

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



SOT-227

### PRIMARY CHARACTERISTICS

|                                      |                             |
|--------------------------------------|-----------------------------|
| $V_{CES}$                            | 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              |
| Speed                                | 8 kHz to 30 kHz             |
| Package                              | SOT-227                     |
| Circuit configuration                | Single switch with AP diode |

### FEATURES

- NPT warp 2 speed 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     | $I_C$      | $T_C = 25\text{ °C}$              | 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     |

**ELECTRICAL SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$  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 | $\Delta V_{GE(th)}/\Delta T_J$ | $V_{CE} = V_{GE}$ , $I_C = 1\text{ mA}$ ( $25\text{ }^{\circ}\text{C}$ to $125\text{ }^{\circ}\text{C}$ ) | -    | -10  | -         | mV/ $^{\circ}\text{C}$ |
| 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                     |

**SWITCHING CHARACTERISTICS** ( $T_J = 25\text{ }^{\circ}\text{C}$  unless otherwise specified)

| PARAMETER                          | SYMBOL              | TEST CONDITIONS                                                                                                                                                    |                                                                   | MIN.                                                                                                                               | TYP. | MAX. | UNITS |   |    |
|------------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|------|------|-------|---|----|
| Total gate charge (turn-on)        | Q <sub>g</sub>      | I <sub>C</sub> = 100 A, V <sub>CC</sub> = 480 V, V <sub>GE</sub> = 15 V                                                                                            |                                                                   | -                                                                                                                                  | 460  | 690  | nC    |   |    |
| Gate to emitter charge (turn-on)   | Q <sub>ge</sub>     |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 160  | 250  |       |   |    |
| Gate to collector charge (turn-on) | Q <sub>gc</sub>     |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 70   | 130  |       |   |    |
| Turn-on switching loss             | E <sub>on</sub>     | I <sub>C</sub> = 100 A, V <sub>CC</sub> = 360 V, V <sub>GE</sub> = 15 V, R <sub>g</sub> = 5 Ω, L = 500 μH, T <sub>J</sub> = 25 °C                                  | Energy losses include tail and diode recovery. Diode used 60APH06 | -                                                                                                                                  | 0.39 | -    | mJ    |   |    |
| Turn-off switching loss            | E <sub>off</sub>    |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 1.10 | -    |       |   |    |
| Total switching loss               | E <sub>tot</sub>    |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 1.49 | -    |       |   |    |
| Turn-on delay time                 | t <sub>d(on)</sub>  |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 245  | -    | ns    |   |    |
| Rise time                          | t <sub>r</sub>      |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 53   | -    |       |   |    |
| Turn-off delay time                | t <sub>d(off)</sub> |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 240  | -    |       |   |    |
| Fall time                          | t <sub>f</sub>      |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 63   | -    |       |   |    |
| Turn-on switching loss             | E <sub>on</sub>     |                                                                                                                                                                    |                                                                   | I <sub>C</sub> = 100 A, V <sub>CC</sub> = 360 V, V <sub>GE</sub> = 15 V, R <sub>g</sub> = 5 Ω, L = 500 μH, T <sub>J</sub> = 125 °C |      | -    | 0.52  | - | mJ |
| Turn-off switching loss            | E <sub>off</sub>    |                                                                                                                                                                    |                                                                   |                                                                                                                                    |      | -    | 1.24  | - |    |
| Total switching loss               | E <sub>tot</sub>    |                                                                                                                                                                    |                                                                   |                                                                                                                                    |      | -    | 1.76  | - | ns |
| Turn-on delay time                 | t <sub>d(on)</sub>  | -                                                                                                                                                                  | 240                                                               |                                                                                                                                    |      | -    |       |   |    |
| Rise time                          | t <sub>r</sub>      | -                                                                                                                                                                  | 54                                                                |                                                                                                                                    |      | -    |       |   |    |
| Turn-off delay time                | t <sub>d(off)</sub> | -                                                                                                                                                                  | 250                                                               |                                                                                                                                    |      | -    |       |   |    |
| Fall time                          | t <sub>f</sub>      | -                                                                                                                                                                  | 80                                                                |                                                                                                                                    |      | -    |       |   |    |
| Reverse bias safe operating area   | RBSOA               | T <sub>J</sub> = 150 °C, I <sub>C</sub> = 300 A, R <sub>g</sub> = 22 Ω, V <sub>GE</sub> = 15 V to 0 V, V <sub>CC</sub> = 400 V, V <sub>P</sub> = 600 V, L = 500 μH |                                                                   | Fullsquare                                                                                                                         |      |      |       |   |    |
| Diode reverse recovery time        | t <sub>rr</sub>     | I <sub>F</sub> = 50 A, dI <sub>F</sub> /dt = 200 A/μs, V <sub>R</sub> = 200 V                                                                                      |                                                                   | -                                                                                                                                  | 95   | -    | ns    |   |    |
| Diode peak reverse current         | I <sub>rr</sub>     |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 10   | -    | A     |   |    |
| Diode recovery charge              | Q <sub>rr</sub>     |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 480  | -    | nC    |   |    |
| Diode reverse recovery time        | t <sub>rr</sub>     | I <sub>F</sub> = 50 A, dI <sub>F</sub> /dt = 200 A/μs, V <sub>R</sub> = 200 V, T <sub>J</sub> = 125 °C                                                             |                                                                   | -                                                                                                                                  | 144  | -    | ns    |   |    |
| Diode peak reverse current         | I <sub>rr</sub>     |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 16   | -    | A     |   |    |
| Diode recovery charge              | Q <sub>rr</sub>     |                                                                                                                                                                    |                                                                   | -                                                                                                                                  | 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                       | $R_{thJC}$     |                       | -    | -    | 0.20       | °C/W        |
| IGBT                                   |                |                       | -    | -    | -          |             |
| Diode                                  | $R_{thCS}$     | Flat, greased surface | -    | 0.1  | -          |             |
| Case to heatsink                       |                |                       | -    | 30   | -          | g           |
| Weight                                 |                |                       | -    | -    | -          |             |
| 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               |      |      |            |             |

