Integrated Power Hybrid IC for Appliance Motor Drive Applications.

**Description**

International Rectifier’s IRAMS10UP60B is an Integrated Power Module developed and optimized for electronic motor control in appliance applications such as washing machines and refrigerators. Plug N Drive technology offers an extremely compact, high performance AC motor-driver in a single isolated package for a very simple design. An internal shunt is also included and offers easy current feedback and overcurrent monitor for precise and safe operation. A built-in temperature monitor and over-current protection, along with the short-circuit rated IGBTs and integrated under-voltage lockout function, deliver high level of protection and fail-safe operation. The integration of the bootstrap diodes for the high-side driver section, and the single polarity power supply required to drive the internal circuitry, simplify the utilization of the module and deliver further cost reduction advantages.

**Features**

- Internal Shunt Resistor
- Integrated Gate Drivers and Bootstrap Diodes
- Temperature Monitor
- Fully Isolated Package
- Low $V_{CE(on)}$ Non Punch Through IGBT Technology
- Undervoltage lockout for all channels
- Matched propagation delay for all channels
- Schmitt-triggered input logic
- Cross-conduction prevention logic
- Lower di/dt gate driver for better noise immunity
- Motor Power range 0.4~0.75kW / 85~253 Vac
- Isolation 2000VRMS /1min and CTI > 600V
- Recognized by UL (E252584), RoHS Compliant

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{CES} / V_{RSM}$</td>
<td>IGBT/Diode Blocking Voltage</td>
<td>600</td>
<td>V</td>
</tr>
<tr>
<td>$V^*$</td>
<td>Positive Bus Input Voltage</td>
<td>450</td>
<td>V</td>
</tr>
<tr>
<td>$I_{O} @ T_{C}=25^\circ C$</td>
<td>RMS Phase Current (Note 1)</td>
<td>10</td>
<td>A</td>
</tr>
<tr>
<td>$I_{O} @ T_{C}=100^\circ C$</td>
<td>RMS Phase Current (Note 1)</td>
<td>5</td>
<td>A</td>
</tr>
<tr>
<td>$I_{P}$</td>
<td>Pulsed RMS Phase Current (Note 2)</td>
<td>15</td>
<td>A</td>
</tr>
<tr>
<td>$F_{PWM}$</td>
<td>PWM Carrier Frequency</td>
<td>20</td>
<td>kHz</td>
</tr>
<tr>
<td>$P_{O}$</td>
<td>Power dissipation per IGBT @ $T_{C}=25^\circ C$</td>
<td>27</td>
<td>W</td>
</tr>
<tr>
<td>$V_{ISO}$</td>
<td>Isolation Voltage (1min)</td>
<td>2000</td>
<td>V_{RMS}</td>
</tr>
<tr>
<td>$T_{J}$ (IGBT &amp; Diodes)</td>
<td>Operating Junction temperature Range</td>
<td>-40 to +150</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{J}$ (Driver IC)</td>
<td>Operating Junction temperature Range</td>
<td>-40 to +150</td>
<td>°C</td>
</tr>
<tr>
<td><strong>T</strong></td>
<td>Mounting torque Range (M3 screw)</td>
<td>0.5 to 1.0</td>
<td>Nm</td>
</tr>
</tbody>
</table>

Note 1: Sinusoidal Modulation at $V^*=400V$, $T_{J}=150^\circ C$, $F_{PWM}=20kHz$, Modulation Depth=0.8, PF=0.6, See Figure 3.
Note 2: $t<100ms$; $T_{C}=25^\circ C$; $F_{PWM}=20kHz$. Limited by $I_{BUS-STRIP}$, see Table “Inverter Section Electrical Characteristics”

