

## Insulated Gate Bipolar Transistor (Trench IGBT), 140 A



**SOT-227**

PRIMARY CHARACTERISTICS	
$V_{CES}$	600 V
$I_C$ DC	140 A at 90 °C <sup>(1)</sup>
$V_{CE(on)}$ typical at 100 A, 25 °C	1.72 V
$I_F$ DC	71 A at 90 °C
Speed	8 kHz to 30 kHz
Package	SOT-227
Circuit configuration	Single switch with AP diode

**Note**

<sup>(1)</sup> Maximum collector current admitted is 100 A, to do not exceed the maximum temperature of terminals

**FEATURES**

- Trench IGBT technology with positive temperature coefficient
- Square RBSOA
- 3  $\mu$ s short circuit capability
- FRED Pt<sup>®</sup> antiparallel diodes with ultrasoft reverse recovery
- $T_J$  maximum = 175 °C
- Fully isolated package
- Very low internal inductance ( $\leq 5$  nH typical)
- Industry standard outline
- UL approved file E78996 
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS  
COMPLIANT**
**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
- 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	$I_C$ <sup>(1)</sup>	$T_C = 25$ °C	200	A
		$T_C = 90$ °C	140	
Pulsed collector current	$I_{CM}$		350	
Clamped inductive load current	$I_{LM}$		350	
Diode continuous forward current	$I_F$	$T_C = 25$ °C	104	
		$T_C = 90$ °C	71	
Gate-to-emitter voltage	$V_{GE}$		$\pm 20$	V
Power dissipation, IGBT	$P_D$	$T_C = 25$ °C	652	W
		$T_C = 90$ °C	370	
Power dissipation, diode	$P_D$	$T_C = 25$ °C	238	
		$T_C = 90$ °C	135	
Isolation voltage	$V_{ISOL}$	Any terminal to case, $t = 1$ min	2500	V

**Note**

<sup>(1)</sup> Maximum collector current admitted is 100 A, to do not exceed the maximum temperature of terminals



