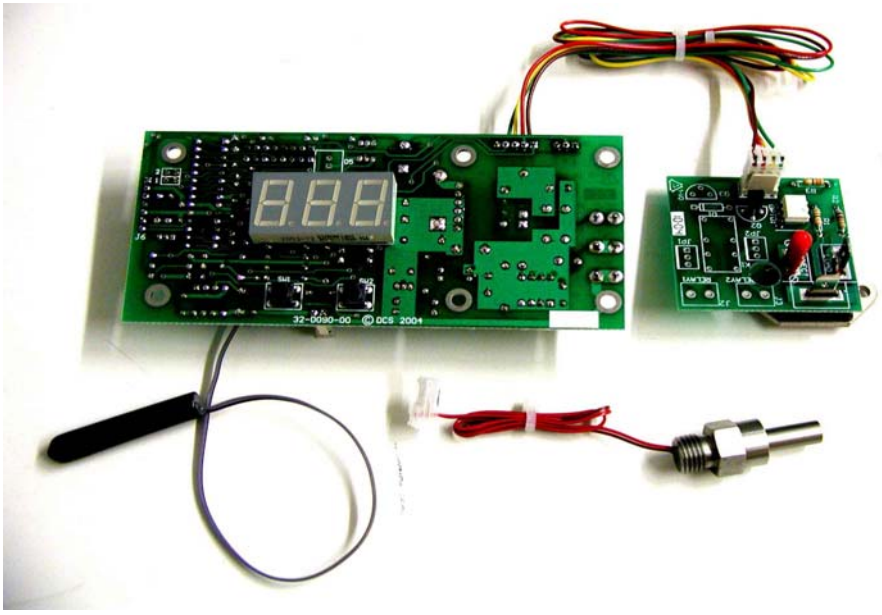
090 SERIES



MICROPROCESSOR BASED PARAMETRIC CONTROLLER

REFERENCE MANUAL

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INTRODUCTION

The 090 series microprocessor based controllers are designed to be incorporated into end products that must accurately maintain the value of an electrically controllable process parameter such as temperature, relative humidity, gas concentration, etc. The 090 series is UL recognized to UL 61010-1 (2nd edition) and CSA C22.2 No. 1010.1 (2nd edition) making it inexpensive to incorporate into equipment that meets domestic and overseas safety certificating agency requirements.

Members of the 090 family accept inputs from a wide variety of variable resistance or voltage sensors and can directly control loads up to 15 Amps at up to 240 VAC. An available second control channel, several alarm output options and the ability to directly operate on power mains from 80 to 280 VAC make the 090 series an economical choice for a wide range of appliance control applications for the worldwide market.

This manual is intended for the OEM purchaser of the control. It describes the controller's operation and covers the installation as well as the front panel operation of the 090 series. Purchasers of 090 series controllers are granted a license to make copies of the Front Panel Operation section of this manual for the sole purpose of providing operating instructions to their end users.

The *Functional Description* section provides a technical overview of the 090 series and their operation. It contains information useful to technical and engineering personnel who will be involved with integrating the controller into the end product.

The *Installation* section of this manual is a guide to integrating the 090 series into the end product. It contains the mechanical mounting dimensions which are common to all 090 series models. A typical installation is described in detail and the pros and cons of several variations are discussed. This section also contains data on electrical connections for operating power, sensor inputs and control outputs.

SPECIFICATIONS

This section covers the basic specifications common to all M090 series controllers. Specific features of different variants are covered in their detail documentation.