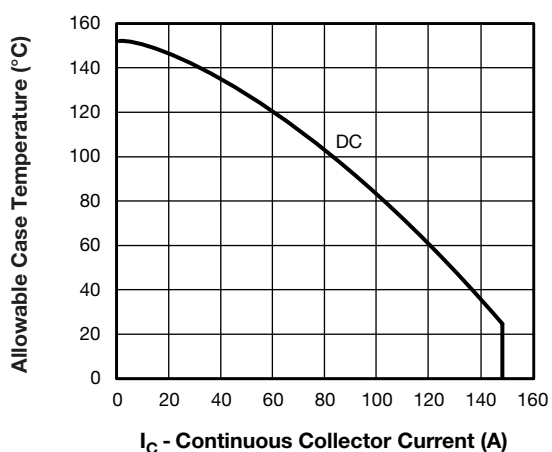


Fig. 1 - Maximum DC IGBT Collector Current vs. Case Temperature

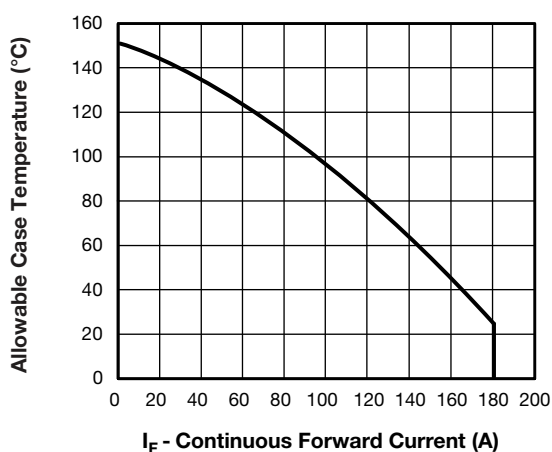


Fig. 3 - Maximum Allowable Forward Current vs. Case Temperature, Diode Leg

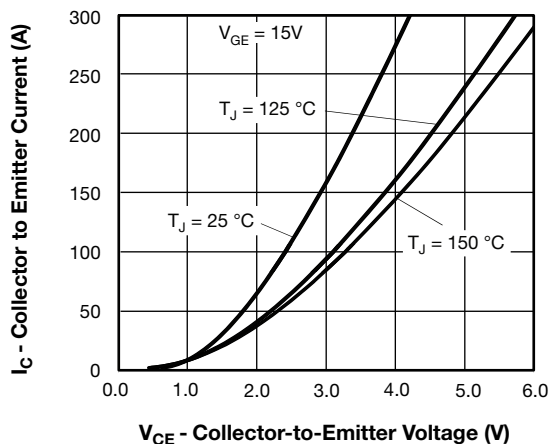


Fig. 2 - Typical Collector to Emitter Voltage (V)