<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	$V_{CE(on)}$	$V_{GE} = 15\text{ V}, I_C = 100\text{ A}$	-	1.7	2.0	
		$V_{GE} = 15\text{ V}, I_C = 100\text{ A}, T_J = 125\text{ }^\circ\text{C}$	-	2.0	2.2	
		$V_{GE} = 15\text{ V}, I_C = 100\text{ A}, T_J = 175\text{ }^\circ\text{C}$	-	2.15	-	
Gate threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}, I_C = 250\text{ }\mu\text{A}$	3.5	4.6	6.5	
		$V_{CE} = V_{GE}, I_C = 250\text{ }\mu\text{A}, T_J = 125\text{ }^\circ\text{C}$	-	2.65	-	
Temperature coefficient of threshold voltage	$\Delta V_{GE(th)}/\Delta T_J$	$V_{CE} = V_{GE}, I_C = 1\text{ mA}$ ( $25\text{ }^\circ\text{C}$ to $125\text{ }^\circ\text{C}$ )	-	-16.8	-	mV/ $^\circ\text{C}$
Collector to emitter leakage current	$I_{CES}$	$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}$	-	0.6	100	$\mu\text{A}$
		$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	0.15	3	mA
		$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}, T_J = 175\text{ }^\circ\text{C}$	-	8	-	
Forward voltage drop, diode	$V_{FM}$	$I_F = 40\text{ A}, V_{GE} = 0\text{ V}$	-	1.74	2.2	V
		$I_F = 40\text{ A}, V_{GE} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	1.35	1.74	
		$I_F = 40\text{ A}, V_{GE} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	1.2	-	
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		
Turn-on switching loss	$E_{on}$	$I_C = 100\text{ A}, V_{CC} = 360\text{ V}, V_{GE} = 15\text{ V}, R_g = 5\text{ }\Omega, L = 500\text{ }\mu\text{H}, T_J = 25\text{ }^\circ\text{C}$	-	0.43	-	mJ		
Turn-off switching loss	$E_{off}$		-	1.50	-			
Total switching loss	$E_{tot}$		-	1.93	-			
Turn-on delay time	$t_{d(on)}$	Energy losses include tail and diode recovery. Diode used 60APH06	-	130	-	ns		
Rise time	$t_r$		-	50	-			
Turn-off delay time	$t_{d(off)}$		-	127	-			
Fall time	$t_f$		-	82	-			
Turn-on switching loss	$E_{on}$		$I_C = 100\text{ A}, V_{CC} = 360\text{ V}, V_{GE} = 15\text{ V}, R_g = 5\text{ }\Omega, L = 500\text{ }\mu\text{H}, T_J = 125\text{ }^\circ\text{C}$	-	0.43		-	mJ
Turn-off switching loss	$E_{off}$			-	2.12		-	
Total switching loss	$E_{tot}$	-		2.55	-			
Turn-on delay time	$t_{d(on)}$	-		130	-			
Rise time	$t_r$	-		52	-			
Turn-off delay time	$t_{d(off)}$	-		130	-			
Fall time	$t_f$	-	100	-				
Reverse bias safe operating area	RBSOA	$T_J = 175\text{ }^\circ\text{C}, I_C = 350\text{ A}, R_g = 22\text{ }\Omega, V_{GE} = 15\text{ V to } 0\text{ V}, V_{CC} = 400\text{ V}, V_P = 600\text{ V}, L = 500\text{ }\mu\text{H}$	Fullsquare					
Diode reverse recovery time	$t_{rr}$	$I_F = 50\text{ A}, di/dt = 200\text{ A}/\mu\text{s}, V_R = 200\text{ V}$	-	72	-	ns		
Diode reverse recovery current	$I_{rr}$		-	5.5	-	A		
Diode recovery charge	$Q_{rr}$		-	200	-	nC		
Diode reverse recovery time	$t_{rr}$	$I_F = 50\text{ A}, di/dt = 200\text{ A}/\mu\text{s}, V_R = 200\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	144	-	ns		
Diode peak reverse current	$I_{rr}$		-	13	-	A		
Diode recovery charge	$Q_{rr}$		-	930	-	nC		
Short circuit safe operating area	SCSOA	$T_J = 175\text{ }^\circ\text{C}, R_g = 22\text{ }\Omega, V_{GE} = 15\text{ V to } 0\text{ V}, V_{CC} = 400\text{ V}, V_P = 600\text{ V}$	3			$\mu\text{s}$		



THERMAL AND MECHANICAL SPECIFICATIONS						
PARAMETER	SYMBOL		MIN.	TYP.	MAX.	UNITS
Junction and storage temperature range	$T_J, T_{Stg}$		-40	-	175	°C
Junction to case	IGBT	$R_{thJC}$	-	-	0.23	°C/W
	Diode		-	-	0.63	
Case to heatsink	$R_{thCS}$	Flat, greased surface	-	0.1	-	
Weight			-	30	-	g
Mounting torque		Torque to terminal	-	-	1.1 (9.7)	Nm (lbf.in)
		Torque to heatsink	-	-	1.8 (15.9)	Nm (lbf.in)
Case style		SOT-227				

