

## Insulated Gate Bipolar Transistor (High Speed Trench IGBT), 93 A


**SOT-227**

PRIMARY CHARACTERISTICS	
$V_{CES}$	600 V
$I_C$ DC	90 A at 92 °C
$V_{CE(on)}$ typical at 100 A, 25 °C	1.64 V
$I_F$ DC	90 A at 103 °C
Speed	8 kHz to 30 kHz
Package	SOT-227
Circuit configuration	Single switch with AP diode

**FEATURES**

- Trench IGBT technology with positive temperature coefficient
- Square RBSOA
- HEXFRED® anti-parallel diodes with ultrasoft reverse recovery
- 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	$I_C$	$T_C = 25$ °C	146	A
		$T_C = 90$ °C	92	
Pulsed collector current	$I_{CM}$	$T_C = 150$ °C, $t_p = 6$ ms, $V_{GE} = 15$ V	300	
Clamped inductive load current	$I_{LM}$		300	
Diode continuous forward current	$I_F$	$T_C = 25$ °C	100	
		$T_C = 90$ °C	108	
Gate-to-emitter voltage	$V_{GE}$		$\pm 20$	V
Power dissipation, IGBT	$P_D$	$T_C = 25$ °C	446	W
		$T_C = 90$ °C	214	
Power dissipation, diode	$P_D$	$T_C = 25$ °C	379	
		$T_C = 90$ °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	$V_{BR(CES)}$	$V_{GE} = 0\text{ V}, I_C = 400\text{ }\mu\text{A}$	600	-	-	V
Collector to emitter voltage	$V_{CE(on)}$	$V_{GE} = 15\text{ V}, I_C = 100\text{ A}$	-	1.64	2.15	
		$V_{GE} = 15\text{ V}, I_C = 100\text{ A}, T_J = 125\text{ }^\circ\text{C}$	-	1.85	-	
		$V_{GE} = 15\text{ V}, I_C = 100\text{ A}, T_J = 150\text{ }^\circ\text{C}$	-	1.91	-	
Gate threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}, I_C = 1.0\text{ mA}$	2.9	4.1	5.3	mV/°C
		$V_{CE} = V_{GE}, I_C = 1\text{ mA}, T_J = 125\text{ }^\circ\text{C}$	-	3.1	-	
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 $125\text{ }^\circ\text{C}$ )	-	-10	-	
Collector to emitter leakage current	$I_{CES}$	$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}$	-	1.5	100	$\mu\text{A}$
		$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}, T_J = 125\text{ }^\circ\text{C}$	-	1.0	-	mA
		$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	3.5	-	
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	-	
		$I_C = 100\text{ A}, V_{GE} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	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)	$Q_g$	$I_C = 100\text{ A}, V_{CC} = 520\text{ V}, V_{GE} = 15\text{ V}$	-	247	-	nC		
Gate to emitter charge (turn-on)	$Q_{ge}$		-	39	-			
Gate to collector charge (turn-on)	$Q_{gc}$		-	85	-			
Turn-on switching loss	$E_{on}$	$I_C = 100\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = 15\text{ V}, R_g = 15\text{ }\Omega, L = 500\text{ }\mu\text{H}, T_J = 25\text{ }^\circ\text{C}$	-	1.89	-	mJ		
Turn-off switching loss	$E_{off}$		-	0.88	-			
Total switching loss	$E_{tot}$		-	2.77	-			
Turn-on delay time	$t_{d(on)}$		Energy losses include tail and diode recovery. Used Antiparallel diode	-	50	-	ns	
Rise time	$t_r$			-	67	-		
Turn-off delay time	$t_{d(off)}$			-	162	-		
Fall time	$t_f$			-	25	-		
Turn-on switching loss	$E_{on}$			-	1.81	-		mJ
Turn-off switching loss	$E_{off}$			-	1.0	-		
Total switching loss	$E_{tot}$			-	2.81	-		
Turn-on delay time	$t_{d(on)}$	$I_C = 100\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = 15\text{ V}, R_g = 15\text{ }\Omega, L = 500\text{ }\mu\text{H}, T_J = 125\text{ }^\circ\text{C}$	-	50	-	ns		
Rise time	$t_r$		-	66	-			
Turn-off delay time	$t_{d(off)}$		-	174	-			
Fall time	$t_f$		-	23	-			
Reverse bias safe operating area	RBSOA	$T_J = 150\text{ }^\circ\text{C}, I_C = 100\text{ A}, R_g = 15\text{ }\Omega, V_{GE} = 15\text{ V to } 0\text{ V}, V_{CC} = 300\text{ V}, V_P = 600\text{ V}, L = 500\text{ }\mu\text{H}$	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	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
Junction and storage temperature range	$T_J, T_{Stg}$		-40	-	150	°C
Junction to case	IGBT		-	-	0.28	°C/W
	Diode		-	-	0.33	
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					