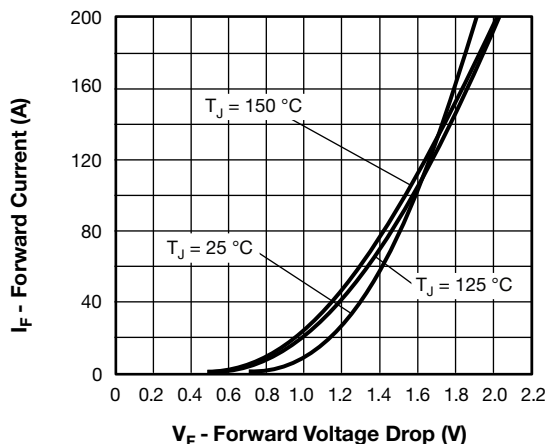


Fig. 4 - Typical Forward Voltage Drop Characteristics

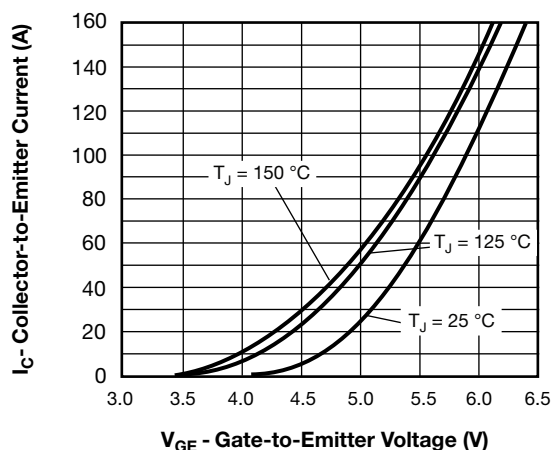


Fig. 5 - Typical IGBT Transfer Characteristics

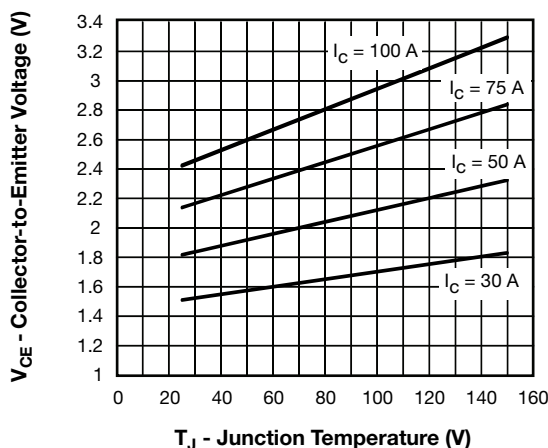
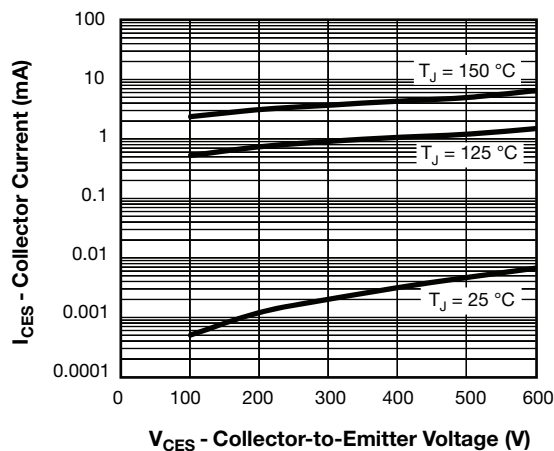

