Features

- Low VCE (on) Non Punch Through IGBT Technology.
- Low Diode Vf.
- 10µs Short Circuit Capability.
- Square RBSOA.
- Ultrasoft Diode Reverse Recovery Characteristics.
- Positive VCE (on) Temperature Coefficient.
- Maximum Junction Temperature Rated at 175°C
- Lead-Free

Benefits

- Benchmark Efficiency for Motor Control.
- Rugged Transient Performance.
- Low EMI.
- Excellent Current Sharing in Parallel Operation.

Absolute Maximum Ratings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_CES Collector-to-Emitter Voltage</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>I_C @ T_C = 25°C</td>
<td>19</td>
<td>A</td>
</tr>
<tr>
<td>I_C @ T_C = 100°C</td>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>I_CM Pulse Collector Current (Ref.Fig.C.5)</td>
<td>38</td>
<td>A</td>
</tr>
<tr>
<td>I_F @ T_C = 25°C</td>
<td>19</td>
<td>A</td>
</tr>
<tr>
<td>I_F @ T_C = 100°C</td>
<td>12</td>
<td>A</td>
</tr>
<tr>
<td>I_FM Diode Maximum Forward Current</td>
<td>38</td>
<td>A</td>
</tr>
<tr>
<td>V_ISO RMS Isolation Voltage, Terminal to Case, t = 1 min</td>
<td>2500</td>
<td>V</td>
</tr>
<tr>
<td>V_GE Gate-to-Emitter Voltage</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>P_D @ T_C = 25°C</td>
<td>52</td>
<td>W</td>
</tr>
<tr>
<td>P_D @ T_C = 100°C</td>
<td>26</td>
<td>W</td>
</tr>
<tr>
<td>T_J Operating Junction and Storage Temperature Range</td>
<td>-55 to +175</td>
<td>°C</td>
</tr>
<tr>
<td>T_STG Soldering Temperature for 10 sec.</td>
<td>300 (0.063 in. (1.6mm) from case)</td>
<td>°C</td>
</tr>
<tr>
<td>Mounting Torque, 6-32 or M3 Screw</td>
<td>10 lbf.in (1.1N.m)</td>
<td>lbf.in</td>
</tr>
</tbody>
</table>

Thermal / Mechanical Characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_JUC Junction-to-Case- IGBT</td>
<td>—</td>
<td>—</td>
<td>2.9</td>
<td>°C/W</td>
</tr>
<tr>
<td>R_JUC Junction-to-Case- Diode</td>
<td>—</td>
<td>—</td>
<td>4.6</td>
<td>°C/W</td>
</tr>
<tr>
<td>R_JCS Case-to-Sink, flat, greased surface</td>
<td>—</td>
<td>0.50</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>R_JUA Junction-to-Ambient, typical socket mount</td>
<td>—</td>
<td>—</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>Wt Weight</td>
<td>—</td>
<td>2.0</td>
<td>—</td>
<td>g</td>
</tr>
</tbody>
</table>

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### IRGIB15B60KD1P

**Electrical Characteristics @ T_J = 25°C (unless otherwise specified)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
<th>Ref.Fig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>V_{BR(CES)}</strong></td>
<td>Collector-to-Emitter Breakdown Voltage</td>
<td>600</td>
<td>—</td>
<td>—</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>ΔV_{BR(CES)}/ΔT_J</strong></td>
<td>Temperature Coefficient of Breakdown Voltage</td>
<td>0.32</td>
<td>—</td>
<td>V/°C</td>
<td></td>
<td>5,6,7</td>
</tr>
<tr>
<td><strong>V_{CE(sat)}</strong></td>
<td>Collector-to-Emitter Voltage</td>
<td>—</td>
<td>1.80</td>
<td>2.20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>ΔV_{CE(sat)}/ΔT_J</strong></td>
<td>Threshold Voltage temp. coefficient</td>
<td>—</td>
<td>1.8</td>
<td>2.20</td>
<td>V</td>
<td>9,10,11</td>
</tr>
<tr>
<td><strong>g_{FE}</strong></td>
<td>Forward Transconductance</td>
<td>—</td>
<td>1.0</td>
<td>150</td>
<td>μA</td>
<td>12</td>
</tr>
<tr>
<td><strong>I_{CES}</strong></td>
<td>Zero Gate Voltage Collector Current</td>
<td>—</td>
<td>163</td>
<td>500</td>
<td>μA</td>
<td>9,10,11</td>
</tr>
<tr>
<td><strong>V_{FM}</strong></td>
<td>Diode Forward Voltage Drop</td>
<td>—</td>
<td>1.69</td>
<td>2.30</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td><strong>I_{CES}</strong></td>
<td>Gate-to-Emitter Leakage Current</td>
<td>—</td>
<td>±100</td>
<td>±100</td>
<td>nA</td>
<td></td>
</tr>
</tbody>
</table>