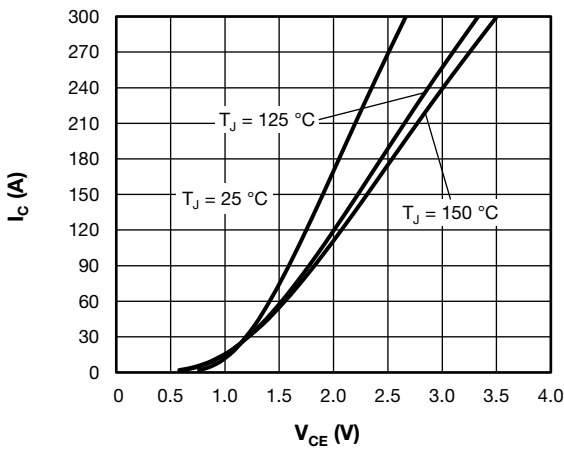


Fig. 1 - Typical Trench IGBT Output Characteristics,  $V_{GE} = 15\text{ V}$

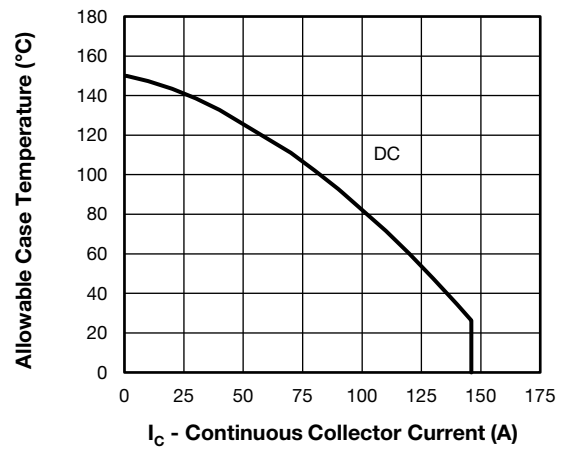


Fig. 3 - Maximum Trench IGBT Continuous Collector Current vs. Case Temperature

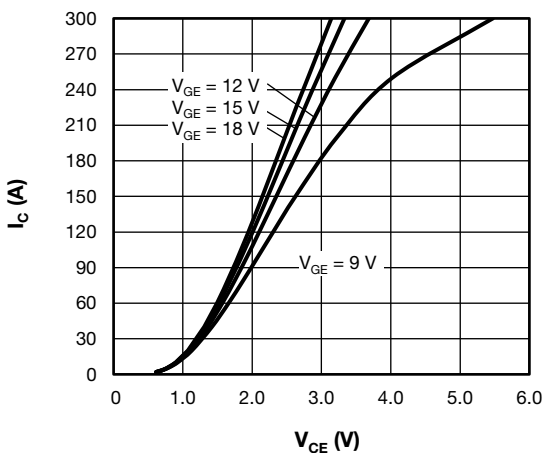


Fig. 2 - Typical Trench IGBT Output Characteristics,  $T_J = 125\text{ °C}$

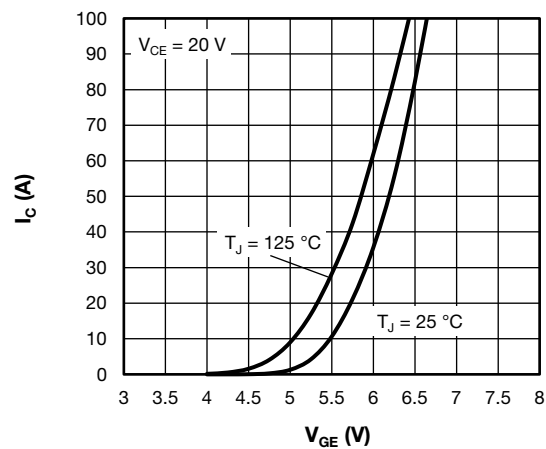


Fig. 4 - Typical Trench IGBT Transfer Characteristics

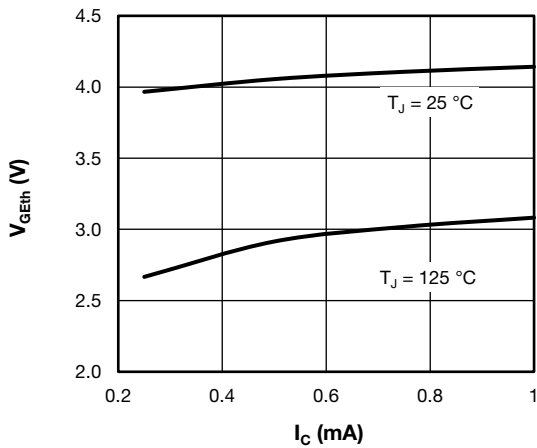


Fig. 5 - Typical Trench IGBT Gate Threshold Voltage

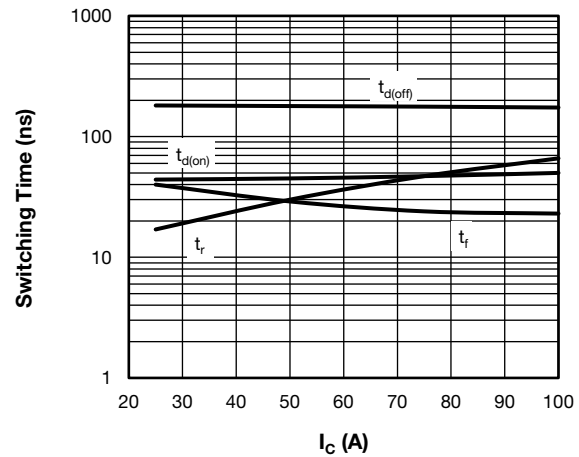


