V}, R_g = 5\text{ }\Omega, L = 500\text{ }\mu\text{H}, T_J = 25\text{ }^\circ\text{C}$	-	0.39	-	mJ		
Turn-off switching loss	$E_{off}$		-	1.10	-			
Total switching loss	$E_{tot}$		-	1.49	-			
Turn-on delay time	$t_{d(on)}$		Energy losses include tail and diode recovery. Diode used 60APH06	-	245	-	ns	
Rise time	$t_r$			-	53	-		
Turn-off delay time	$t_{d(off)}$			-	240	-		
Fall time	$t_f$			-	63	-		
Turn-on switching loss	$E_{on}$			-	0.52	-		mJ
Turn-off switching loss	$E_{off}$			-	1.24	-		
Total switching loss	$E_{tot}$			-	1.76	-		
Turn-on delay time	$t_{d(on)}$	$I_C = 100\text{ A}, V_{CC} = 360\text{ V}, V_{GE} = 15\text{ V}, R_g = 5\text{ }\Omega, L = 500\text{ }\mu\text{H}, T_J = 125\text{ }^\circ\text{C}$	-	240	-	ns		
Rise time	$t_r$		-	54	-			
Turn-off delay time	$t_{d(off)}$		-	250	-			
Fall time	$t_f$		-	80	-			
Reverse bias safe operating area	RBSOA	$T_J = 150\text{ }^\circ\text{C}, I_C = 300\text{ A}, R_g = 22\text{ }\Omega, V_{GE} = 15\text{ V to } 0\text{ V}, V_{CC} = 400\text{ V}, V_P = 600\text{ V}, L = 500\text{ }\mu\text{H}$	Fullsquare					
Diode reverse recovery time	$t_{rr}$	$I_F = 50\text{ A}, dI_F/dt = 200\text{ A}/\mu\text{s}, V_R = 200\text{ V}$	-	95	-	ns		
Diode peak reverse current	$I_{rr}$		-	10	-	A		
Diode recovery charge	$Q_{rr}$		-	480	-	nC		
Diode reverse recovery time	$t_{rr}$	$I_F = 50\text{ A}, dI_F/dt = 200\text{ A}/\mu\text{s}, V_R = 200\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	144	-	ns		
Diode peak reverse current	$I_{rr}$		-	16	-	A		
Diode recovery charge	$Q_{rr}$		-	1136	-	nC		



THERMAL AND MECHANICAL SPECIFICATIONS					
PARAMETER	SYMBOL	MIN.	TYP.	MAX.	UNITS
Maximum junction and storage temperature	$T_J, T_{Stg}$	- 40	-	150	°C
Junction to case	IGBT	-	-	0.20	°C/W
	Diode	-	-	0.33	
Case to sink thermal resistance, flat greased surface	$R_{thCS}$	-	0.1	-	
Mounting torque, on terminals and heatsink	T	-	-	1.3	Nm
Weight		-	30	-	g
Case style		SOT-227			