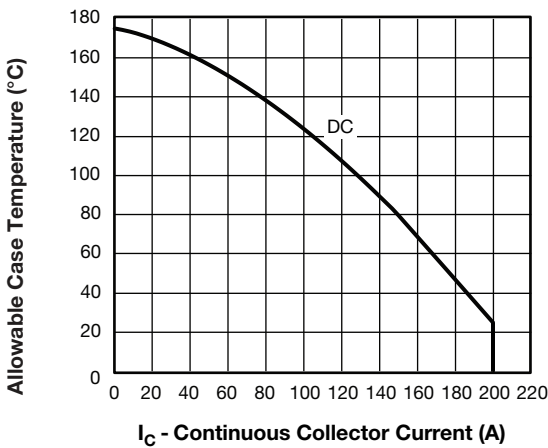


Fig. 1 - Maximum DC IGBT Collector Current vs. Case Temperature

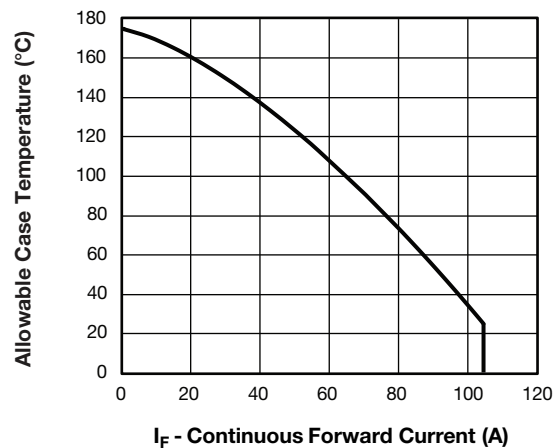


Fig. 3 - Maximum Allowable Forward Current vs. Case Temperature, Diode Leg

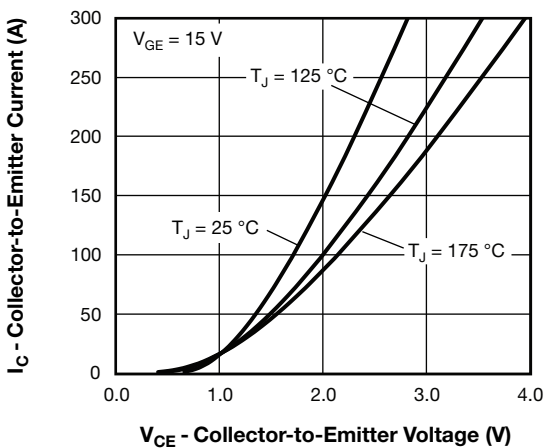


Fig. 2 - Typical Collector to Emitter Current Output Characteristics of IGBT

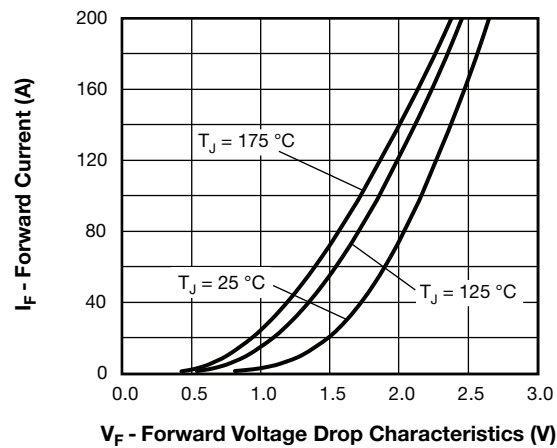


Fig. 4 - Typical Diode Forward Voltage Drop Characteristics

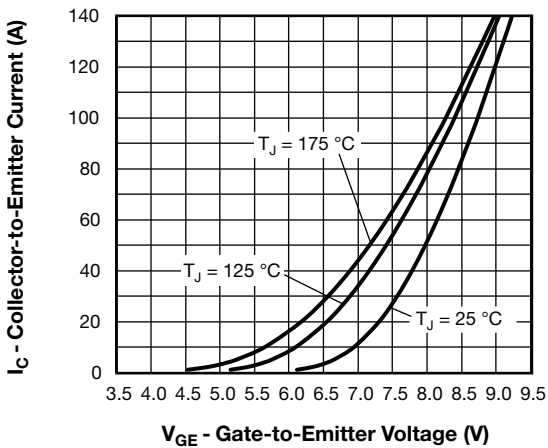


Fig. 5 - Typical IGBT Transfer Characteristics

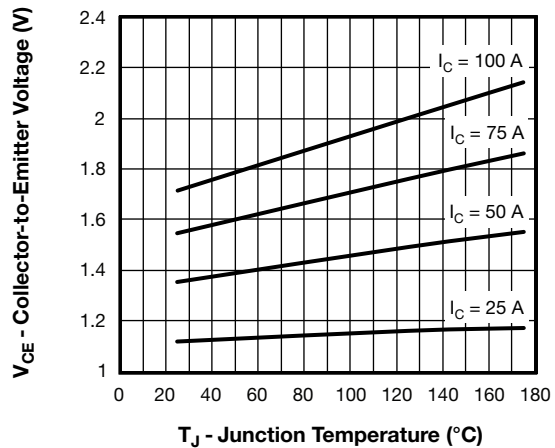


Fig. 8 - Typical IGBT Collector to Emitter Voltage vs. Junction Temperature,  $V_{GE} = 15\text{ V}$