Fig. 8 - Typical IGBT Collector to Emitter Voltage vs. Junction Temperature,  $V_{GE} = 15$  V


Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

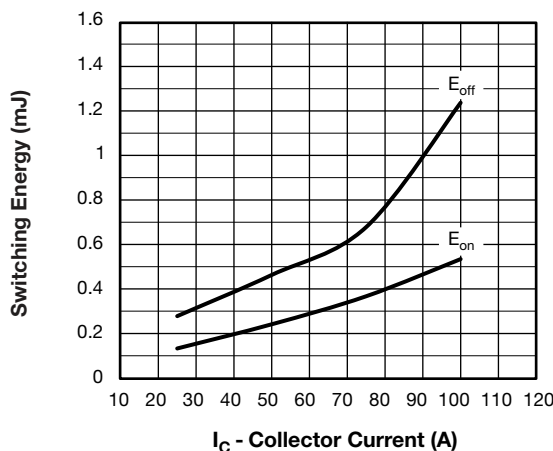
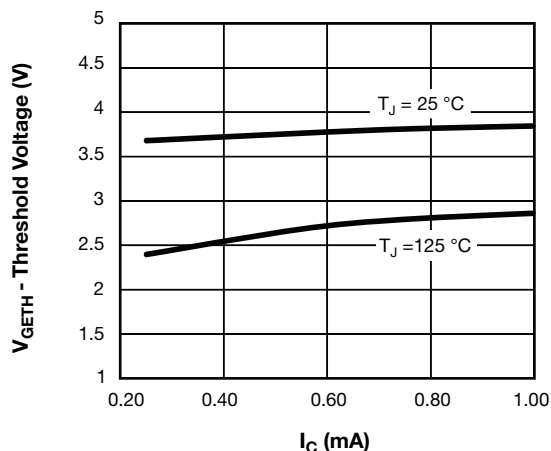
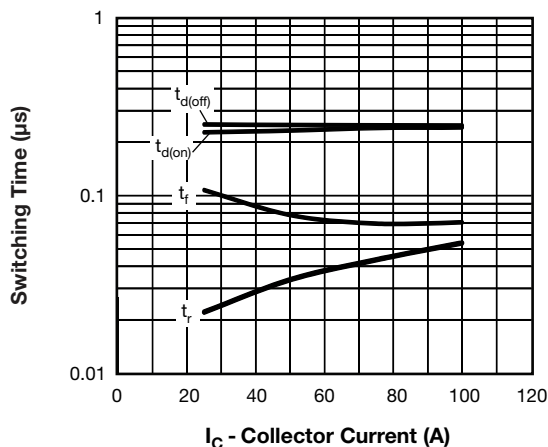

Fig. 9 - Typical IGBT Energy Losses vs.  $I_C$   
 $T_J = 125$  °C,  $L = 500$   $\mu$ H,  $V_{CC} = 360$  V,  
 $R_g = 5$   $\Omega$ ,  $V_{GE} = 15$  V, Diode used: 60APH06


Fig. 7 - Typical IGBT Threshold Voltage


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

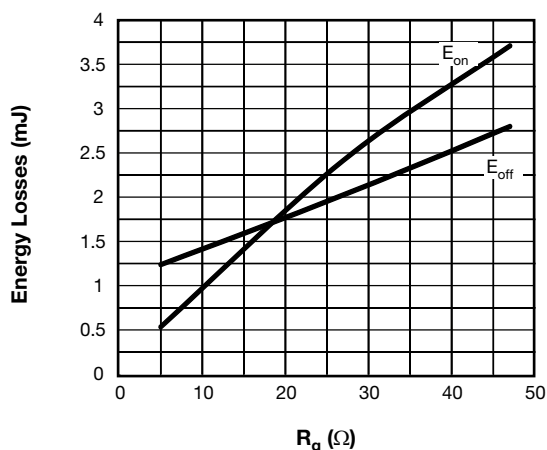


Fig. 11 - Typical IGBT Energy Loss vs.  $R_g$   
 $T_J = 125^\circ\text{C}$ ,  $I_C = 100\text{ A}$ ,  $L = 500\text{ }\mu\text{H}$ ,  
 $V_{CC} = 360\text{ V}$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

