

IR2137/IR2171 Reference Design Kit For 3-phase/230V 3HP AC Motor Drives

IR2137/IR2171 Power Board

- 230V AC input / 2.2kW output
- IR2137Q monolithic 3-phase HVIC driver.
- IR2171S monolithic linear current sensing IC
- DC bus capacitor with NTC inrush current limiter.
- On-board +15V and 2 X +5V power supply.
- Linear Motor Phase Current Feedback.
- DC bus voltage and current feedback.
- Full protection for short circuit, earth/ground fault and over-temperature.
- Optically isolated PWM gate/Fault signals.
- Terminal blocks for 3-phase input/output connections.

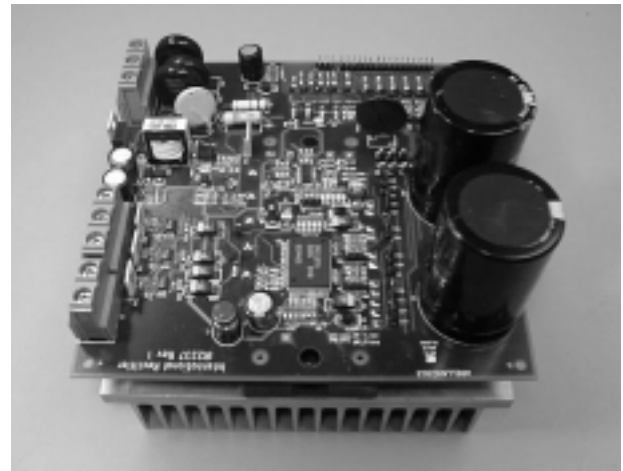


Figure 1 IRMDAC4 IR2137/IR2171 Reference Design Kit (Shown with Optional Heatsink and IGBT Power Module)

Power Module

- Standard EconoPIM2 IGBT module.
- 600V/30A short circuit rated IGBT.
- 600V/20A short circuit rated BRAKE IGBT.
- 800V/30A 3-phase rectifier bridge.
- Built-in Temperature sensor.
- Pin-to-base plate isolation 2500VAC rms.
- Easy-to-mount two screw package.

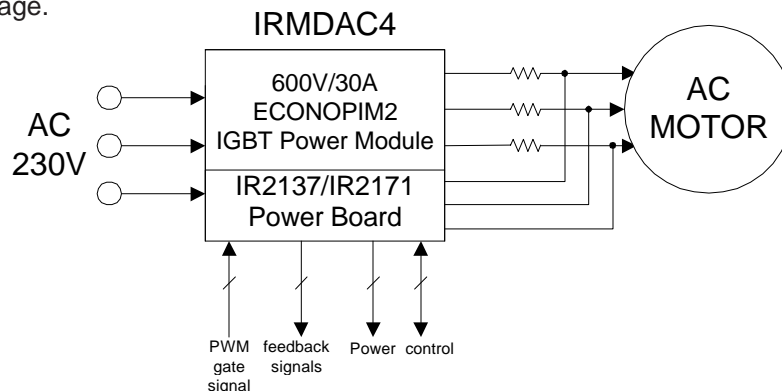


Figure 2 Typical Connection Diagram

System Description

The IRMDAC4 is the AC motor reference design kit for the IR2137Q 3-phase gate driver IC and the IR2171 current Sensing IC. It is the power conversion unit for a 3-phase/230V 3HP (2.2kW) AC PWM (Pulse Width Modulated) drives. This design kit consists of the IR2137/IR2171 power board based on 4-layer PCB. The ECONOPIM2 power module and the heat sink are supplied separately. User must provide soldering connection between the power board and the power module, and the appropriate heat sink to complete the power conversion function.

Figure 1 shows the complete assembly of the IRMDAC4 Reference Design Kit. Figure 2 illustrates the typical connection block diagram of the IRMDAC4.