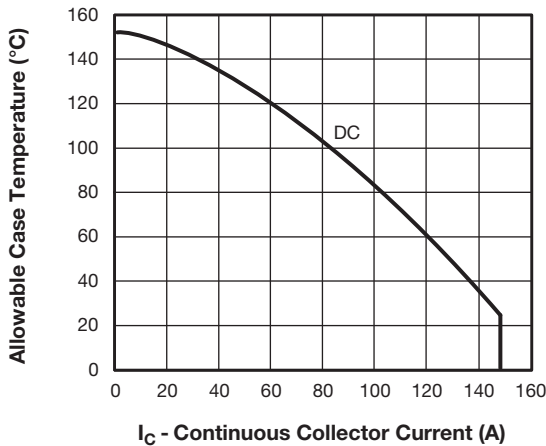


Fig. 1 - Maximum DC IGBT Collector Current vs. Case Temperature

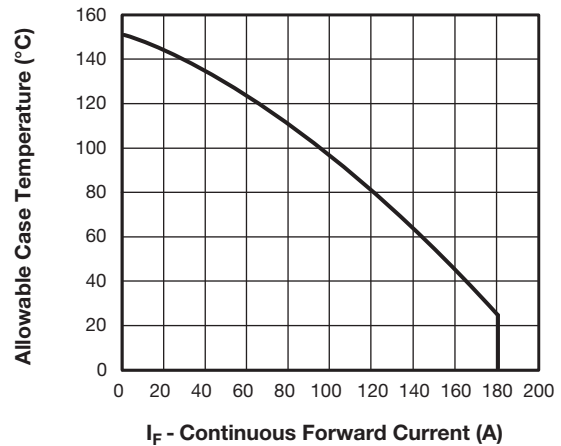


Fig. 3 - Maximum Allowable Forward Current vs. Case Temperature, Diode Leg

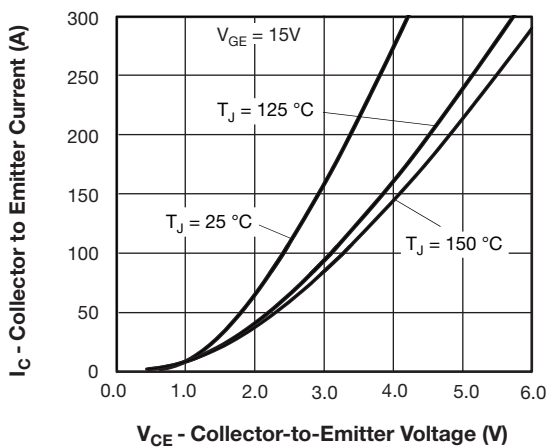


Fig. 2 - Typical Collector to Emitter Voltage (V)

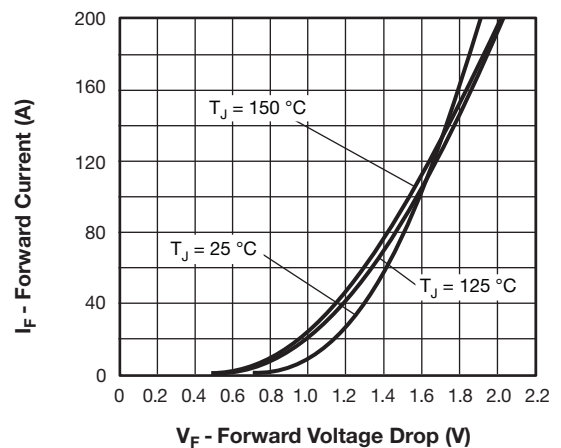


Fig. 4 - Typical Forward Voltage Drop Characteristics

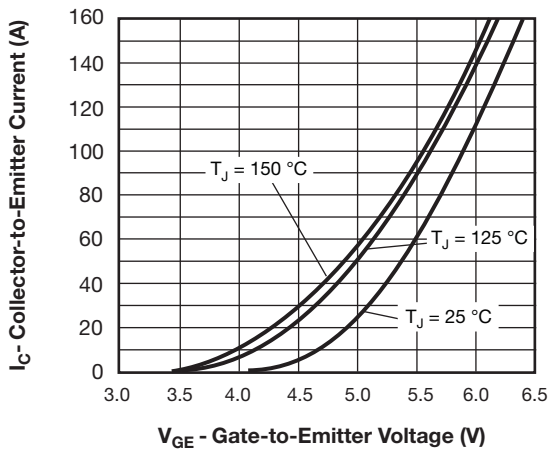


Fig. 5 - Typical IGBT Transfer Characteristics

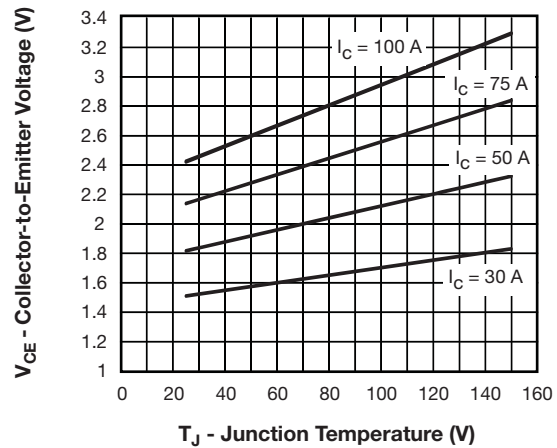


Fig. 8 - Typical IGBT Collector to Emitter Voltage vs. Junction Temperature,  $V_{GE} = 15\text{ V}$