### Switching Characteristics @ T_J = 25°C (unless otherwise specified)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
<th>Ref.Fig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q_g</strong></td>
<td>Total Gate Charge (turn-on)</td>
<td>—</td>
<td>56</td>
<td>84</td>
<td>nC</td>
<td>23</td>
</tr>
<tr>
<td><strong>Q_{ge}</strong></td>
<td>Gate-to-Emitter Charge (turn-on)</td>
<td>—</td>
<td>7.0</td>
<td>10</td>
<td>μC</td>
<td>23</td>
</tr>
<tr>
<td><strong>Q_{gc}</strong></td>
<td>Gate-to-Collector Charge (turn-on)</td>
<td>—</td>
<td>26</td>
<td>39</td>
<td>μC</td>
<td>23</td>
</tr>
<tr>
<td><strong>E_{on}</strong></td>
<td>Turn-On Switching Loss</td>
<td>—</td>
<td>127</td>
<td>140</td>
<td>μJ</td>
<td>CT4</td>
</tr>
<tr>
<td><strong>E_{off}</strong></td>
<td>Turn-Off Switching Loss</td>
<td>—</td>
<td>334</td>
<td>422</td>
<td>μJ</td>
<td>CT4</td>
</tr>
<tr>
<td><strong>E_{on,dc}</strong></td>
<td>Total Switching Loss</td>
<td>—</td>
<td>461</td>
<td>556</td>
<td>μJ</td>
<td>WF1,WF2</td>
</tr>
<tr>
<td><strong>I_{on}</strong></td>
<td>Turn-On delay time</td>
<td>—</td>
<td>30</td>
<td>39</td>
<td>ns</td>
<td>CT4</td>
</tr>
<tr>
<td><strong>I_{rise}</strong></td>
<td>Rise time</td>
<td>—</td>
<td>25</td>
<td>35</td>
<td>ns</td>
<td>CT4</td>
</tr>
<tr>
<td><strong>I_{off}</strong></td>
<td>Turn-Off delay time</td>
<td>—</td>
<td>173</td>
<td>188</td>
<td>ns</td>
<td>WF1</td>
</tr>
<tr>
<td><strong>I_{fall}</strong></td>
<td>Fall time</td>
<td>—</td>
<td>41</td>
<td>53</td>
<td>ns</td>
<td>WF2</td>
</tr>
<tr>
<td><strong>L_e</strong></td>
<td>Internal Emitter Inductance</td>
<td>—</td>
<td>7.5</td>
<td>—</td>
<td>nH</td>
<td></td>
</tr>
<tr>
<td><strong>C_{ies}</strong></td>
<td>Input Capacitance</td>
<td>—</td>
<td>850</td>
<td>1275</td>
<td>pF</td>
<td>22</td>
</tr>
<tr>
<td><strong>C_{oies}</strong></td>
<td>Output Capacitance</td>
<td>—</td>
<td>100</td>
<td>150</td>
<td>pF</td>
<td>22</td>
</tr>
<tr>
<td><strong>C_{res}</strong></td>
<td>Reverse Transfer Capacitance</td>
<td>—</td>
<td>32</td>
<td>48</td>
<td>f = 1.0MHz</td>
<td></td>
</tr>
<tr>
<td><strong>RBSOA</strong></td>
<td>Reverse Bias Safe Operating Area</td>
<td>FULL SQUARE</td>
<td>—</td>
<td>—</td>
<td></td>
<td>C4</td>
</tr>
<tr>
<td><strong>SCSOA</strong></td>
<td>Short Circuit Safe Operating Area</td>
<td>10</td>
<td>—</td>
<td>— μs</td>
<td></td>
<td>C5</td>
</tr>
<tr>
<td><strong>I_{SC(Peak)}</strong></td>
<td>Peak Short Circuit Collector Current</td>
<td>—</td>
<td>140</td>
<td>—</td>
<td>A</td>
<td>WF4</td>
</tr>
<tr>
<td><strong>E_{rec}</strong></td>
<td>Recovery Reverse Energy of the Diode</td>
<td>—</td>
<td>267</td>
<td>347</td>
<td>μJ</td>
<td>CT4,WF3</td>
</tr>
<tr>
<td><strong>I_{drr}</strong></td>
<td>Diode Reverse Recovery Time</td>
<td>—</td>
<td>67</td>
<td>87</td>
<td>ns</td>
<td>17,18,19</td>
</tr>
<tr>
<td><strong>I_{rr}</strong></td>
<td>Peak Reverse Recovery Current</td>
<td>—</td>
<td>23</td>
<td>30</td>
<td>A</td>
<td>20,21</td>
</tr>
</tbody>
</table>

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1. Vcc = 80% (V_{CES}), V_{GE} = 15V, L = 100µH, R_G = 22Ω.
2. Energy losses include "tail" and diode reverse recovery.
Fig. 1 - Maximum DC Collector Current vs. Case Temperature

Fig. 2 - Power Dissipation vs. Case Temperature

Fig. 3 - Forward SOA
\[ T_C = 25^\circ\text{C}; T_J \leq 150^\circ\text{C} \]