Parameter	Value
Display (display type must be specified when ordering)	3 or 4 digit, 0.56" 7 segment LED Optional 'Output Active' LED (Green is standard, red & yellow available)
Operator Controls	Front panel 'UP' and 'DOWN' buttons On-board jumpers for option control
Resolution (Control and Display)	± 1 least significant display digit
Control Algorithm	PID
Load Control	PWM Triac contact rated 15 Amps RMS
Sensor inputs available (sensor type must be specified when ordering)	10 mV/ °C integrated sensor Type 'J' or 'K' thermocouple 100 Ohm RTD Analog voltage (5 volts max)
Alarm Contact (optional)	2 dry contacts field configurable as NO or NC. Rated 110VAC, 1A.
Alarm Sounder (optional)	85dB, 2 KHz beeper
Operating Power Requirements	80 to 280 VAC, 45 - 65 Hz, 5W max
Ambient Operating Conditions	0 to 50 degrees Celsius 0 to 80 %RH non-condensing Pollution Degree 2
Mechanical Dimensions	Main ECB: 5.25" x 2.35" (13.5 x 6 cm) Power ECB: 1.9" x 2.0" (5 x 5 cm)
Weight	Main ECB: 2.3 Oz (65 g) Power ECB: 1.5 Oz (42 g)
Ambient Storage Conditions	-30 to 85 °C 0 to 90%RH (non-condensing)

FRONT PANEL OPERATION

The front panel of the 090 series consists of a three or four digit numeric LED display, and two momentary push button switches labeled 'UP' and 'DOWN'. In normal operation the current process value is displayed.

Several other parameters can be displayed, depending on the operating modes as described below. Whenever a parameter other than the current process value is first displayed, it is annunciated by a two letter code displayed for several seconds before the parameter's value is displayed.

Start up

Whenever power is first applied to the controller, its firmware version data is displayed as three separate numbers, each preceded by an identifying quasi-alpha string as shown in the table below.

Identifier	Meaning
SN1	Firmware type number
Sn2	Firmware major version number
Sn3	Firmware minor version number

Table 1: Version Number Display Annunciation.

After these values are displayed, the controller begins operation in normal operation mode as described below.

Normal Operation

In this mode the display shows the current process value. The display intensity is steady and at most a single decimal point is illuminated. The controller always returns to this mode from any other mode after approximately five seconds of no front panel button activity.

If over/under alarms are enabled *and* the process value is in either over or under alarm the display will alternate between showing either 'HI' or 'LO' (depending on process value) and the actual process value. When in alarm, the audible beeper will also sound if installed.

Viewing and Modifying the Setpoint

The current setpoint can be displayed by momentarily pressing and releasing either the 'UP' or 'DOWN' button. The display briefly shows 'SP' to annunciate the value about to be displayed, then shows the setpoint value.

Whenever the setpoint value is showing, the display blinks. While the setpoint value is blinking its value can be adjusted with the 'UP' and 'DOWN' buttons.

The controller automatically stores the current display value as the new setpoint and reverts to Normal Operation mode after approximately five seconds of no front panel button activity.

Calibrating Process Input

The process input can be calibrated from the front panel by pressing and holding both 'UP' and 'DOWN' buttons for approximately three seconds until the display shows one of the calibration indicators shown in the table below:

INDICATOR	Cal Mode
CP	IC temp probe calibration
CO	Offset Calibration
CS	Span Calibration

Table 2: Calibration Mode Annunciation

The type of calibration is determined by the sensor input configuration.

After displaying the calibration indicator for several seconds, the display blinks the current process value to indicate that it can be changed with the 'UP' and 'DOWN' buttons.

After approximately five seconds elapse without either button being pressed, the controller will exit calibration mode. If the displayed value is to be changed, the operator must begin making the change within a few seconds after the display begins to blink. When the changes are complete, the controller will return to normal operation approximately five seconds after the last button press.

At this point the new calibration value is stored in non-volatile memory and takes effect immediately.

FUNCTIONAL DESCRIPTION

This section provides a technical overview of the M090 series.

Block Diagram Hardware Description.

The block diagram of the 090 series is shown as Figure 1.