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### Absolute Maximum Ratings (Continued)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>I_BDF</td>
<td>Bootstrap Diode Peak Forward Current</td>
<td>---</td>
<td>4.5</td>
<td>A</td>
<td>$t_p=10\text{ms}, \quad T_J=150^\circ\text{C}, \quad T_C=100^\circ\text{C}$</td>
</tr>
<tr>
<td>P_PBR</td>
<td>Bootstrap Resistor Peak Power (Single Pulse)</td>
<td>---</td>
<td>80</td>
<td>W</td>
<td>$t_p=100\mu\text{s}, \quad T_J=150^\circ\text{C}$ ESR / ERJ series</td>
</tr>
<tr>
<td>V_B1,2,3</td>
<td>High side floating supply offset voltage</td>
<td>$V_{B1,2,3}\ -\ 25$</td>
<td>$V_{B1,2,3}\ +\ 0.3$</td>
<td>V</td>
<td>$\text{Lower of } (V_{SS}+15\text{V}) \text{ or } V_{CC}+0.3\text{V}$</td>
</tr>
<tr>
<td>V_B1,2,3</td>
<td>High side floating supply voltage</td>
<td>-0.3</td>
<td>600</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>V_CC</td>
<td>Low Side and logic fixed supply voltage</td>
<td>-0.3</td>
<td>20</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>V_EN, V_EN, V_TTRIP</td>
<td>Input voltage LIN, HIN, EN, I_TRIP</td>
<td>-0.3</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>