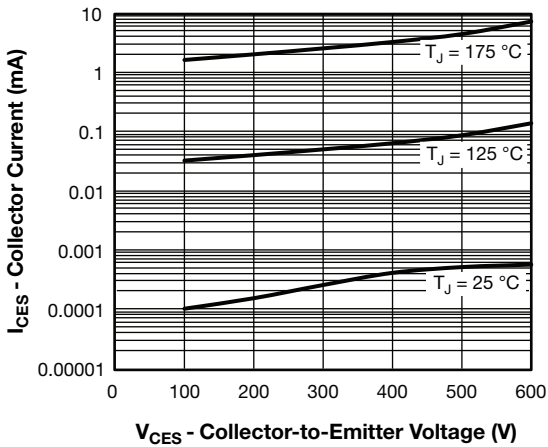


Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

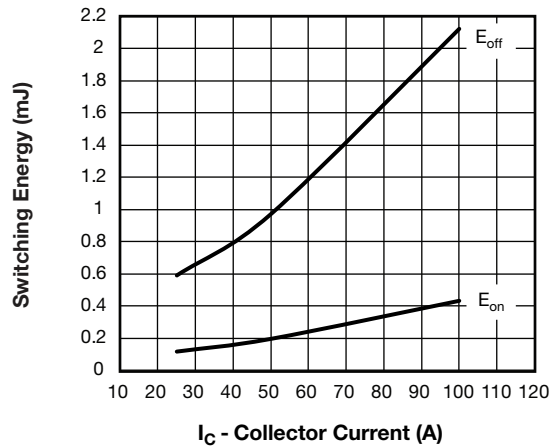


Fig. 9 - Typical IGBT Energy Losses vs.  $I_C$   
 $T_J = 125\text{ °C}$ ,  $L = 500\text{ }\mu\text{H}$ ,  $V_{CC} = 360\text{ V}$ ,  
 $R_g = 5\text{ }\Omega$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

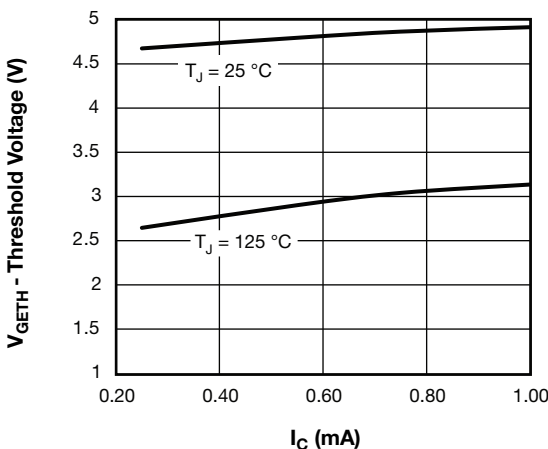


Fig. 7 - Typical IGBT Threshold Voltage

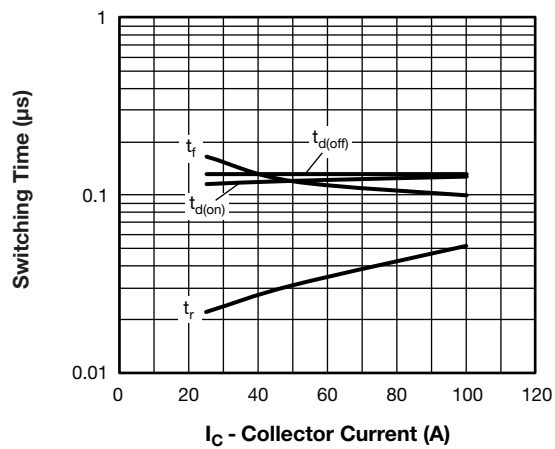


Fig. 10 - Typical IGBT Switching Time vs.  $I_C$   
 $T_J = 125\text{ °C}$ ,  $L = 500\text{ }\mu\text{H}$ ,  $V_{CC} = 360\text{ V}$ ,  
 $R_g = 5\text{ }\Omega$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