The IR2137/IR2171 power board contains an IR2137Q gate driver High Voltage IC, DC link capacitors, soft start function using NTC thermistor, AC input MOVs for surge suppression, switching power supply, brake IGBT buffering circuit, over-current/ground fault/over-temperature protection circuit, DC bus voltage and current feedback signals. On-board 16-pin single row header connector (J9) is provided to interface the control signals, and two terminal blocks are provided to facilitate connection to 3-phase AC input (J7) and output (J6).

The power module contains a 3-phase input bridge rectifier, 3-phase IGBT inverter; brake IGBT/diode, and the temperature thermistor on the substrate base. It is designed for easy mounting to a heat sink.

Output power is PWM 3-phase, variable frequency and voltage controlled by a user provided 5V PWM signal input. The limited amount of the power is available for two 5VDC (one ground isolated and one non-isolated), and 15VDC non-isolated to facilitate the PWM interface. The non-isolated powers are referenced to the negative DC bus that the IR2137Q gate driver IC is also referenced to.

The IRMDAC4 offers several benefits to the users listed below:

- It gives a complete working reference of the 3HP AC drive power conversion based on the state-of-art 3-phase gate driver and IGBT power module. User can gain immediate hands-on experience based on the system. The design detail can be further utilized in the area of: PCB layout, gate drive optimization, protection circuit, and on-board switching power supply.
- Gate drive and protection circuits are designed to closely match the operating characteristics of the power semiconductors. This allows power losses to be minimized and power rating to be maximized to a greater extent than is possible by designing with individual components.
- It reduces the effort of calculating and evaluating power semiconductor losses and junction temperature.

IR2137 Driver Board

The IR2137/IR2171 power board also contains the feedback signal circuit, brake driver, soft start circuit, and the local switching power supply. The driver also interfaces to the AC input line. It houses the DC link capacitors, current sensing shunt resistor, NTC in-rush limiting thermistor, and surge suppression MOVs.

The inverter **gate drive circuits**, implemented with an IR2137Q monolithic 3-phase HVIC driver, delivers gate drive to the IGBTs corresponding to PWM control signals $\overline{HIN1}$ through $\overline{HIN3}$, and $\overline{LIN1}$ through $\overline{LIN3}$ into J9 connector. It introduces a 0.2 μ sec deadtime between upper and lower gate signals for each phase. Any additional deadtime necessary to expand must be included in the PWM signals. Gate drives must be enabled with an active low pulse applied to the \overline{RESET} pin into J9 pin 14 while PWM inputs $\overline{HIN1}$ through $\overline{HIN3}$, and $\overline{LIN1}$ through $\overline{LIN3}$ are held high (off condition).

After power up, the \overline{RESET} pin must be pulled low before any input signals are activated.

The **protection circuitry** of the system is incorporated by two means: One is by the function of the high side de-saturation protection input (DESAT) in the IR2137Q IC, and the other is by the comparator circuit and current sensing shunt resistor (R44) for the low side gate driver that enables the ITRIP input of the IR2137Q device. The internal fault logic of the IR2137Q will enable the \overline{FAULT} output in an event of a short circuit, earth/ground fault, over-temperature, or over-voltage/over-current conditions with Soft Shutdown, as specified. Over-current signals are sensed through shunt resistors located in the negative DC bus rail. Earth/ground faults are sensed using the high side shunt resistor and the signal is level shifted through the optoisolator to the protection circuitry. Over-temperature protection is obtained using a thermistor inside the

power module. A $\overline{\text{FAULT}}$ condition occurs when the temperature of the power module substrate exceeds 110°C. After a fault condition all inverter gate drivers are disabled and latched, which illuminates the on-board red LED. The resulting $\overline{\text{FAULT}}$ signal can be monitored at pin 1 of J9.