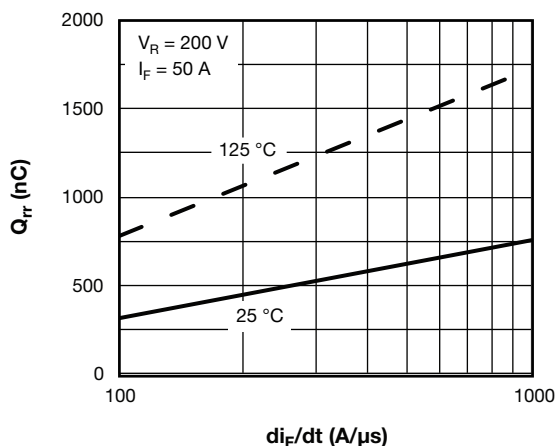


Fig. 14 - Typical Stored Charge vs.  $dI_F/dt$  of Diode

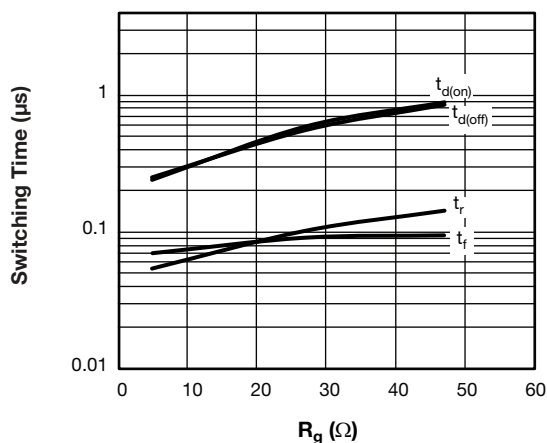


Fig. 12 - Typical IGBT Switching Time vs.  $R_g$   
 $T_J = 125^\circ\text{C}$ ,  $L = 500\text{ }\mu\text{H}$ ,  $V_{CC} = 360\text{ V}$ ,  
 $I_C = 100\text{ A}$ ,  $V_{GE} = 15\text{ V}$ , Diode used: 60APH06