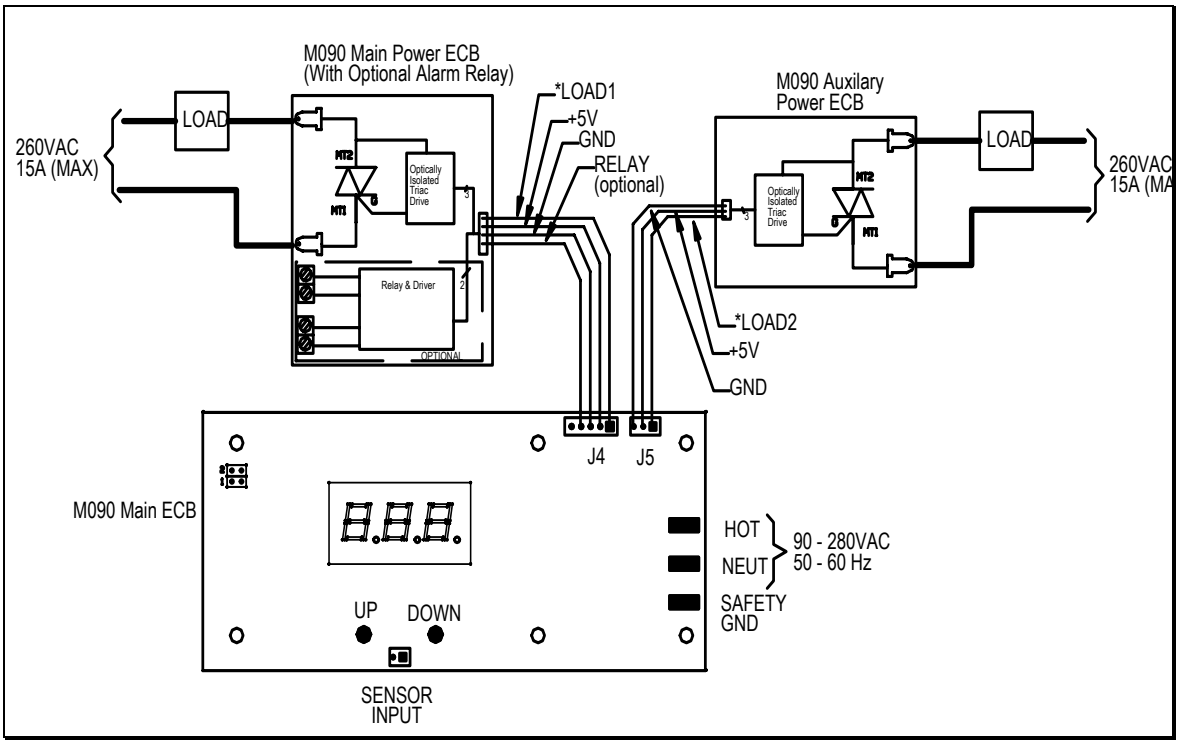

Figure 1: 090 Series Block Diagram

Overview

The 090 Series controller's main ECB contains the power supply as well as controller logic and implements the user interface consisting of two buttons ('UP' and 'DOWN') and a numeric LED display. The process sensor (various temperature sensors and voltage inputs are supported depending on the exact controller configuration) and line voltage operating power are the inputs to the main ECB. The controller's load and alarm outputs are generated as isolated, TTL level signals on the main ECB and used to actuate the alarm relay and load contacts located on the Power ECB.

A maximum of two power ECBs can be connected to each main ECB. The power ECB implements an optically isolated, electrically floating triac. The two power terminals of the triac (MT1 & MT2) are terminated with ¼" 'quick connect' tabs and intended to be connected in series with the controlled load as shown in Figure 1. The 090 series triac power ECBs can control only alternating current. Do not attempt to use them for controlling direct current loads.

Main ECB

The 090 series main ECB is designed for mounting behind the front panel of the end-user's equipment. It implements all the front panel displays and controls, requiring only descriptive annunciation on the equipment panel. An audible alarm beeper, intended to sound through the front panel, is available.

The 090 is powered directly from the AC power line, draws under 5W and operates on voltages from less than 80 to 280 VAC at 45 to 65 Hz making it directly connectable to virtually any power grid worldwide. The circuitry on the primary side of the transformer T1 (shown cross-hatched in **Figure 2**) has voltages significantly above the input line voltage and can provide unpleasant and potentially lethal electrical shocks both to earth ground and other components on the board.

The low voltage side of the power supply is electrically isolated so that all control connections to the power ECBs present no shock hazard. The earth ground connection is tied to the ground side of the low voltage supply and passes through to the power ECB(s).