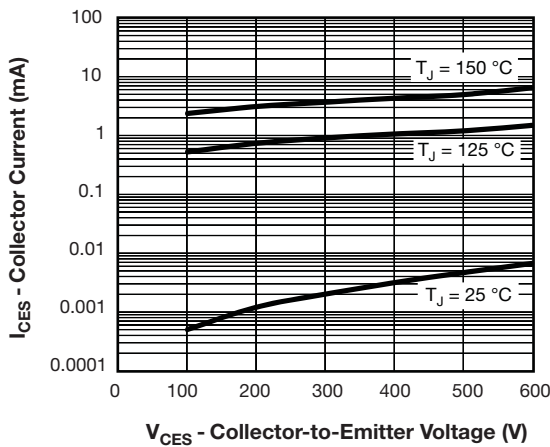


Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

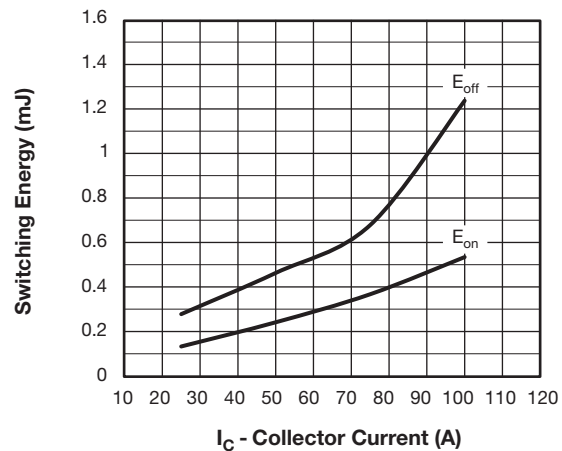


Fig. 9 - Typical IGBT Energy Losses vs.  $I_C$   
 $T_J = 125\text{ }^\circ\text{C}$ ,  $L = 500\text{ }\mu\text{H}$ ,  $V_{CC} = 360\text{ V}$ ,  
 $R_g = 5\text{ }\Omega$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

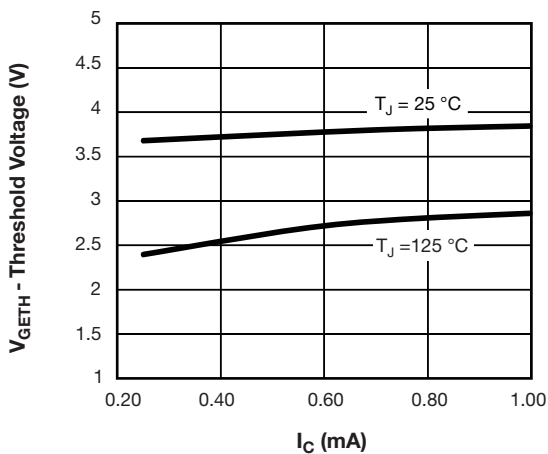


Fig. 7 - Typical IGBT Threshold Voltage

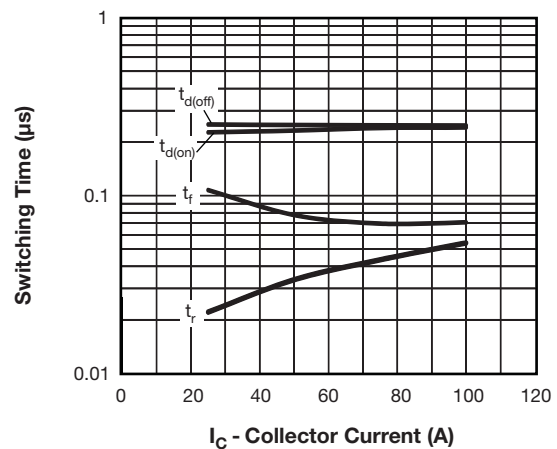


Fig. 10 - Typical IGBT Switching Time vs.  $I_C$   
 $T_J = 125\text{ }^\circ\text{C}$ ,  $L = 500\text{ }\mu\text{H}$ ,  $V_{CC} = 360\text{ V}$ ,  
 $R_g = 5\text{ }\Omega$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

