INTRODUCTION

The power electronics for a fractional HP AC or BL-DC motor drive can be built in a volume not much larger than a pack of cigarettes. Control IC drivers and co-packaged IGBTs in surface mounted TO-220 (IRGBC30KD2-S) are the key to achieve this level of power density (see Figure 1).

Figure 2 shows the schematic of the power stage. The input is the logic signal from the modulator (standard TTUCMOS) and the outputs are the three phases to the motor.

If isolation is required between the modulator and the power stage, it can be provided with inexpensive (low dV/dt) opto-isolators at the input of the IR2130 (see Figure 3).

In addition to the logic inputs, the power stage requires a single 12 - 15V, 20 mA supply. It can operate to bus voltages up to 600V.

The power stage is split into two boards, one with the power devices (see Figures 4 & 4A), the other with the Control IC (gate driver and overcurrent protection and shutdown). Figures 5 and 5A show the control board layout using IR2130S (SOIC), whereas Figures 6 and 6A show the control board layout using IR2130J (PLCC). Either of these control boards can be interconnected with the power board using standard .100” center headers into mating receptacles.

Figure 7 shows how much current can be delivered to an AC motor operated with pulsewidth modulation. Larger currents can be obtained from a board with better thermal characteristics than a standard FR4, 4 oz. copper. The thermal resistance between junction and air for this specific designs was measured at 40°C/W per device. The attached sheet shows a breakdown of the different components of losses.
Miniaturization of the Power Electronics for Motor Drives

Figure 2
3-Phase SMD Power Stage (Schematic Diagram - IR2130S)

Figure 2A
3-Phase SMD Power Stage (Schematic Diagram - IR2130J)
Miniaturization of the Power Electronics for Motor Drives

Figure 3
Input Isolation Stage

Power Circuit

Figure 4
Power Circuit (top view)

Figure 4A
Power Circuit (bottom view)
Miniaturization of the Power Electronics for Motor Drives

IR2130S Control Circuit

- Figure 5: IR2130S Control Circuit (top view)
- Figure 6A: IR2130S Control Circuit (bottom view)

IR2130J Control Circuit

- Figure 6: IR2130J Control Circuit (top view)
- Figure 6A: IR2130J Control Circuit (bottom view)

Voltage = 360V
$T_A = 55^\circ C$
$T_J = 125^\circ C$
Modulation Depth = 80%
Power Factor = 0.8
FR4 board

Figure 7: Typical Output vs. Frequency of a 3-Phase Bridge with IRGBC30UD2S
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Components Placement Diagrams

Power Circuit

Top View

Bottom View

Control Circuit

IR2130S (SOIC)

Top View

Bottom View

IR2130J (PLCC)

Top View

Bottom View

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3-Phase SMD Power Stage Components List

IC
Q1 - Q6
R1
R2, R3
R4
R5, R6
R10, R11, R12, R13, R14, R15
R7, R8, R9
RS
D1-D6
C2
C3
C1, C4, C5, C6
C7
C8
Header & Receptacle
IR2130S or IR2130J Control IC
See Table I
9.1 kΩ, thick film resistor, type 0805
1.0 kΩ, thick film resistor, type 0805
50Ω, Bours trimmer type 3314G
10Ω, thick film resistor, type 0805
100Ω, thick film resistor, type 1206
47Ω, thick film resistor, type 1206
.100Ω, 16W, (Caddock type MP816)
10DF6 Ultra-fast recovery diode
10 μF, 25V tantalum capacitor
1 nF, 50V Ceramic capacitor, type 1206
0.1 μF, 50V Ceramic capacitor, type 1206
10 μF, 450V Aluminum electrolytic capacitor (external - use appropriate value for intended application)
0.100" center, square pins

Table I

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Short Circuit Rating Required</th>
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<tbody>
<tr>
<td>1 to 6 kHz</td>
<td>IRGBC30MD2-S</td>
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<tr>
<td></td>
<td>or IRGBC20MD2-S</td>
</tr>
<tr>
<td>60 to 25kHz</td>
<td>IRGBC30KD2-S</td>
</tr>
<tr>
<td></td>
<td>or IRGBC20KD2-S</td>
</tr>
</tbody>
</table>

For more information, please refer to:

AN-983A IGBT Characteristics and Applications.
AN-985 The IR2130: A Six-Output, High Voltage MOS Gate Driver.
AN-978 High Speed, High Voltage IC Drive for HEXFET or IGBT Bridge Circuits.
AN-990 Application Characterization of IGBTs

"An Algorithm for the Section of the Optimum Power Device" (Section 3) by Steve Clemente and Brian Pelly.

"Accurate Junction Temperature Calculations" by Steve Clemente and Don Dapkus II.
# Miniaturization of the Power Electronics for Motor Drives

**APPLICATION PARAMETERS**
- Switching voltage: 300 V
- Displacement angle: 0.64 rad
- Power factor: 0.8
- Modulation depth: 0.8

**THERMAL OPERATING CONDITIONS**
- Ambient temperature: 55 °C
- Thermal resistance: 40.00 K/W

**IGBT MODEL AND PARAMETERS: IRGC30UD2-S (typical)**
- Temperature of ref. parameters: 125.00 °C
- $V_{th}$: 0.636 V
- $a$: 0.390 $\Omega$
- $b$: 0.674
- $\Gamma_{(b+2)/2}$: 1.337, 0.892
- $\Gamma_{(b+3)/2}$: 1.837, 0.941
- $h$: 2.15E-2 mJ/A
- $k$: 1.352
- $\Gamma_{(k+1)/2}$: 1.176, 0.824
- $\Gamma_{(k+2)/2}$: 1.676, 0.804
- $m$: 5.27E-2 mJ/A
- $n$: 1.102
- $\Gamma_{(n+1)/2}$: 1.051, 0.873
- $\Gamma_{(n+2)/2}$: 1.551, 0.889
- Reference voltage: 480 V

**DIODE MODEL**
- $V_{th}$: 0.60 V
- $a$: 0.120
- $b$: 1.000
- Gamma: 0.88623

**ELECTRICAL OPERATING CONDITIONS**
- Operating frequency: 1 kHz
- Peak current: 1.00 A
- RMS line voltage: 129.60 V
- RMS Current, fundamental: 2.85 A
- Output power, fundamental: 0.89 kW
- Voltage drop at peak current: 1.63 V
- Conduction losses: 1.44 W
- Turn-on losses, ideal diode: 0.00 W
- Correction factors for gate drive: 23.2
- Corrected turn-on losses: 0.00 W
- Turn-off losses: 0.01 W
- Total IGBT losses: 1.45 W
- Diode conduction losses: 0.30 W
- Diode switching losses: 0.00 W
- Total diode losses: 0.30 W
- Total losses in Co-Pack: 1.75 W
- Junction temperature: 125.00 °C
- Semiconductor Efficiency: 98.82 %