There are three control outputs from the main ECB. Two load contact controls designated *LOAD1 & *LOAD2 as well as one relay control designated RELAY. All these signals are TTL level referenced to earth ground. *LOAD1 & *LOAD2 are active low (i.e. the load contact is closed when the voltage is less than approximately 0.4V), RELAY is active high. (see Table 3 on page 9)

These outputs are intended to drive the corresponding features on power ECBs. *LOAD1 and RELAY actuate the triac and alarm relay respectively on the primary power ECB. *LOAD2 actuates the triac on the auxiliary power ECB if present.

All three signals (along with power) appear on connector J4 so that a single control cable can be used to remotely drive the full complement of outputs. In addition, *LOAD2 (along with power) appears on J5 for applications where the main and auxiliary power ECBs are most efficiently served with two separate cables.

There are 2 two-pin jumpers (designated JP1 & JP2) located in the lower right-hand corner of the main ECB when viewed from the rear. These are to implement various user functions in different configurations. Each jumper has two states: *OPEN* and *CLOSED*. A jumper is considered OPEN when its two pins ARE NOT electrically connected. A jumper is considered closed whenever its two pins ARE electrically connected. A jumper is typically closed momentarily with a small bladed screwdriver and closed semi-permanently with a shorting block that slides over the two pins of the jumper.

The sensor input connector is located on the back side near the bottom edge of the main ECB just to right of center. Various sensor inputs are supported depending on the exact configuration. Each 090 series has only a single sensor input. The value displayed on the front panel during normal operation is the process value associated with this sensor.

Power ECB

The load contact is implemented with a 25 amp, 600 volt triac, triggered with an optically isolated, zero crossing triac trigger. All control inputs are electrically isolated from the controlled circuit so there is no shock hazard from the interconnect cabling.

When controlling load currents above 1 amp the mounting tab of the triac MUST be firmly screwed down to a suitable metal surface that can sink the heat generated by the triac while passing the full-load current. The higher the load current, the more thermal energy must be removed to keep the triac within safe operating limits. An approximately 6 x 6 inch square of 18 Ga cold rolled steel is usually adequate for most loads up to 10 Amps.

The load contacts are the two ¼" quick connect tabs marked 'LOAD' and 'HOT'. A third 3/16" quick connect tab, covered by a plastic cap, is located near the two load terminals. This tab is electrically hot (under the cap) and must never be electrically connected-to.

The load contact is intended to be connected in series with the load as shown in Figure 1. Because the triac floats electrically, it can operate in either polarity on either side of the load. The triac always operates in quadrants I & III regardless of the connection topology.

The standard power ECB is intended for control of primarily resistive loads in the .25 to 15 amp range. Specific options exist for driving small inductive loads (such as solenoids). Consult the factory for applications driving inductive and higher power (above 15 amps) loads.

The load contact is **NOT** fused. IT IS THE RESPONSIBILITY OF THE END USE EQUIPMENT TO PROVIDE THE OVER CURRENT PROTECTION APPROPRIATE TO THE APPLICATION.

Power ECBs are connected to the main ECB through an isolated, low voltage (TTL) interface connected at J1. At a minimum the power ECB requires +5, GND and the *LOADx control signal, so at least a three conductor cable is required. A 4th conductor must be added to drive the optional relay.

One power ECB can optionally be provisioned with a DPDT relay. In this configuration it is referred-to as the main power ECB to distinguish it from the auxiliary power ECB which has only a load contact. Two electrically separate dry contacts are provided at the two position screw terminal blocks J2 & J3. Both contacts actuate simultaneously but can be separately configured to operate as either normally open or normally closed using the jumpers JP1 and JP2. The RELAY signal from the main ECB must be connected to the power ECB for the relay to operate.

INSTALLATION

This section covers the major points to consider when incorporating the 090 series into the end product's design.

