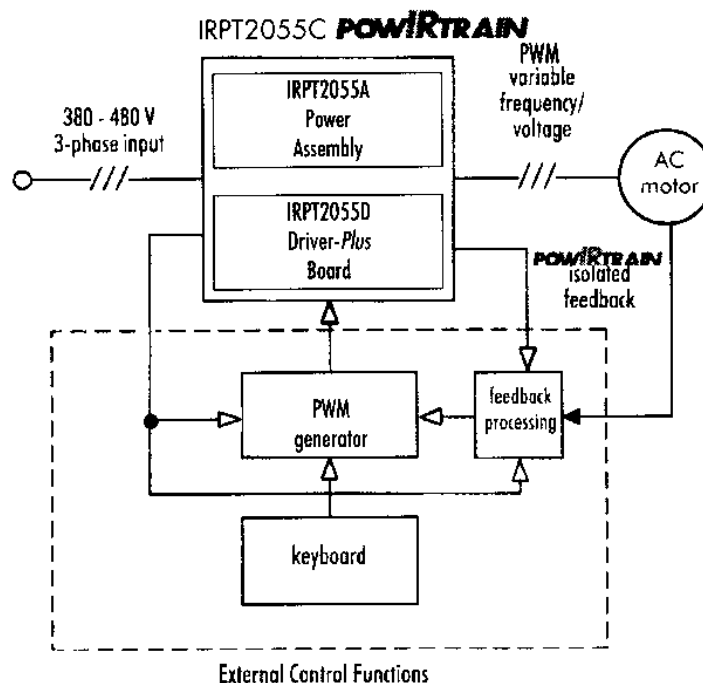


## Power Module for 1.5 hp Motor Drives

- 1.5 hp (1.1 kW) power output  
Industrial rating at 150% overload for 1 minute
- 380-480V AC input, 50/60 Hz
- 3-phase rectifier bridge
- 3-phase, short circuit rated, ultrafast IGBT inverter
- HEXFRED ultrafast soft recovery-freewheeling diodes
- Brake IGBT and diode
- Low inductance (current sense) shunts in positive and negative DC rail
- NTC temperature sensor
- Pin-to-base plate isolation 2500V rms
- Easy-to-mount package
- Case temperature range -25°C to 125°C operational



**Figure 1.** IRPT2055A Power Module



**Figure 2.** The power module and **POWIRTRAIN** within a motor control system

## System Description

### Power Module

The IRPT2055A power module shown in Figure 1 is a chip and wire epoxy encapsulated module. It houses input rectifiers, brake IGBT and freewheeling diode, output inverter, current sense shunts and NTC thermistor. The 3-phase input bridge rectifiers are rated at 1600V. The brake circuit uses 1200V IGBT and freewheeling diode. The inverter section employs 1200V, short circuit rated ultrafast IGBT's and ultrafast freewheeling diodes. Current sensing is achieved through 45 mΩ low inductance shunts provided in the positive and negative DC bus rail. The NTC thermistor provides temperature sensing capability. The lead spacing on the power module meets UL840 pollution level 3 requirements.

The power circuit and layout within the module are carefully designed to minimize inductance in the power path, to reduce noise during inverter operation and to improve the inverter efficiency. The driver board required to run the inverter can be soldered to the power module pins, thus minimizing assembly and alignment. The power module is designed to be a heat sink with two screw mount positions, in order to insure good thermal contact between the module substrate and the heat sink.

### **POWIRTRAIN** and Design Kit

The IRPT2055C **POWIRTRAIN** (Figure 3) provides the complete power conversion function for a 1.5 hp (1.1 kW) variable voltage, variable frequency AC motor controller. The **POWIRTRAIN** combines the Power Module (IRPT2055A) with a Driver-Plus Board (IRPT2055D) as shown in the block diagram of Figure 2. The **POWIRTRAIN** Design Kit, IRPT2055E includes the following:

- Complete **POWIRTRAIN** integrated power stage
- Specification and operating instructions
- Bill of materials
- Electrical schematic
- Mechanical layouts
- Software transferrable file for easy design integration
- Application information and layout considerations

