Insulated Gate Bipolar Transistor (Trench IGBT), 140 A

**FEATURES**
- Trench IGBT technology with positive temperature coefficient
- Square RBSOA
- 3 μs short circuit capability
- FRED Pt® antiparallel diodes with ultrasoft reverse recovery
- TJ maximum = 175 °C
- Fully isolated package
- Very low internal inductance (≤ 5 nH typical)
- Industry standard outline
- UL approved file E78996

**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

**PRIMARY CHARACTERISTICS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Test Conditions</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector to emitter voltage</td>
<td>VCES</td>
<td>TC = 25 °C</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>Continuous collector current</td>
<td>IC (1)</td>
<td>TC = 25 °C</td>
<td>200</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TC = 90 °C</td>
<td>140</td>
<td>A</td>
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<tr>
<td>Pulsed collector current</td>
<td>IDM</td>
<td></td>
<td>350</td>
<td>A</td>
</tr>
<tr>
<td>Clamped inductive load current</td>
<td>ILM</td>
<td></td>
<td>350</td>
<td>A</td>
</tr>
<tr>
<td>Diode continuous forward current</td>
<td>IF</td>
<td>TC = 25 °C</td>
<td>104</td>
<td>A</td>
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<tr>
<td></td>
<td></td>
<td>TC = 90 °C</td>
<td>71</td>
<td>A</td>
</tr>
<tr>
<td>Gate-to-emitter voltage</td>
<td>VGE</td>
<td></td>
<td>± 20</td>
<td>V</td>
</tr>
<tr>
<td>Power dissipation, IGBT</td>
<td>PD</td>
<td>TC = 25 °C</td>
<td>652</td>
<td>W</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TC = 90 °C</td>
<td>370</td>
<td>W</td>
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<tr>
<td>Power dissipation, diode</td>
<td>PD</td>
<td>TC = 25 °C</td>
<td>238</td>
<td>W</td>
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<tr>
<td></td>
<td></td>
<td>TC = 90 °C</td>
<td>135</td>
<td>W</td>
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<tr>
<td>Isolation voltage</td>
<td>VISOL</td>
<td>Any terminal to case, t = 1 min</td>
<td>2500</td>
<td>V</td>
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</table>

**Note**
(1) Maximum collector current admitted is 100 A, to do not exceed the maximum temperature of terminals
### ELECTRICAL SPECIFICATIONS (TJ = 25 °C unless otherwise specified)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collector to emitter breakdown voltage</td>
<td>VBR(CES)</td>
<td>VGE = 0 V, IC = 250 μA</td>
<td>600</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>Collector to emitter voltage</td>
<td>VCE(on)</td>
<td>VGE = 15 V, IC = 100 A</td>
<td>-</td>
<td>1.7</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VGE = 15 V, IC = 100 A, TJ = 125 °C</td>
<td>-</td>
<td>2.0</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>VGE = 15 V, IC = 100 A, TJ = 175 °C</td>
<td>-</td>
<td>2.15</td>
<td>-</td>
<td></td>
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<tr>
<td>Gate threshold voltage</td>
<td>VGE(th)</td>
<td>VGE = VGE, IC = 250 μA</td>
<td>3.5</td>
<td>4.6</td>
<td>6.5</td>
<td>V</td>
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<tr>
<td>Temperature coefficient of threshold voltage</td>
<td>ΔVGE(th)/ΔTJ</td>
<td>VGE = VGE, IC = 1 mA (25 °C to 125 °C)</td>
<td>-</td>
<td>16.8</td>
<td>-</td>
<td>mV/°C</td>
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<tr>
<td>Collector to emitter leakage current</td>
<td>IGES</td>
<td>VGE = 0 V, VCE = 600 V</td>
<td>-</td>
<td>0.6</td>
<td>100</td>
<td>μA</td>
</tr>
<tr>
<td>Forward voltage drop, diode</td>
<td>VFM</td>
<td>IF = 40 A, VGE = 0 V</td>
<td>-</td>
<td>1.74</td>
<td>2.2</td>
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<tr>
<td></td>
<td></td>
<td>IF = 40 A, VGE = 0 V, TJ = 125 °C</td>
<td>-</td>
<td>1.35</td>
<td>1.74</td>
<td></td>
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<tr>
<td>Gate to emitter leakage current</td>
<td>IGES</td>
<td>VGE = ± 20 V</td>
<td>-</td>
<td>-</td>
<td>± 200</td>
<td>nA</td>
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</table>

### SWITCHING CHARACTERISTICS (TJ = 25 °C unless otherwise specified)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>TEST CONDITIONS</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn-on switching loss</td>
<td>E_on</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>0.43</td>
<td>-</td>
<td>mJ</td>
</tr>
<tr>
<td>Turn-off switching loss</td>
<td>E_off</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>1.50</td>
<td>-</td>
<td>mJ</td>
</tr>
<tr>
<td>Total switching loss</td>
<td>E_tot</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>1.93</td>
<td>-</td>
<td>mJ</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>t_d(on)</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>130</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Rise time</td>
<td>t_r</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>ns</td>
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<tr>
<td>Turn-off delay time</td>
<td>t_d(off)</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>127</td>
<td>-</td>
<td>ns</td>
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<tr>
<td>Fall time</td>
<td>t_f</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>82</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Turn-on switching loss</td>
<td>E_on</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>0.43</td>
<td>-</td>
<td>mJ</td>
</tr>
<tr>
<td>Turn-off switching loss</td>
<td>E_off</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>2.12</td>
<td>-</td>
<td>mJ</td>
</tr>
<tr>
<td>Total switching loss</td>
<td>E_tot</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>2.55</td>
<td>-</td>
<td>mJ</td>
</tr>
<tr>
<td>Turn-on delay time</td>
<td>t_d(on)</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>130</td>
<td>-</td>
<td>ns</td>
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<tr>
<td>Rise time</td>
<td>t_r</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>52</td>
<td>-</td>
<td>ns</td>
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<tr>
<td>Turn-off delay time</td>
<td>t_d(off)</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>130</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Fall time</td>
<td>t_f</td>
<td>Ic = 100 A, Vcc = 360 V, Vge = 15 V, Rg = 5 Ohm, L = 500 μH, TJ = 25 °C</td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>ns</td>
</tr>
</tbody>
</table>