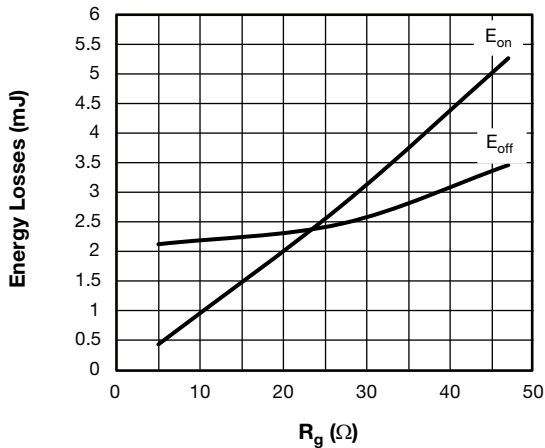


Fig. 11 - Typical IGBT Energy Loss vs.  $R_g$   
 $T_J = 125\text{ }^\circ\text{C}$ ,  $I_C = 100\text{ A}$ ,  $L = 500\text{ }\mu\text{H}$ ,  
 $V_{CC} = 360\text{ V}$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

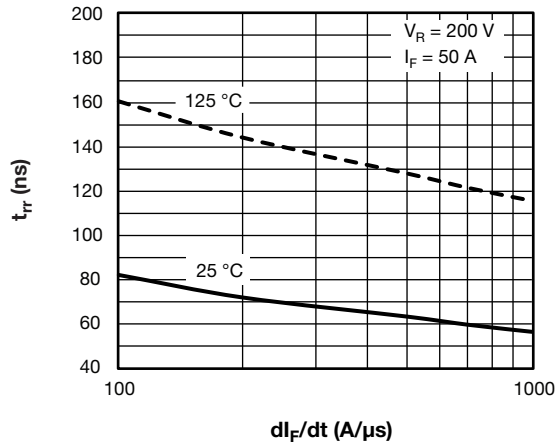


Fig. 13 - Typical Reverse Recovery Time vs.  $di_F/dt$  of Diode

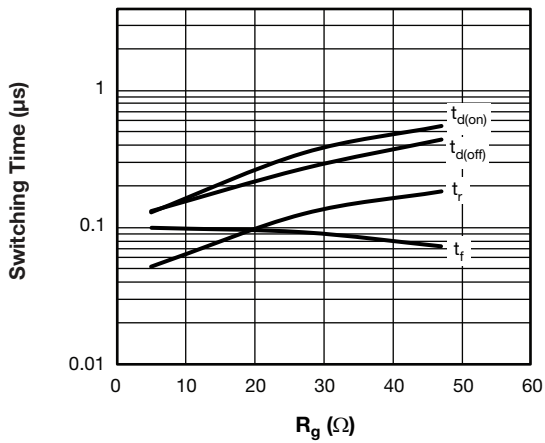


Fig. 12 - Typical IGBT Switching Time vs.  $R_g$   
 $T_J = 125\text{ }^\circ\text{C}$ ,  $L = 500\text{ }\mu\text{H}$ ,  $V_{CC} = 360\text{ V}$ ,  
 $I_C = 100\text{ A}$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