### Inverter Section Electrical Characteristics @ $T_J=25^\circ\text{C}$

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_BR(CES)</td>
<td>Collector-to-Emitter Breakdown Voltage</td>
<td>600</td>
<td>---</td>
<td>---</td>
<td>V</td>
<td>$V_{IN}=5\text{V}, \quad I_C=250\mu\text{A}$</td>
</tr>
<tr>
<td>ΔV_BR(CES) / ΔT</td>
<td>Temperature Coefficient of Breakdown Voltage</td>
<td>---</td>
<td>0.57</td>
<td>---</td>
<td>V/^°C</td>
<td>$V_{IN}=5\text{V}, \quad I_C=1.0\text{mA}$ (25°C - 150°C)</td>
</tr>
<tr>
<td>V_CE(ON)</td>
<td>Collector-to-Emitter Saturation Voltage</td>
<td>---</td>
<td>1.70</td>
<td>2.00</td>
<td>V</td>
<td>$I_C=5\text{A}, \quad V_{CC}=15\text{V}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>---</td>
<td>2.00</td>
<td>2.40</td>
<td></td>
<td>$I_C=5\text{A}, \quad V_{CC}=15\text{V}, \quad T_J=150^\circ\text{C}$</td>
</tr>
<tr>
<td>I_CES</td>
<td>Zero Gate Voltage Collector Current</td>
<td>---</td>
<td>5</td>
<td>80</td>
<td>μA</td>
<td>$V_{IN}=5\text{V}, \quad V^*=600\text{V}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>---</td>
<td>10</td>
<td></td>
<td></td>
<td>$V_{IN}=5\text{V}, \quad V^*=600\text{V}, \quad T_J=150^\circ\text{C}$</td>
</tr>
<tr>
<td>V_FM</td>
<td>Diode Forward Voltage Drop</td>
<td>---</td>
<td>1.80</td>
<td>2.35</td>
<td>V</td>
<td>$I_C=5\text{A}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>---</td>
<td>1.30</td>
<td>1.70</td>
<td></td>
<td>$I_C=5\text{A}, \quad T_J=150^\circ\text{C}$</td>
</tr>
<tr>
<td>V_BDFM</td>
<td>Bootstrap Diode Forward Voltage Drop</td>
<td>--</td>
<td>--</td>
<td>1.25</td>
<td>V</td>
<td>$I_C=1\text{A}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>---</td>
<td>---</td>
<td>1.10</td>
<td></td>
<td>$I_C=1\text{A}, \quad T_J=150^\circ\text{C}$</td>
</tr>
<tr>
<td>R_BR</td>
<td>Bootstrap Resistor Value</td>
<td>---</td>
<td>2</td>
<td>---</td>
<td>Ω</td>
<td>$T_J=25^\circ\text{C}$</td>
</tr>
<tr>
<td>ΔR_BR/R_BR</td>
<td>Bootstrap Resistor Tolerance</td>
<td>---</td>
<td>---</td>
<td>±5</td>
<td>%</td>
<td>$T_J=25^\circ\text{C}$</td>
</tr>
<tr>
<td>I_EUS,TRIP</td>
<td>Current Protection Threshold (positive going)</td>
<td>13.1</td>
<td>---</td>
<td>16.4</td>
<td>A</td>
<td>$T_J=-40^\circ\text{C}$ to 125°C See fig. 2</td>
</tr>
</tbody>
</table>
## Inverter Section Switching Characteristics @ \( T_J = 25^\circ C \)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
</table>
| \( E_{ON} \) | Turn-On Switching Loss | --- | 200 | 235 | \( \mu J \) | \( I_C = 5A, V^* = 400V \)  
Energy losses include "tail" and diode reverse recovery |
| \( E_{OFF} \) | Turn-Off Switching Loss | --- | 75 | 100 | \( \mu J \) | \( I_C = 5A, V^* = 400V \)  
Energy losses include "tail" and diode reverse recovery |
| \( E_{TOT} \) | Total Switching Loss | --- | 275 | 335 | \( \mu J \) | \( I_C = 5A, V^* = 400V \)  
Energy losses include "tail" and diode reverse recovery |
| \( E_{REC} \) | Diode Reverse Recovery energy | --- | 15 | 25 | | |
| \( t_{RR} \) | Diode Reverse Recovery time | --- | 70 | 100 | ns | \( I_C = 15A, V^* = 400V, V_{GE} = 15V \) |
| \( E_{ON} \) | Turn-On Switching Loss | --- | 300 | 360 | \( \mu J \) | \( I_C = 5A, V^* = 400V \)  
Energy losses include "tail" and diode reverse recovery |
| \( E_{OFF} \) | Turn-Off Switching Loss | --- | 135 | 165 | \( \mu J \) | \( I_C = 15A, V^* = 400V \)  
Energy losses include "tail" and diode reverse recovery |
| \( E_{TOT} \) | Total Switching Loss | --- | 435 | 525 | \( \mu J \) | \( I_C = 15A, V^* = 400V \)  
Energy losses include "tail" and diode reverse recovery |
| \( E_{REC} \) | Diode Reverse Recovery energy | --- | 30 | 40 | | |
| \( t_{RR} \) | Diode Reverse Recovery time | --- | 100 | 145 | ns | \( I_C = 15A, V^* = 400V, V_{GE} = 15V \) |
| \( Q_G \) | Turn-On IGBT Gate Charge | --- | 29 | 44 | nC | \( I_C = 15A, V^* = 400V, V_{GE} = 15V \) |
| \( R_{BSOA} \) | Reverse Bias Safe Operating Area | FULL SQUARE | | | | \( T_J = 150^\circ C, I_C = 5A, V^* = 400V \)  
\( V_C = +15V \) to 0V  
See CT2 |
| \( S_{CSOA} \) | Short Circuit Safe Operating Area | 10 | --- | --- | \( \mu S \) | \( T_J = 150^\circ C, V^* = 360V, V_C = +15V \) to 0V  
See CT1 |
| \( I_{SC} \) | Short Circuit Collector Current | --- | 47 | --- | A | \( T_J = 150^\circ C, V^* = 360V, V_{GE} = 15V \)  
\( V_C = +15V \) to 0V  
See CT2 |