Fig. 4 - Reverse Bias SOA
\[ T_J = 150^\circ\text{C}; V_{GE} = 15\text{V} \]
Fig. 5 - Typ. IGBT Output Characteristics
$T_J = -40^\circ C; \ t_p = 60\mu s$

Fig. 6 - Typ. IGBT Output Characteristics
$T_J = 25^\circ C; \ t_p = 60\mu s$

Fig. 7 - Typ. IGBT Output Characteristics
$T_J = 150^\circ C; \ t_p = 60\mu s$

Fig. 8 - Typ. Diode Forward Characteristics
$t_p = 60\mu s$
Fig. 9 - Typical $V_{CE}$ vs. $V_{GE}$
$T_J = -40^\circ C$

Fig. 10 - Typical $V_{CE}$ vs. $V_{GE}$
$T_J = 25^\circ C$

Fig. 11 - Typical $V_{CE}$ vs. $V_{GE}$
$T_J = 150^\circ C$

Fig. 12 - Typ. Transfer Characteristics
$V_{CE} = 50V; \, t_p = 10\mu s$
**IRGIB15B60KD1P**

**Fig. 13** - Typ. Energy Loss vs. $I_C$
- $T_J = 150^\circ C$; $L=1.07\text{mH}$; $V_{CE}= 400\text{V}$
- $R_G= 22\Omega$; $V_{GE}= 15\text{V}$

**Fig. 14** - Typ. Switching Time vs. $I_C$
- $T_J = 150^\circ C$; $L=1.07\text{mH}$; $V_{CE}= 400\text{V}$
- $R_G= 22\Omega$; $V_{GE}= 15\text{V}$

**Fig. 15** - Typ. Energy Loss vs. $R_G$
- $T_J = 150^\circ C$; $L=1.07\text{mH}$; $V_{CE}= 400\text{V}$
- $I_{CE}= 15\text{A}$; $V_{GE}= 15\text{V}$

**Fig. 16** - Typ. Switching Time vs. $R_G$
- $T_J = 150^\circ C$; $L=1.07\text{mH}$; $V_{CE}= 400\text{V}$
- $I_{CE}= 15\text{A}$; $V_{GE}= 15\text{V}$
Fig. 17 - Typical Diode $I_{RR}$ vs. $I_F$
$T_J = 150^\circ C$

Fig. 18 - Typical Diode $I_{RR}$ vs. $R_G$
$T_J = 150^\circ C; I_F = 15A$

Fig. 19 - Typical Diode $I_{RR}$ vs. $\frac{dI_F}{dt}$
$V_{CC} = 400V; V_{GE} = 15V; I_{CE} = 15A; T_J = 150^\circ C$

Fig. 20 - Typical Diode $Q_{RR}$
$V_{CC} = 400V; V_{GE} = 15V; T_J = 150^\circ C$
**Fig. 21** - Typical Diode $E_{RR}$ vs. $I_F$
$T_J = 150°C$

**Fig. 22** - Typ. Capacitance vs. $V_{CE}$
$V_{GE} = 0V$; $f = 1MHz$

**Fig. 23** - Typical Gate Charge vs. $V_{GE}$
$I_{CE} = 15A$; $L = 2500μH$

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Fig 24. Maximum Transient Thermal Impedance, Junction-to-Case (IGBT)

Fig 25. Maximum Transient Thermal Impedance, Junction-to-Case (DIODE)
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**Fig.C.T.1** - Gate Charge Circuit (turn-off)

**Fig.C.T.2** - RBSOA Circuit

**Fig.C.T.3** - S.C.SOA Circuit

**Fig.C.T.4** - Switching Loss Circuit

**Fig.C.T.5** - Resistive Load Circuit
Fig. WF1- Typ. Turn-off Loss Waveform  
@ $T_J = 150^\circ C$ using Fig. CT.4

Fig. WF2- Typ. Turn-on Loss Waveform  
@ $T_J = 150^\circ C$ using Fig. CT.4

Fig. WF3- Typ. Diode Recovery Waveform  
@ $T_J = 150^\circ C$ using Fig. CT.4

Fig. WF4- Typ. S.C Waveform  
@ $T_C = 150^\circ C$ using Fig. CT.3
IRGIB15B60KD1P

TO-220 Full-Pak Package Outline

Dimensions are shown in millimeters (inches)

TO-220 Full-Pak Part Marking Information

EXAMPLE: THIS IS AN IRF140G WITH ASSEMBLY LOT CODE 3432 ASSEMBLED ON WW 24 1999 IN THE ASSEMBLY LINE "K".

Note: "P" in assembly line position indicates "Lead-Free"

TO-220 FullPak packages are not recommended for Surface Mount Application.

Data and specifications subject to change without notice.
This product has been designed and qualified for the Industrial market.
Qualification Standards can be found on IR’s Web site.

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Visit us at www.irf.com for sales contact information.12/03

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Note: For the most current drawings please refer to the IR website at:
http://www.irf.com/package/