Like all logic inputs for high/low side gate driver outputs (J9 pins 1 through 6), the $\overline{\text{SD}}$ input is fed through an opto-isolator and into the IR2137Q device and must be an active high input signal at the input of the opto-isolator. When $\overline{\text{SD}}$ is active low, all output drivers will simultaneously shut down without being latched (real time). Furthermore, in a soft shutdown scheme, simultaneous shutdown of all 6 IGBTs is required to prevent a potential false turn-on while the IGBTs are in the soft shutdown mode. The system is designed for 150% overload for one minute while operating with the specified heatsink. The controller should shut off the PWM signals if the overload condition persists over one minute.

Current sensing is implemented via 0.01Ω current sensing shunt resistors in series with each of the 3φ output lines at J6, and decoupled with 1000PF capacitors in parallel with each shunt resistor. Each pair of the shunt resistors is tied into the inputs of the linear current sensing IC, IR2171. The output of each IR2171 device is fed into an opto-isolator. The output of each opto-isolator is routed to pins 11, 12 and 13 of connector J9, current sensing outputs. When over-current occurs, the PWM output (PO) of IR2171 goes low and initiates the opto-isolator that flags a signal at the current sense output at J9. In addition, the dedicated over-current trip (OC) output of the IR2171 initiates a signal into the opto-isolator, which in turn, flags a signal at J9 pin 3 ($\overline{\text{OCrt/s}}$). Output $\overline{\text{OC}}$ is a negative logic output signal that facilitates IGBT short circuit protection.

The **brake function** is implemented by connecting a power resistor between the terminals on the Brake terminal block. The external power resistor will determine the maximum braking capability in conjunction with the drives regenerative power. The value of resistor should be carefully chosen not to exceed the maximum current handled by the brake IGBT. The input signal on the $\overline{\text{BRAKE}}$ pin of J9 pin 14 is active low and CMOS or LSTTL compatible. The $\overline{\text{BRAKE}}$ input is permanently pulled high to +5V VDD via a 10KΩ resistor to ensure CMOS or LSTTL compatibility.

The **switching power supply** employs a UC2844AD8 current mode PWM controller and self-oscillating driver chip to deliver a nominal 5V and 15V DC through a line isolation transformer with respect to the negative DC bus. The power supply feeds the gate drive and protection circuits. At an input voltage of 230VAC the PWM Carrier Frequency is 8kHz and the output Frequency is 60Hz. The minimum and maximum required DC Bus Voltage are 90V and 400V, respectively. The 15V (VCC) and 5V (VDD) outputs are available on the interface pins for the external control logic circuit.

As part of the switching power supply, a +5V isolated (floating) power supply is available for powering most opto-isolators and isolating all opto-isolator's ground from the COM pin of the IR2137Q IC. The isolated +5V supply can be monitored at J9 pin 2 (VC_ISO) with reference to the isolated supply ground, J9 pin 16 (GNDISO).

The ECONOPIM2 Power Module

The ECONOPIM2 Power Module is an IGBT power Module based on Direct Bonded Copper substrate (DBC). It houses input rectifiers, output inverter, brake IGBT/diode, and a thermistor. The 3-phase input bridge rectifiers are rated 600V/30A. The inverter section employs 600V, short circuit rated, ultrafast IGBTs and ultrafast freewheeling diodes. The internal thermistor provides temperature-sensing capability.

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 IR2137/IR2171 driver board required to run the inverter can be soldered to the power module pins, this minimizing assembly and alignment. The power module is designed to mount on a heatsink with two screw mount positions, in order to insure good thermal contact between the module substrate and the heatsink.

For detailed electrical specifications, please refer to each power module data sheet.