### Recommended Operating Conditions Driver Function

The Input/Output logic timing diagram is shown in Figure 1. For proper operation the device should be used within the recommende conditions. All voltages are absolute referenced to COM/I\(_{TRIP}\). The \( V_G \) offset is tested with all supplies biased at 15V differential (Note 3).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{B1,2,3} )</td>
<td>High side floating supply voltage</td>
<td>( V_S + 12 )</td>
<td>( V_S + 20 )</td>
<td>V</td>
</tr>
<tr>
<td>( V_{B1,2,3} )</td>
<td>High side floating supply offset voltage</td>
<td>Note 4</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>( V_{CC} )</td>
<td>Low side and logic fixed supply voltage</td>
<td>12</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>( V_{TRIP} )</td>
<td>( I_{TRIP} ) input voltage</td>
<td>( V_{SS} )</td>
<td>( V_{SS} + 5 )</td>
<td></td>
</tr>
<tr>
<td>( V_{EN} )</td>
<td>Logic input voltage LIN, HIN</td>
<td>( V_{SS} )</td>
<td>( V_{SS} + 5 )</td>
<td>V</td>
</tr>
<tr>
<td>( V_{EN} )</td>
<td>Logic input voltage EN</td>
<td>( V_{SS} )</td>
<td>( V_{SS} + 5 )</td>
<td>V</td>
</tr>
</tbody>
</table>

Note 3: For more details, see IR21363 data sheet

Note 4: Logic operational for \( V_G \) from COM-5V to COM+600V. Logic state held for \( V_G \) from COM-5V to COM-V\(_{BS} \).  
(please refer to DT97-3 for more details)
### Static Electrical Characteristics Driver Function

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{INH}, V_{BH}$</td>
<td>Logic “0” input voltage</td>
<td>3.0</td>
<td>---</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td>$V_{INL}, V_{BNL}$</td>
<td>Logic “1” input voltage</td>
<td>---</td>
<td>---</td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CCUV+}, V_{BSUV+}$</td>
<td>$V_{CC}$ and $V_{BS}$ supply undervoltage Positive going threshold</td>
<td>10.6</td>
<td>11.1</td>
<td>11.6</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CCUV-}, V_{BSUV-}$</td>
<td>$V_{CC}$ and $V_{BS}$ supply undervoltage Negative going threshold</td>
<td>10.4</td>
<td>10.9</td>
<td>11.4</td>
<td>V</td>
</tr>
<tr>
<td>$V_{CCUVH}, V_{BSUVH}$</td>
<td>$V_{CC}$ and $V_{BS}$ supply undervoltage lock-out hysteresis</td>
<td>---</td>
<td>0.2</td>
<td>---</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IN,Clamp}$</td>
<td>Input Clamp Voltage ($H_{IN}, L_{IN}, I_{TRIP}$) $I_{IN}=10\mu A$</td>
<td>4.9</td>
<td>5.2</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td>$I_{QBS}$</td>
<td>Quiescent $V_{BS}$ supply current $V_{IN}=0 V$</td>
<td>---</td>
<td>---</td>
<td>165</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{QCC}$</td>
<td>Quiescent $V_{CC}$ supply current $V_{IN}=0 V$</td>
<td>---</td>
<td>---</td>
<td>3.35</td>
<td>mA</td>
</tr>
<tr>
<td>$I_{L}$</td>
<td>Offset Supply Leakage Current</td>
<td>---</td>
<td>---</td>
<td>60</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{IN+}, I_{EN+}$</td>
<td>Input bias current $V_{IN}=5 V$</td>
<td>---</td>
<td>200</td>
<td>300</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{IN-}, I_{EN-}$</td>
<td>Input bias current $V_{IN}=0 V$</td>
<td>---</td>
<td>100</td>
<td>220</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{TRIP+}$</td>
<td>$I_{TRIP}$ bias current $V_{TRIP}=5 V$</td>
<td>---</td>
<td>30</td>
<td>100</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$I_{TRIP-}$</td>
<td>$I_{TRIP}$ bias current $V_{TRIP}=0 V$</td>
<td>---</td>
<td>0</td>
<td>1</td>
<td>$\mu A$</td>
</tr>
<tr>
<td>$V(I_{TRIP})$</td>
<td>$I_{TRIP}$ threshold Voltage</td>
<td>440</td>
<td>490</td>
<td>540</td>
<td>mV</td>
</tr>
<tr>
<td>$V(I_{TRIP}, HYS)$</td>
<td>$I_{TRIP}$ Input Hysteresis</td>
<td>---</td>
<td>70</td>
<td>---</td>
<td>mV</td>
</tr>
<tr>
<td>$R_{ON,FLT}$</td>
<td>Fault Output ON Resistance</td>
<td>---</td>
<td>50</td>
<td>100</td>
<td>ohm</td>
</tr>
</tbody>
</table>