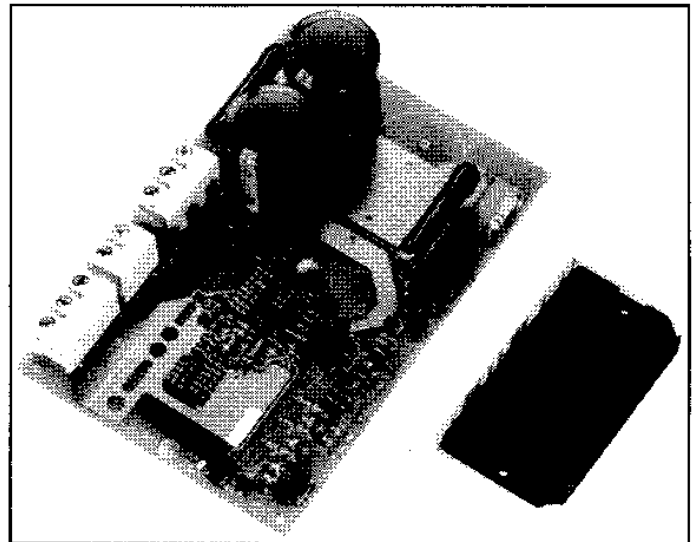
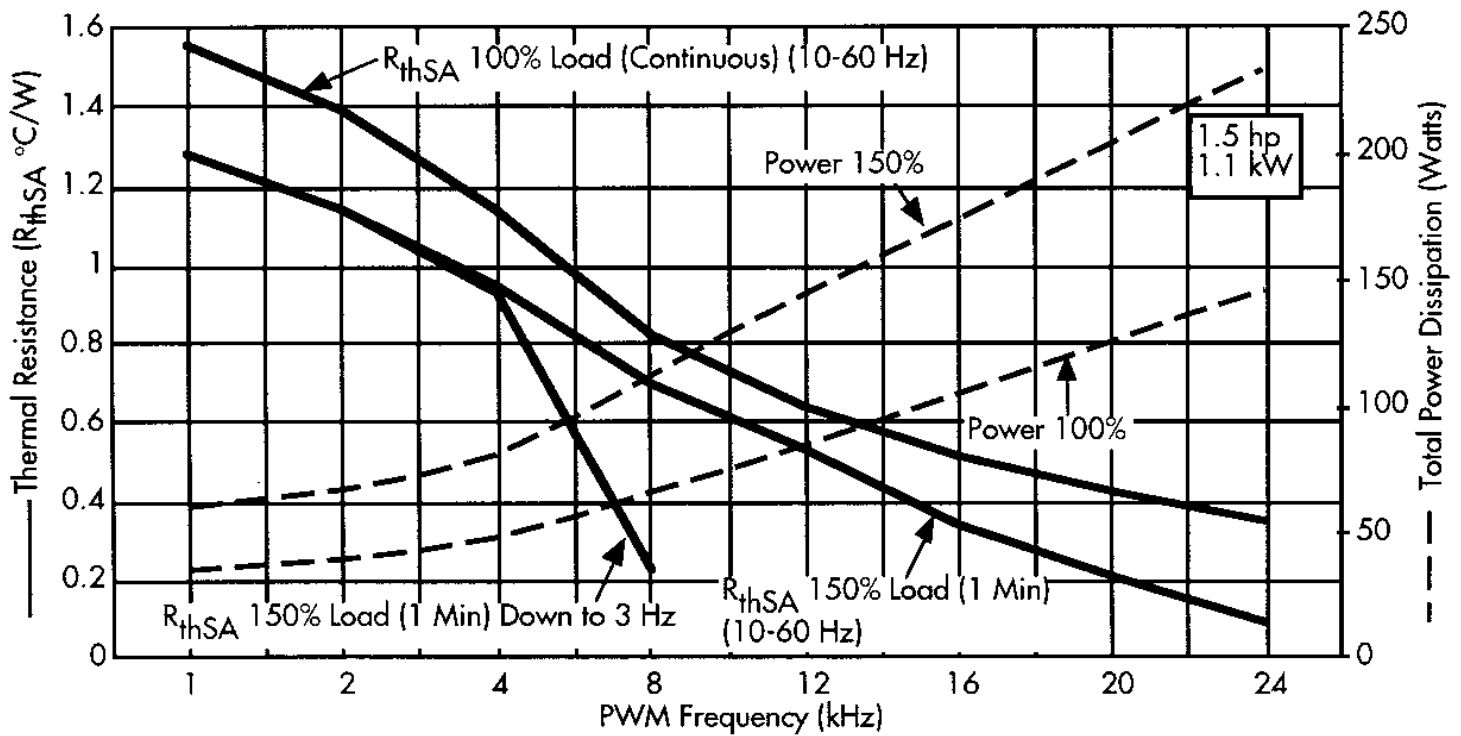