Fig. 8 - Typical Trench IGBT Switching Time vs.  $I_C$   
(with Antiparallel Diode)  
 $T_J = 125\text{ }^\circ\text{C}$ ,  $V_{CC} = 300\text{ V}$ ,  $R_g = 15\ \Omega$ ,  $V_{GE} = +15\text{ V}/-15\text{ V}$ ,  $L = 500\ \mu\text{H}$

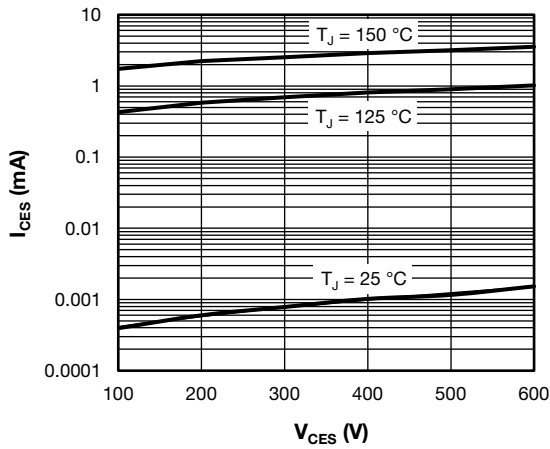


Fig. 6 - Typical Trench IGBT Zero Gate Voltage Collector Current

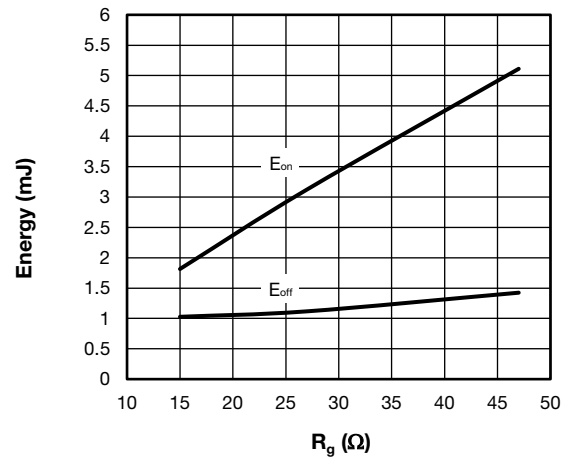


Fig. 9 - Typical Trench IGBT Energy Loss vs.  $R_g$   
(with Antiparallel Diode)  
 $T_J = 125\text{ }^\circ\text{C}$ ,  $V_{CC} = 300\text{ V}$ ,  $I_C = 100\text{ A}$ ,  $V_{GE} = +15\text{ V}/-15\text{ V}$ ,  $L = 500\ \mu\text{H}$