**Note**: $V_{IN}$ and $I_{IN}$ parameters are referenced to COM/I_{TRIP} and are applicable to all six channels. (Note 3)

### Dynamic Electrical Characteristics

**Driver only timing unless otherwise specified.**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{ON}$</td>
<td>Input to Output propagation turn-on delay time (see fig.11)</td>
<td>---</td>
<td>590</td>
<td>---</td>
<td>ns</td>
<td>$V_{CC}=V_{BS}=15 V, I_{C}=10 A, V^+ =400 V$</td>
</tr>
<tr>
<td>$T_{OFF}$</td>
<td>Input to Output propagation turn-off delay time (see fig.11)</td>
<td>---</td>
<td>700</td>
<td>---</td>
<td>ns</td>
<td>$V_{CC}=V_{BS}=15 V, I_{C}=10 A, V^+ =400 V$</td>
</tr>
<tr>
<td>$T_{FLIN}$</td>
<td>Input Filter time ($H_{IN}, L_{IN}$)</td>
<td>100</td>
<td>200</td>
<td>---</td>
<td>ns</td>
<td>$V_{IN}=0 &amp; V_{IN}=5 V$</td>
</tr>
<tr>
<td>$T_{BLT,Trip}$</td>
<td>$I_{TRIP}$ Blanking Time</td>
<td>100</td>
<td>150</td>
<td>ns</td>
<td>$V_{IN}=0 &amp; V_{IN}=5 V$</td>
<td></td>
</tr>
<tr>
<td>$D_{T}$</td>
<td>Dead Time ($V_{BS}=V_{DD}=15 V$)</td>
<td>220</td>
<td>290</td>
<td>360</td>
<td>ns</td>
<td>$V_{BS}=V_{CC}=15 V$</td>
</tr>
<tr>
<td>$M_{T}$</td>
<td>Matching Propagation Delay Time (On &amp; Off)</td>
<td>100</td>
<td>150</td>
<td>ns</td>
<td>$V_{CC}=V_{BS}=15 V, external dead time&gt; 400ns$</td>
<td></td>
</tr>
<tr>
<td>$T_{TRIP}$</td>
<td>$I_{TRIP}$ to six switch to turn-off propagation delay (see fig. 2)</td>
<td>---</td>
<td>40</td>
<td>75</td>
<td>ns</td>
<td>$V_{CC}=V_{BS}=15 V, I_{C}=10 A, V^+ =400 V$</td>
</tr>
<tr>
<td>$T_{FLT-CLR}$</td>
<td>Post $I_{TRIP}$ to six switch to turn-off clear time (see fig. 2)</td>
<td>---</td>
<td>7.7</td>
<td>---</td>
<td>ms</td>
<td>$T_{C} = 25^\circ C$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>---</td>
<td>6.7</td>
<td>---</td>
<td>ms</td>
<td>$T_{C} = 100^\circ C$</td>
</tr>
</tbody>
</table>
Input-Output Logic Level Table

<table>
<thead>
<tr>
<th>FLT- EN</th>
<th>HIN1,2,3</th>
<th>LIN1,2,3</th>
<th>U,V,W</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>0</td>
<td>X</td>
<td>X</td>
<td>Off</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sequence of events:
1-2) Current begins to rise
2-3) Current is higher than \( I_{\text{BUS}, \text{Trip}} \) for at least 6\( \mu \)s. This value is the worst-case condition with very low over-current. In case of high current (short circuit), the actual delay will be smaller.
3-4) Delay between driver identification of over-current condition and disabling of all outputs
4) Current starts decreasing, eventually reaching 0
5) Current goes below \( I_{\text{BUS}, \text{Trip}} \), the driver starts its auto-reset sequence
6) Driver is automatically reset and normal operation can resume (over-current condition must be removed by the time the drivers automatically resets itself)