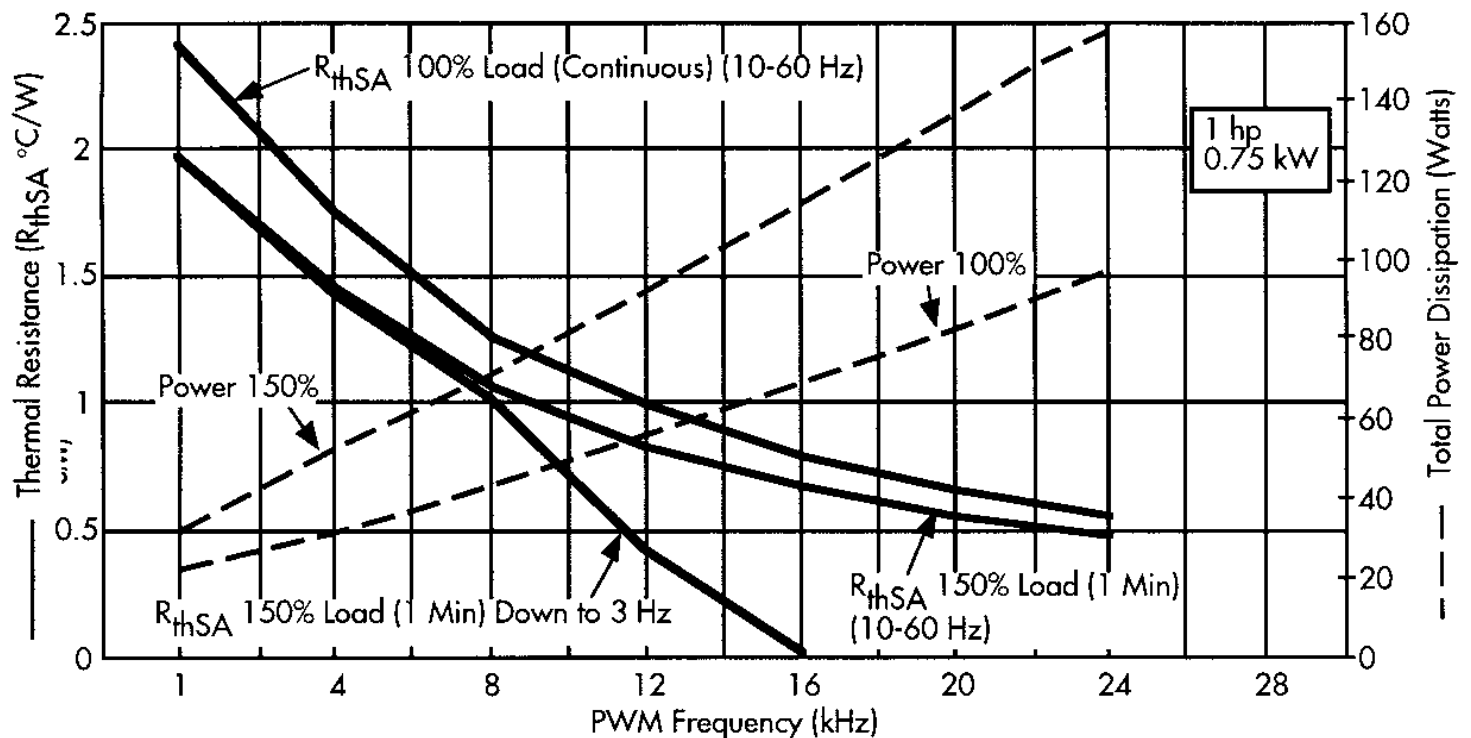
Figure 3. IRPT2055C **POWIRTRAIN**

**Specifications**

PARAMETERS	VALUES	CONDITIONS
<b>Input Power</b>		
Voltage	380V, -15%, 480V +10%, 3-phase	
Frequency	50/60 Hz	
Current	4.4A rms @ nominal output	$T_A = 40^{\circ}\text{C}$ , $R_{thSA} = 0.95^{\circ}\text{C/W}$
$I_{FSM}$	400A	10 ms half-cycle, non-repetitive surge
<b>Output Power</b>		
Voltage	0 - 480V rms	defined by external PWM control
Nominal motor hp (kW)	1.5 hp (1.1 kW) nominal full load power 150% overload for 1 minute	$V_{in} = 460\text{VAC}$ , $f_{pwm} = 4\text{kHz}$ , $f_0 = 60\text{Hz}$ , $T_A = 40^{\circ}\text{C}$ , $R_{thSA} = 0.95^{\circ}\text{C/W}$
Nominal motor current	3.1A rms nominal full load power 4.65A rms 150% overload for 1 minute	
<b>DC Link</b>		
DC link voltage	850V maximum	
<b>Brake</b>		
Current	5.6A	
<b>Sensor</b>		
Temp. sense resistance	50 kOhms $\pm 5\%$ 3.1 kOhms $\pm 10\%$	@ $T_{NTC} = 25^{\circ}\text{C}$ @ $T_{NTC} = 100^{\circ}\text{C}$
Current sense	45mOhms $\pm 5\%$ maximum	@ $T_{SHUNT} = 25^{\circ}\text{C}$
<b>Protection</b>		
IGBT short circuit time	5 $\mu\text{s}$	DC Bus = 850V, $V_{GE} = 15\text{V}$ , line to line short
Recommended short circuit-shutdown current	14A peak	
<b>Gate Drive</b>		
$Q_G$	31 nC (typical)	$V_{GE} = 15\text{V}$ , refer Figure 5b
Recommended gate driver	IR2233 (refer Figure 10)	refer design kit IRPT2055E
<b>Module</b>		
Isolation voltage	2500V rms	pin-to-base plate, 60 Hz, 1 min.
Operating case temperature	-25°C to 125°C	95% RH max. (non-condensing)
Mounting torque	1 Nm	M4 screw type
Storage temperature range	-40°C to 150°C	
Soldering temp. for 10 seconds	260°C maximum	at the pins (.06" from case)