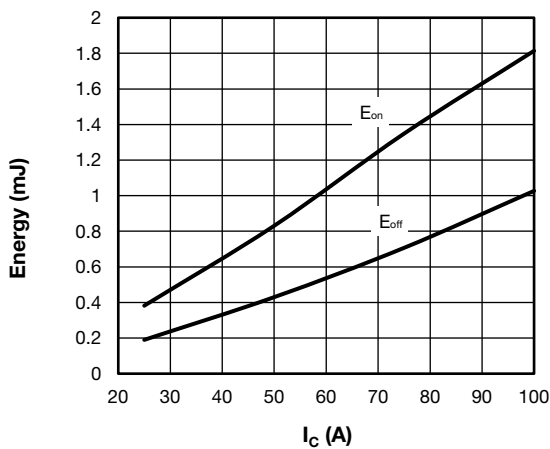


Fig. 7 - Typical Trench IGBT Energy Loss vs.  $I_C$   
(with Antiparallel Diode)  
 $T_J = 125\text{ }^\circ\text{C}$ ,  $V_{CC} = 300\text{ V}$ ,  $R_g = 15\ \Omega$ ,  $V_{GE} = +15\text{ V}/-15\text{ V}$ ,  $L = 500\ \mu\text{H}$

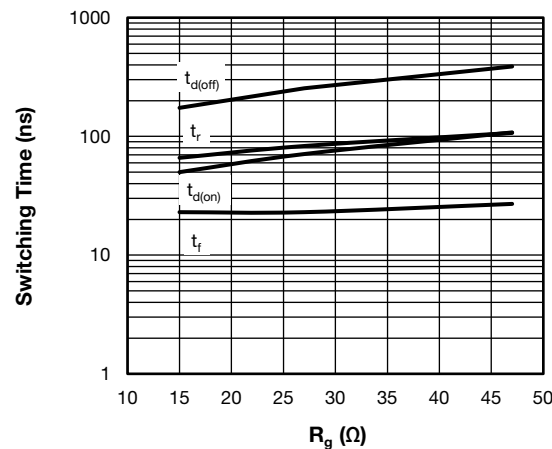


Fig. 10 - Typical Trench IGBT Switching Time vs.  $R_g$   
 $T_J = 125\text{ }^\circ\text{C}$ ,  $V_{CC} = 300\text{ V}$ ,  $I_C = 100\text{ A}$ ,  $V_{GE} = +15\text{ V}/-15\text{ V}$ ,  $L = 500\ \mu\text{H}$