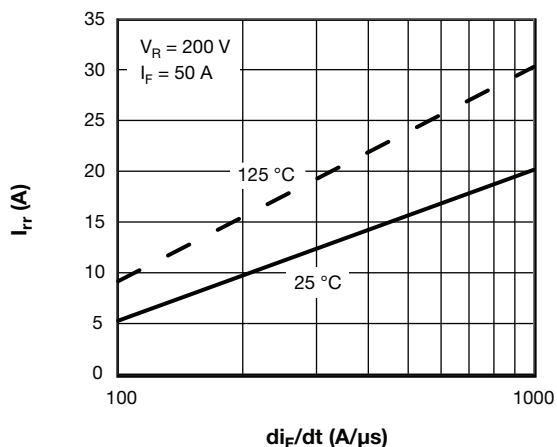


Fig. 15 - Typical Reverse Recovery Current vs.  $dI_F/dt$  of Diode

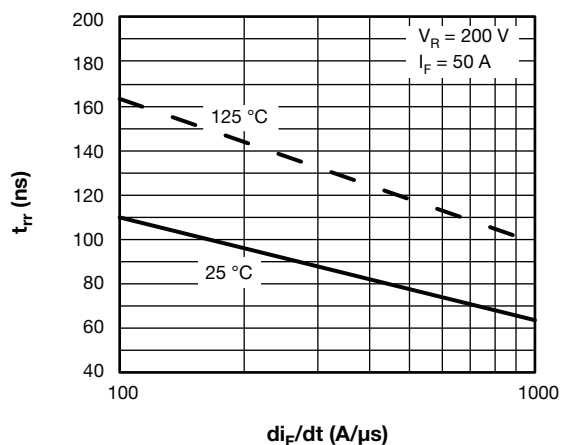
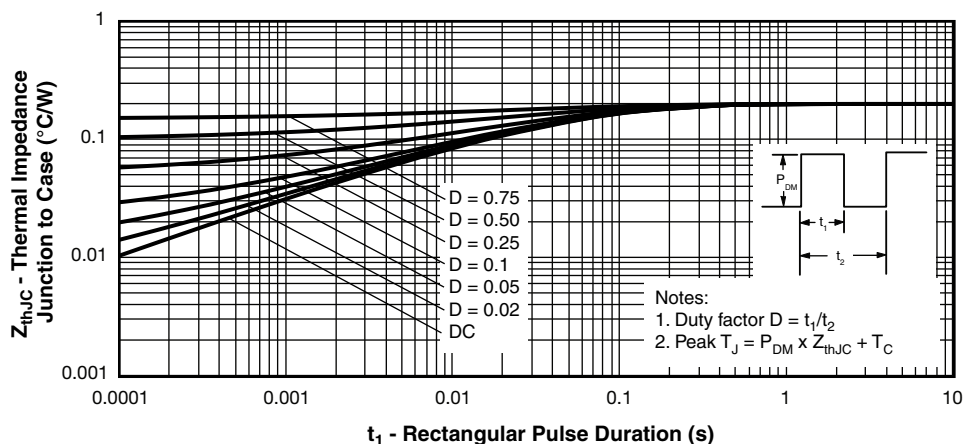
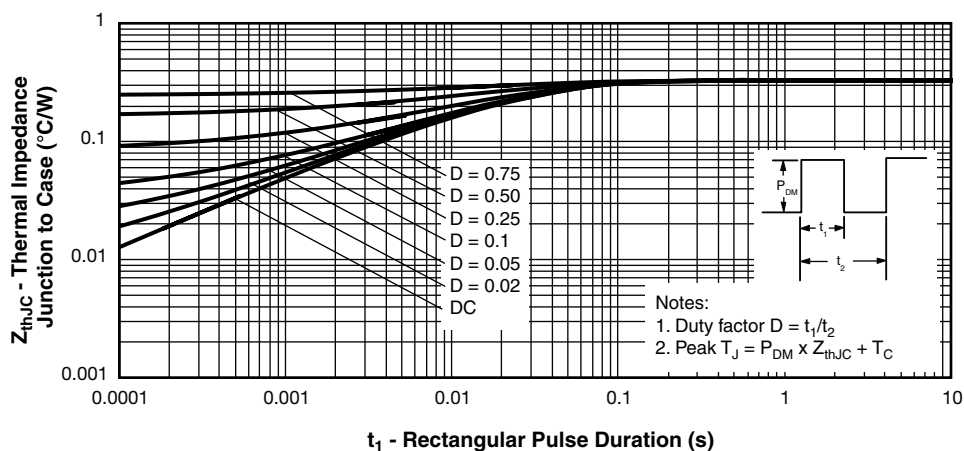
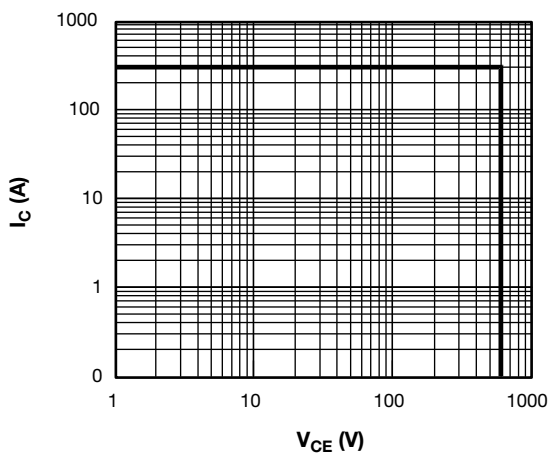
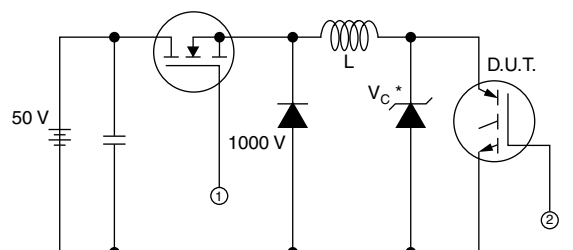