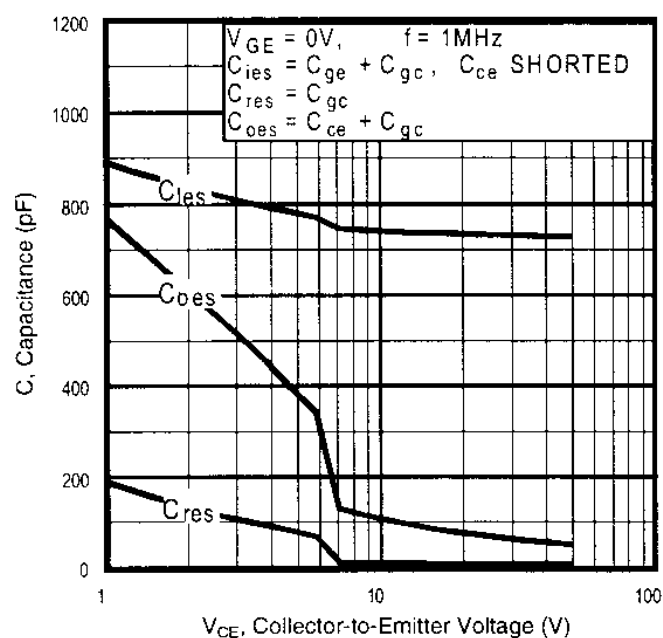


**Figure 4a.** 1.5hp/3.1A output Heat Sink Thermal Resistance and Power Dissipation vs. PWM Frequency (Induction Motor Load)

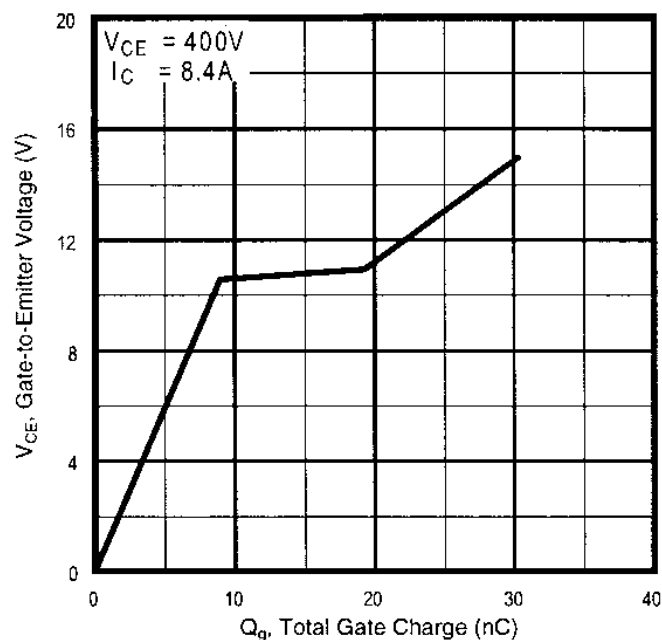


**Figure 4b.** 1hp/2.2A output Heat Sink Thermal Resistance and Power Dissipation vs. PWM Frequency (Induction Motor Load)

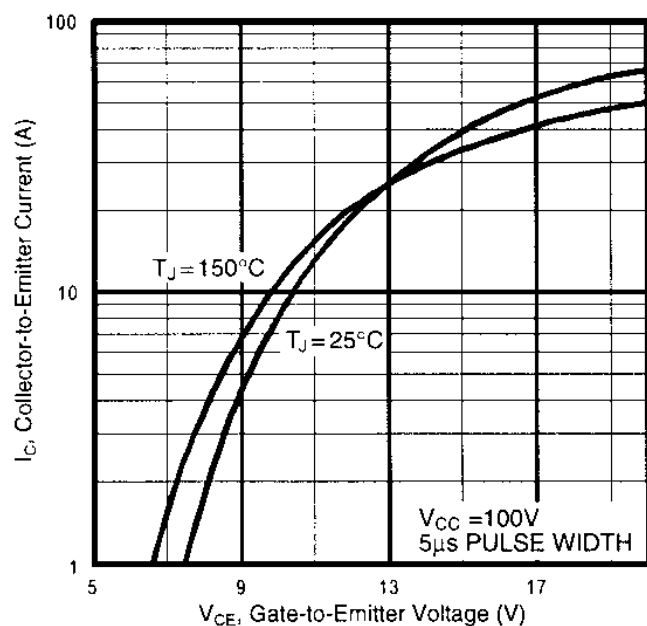
Operating Conditions:  $V_{in} = 460V_{rms}$ ,  $MI = 1.15$ ,  $PF = 0.8$ ,  $T_A = 40^\circ C$ ,  $T_i = 145^\circ C$ ,  $T_S = 95^\circ C$ ,  $Z_{thSA}$  limits  $\Delta T_c$  during 1 minute overload to  $10^\circ C$