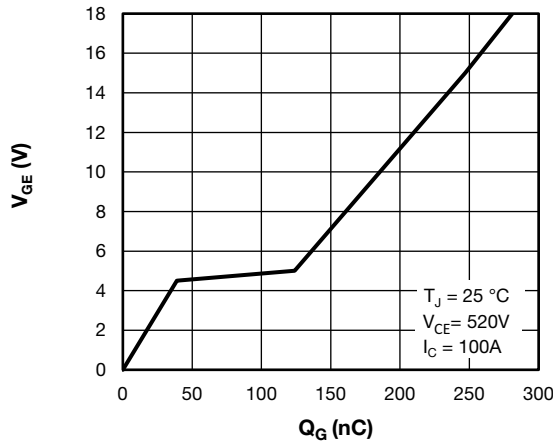


Fig. 11 - Typical Trench IGBT Gate Charge vs. Gate to Emitter Voltage

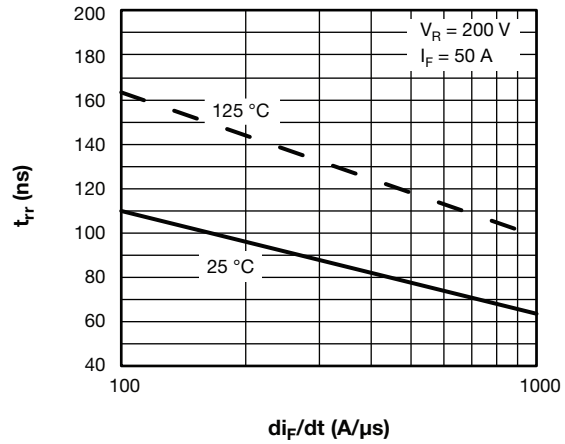


Fig. 14 - Typical Reverse Recovery Time vs.  $di_F/dt$  of Diode

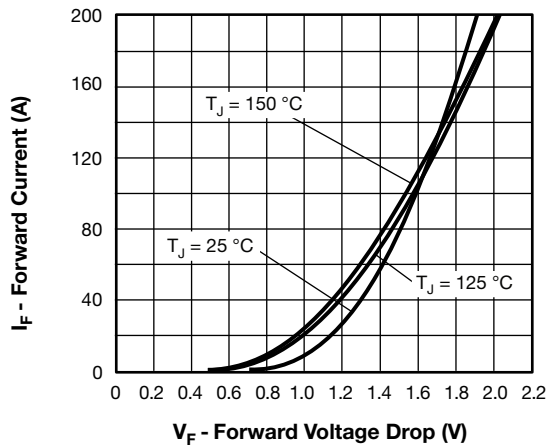


Fig. 12 - Typical Forward Voltage Drop Characteristics

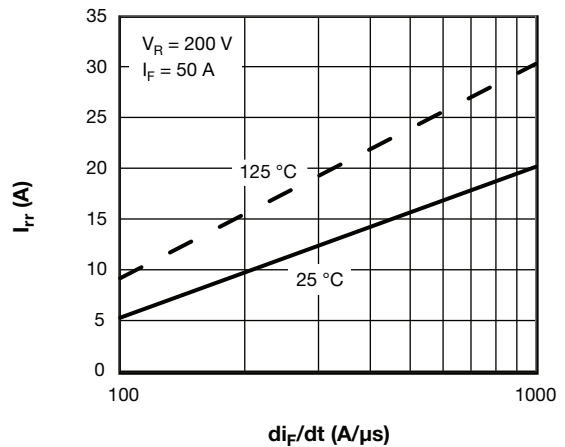


Fig. 15 - Typical Reverse Recovery Current vs.  $di_F/dt$  of Diode

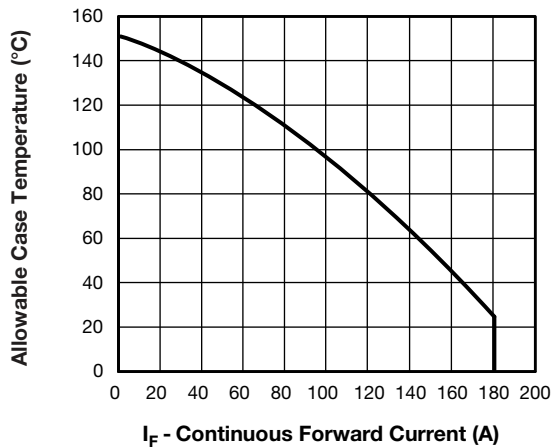


Fig. 13 - Maximum Antiparallel Diode Continuous Forward Current vs. Case Temperature