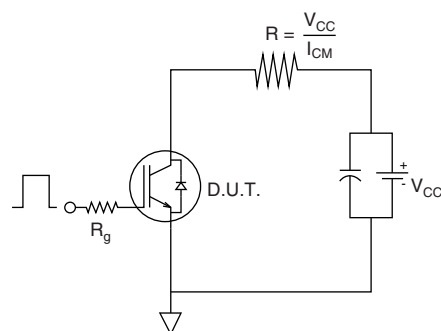
Fig. 13 - Typical Reverse Recovery Time vs.  $dI_F/dt$ , of Diode


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

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

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

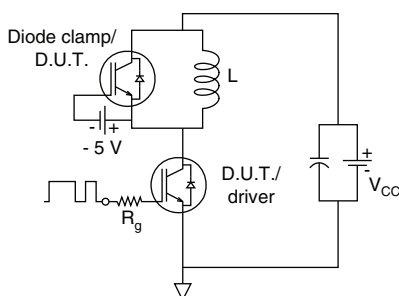


\* Driver same type as D.U.T.;  $V_C = 80\%$  of  $V_{ce(max)}$   
 \* Note: Due to the 50 V power supply, pulse width and inductor will increase to obtain  $I_d$

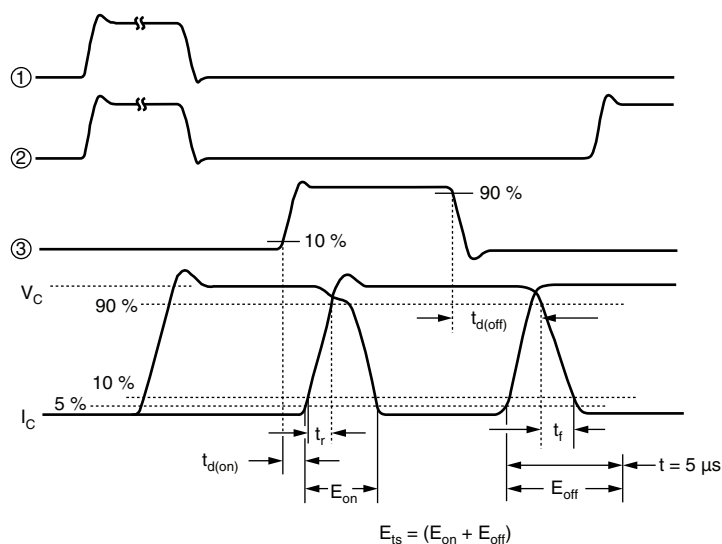
### 19a - Clamped Inductive Load Test Circuit



### 19b - Pulsed Collector Current Test Circuit



### 20a - Switching Loss Test Circuit

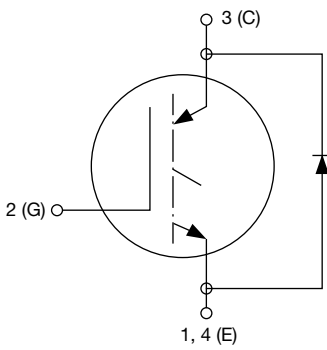
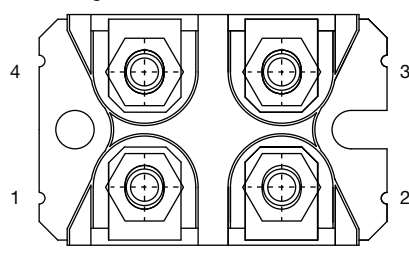