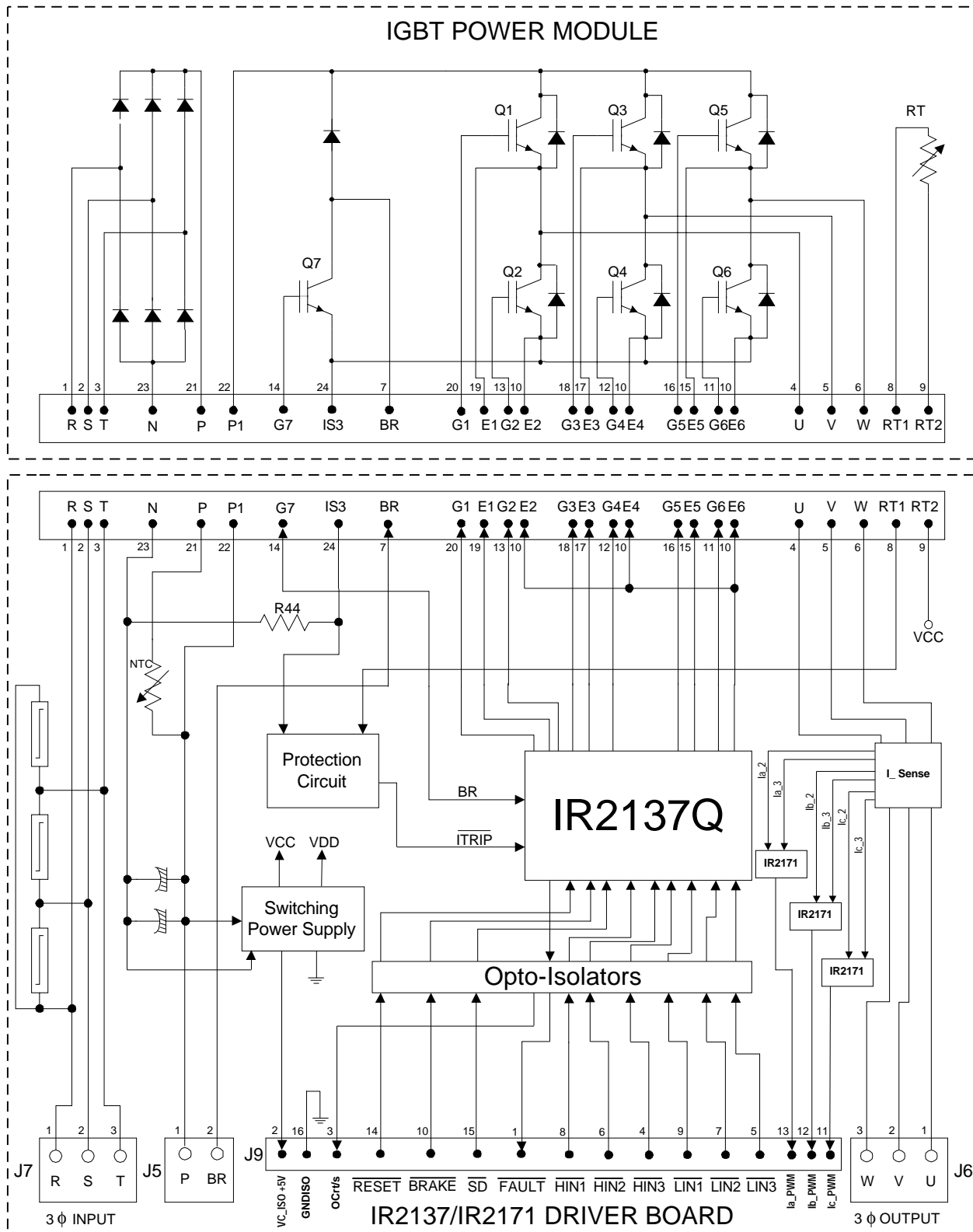


Figure 3 IRMDAC4 Block Diagram

Specifications Tc = 25°C unless otherwise specified

Parameters	Values	Conditions
Input Power		
Voltage	115 - 230V, -20%, +10%	Output Power Rating is half at 115VAC Input
Frequency	50/60Hz	
Input current	15.4A rms (Continuous) 150A (Peak Inrush Current)	Ambient Temperature, TA=40°C Heat Sink RthSA=0.35°C/W
Input line impedance	4%~8% recommended	
Output Power		
Voltage	0-230V _{rms}	
HP	3HP (2.2kW) nominal power 150% overload for 1 minute	Input Voltage=230V AC, PWM Carrier Frequency=8kHz, Output Frequency=60Hz, Ambient Temperature=40°C, Heatsink Rth=0.35°C/W
Current	11A _{rms} Continuous, 16.5A _{rms} Overload	
Control Inputs		
$\overline{\text{IN1}}, \overline{\text{IN2}}, \overline{\text{IN3}}, \overline{\text{LN1}}, \overline{\text{LN2}}, \overline{\text{LN3}}$	10mA Source Current	Primary PWM input of Opto-coupler
$\overline{\text{RESET}}, \overline{\text{SD}}, \overline{\text{BR}}$	10mA Sink Current	Primary PWM input of Opto-coupler
$\overline{\text{FAULT}}, \overline{\text{IA}}, \overline{\text{IB}}, \overline{\text{IC}}, \overline{\text{OC}}$	Open Drain Output	Output of out-coupler (1.2kΩ pull-up)
IA, IB, IC (Current Feedback)	40kHz Digital PWM Output	Motor Current
Deadtime	Minimum 700nsec required	Internal 0.2μsec provided by IR2137
Protection		
Line-to Line short	87A peak, ±30%, Response time = 2.5μsec (typical)	IR2137 Internal Function
Ground fault	100A peak, ±30%	IR2137 Internal Function
Over Temperature	110°C, ±10%	IGBT Module Substrate Temperature
DC Bus Voltage		
Maximum	400V	
Minimum	90V	
Power Supply		
V _{CC1}	15V, ±10%, 130mA	
V _{DD2}	5V, ±5%, 100mA	For Isolate Primary Circuit of OptoCoupler
V _{DD1}	5V, ±5%, 120mA	