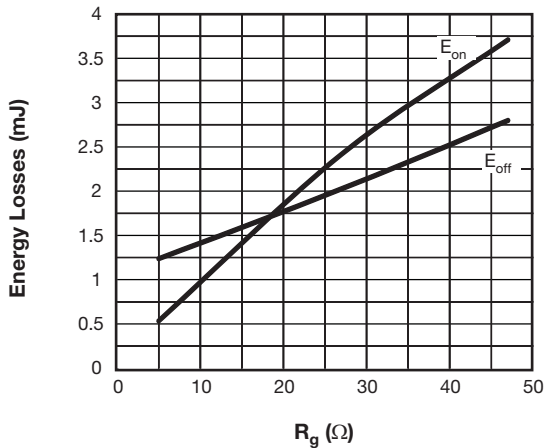


Fig. 11 - Typical IGBT Energy Loss vs.  $R_g$   
 $T_J = 125\text{ }^\circ\text{C}$ ,  $I_C = 100\text{ A}$ ,  $L = 500\text{ }\mu\text{H}$ ,  
 $V_{CC} = 360\text{ V}$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

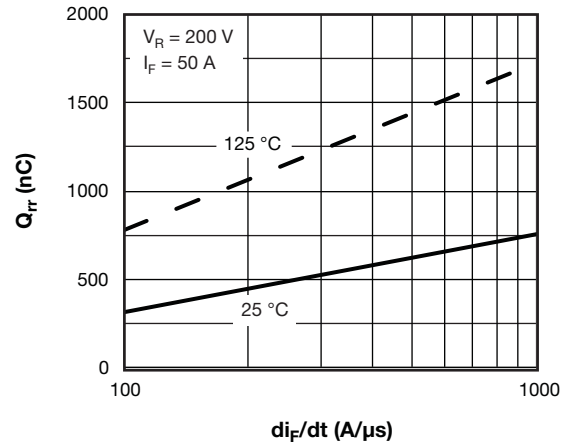


Fig. 14 - Typical Stored Charge vs.  $di_F/dt$  of Diode

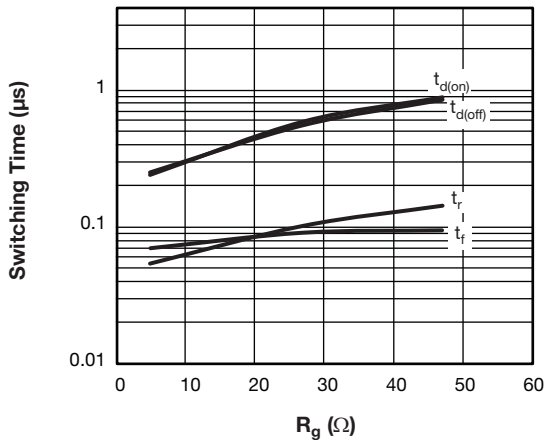


Fig. 12 - Typical IGBT Switching Time vs.  $R_g$   
 $T_J = 125\text{ }^\circ\text{C}$ ,  $L = 500\text{ }\mu\text{H}$ ,  $V_{CC} = 360\text{ V}$ ,  
 $I_C = 100\text{ A}$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