## 20b - Switching Loss Waveforms Test Circuit

**ORDERING INFORMATION TABLE**

| Device code | VS- | G | B | 90 | D | A | 60 | U |
|-------------|-----|---|---|----|---|---|----|---|
|             | 1   | 2 | 3 | 4  | 5 | 6 | 7  | 8 |

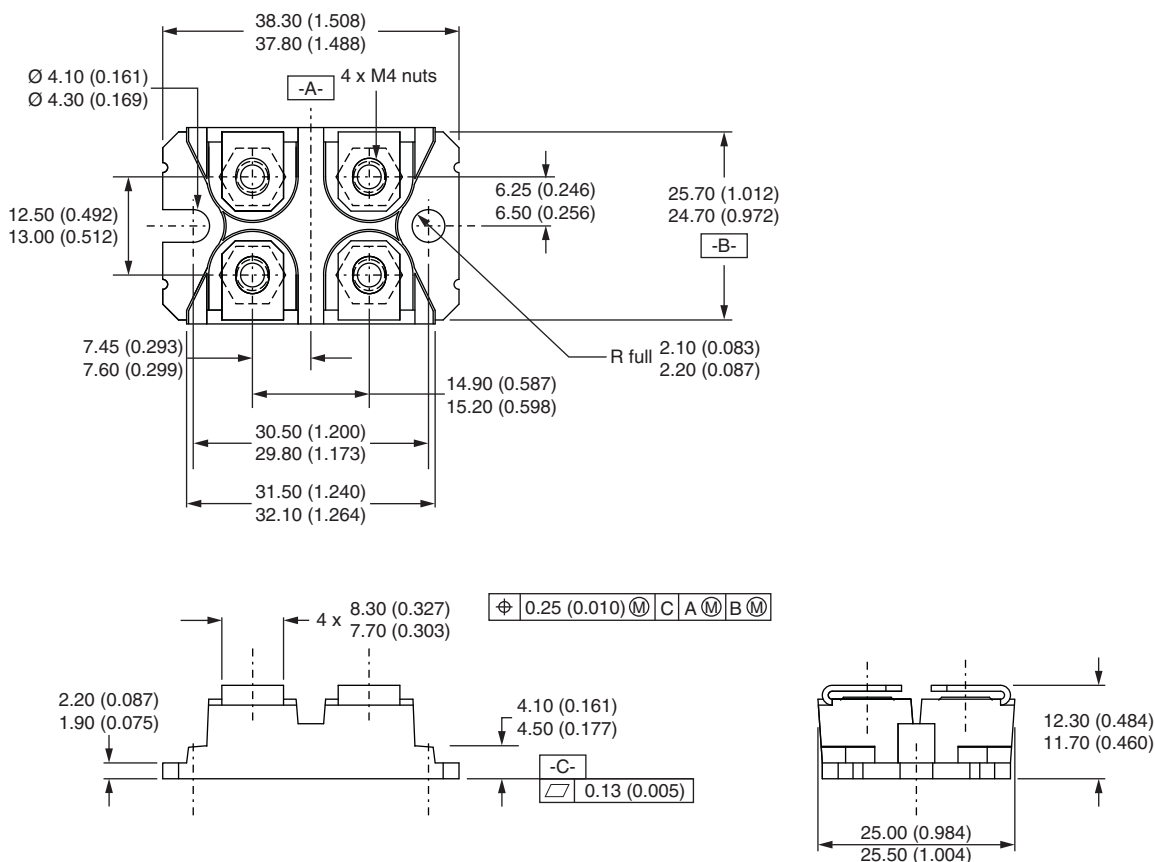
- |   |                                                           |
|---|-----------------------------------------------------------|
| 1 | - Vishay Semiconductors product                           |
| 2 | - Insulated gate bipolar transistor (IGBT)                |
| 3 | - B = IGBT Gen 5                                          |
| 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                          |   |

| 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



## Disclaimer

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