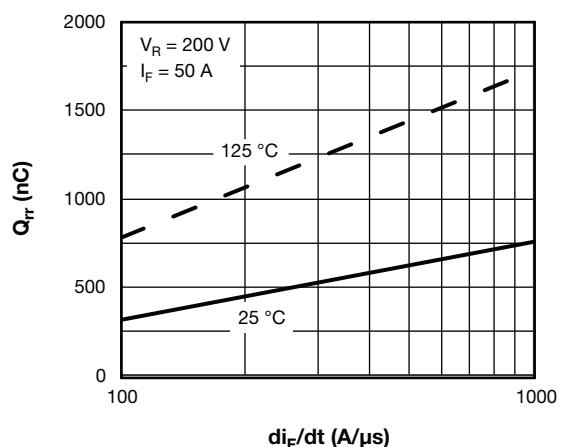


Fig. 16 - Typical Stored Charge vs.  $di_F/dt$  of Diode

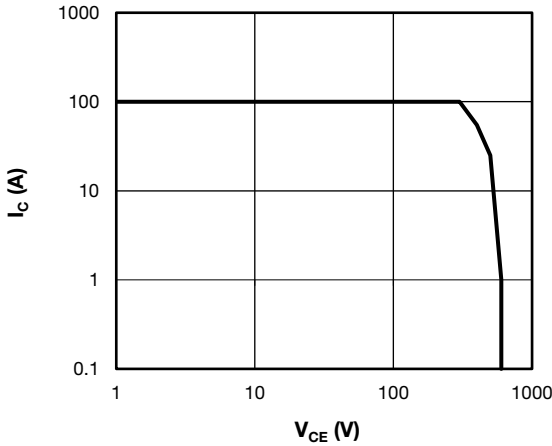


Fig. 17 - Trench IGBT Reverse BIAS SOA  
 $T_J = 150\text{ }^\circ\text{C}$ ,  $I_C = 100\text{A}$ ,  $R_{\theta} = 15\text{ }\Omega$ ,  $V_{GE} = +15\text{ V/0 V}$ ,  
 $V_{CC} = 300\text{ V}$ ,  $V_p = 600\text{ V}$