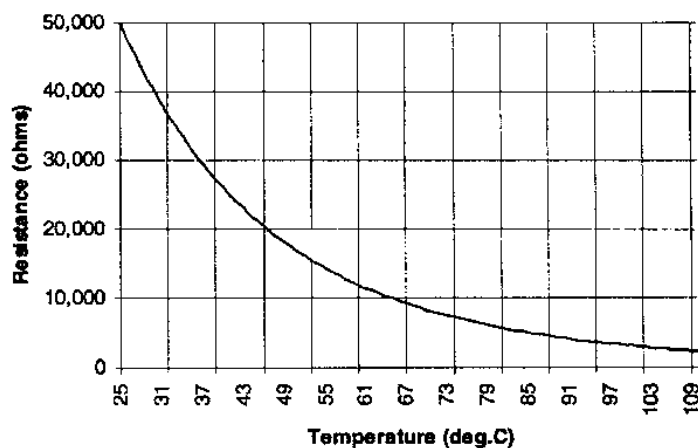
**Figure 5a.** Typical Capacitance vs Collector-to-Emitter Voltage of the IGBT



**Figure 5b.** Typical Gate Charge vs Gate-to-Emitter Voltage of the IGBT



**Figure 5c.** Typical Transfer Characteristics of the IGBT

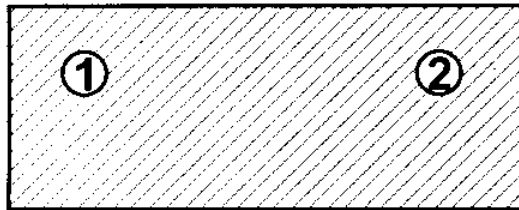


**Figure 6.** Nominal R-T Characteristics of the NTC Thermistor (YNE503J01TR)

## Mounting Procedure

### Mounting

1. Connect the driver board and the IRPT 2055A power module.
2. Remove all particles and grit from the heat sink and power substrate.
3. Spread a .004" to .005" layer of silicone grease on the heat sink, covering the entire area that the power substrate will occupy. Recommended heat sink flatness in .001 inch/inch and Total Indicator Readout (TIR) of .003 inch below substrate.
4. Place the power substrate onto the heat sink with the mounting holes aligned and press it firmly into the silicone grease.
5. Insert the two M4 mounting screws through the PCB, power substrate and into the heat sink and tighten the screws to 1 Nm torque, according to the sequence shown in Figure 7.



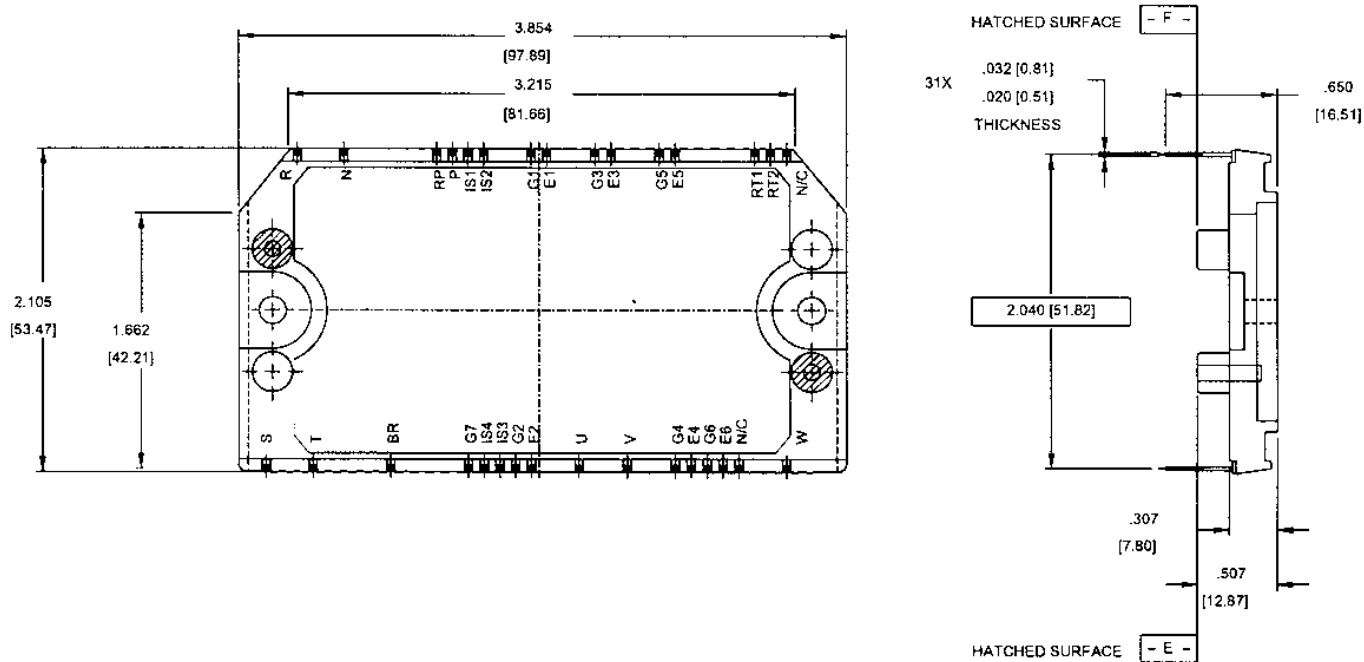
**Figure 7.** Power Module Mounting Screw Sequence