Minimum Operating Voltage	90V	AC Input Voltage Greater than 70V
Brake IGBT		
Current	20A Peak	
HeatSink		
Thermal Resistance	Less than 0.35°C/W	3HP Continuous Output, fc = 8kHz
Ambient Temperature		
Heatsink Temperature	Maximum 80°C	
Humidity	Maximum 95%	No Condensing

Mounting, Hookup and Application Instructions

1. Remove all particles and grit from the heatsink and power substrate
2. Spread a .004" to .005" layer of silicone grease on the heatsink, covering the entire area that the power substrate will occupy Recommended heatsink flatness is .001inch/inch and Total Indicator Readout (TIR) of .003 inch below substrate
3. Place the power substrate onto the heatsink with the mounting holes aligned and press it firmly into the silicone grease
4. Place the 2XM4 mounting screws through the PCB and power module and into the heatsink and tighten the screws to 1NM torque

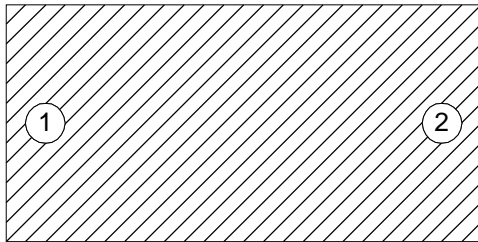


Figure 4 Power Module Mounting Screw Sequence

All input and output control connections are made via a 16-pin terminal female connector to J9. J8 shown in Figure 5 is the output connector for the +5V Isolation power supply (VCC_ISO). This power supply is mainly used to power all on-board Opto-Isolators where its ground is isolated from the COM pin of the IR2137Q IC. Note that pin 1 of J8 and J9 is physically located adjacent to the connector reference designator.

Power Connections

3-phase input connections are made to terminals R, S and T (J7). Inverter output terminal connections are made to terminals U, V and W (J6). Positive DC bus and Brake IGBT collector connections are brought out to terminals P (positive) and BR (brake) of J5 connector. An external resistor for braking can be connected across these terminals.