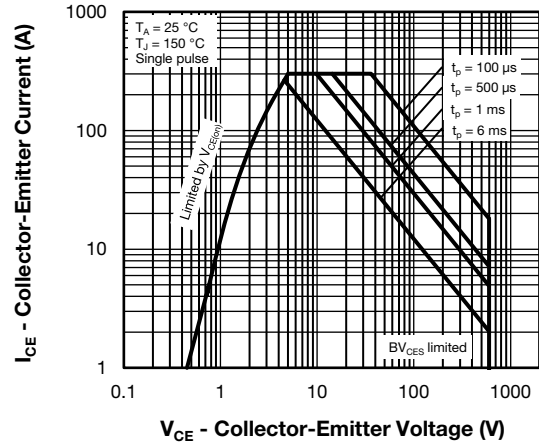


Fig. 18 - Trench IGBT Safe Operating Area

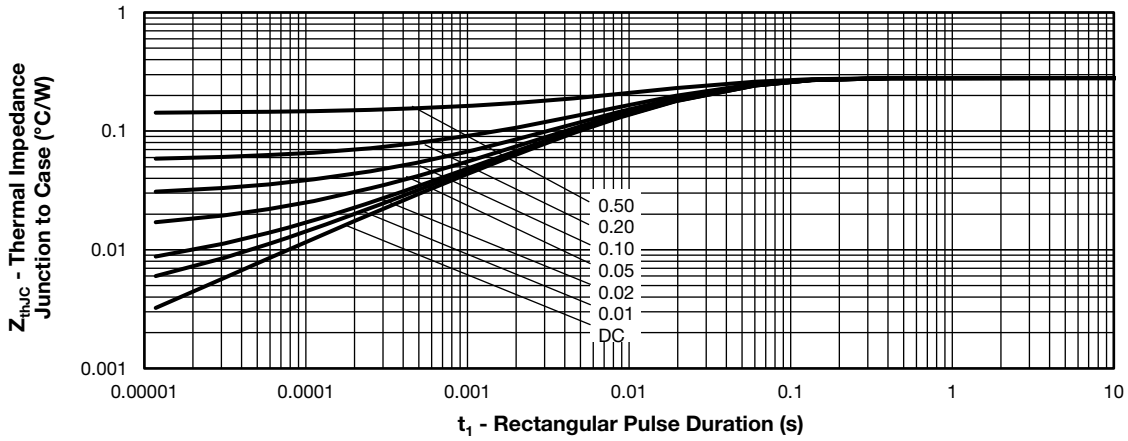


Fig. 19 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics, IGBT

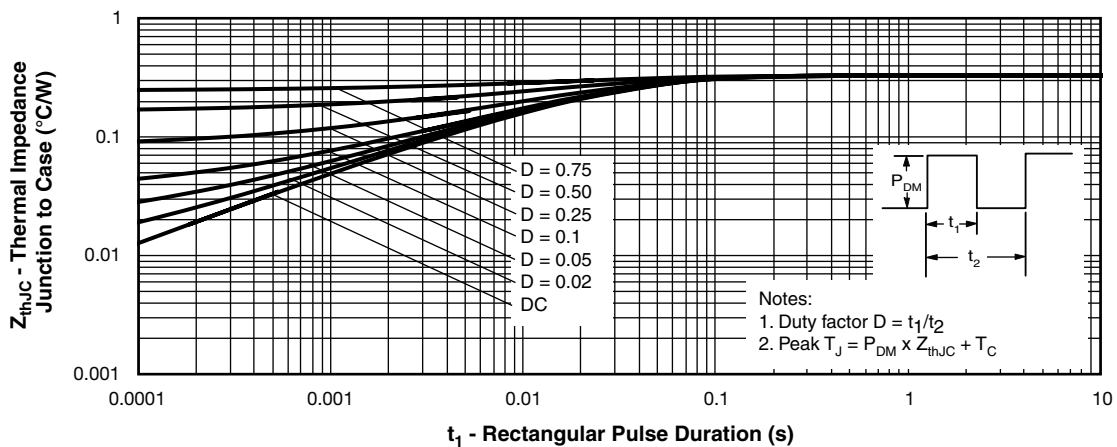
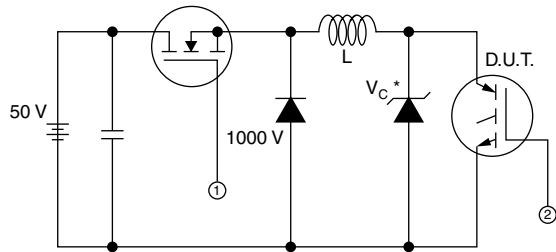


Fig. 20 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics, Diode



\* 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  $I_d$

Fig. 21 - Clamped Inductive Load Test Circuit

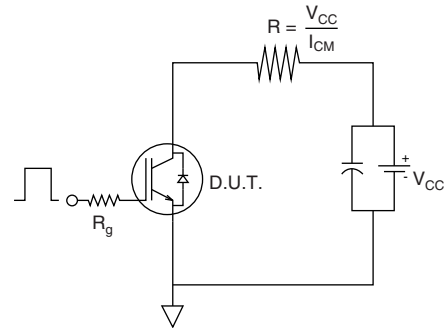


Fig. 22 - Pulsed Collector Current Test Circuit

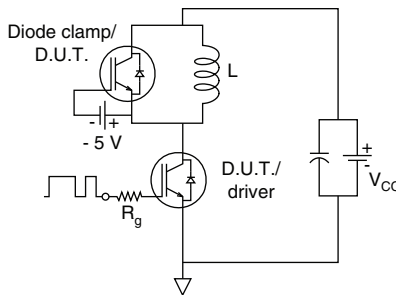


Fig. 23 - Switching Loss Test Circuit

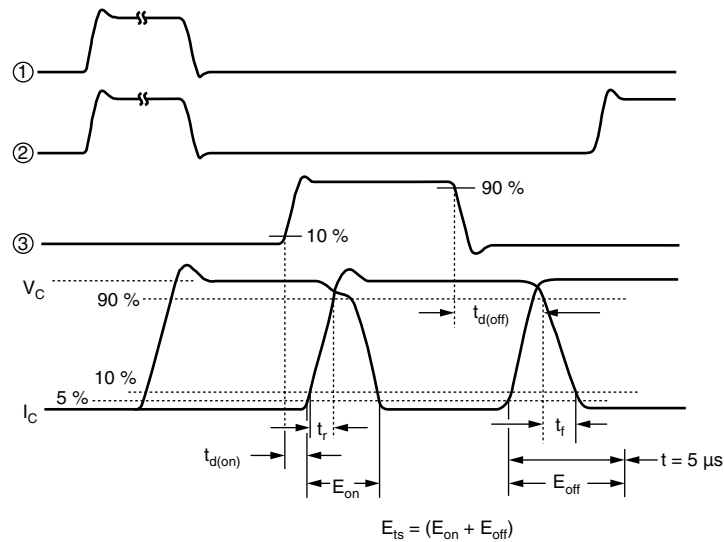


Fig. 24 - Switching Loss Waveforms Test Circuit

**ORDERING INFORMATION TABLE**

Device code	<b>VS-</b>	<b>G</b>	<b>T</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** - T = Trench IGBT
- 4** - Current rating (90 = 90 A)
- 5** - Circuit configuration (D = single switch with AP 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	<div style="display: inline-block; vertical-align: top; margin-left: 20px;"> <p>Lead Assignment</p> </div>