Figure 2. \( I_{\text{sp}} \) Timing Waveform

Note 5: The shaded area indicates that both high-side and low-side switches are off and therefore the half-bridge output voltage would be determined by the direction of current flow in the load.
IRAMS10UP60B

Module Pin-Out Description

<table>
<thead>
<tr>
<th>Pin</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$V_{B3}$</td>
<td>High Side Floating Supply Voltage 3</td>
</tr>
<tr>
<td>2</td>
<td>$W_{VS3}$</td>
<td>Output 3 - High Side Floating Supply Offset Voltage</td>
</tr>
<tr>
<td>3</td>
<td>NA</td>
<td>none</td>
</tr>
<tr>
<td>4</td>
<td>$V_{B2}$</td>
<td>High Side Floating Supply Voltage 2</td>
</tr>
<tr>
<td>5</td>
<td>$V_{VS2}$</td>
<td>Output 2 - High Side Floating Supply Offset Voltage</td>
</tr>
<tr>
<td>6</td>
<td>NA</td>
<td>none</td>
</tr>
<tr>
<td>7</td>
<td>$V_{B1}$</td>
<td>High Side Floating Supply Voltage 1</td>
</tr>
<tr>
<td>8</td>
<td>$U_{VS1}$</td>
<td>Output 1 - High Side Floating Supply Offset Voltage</td>
</tr>
<tr>
<td>9</td>
<td>NA</td>
<td>none</td>
</tr>
<tr>
<td>10</td>
<td>$V^+$</td>
<td>Positive Bus Input Voltage</td>
</tr>
<tr>
<td>11</td>
<td>NA</td>
<td>none</td>
</tr>
<tr>
<td>12</td>
<td>$V^-$</td>
<td>Negative Bus Input Voltage</td>
</tr>
<tr>
<td>13</td>
<td>$V_{TH}$</td>
<td>Temperature Feedback</td>
</tr>
<tr>
<td>14</td>
<td>$V_{CC}$</td>
<td>+15V Main Supply</td>
</tr>
<tr>
<td>15</td>
<td>$H_{IN1}$</td>
<td>Logic Input High Side Gate Driver - Phase 1</td>
</tr>
<tr>
<td>16</td>
<td>$H_{IN2}$</td>
<td>Logic Input High Side Gate Driver - Phase 2</td>
</tr>
<tr>
<td>17</td>
<td>$H_{IN3}$</td>
<td>Logic Input High Side Gate Driver - Phase 3</td>
</tr>
<tr>
<td>18</td>
<td>$L_{IN1}$</td>
<td>Logic Input Low Side Gate Driver - Phase 1</td>
</tr>
<tr>
<td>19</td>
<td>$L_{IN2}$</td>
<td>Logic Input Low Side Gate Driver - Phase 2</td>
</tr>
<tr>
<td>20</td>
<td>$L_{IN3}$</td>
<td>Logic Input Low Side Gate Driver - Phase 3</td>
</tr>
<tr>
<td>21</td>
<td>FLT/Enable</td>
<td>Fault Output and Enable Pin</td>
</tr>
<tr>
<td>22</td>
<td>$I_{TRIP}$</td>
<td>Current Sense and Itrip Pin</td>
</tr>
<tr>
<td>23</td>
<td>$V_{SS}$</td>
<td>Negative Main Supply</td>
</tr>
</tbody>
</table>
1. Electrolytic bus capacitors should be mounted as close to the module bus terminals as possible to reduce ringing and EMI problems. Additional high frequency ceramic capacitor mounted close to the module pins will further improve performance.

2. In order to provide good decoupling between VCC-VSS and VB1,2,3-VS1,2,3 terminals, the capacitors shown connected between these terminals should be located very close to the module pins. Additional high frequency capacitors, typically 0.1µF, are strongly recommended.