Power-Up Procedure

When 3-phase input power is first switched on, PWM inputs to IRMDAC4 must be inhibited (held high) until the protection latch circuitry is reset. To reset this latch before inverter start-up, RESET pin on J9 connector must be pulled down low for at least 2usec. This will set the Fault feedback signal on J9 high. Now, the PWM input signals can be applied for inverter start-up.

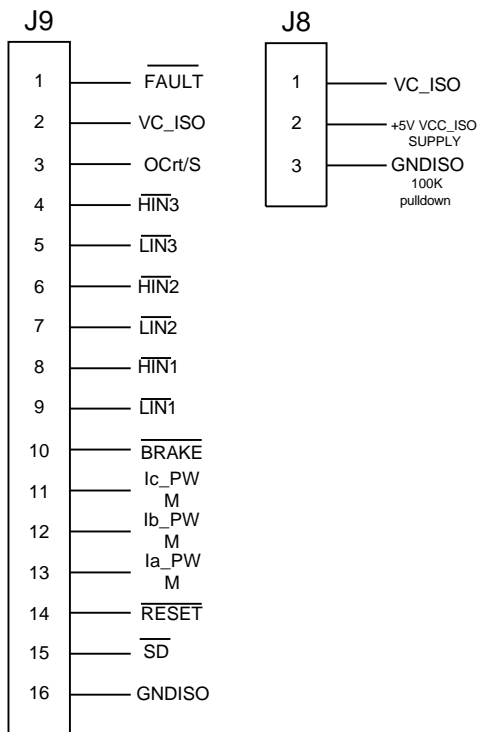


Figure 5 Control Signal Connector

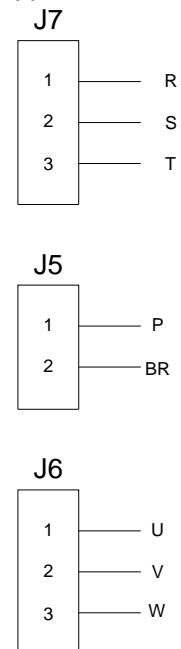


Figure 6 Input and Output Terminal Blocks

IRMDAC4 Mechanical Dimensions

inches [millimeters]