Main ECB Electrical Connections

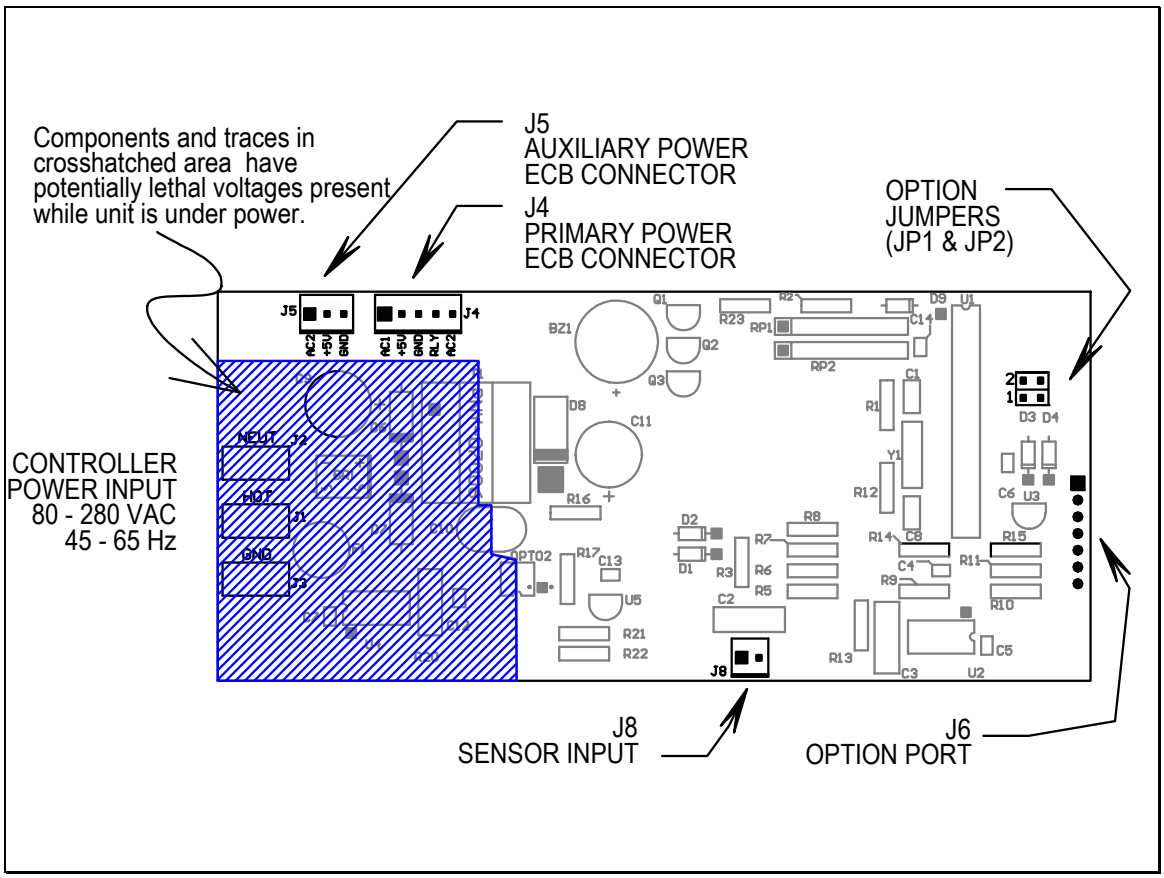

Figure 2: 090 Main ECB Part Locations (Viewed from rear)

Sensor Connection

The sensor is connected to the two pin header J8 located at the bottom of the power board as shown in **Figure 2**. The exact sensor type is determined by the controller configuration. The sensor cable should not be routed near power carrying wires to minimize noise pick-up.

Power Line Connection

The controller's operating power is connected at the three ¼" quick connect tabs located on the left hand edge of the main ECB as shown in **Figure 2**. Beware that traces and components in the area shown crosshatched in **Figure 2** can have potentially lethal voltages to ground and each other while the unit is under power.

If one leg of the power supply is grounded (i.e. neutral for domestic applications) it should be connected to the power tab marked 'NEUT', since the 'HOT' terminal is the fused input.

The 'GND' terminal is the ground of the low voltage power supply and should be connected directly to earth ground.

Fusing

The operating power input is fused for fire protection in the event of a component failure by a 1 Amp fuse F1 located near the power input tabs. This fuse is not intended for operator replacement and should never open during normal operation. It is very unlikely that normal operation can be restored by simply replacing F1 after it blows.