### Power Connections

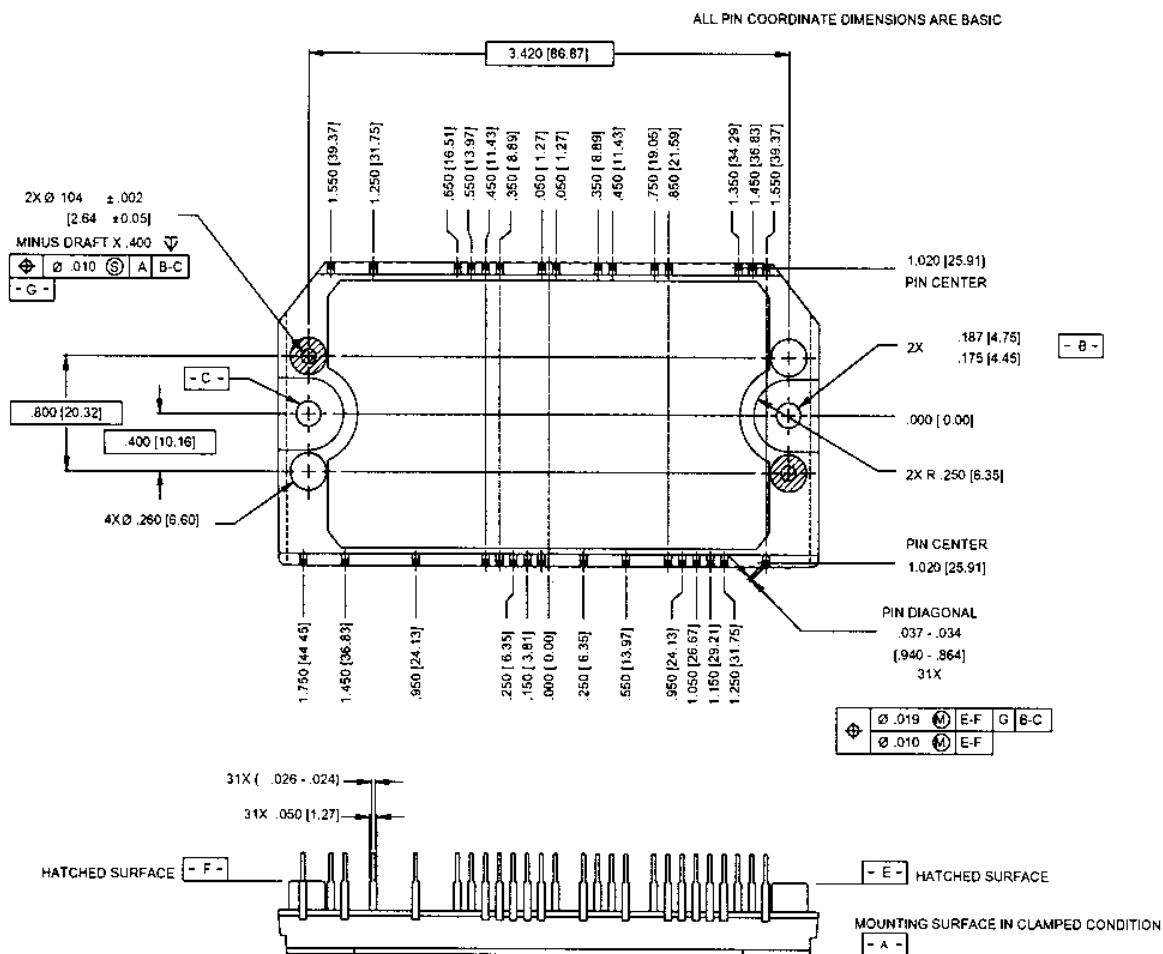
The power module pin designation, function and other details can be obtained from the package outline in Figure 8 and circuit diagram in Figure 9. Three phase input connections are made to pins R, S and T and inverter output connections are made to pins U, V and W. Positive DC bus and brake IGBT collector connections are brought out to pins P and BR respectively. Positive rectifier output and positive inverter bus are brought out to pins BP and P respectively in order to provide DC bus capacitor to pins IS1, IS2 and IS3, IS4 on the positive and negative DC rails, respectively.