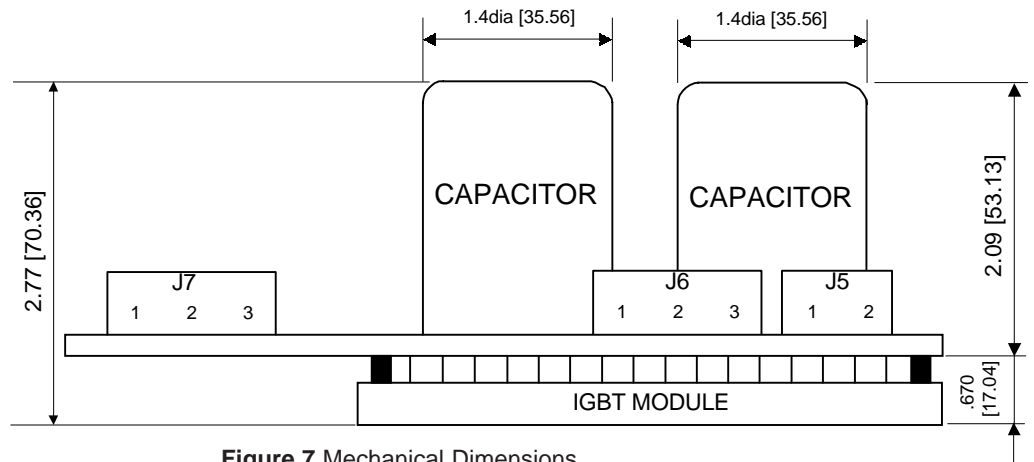
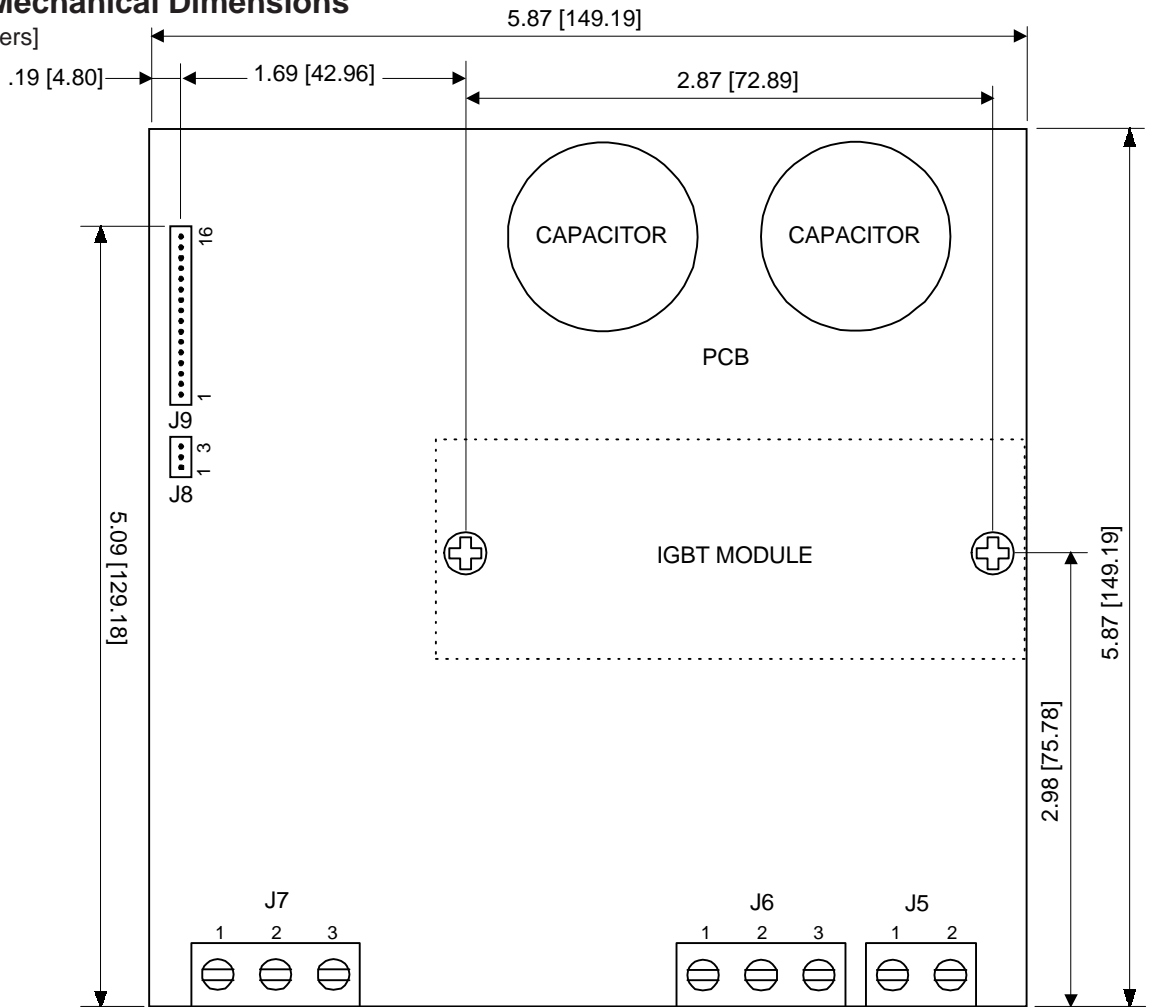


Figure 7 Mechanical Dimensions

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