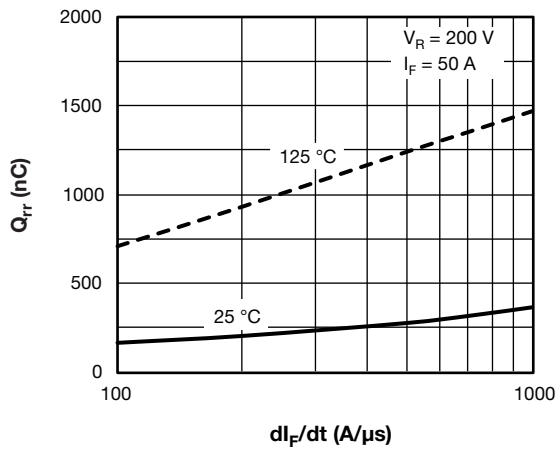


Fig. 14 - Typical Stored Charge vs.  $di_F/dt$  of Diode

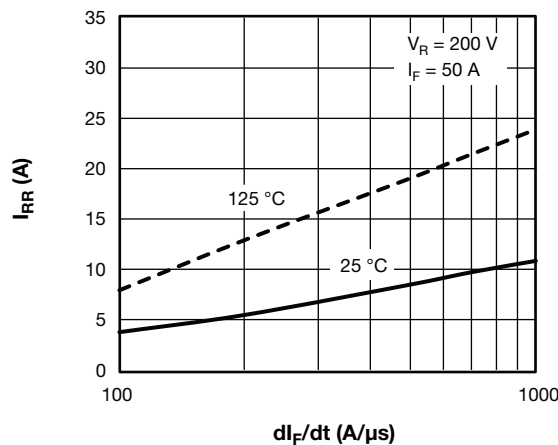


Fig. 15 - Typical Reverse Recovery Current vs.  $di_F/dt$  of Diode

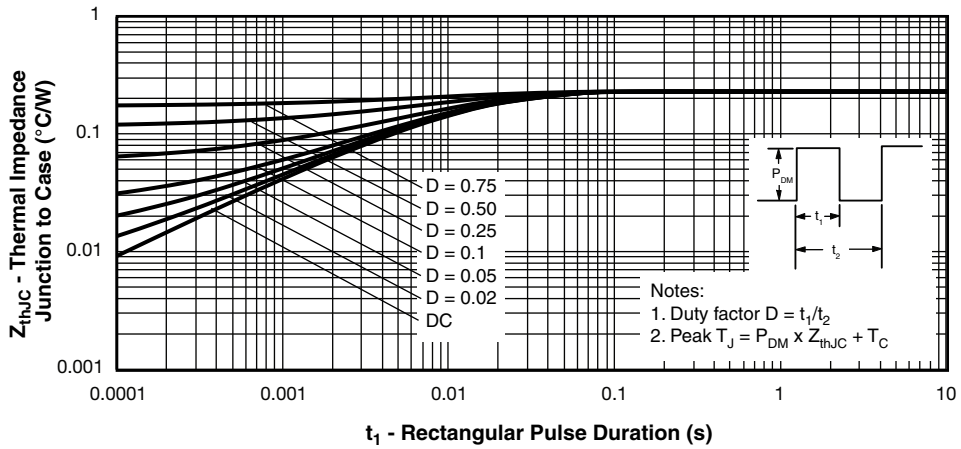


Fig. 16 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics, IGBT

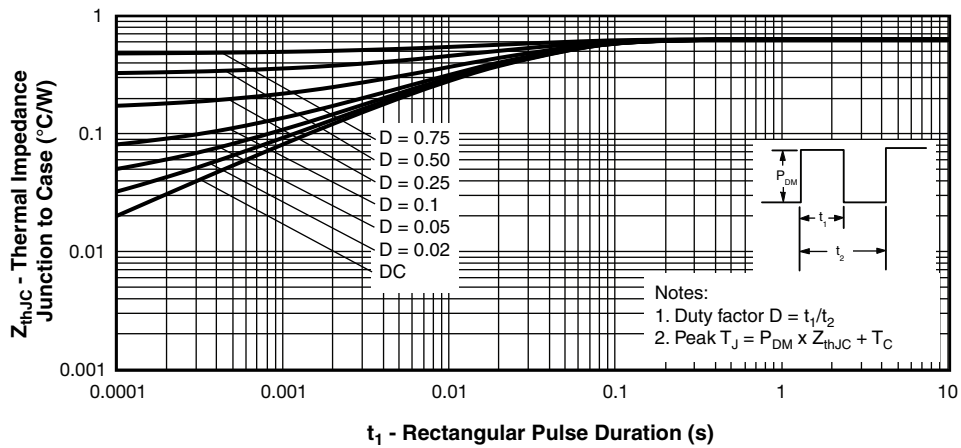


Fig. 17 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics, Diode

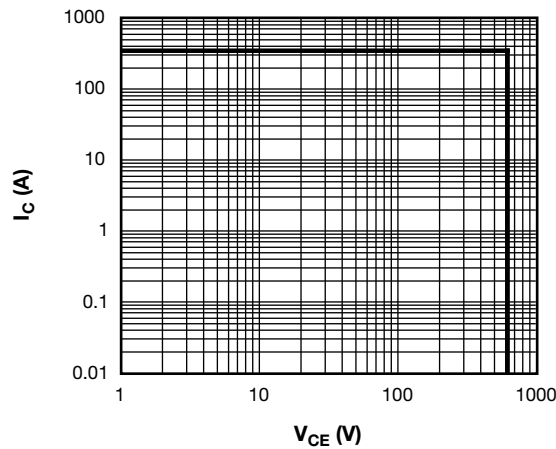


Fig. 18 - IGBT Reverse BIAS SOA,  $T_J = 175\text{ }^\circ\text{C}$ ,  $V_{GE} = 15\text{ V}$

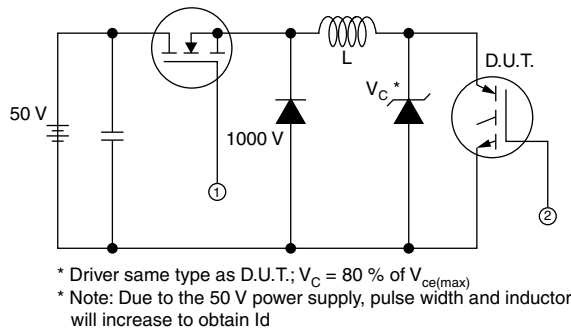