If replaced, it must be replaced with a fuse of like rating (1 Amp at 250V) for continued protection against fire.

Control Output Connections

All control outputs of the M090 main ECB appear on the five pin header J4. The *LOAD2 output as well as +5 VDC and ground are duplicated on the three pin header JP5. This is done to give the user the option of providing a unique cable to the auxiliary power ECB if one is present in the system. If both power ECBs are located distant from the main ECB, it may be more convenient to run a single cable that carries all the signals needed to run both power ECBs.

The signals on J4 and J5 are shown in the table below.

Signal	Description	J4 Pin #	J5 Pin #
*LOAD1	Active Low TTL control signal for main triac. Connects to *LOAD pin on power ECB.	1	N/C
+5 V	5 volt DC operating power	2	2
GND	system ground	3	3
RLY	Active high TTL relay control signal	4	N/C
*LOAD2	Active Low TTL control signal for auxiliary triac. Connects to *LOAD pin on power ECB	5	1

Table 3: Main ECB Control Output Connector Pinout

Jumpers

There are two contact closure inputs called option jumpers as shown in **Figure 2**. When the two pins (.025" square pins spaced 0.1" apart) associated with each jumper are electrically connected the jumper is considered closed. The result of closing a jumper varies by firmware configuration.

Option Port

A seven pin header called J6 is used for factory testing and connecting to various options such as RS-232.

Power ECB Electrical Connections

The layout of the M090 power ECB is shown in Figure 3.

Load Connection

The load(s) to be controlled by the 090 must be connected in series with the power ECB triac as shown schematically in Figure 1. The two floating triac contacts appear as ¼" quick connect tabs labeled 'HOT' and 'LOAD' as shown in Figure 3.

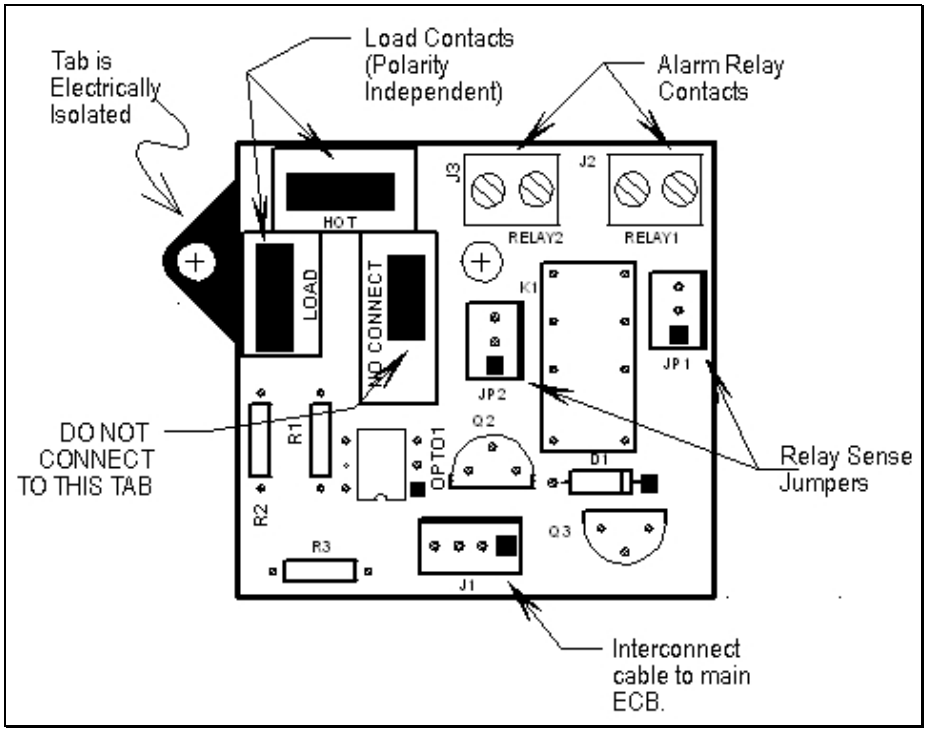

Figure 3: Power ECB Component Locations

One side of the load must be connected to either one of these quick connects. The power line leg not connected to the load is connected to the quick connect. Power line polarity and whether the triac is switching the load's supply or return are irrelevant despite the nomenclature of the contacts. The triac always operates in quadrants I and III.