Reverse bias safe operating area (RBSOA) = TJ = 175 °C, IC = 350 A, Rg = 22 Ω, VGE = 15 V to 0 V, VCC = 400 V, VP = 600 V, L = 500 μH

Diode reverse recovery time (t_tr) = Ic = 50 A, dIc/dt = 200 A/μs, VR = 200 V
Diode reverse recovery current (Itr) = Ic = 50 A, dIc/dt = 200 A/μs
Diode recovery charge (Qtr) = Ic = 50 A, dIc/dt = 200 A/μs
Diode peak reverse current (Ipm) = VR = 200 V, TJ = 125 °C
Diode recovery charge (Qpm) = VR = 200 V, TJ = 125 °C
Short circuit safe operating area (SCSOA) = TJ = 175 °C, Rg = 22 Ω, VGE = 15 V to 0 V, VCC = 400 V, VP = 600 V
THERMAL AND MECHANICAL SPECIFICATIONS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction and storage temperature range</td>
<td>$T_J, T_	ext{Stg}$</td>
<td>-40</td>
<td>-</td>
<td>175</td>
<td>°C</td>
</tr>
<tr>
<td>Junction to case</td>
<td>$R_	ext{ThJC}$</td>
<td>-</td>
<td>-</td>
<td>0.23</td>
<td>°C/W</td>
</tr>
<tr>
<td>Case to heatsink</td>
<td>$R_	ext{ThCS}$</td>
<td>-</td>
<td>0.1</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td>-</td>
<td>30</td>
<td>-</td>
<td>g</td>
</tr>
<tr>
<td>Mounting torque</td>
<td></td>
<td>-</td>
<td></td>
<td>1.1</td>
<td>(9.7) Nm (lbf.in)</td>
</tr>
<tr>
<td>Case style</td>
<td></td>
<td></td>
<td></td>
<td>1.8</td>
<td>(15.9) Nm (lbf.in)</td>
</tr>
</tbody>
</table>

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

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

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

Fig. 4 - Typical Diode Forward Voltage Drop Characteristics
Fig. 5 - Typical IGBT Transfer Characteristics

Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

Fig. 7 - Typical IGBT Threshold Voltage

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

Fig. 9 - Typical IGBT Energy Losses vs. $I_C$

Fig. 10 - Typical IGBT Switching Time vs. $I_C$
Fig. 11 - Typical IGBT Energy Loss vs. $R_g$
$T_J = 125 \, ^\circ C$, $I_C = 100 \, A$, $L = 500 \, \mu H$, $V_{CC} = 360 \, V$, $V_{GE} = 15 \, V$, Diode used: 60APH06

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

Fig. 13 - Typical Reverse Recovery Time vs. $\frac{dI_F}{dt}$ of Diode

Fig. 14 - Typical Stored Charge vs. $\frac{dI_F}{dt}$ of Diode

Fig. 15 - Typical Reverse Recovery Current vs. $\frac{dI_F}{dt}$ 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, $T_J = 175 \, ^\circ C$, $V_{GE} = 15 \, V$
* 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 \( I_d \)

---

**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**

\[
V_{CC} \quad R = \frac{V_{CC}}{I_{CM}} 
\]

\[
D.U.T./\text{driver} 
\]

\[
Diode\ clamp/\ D.U.T. 
\]

\[
50 \text{ V} 
\]

\[
1000 \text{ V} 
\]

\[
V_C \quad * 
\]

\[
R_g \quad V_{CC} 
\]

\[
L 
\]

\[
L \quad R_g 
\]

\[
V_{CC} \quad R = \frac{V_{CC}}{I_{CM}} 
\]

\[
D.U.T. 
\]

\[
V_C \quad * 
\]

\[
E_{on} = (E_{on} + E_{off}) 
\]

\[
t = 5 \mu s 
\]

\[
E_{on} \quad t_{ftr} 
\]

\[
t_{d(on)} 
\]

\[
10 \% 
\]

\[
90 \% 
\]

\[
5 \% 
\]

\[
10 \% 
\]

\[
90 \% 
\]

\[
10 \% 
\]

\[
t_{f(off)} 
\]

\[
E_{off} 
\]

\[
t_{d(off)} 
\]

\[
t 
\]
### ORDERING INFORMATION TABLE

<table>
<thead>
<tr>
<th>Device code</th>
<th>VS-</th>
<th>G</th>
<th>T</th>
<th>140</th>
<th>D</th>
<th>A</th>
<th>60</th>
<th>U</th>
</tr>
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<tbody>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>CIRCUIT CONFIGURATION CODE</th>
<th>CIRCUIT DRAWING</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td><img src="image" alt="Circuit Diagram" /></td>
</tr>
</tbody>
</table>

**CIRCUIT**  
Single switch with AP diode

**Lead Assignment**

1. 1, 4 (E)  
2. 2 (G)  
3. 3 (C)  
4. 4

### LINKS TO RELATED DOCUMENTS

- Packaging information: [www.vishay.com/doc?95425](www.vishay.com/doc?95425)
DIMENSIONS in millimeters (inches)

Note
• Controlling dimension: millimeter
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