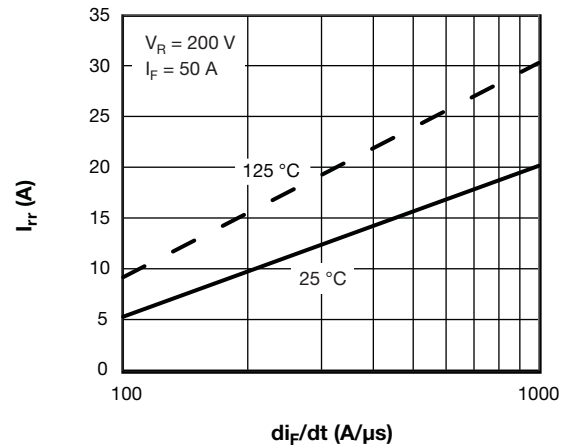


Fig. 15 - Typical Reverse Recovery Current vs.  $di_F/dt$  of Diode

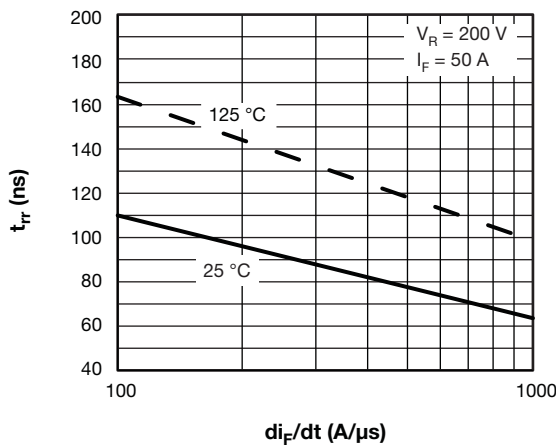


Fig. 13 - Typical Reverse Recovery Time vs.  $di_F/dt$ , of Diode

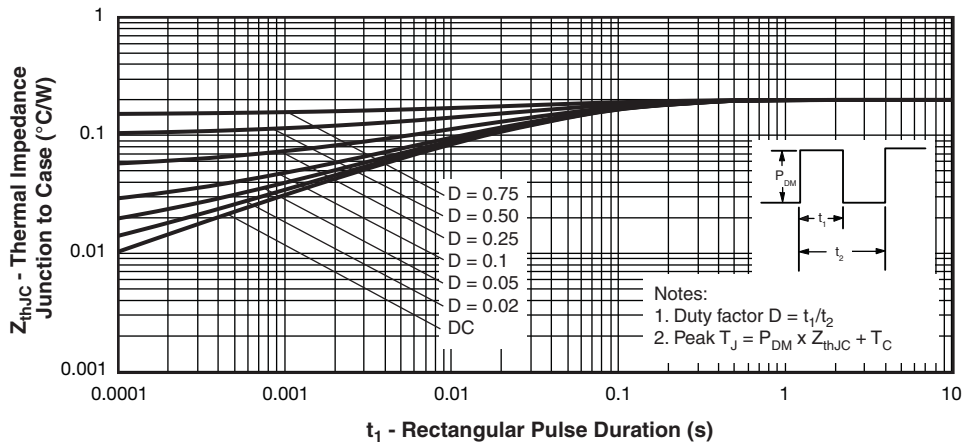


Fig. 16 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics, IGBT

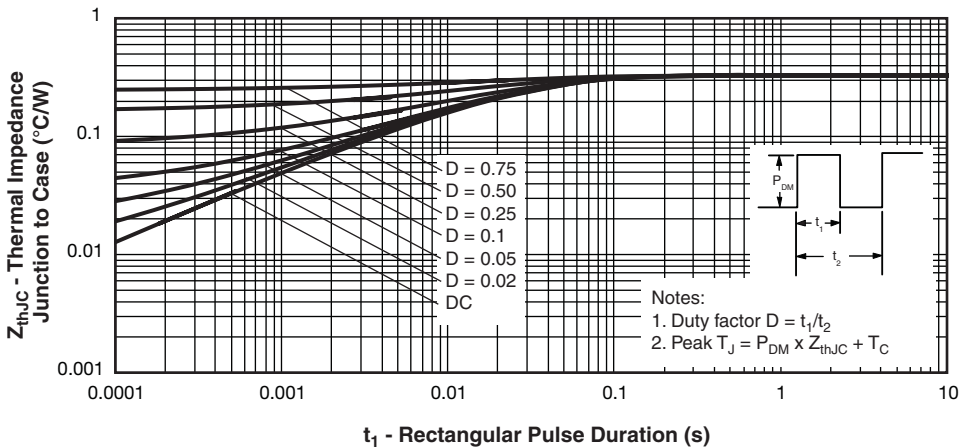


Fig. 17 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics, Diode

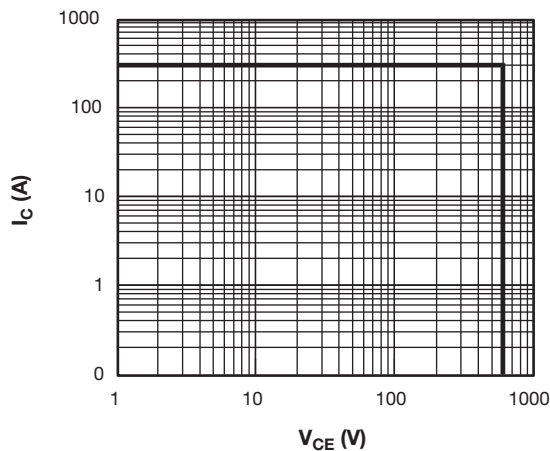
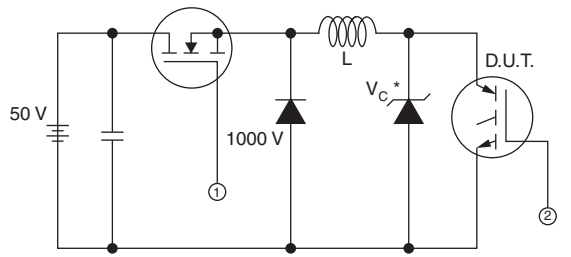
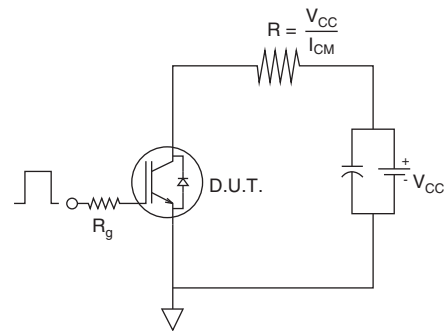