Fig. 19 - Clamped Inductive Load Test Circuit

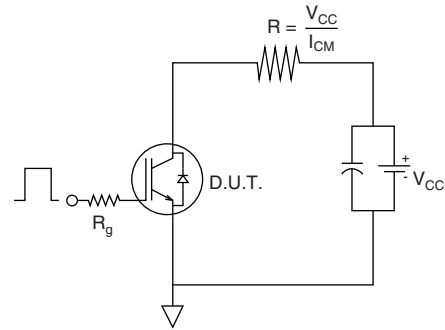


Fig. 20 - Pulsed Collector Current Test Circuit

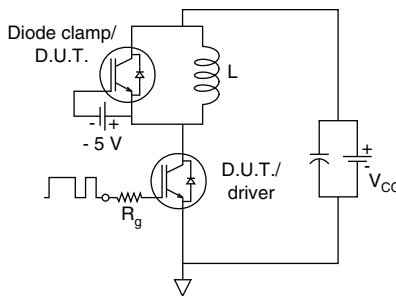


Fig. 21 - Switching Loss Test Circuit

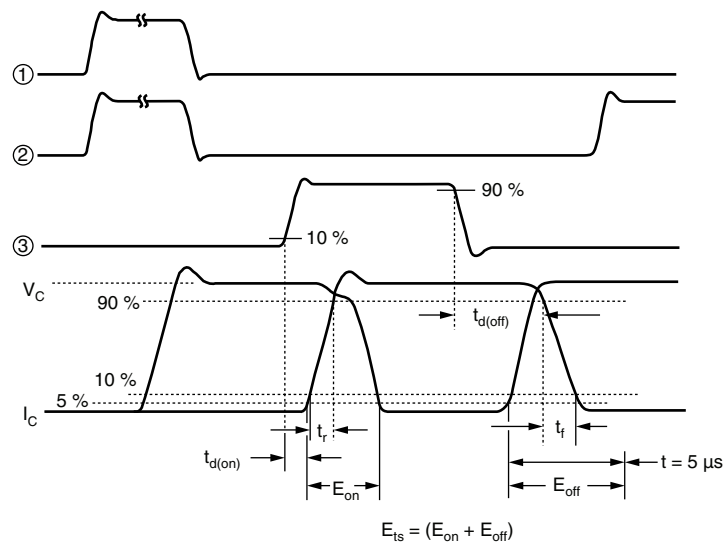


Fig. 22 - Switching Loss Waveforms Test Circuit

## ORDERING INFORMATION TABLE

Device code	<b>VS-</b>	<b>G</b>	<b>T</b>	<b>140</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** - T = trench IGBT Technology
- 4** - Current rating (140 = 140 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
Single switch with AP diode	D	 