## IRPT2055A Package Outline and Mechanical Specifications

**NOTE:** Dimensions are in inches (millimeters)

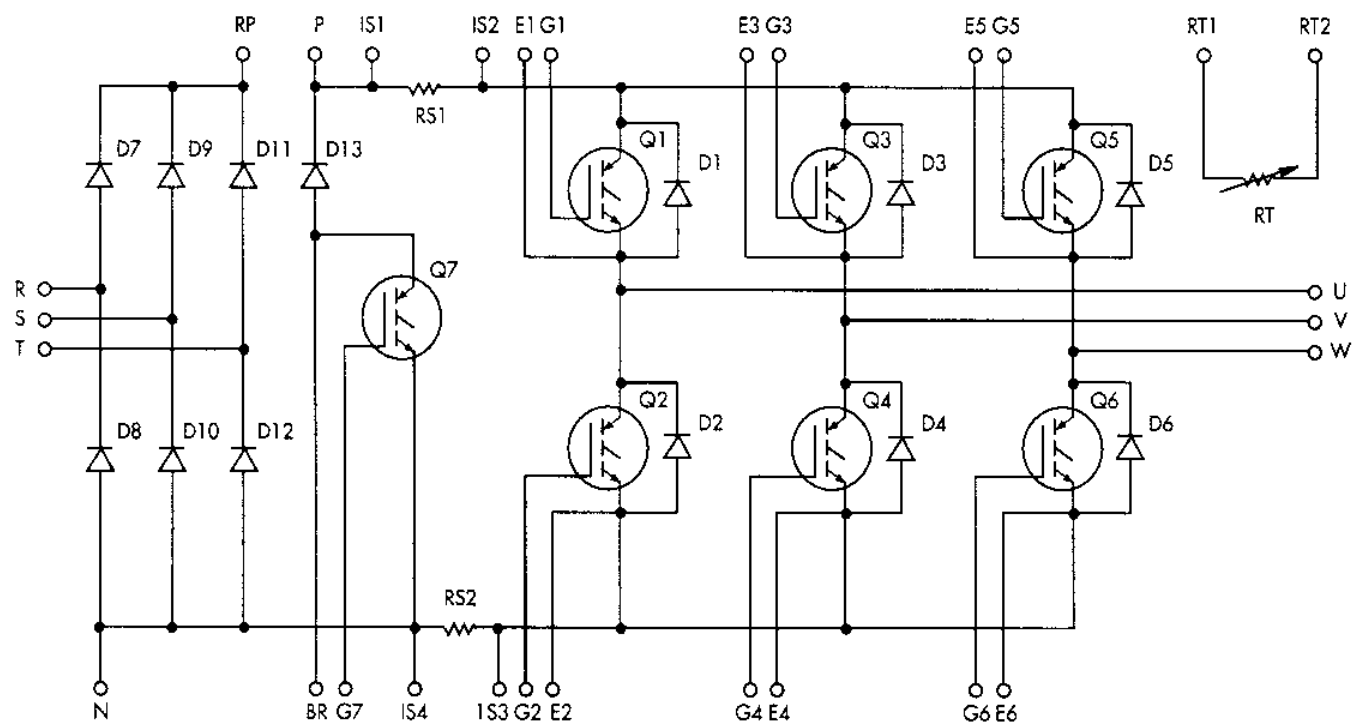


**Figure 8a.** Package Outline and Mechanical Specifications

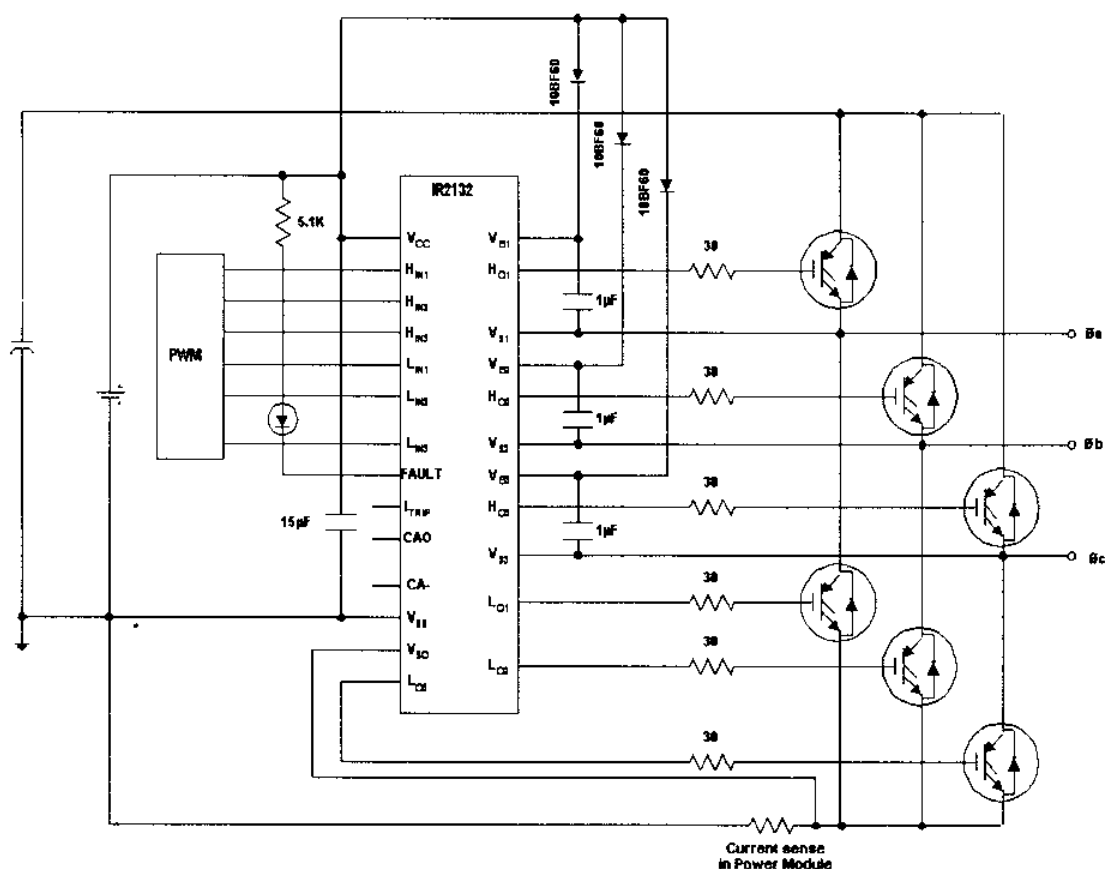


**Figure 8b.** Package Outline and Mechanical Specifications





**Figure 9.** Power Module Circuit Diagram



**Figure 10. Recommended Gate Drive Circuit**

## Application Information

### *Heat Sink Requirements*

Figures 4a through 4b show the thermal resistance of the heat sink required for various output power levels and pulse-width-modulated (PWM) switching frequencies. Maximum total losses of the unit are also shown. This data is based on the following key operating conditions:

- The maximum continuous combined losses of the rectifier and inverter occur at full pulse-width-modulation. These losses set the maximum continuous operating temperature of the heat sink.
- The maximum combined losses of the rectifier and inverter at full pulse-width modulation under overload set the increment temperature rise of the heat sink during overload.
- The minimum output frequency at which full load current is to be delivered, sets the peak IGBT junction temperature.
- At low frequency, IGBT junction temperature tends to follow the instantaneous fluctuations of the output current. Thus, peak junction temperature rise increases as output frequency decreases.

### *Over Temperature Protection*

Over temperature can be detected using the NTC thermistor included in the power module for thermal sensing. Protection circuit that initiates a shutdown if the temperature of the IMS substrate exceeds a set level can be implemented. The nominal resistance vs. temperature characteristic of the thermistor is given in Figure 6.