Fig. 18 - IGBT Reverse BIAS SOA,  $T_J = 150\text{ }^\circ\text{C}$ ,  $V_{GE} = 15\text{ V}$

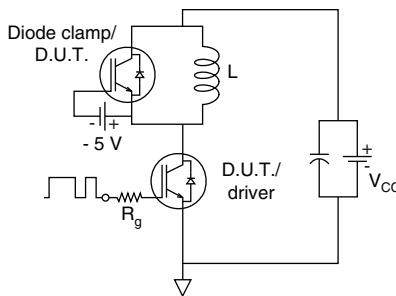


\* Driver same type as D.U.T.;  $V_C = 80\%$  of  $V_{ce(max)}$   
 \* Note: Due to the 50 V power supply, pulse width and inductor will increase to obtain  $I_d$

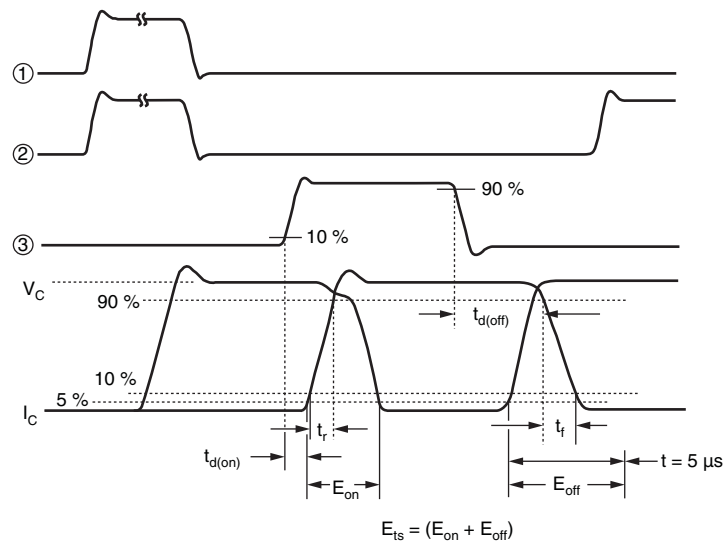
19a - Clamped Inductive Load Test Circuit



19b - Pulsed Collector Current Test Circuit



20a - Switching Loss Test Circuit



20b - Switching Loss Waveforms Test Circuit

**ORDERING INFORMATION TABLE**

Device code	<b>VS-</b>	<b>G</b>	<b>B</b>	<b>90</b>	<b>D</b>	<b>A</b>	<b>60</b>	<b>U</b>
	①	②	③	④	⑤	⑥	⑦	⑧