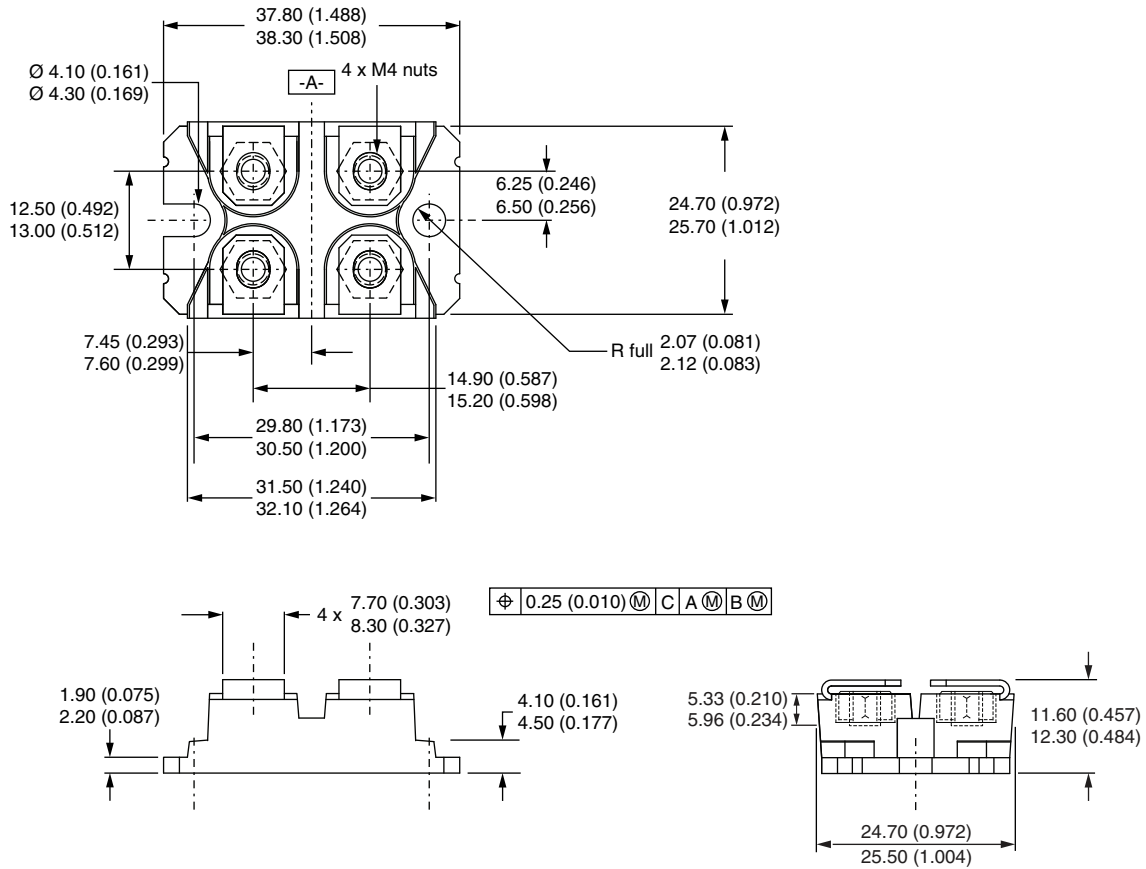
LINKS TO RELATED DOCUMENTS	
Dimensions	<a href="http://www.vishay.com/doc?95423">www.vishay.com/doc?95423</a>
Packaging information	<a href="http://www.vishay.com/doc?95425">www.vishay.com/doc?95425</a>





## SOT-227 Generation 2

**DIMENSIONS** in millimeters (inches)



**Note**

- Controlling dimension: millimeter



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