### *Voltage Rise During Braking*

The motor will feed energy back to the DC link during regenerative braking, forcing the bus voltage to rise above the level defined by the input voltage. Deceleration of the motor must be controlled by appropriate PWM control to keep the DC bus voltage within the rated maximum value. For high inertial loads, or for very fast deceleration rates, this can be achieved by connecting an external braking resistor across P and BR and controlling the brake IGBT switching when the bus voltage exceeds the allowable limit.

## Part Number Identification and Ordering Instructions

### IRPT2055A Power Module

Chip and wire epoxy encapsulated module with 1600V input rectifiers, 1200V brake IGBT and freewheeling diode, 1200V short-circuit rated, ultrafast IGBT inverter with ultrafast freewheeling diodes, temperature sensing NTC thermistor and current sensor low inductance shunts.

### IRPT2055C Complete **POWERTRAIN**

Power assembly (IRPT2055A) and Driver-*Plus* Board (IRPT2055D), pre-assembled and tested to meet all system specifications.

### IRPT2055D Driver-*Plus* Board

Printed circuit board assembled with DC link capacitors, in-rush current limiting NTC thermistor, high-power terminal blocks, surge suppression MOVs, IGBT gate drivers, protection circuitry and low power supply. The PCB is functionally tested with standard power module to meet all system specifications.

### IRPT2055E Design Kit

Complete **POWERTRAIN** (IRPT2055C), with full set of design documentation including schematic diagram, bill of material, mechanical layout of Driver-*Plus* Board, schematic file, Gerber files and design tips.

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**WORLD HEADQUARTERS:** 233 Kansas St., El Segundo, California 90245, Tel: (310) 322 3331

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