There is a 3/16" quick connect tab marked 'NO CONNECT' and covered with a plastic cap located as shown in Figure 3. This is the gate terminal of the triac. It is at power line potential and must never be connected to.

The power ECB triac starts conducting at the next power line **voltage** zero crossing after the *LOAD signal voltage falls below the logic low threshold. The triac stops conducting at the next load **current** zero crossing after the *LOAD signal rises above the TTL high threshold.

Control Cable Connection

The cable from the M090 power ECB is connected at J1 located as shown in Figure 3. Power ECBs that have the relay option installed have a four pin connector at J1. Those without the relay option can operate with only a three pin connector at J1. The pinout of J1 is shown in the table below:

Pin #	Name	Description
1	*LOAD	Active low TTL triac control signal (triac conducts when < 0.4 V)
2	+5	5 VDC power supply
3	GND	Power supply ground
4	RELAY	Active high TTL relay control signal (relay actuated when > 2.5 V)

Table 4: Power ECB Control Connector Pinout.

All signals in the control cable connecting the main ECB to the power ECB(s) are low voltage (under 10 volts) and do not require line voltage capable cabling. Current requirements of all conductors is below 0.2 amps. Conductor sizes of 24 – 26 AWG are recommended.

Control cable connectors at both ECBs are .025" square pin, 0.1" pitch headers with a locking tab. Several manufacturers offer insulation displacement style connectors that mate directly with headers on the ECBs, such as the AMP MTA-100 series and ITW Pancon Mas-Con series CE/CT. Some typical part numbers are shown below. There are other manufacturers as well.

ITW Pancon PN	AMP PN	Description
CE100F26-04	640442-4	4 position IDC connector for 26 AWG wire
CE100F24-03	640441-3	3 position IDC connector for 24 AWG wire

Table 5: Control Cable Connector Vendor PNs.

Alarm Relay

An optional DPDT relay rated 120 VAC, 1A can be supplied on only one power ECB per Model 090. When the relay option is installed two independent dry contact closures appear on the two 2 position screw terminals J2 & J3. The circuit for a typical contact is shown in Figure 4.

The two 3 position headers at JP1 & JP2 program the sense of the two relay contact outputs as shown in the table below. The two jumper pins are connected with supplied shorting blocks. Pin 1 on all connectors is denoted with a square pad.

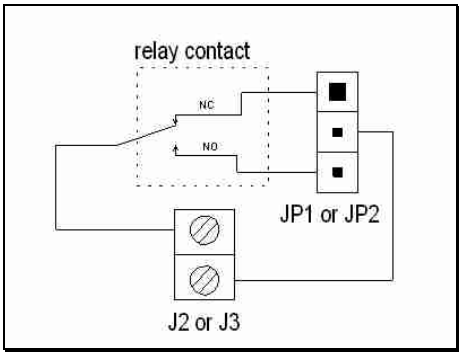

Figure 4: Alarm Relay Contact Circuit

JP1 pins connected	J2 Sense	JP2 pins connected	J3 Sense
1 - 2	Normally closed (NC)	1 - 2	Normally Closed (NC)
2 - 3	Normally Open (NO)	2 - 3	Normally Open (NO)

Table 6: Relay Contact Sense Jumper Settings.

Normally Closed means the relay contact is closed when the RELAY signal is at logic low.

Load Circuit Considerations

Triac Power Dissipation

The load is switched with a triac rated for 25 amps at 600 volts. When conducting, the triac dissipates up to 1.4 Watts per Ampere of load current. At load currents above 1 amp the mounting flange of the triac **must** be secured to a suitable heat sink. For moderate loads (less than 8 to 10 amps) the triac can be screwed directly to painted metal. For higher loads direct contact to bare metal is usually required and actual temperature at full load must be verified as described below.