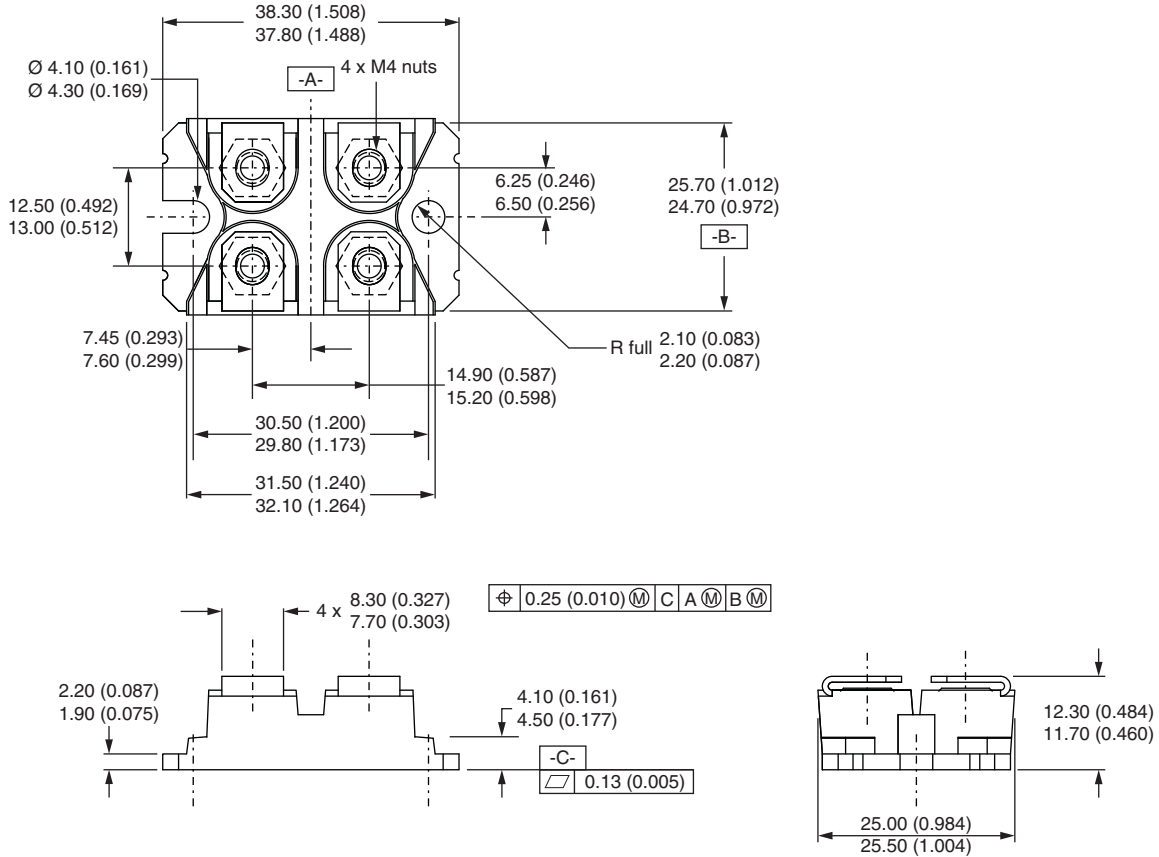
LINKS TO RELATED DOCUMENTS	
Dimensions	<a href="http://www.vishay.com/doc?95423">www.vishay.com/doc?95423</a>
Packaging information	<a href="http://www.vishay.com/doc?95425">www.vishay.com/doc?95425</a>





### SOT-227 Generation II

**DIMENSIONS** in millimeters (inches)



**Note**

- Controlling dimension: millimeter



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