3. Value of the boot-strap capacitors depends upon the switching frequency. Their selection should be made based on IR design tip DN 98-2a, application note AN-1044 or Figure 9. Bootstrap capacitor value must be selected to limit the power dissipation of the internal resistor in series with the VCC. (see maximum ratings Table on page 3).

4. Current sense signal can be obtained from pin 22 and pin 23. Care should be taken to avoid having inverter current flowing through pin 22 to maintain required current measurement accuracy.

5. After approx. 8ms the FAULT is reset. (see Dynamic Characteristics Table on page 5).

6. PWM generator must be disabled within Fault duration to guarantee shutdown of the system, overcurrent condition must be cleared before resuming operation.

7. Fault/Enable pin must be pulled-up to +5V.
Figure 3. Maximum Sinusoidal Phase Current vs. PWM Switching Frequency

\[ V^+ = 400V, \ T_J = 150°C, \ \text{Modulation Depth} = 0.8, \ \text{PF} = 0.6 \]

Figure 4. Maximum Sinusoidal Phase Current vs. Modulation Frequency

\[ V^+ = 400V, \ T_J = 150°C, \ T_C = 100°C, \ \text{Modulation Depth} = 0.8, \ \text{PF} = 0.6 \]
Figure 5. Total Power Losses vs. PWM Switching Frequency, Sinusoidal modulation

\[ V_+ = 400\,V, \quad T_J = 150°C, \quad \text{Modulation Depth}=0.8, \quad \text{PF}=0.6 \]

Figure 6. Total Power Losses vs. Output Phase Current, Sinusoidal modulation

\[ V_{\text{BUS}} = 400\,V, \quad T_J = 150°C, \quad \text{Modulation Depth}=0.8, \quad \text{PF}=0.6 \]
Figure 7. Maximum Allowable Case temperature vs. Output RMS Current per Phase

Figure 8. Estimated Maximum IGBT Junction Temperature vs. Thermistor Temperature
Figure 9. Thermistor Readout vs. Temperature (47k ohm pull-up resistor, 5V) and Nominal Thermistor Resistance values vs. Temperature Table.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Min</th>
<th>Avg.</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C</td>
<td>°C</td>
<td>Ω</td>
<td>°C</td>
</tr>
<tr>
<td>-40</td>
<td>4397</td>
<td>119</td>
<td>90</td>
</tr>
<tr>
<td>-35</td>
<td>3088</td>
<td>59</td>
<td>80</td>
</tr>
<tr>
<td>-30</td>
<td>2182</td>
<td>39</td>
<td>70</td>
</tr>
<tr>
<td>-25</td>
<td>1400</td>
<td>29</td>
<td>60</td>
</tr>
<tr>
<td>-20</td>
<td>847</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>-15</td>
<td>528</td>
<td>11</td>
<td>40</td>
</tr>
<tr>
<td>-10</td>
<td>329</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>-5</td>
<td>275</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>0</td>
<td>222</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
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<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>58</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 10. Recommended Bootstrap Capacitor Value vs. Switching Frequency
Figure 11. Switching Parameter Definitions

Figure 11a. Input to Output Propagation
turn-on Delay Time

Figure 11b. Input to Output Propagation
turn-off Delay Time

Figure 11c. Diode Reverse Recovery
Figure CT1. Switching Loss Circuit

Figure CT2. S.C.SOA Circuit

Figure CT3. R.B.SOA Circuit
dimensions in mm
for mounting instruction see AN-1049
note2: Mirror Surface Mark indicates Pin1 Identification.
Note3: Part Number Marking.
Characters Font in this drawing differs from Font shown on Module.
Note4: Lot Code Marking.
Characters Font in this drawing differs from Font shown on Module.
Note5: “P” Character denotes Lead Free.
Characters Font in this drawing differs from Font shown on Module.

Dimensions in mm
For mounting instruction see AN-1049

Data and Specifications are subject to change without notice

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