- 1** - Vishay Semiconductors product
- 2** - Insulated Gate Bipolar Transistor (IGBT)
- 3** - B = IGBT Generation 5
- 4** - Current rating (90 = 90 A)
- 5** - Circuit configuration (D = Single switch with antiparallel diode)
- 6** - Package indicator (A = SOT-227)
- 7** - Voltage rating (60 = 600 V)
- 8** - Speed/type (U = Ultrafast IGBT)

CIRCUIT CONFIGURATION		
CIRCUIT	CIRCUIT CONFIGURATION CODE	CIRCUIT DRAWING
2 separate diodes, parallel pin-out	D	<div style="display: inline-block; vertical-align: top; margin-left: 20px;"> <p>Lead Assignment</p> </div>

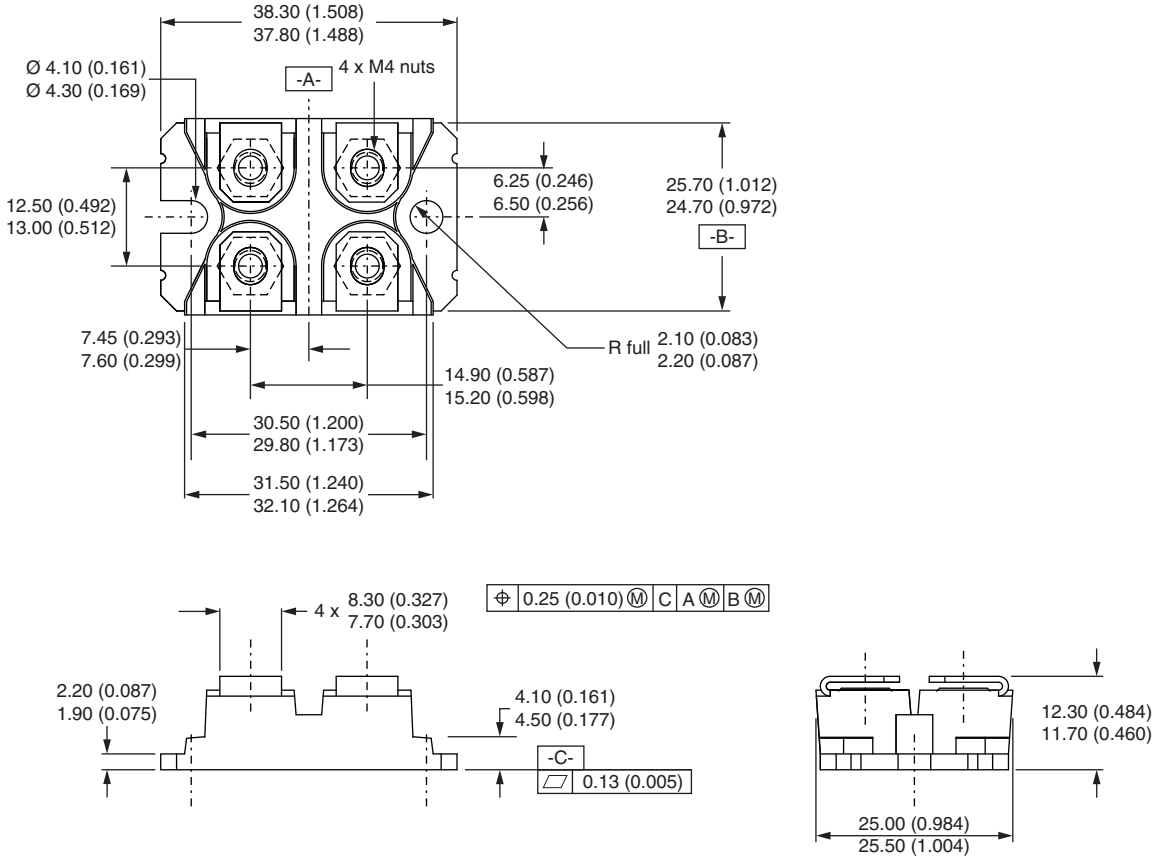
LINKS TO RELATED DOCUMENTS	
Dimensions	<a href="http://www.vishay.com/doc?95423">www.vishay.com/doc?95423</a>
Packaging information	<a href="http://www.vishay.com/doc?95425">www.vishay.com/doc?95425</a>





### SOT-227 Generation II

**DIMENSIONS** in millimeters (inches)



**Note**

- Controlling dimension: millimeter



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