The power ECB is intended to be installed by screwing the triac's mounting flange to a flat metal surface with two # 6 screws. A 6" x 6" area of 18 Ga. cold rolled is usually adequate heat sinking. Larger area will result in cooler operation for the same load current. Actual heat sink temperature must be evaluated under full load conditions to ensure maximum operating temperature of the triac is not exceeded.

Case temperature of the triac is measured at the exposed portion of the mounting flange immediately adjacent to the mounting screw's head. The maximum temperature at this point is 85 °C. If the temperature at this point exceeds 85 °C, more heat sink area must be provided or the load current reduced.

Triac Fault Protection

The load circuit is not fused. The triac used on the power ECBs is extremely rugged and can usually endure load short-circuit current for long enough to trip a 15 to 20A branch circuit breaker in most applications. In low source impedance applications where triac protection under short circuit conditions is required, a fuse with an i^2t rating of 260 $Amps^2$ sec or less must be installed in series with the load circuit.

Mechanical Mounting

The 090 series consists of a main ECB intended to mount behind a control panel, and one or two smaller power ECBs.

The numeric LED digits and two buttons on the main ECB are the 090 series' user interface. This board is intended to be mounted behind the end product's front panel with the LED display showing through a cutout. Two additional cutouts below it allow actuation of the switches.

The power board contains the power and (optional) alarm relay connectors, and need not be accessible to the user. It is intended to be mounted on an internal metal wall which also acts as the triac's heat sink.

Main Board Mounting

The preferred mounting for the main board is shown in

Figure 5. The board is mounted on standard 3/8 inch self-clinching studs (PEM SOS-12-440 or equivalent) pressed into holes drilled through the end product's front panel. Using self-clinching standoffs is preferred because the thickness of the front panel does not affect the position of the switch shaft relative to the front surface of the panel. The length tolerance of the stand offs should be ± .006" or better.

Proper standoff installation is critical. Insufficient standoff protrusion may cause the button shafts to interfere with the overlay at worst case tolerance conditions. Excessive protrusion makes the button difficult or impossible to actuate. Embossing a .030" inch raised 'button' into the overlay will minimize tolerancing problems.

Maximum required switch shaft travel is .015 inches. At the worst case tolerance condition of maximum stroke, shortest shaft length and longest standoff length, the front of the switch shaft must be depressed .027" below the front surface of the panel.

In applications where other mounting schemes will be used, some important tolerances to keep in mind are shown the table below.

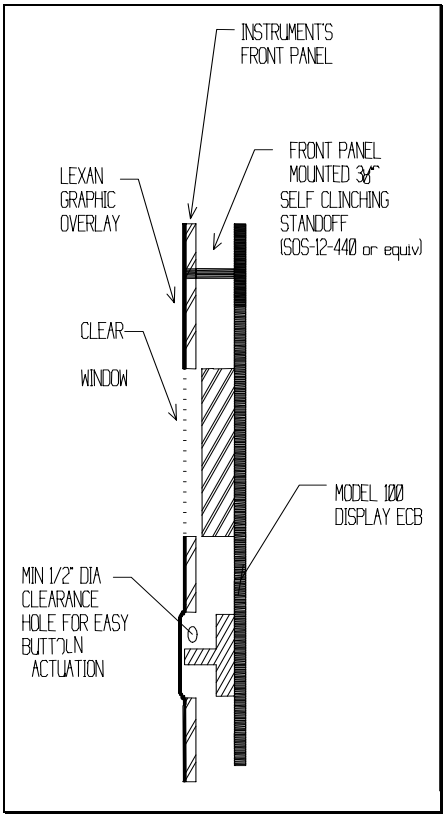

Figure 5: Main ECB Front Panel Mounting

Dimension	Value in Inches
Switch shaft length (from front surface of ECB)	.374 ± .006
Switch actuation travel	.010 ± .005
Thickness of plating at display board mounting holes	.004 ± .001

Table 7: Important Front Panel Mounting Dimensions

Clearance and Ventilation

All main board components except the display and buttons are on the side facing away from the front panel. Clearance of at least 1 inch (2.54 cm) must be provided behind the main board to ensure that there is no mechanical interference with components on the board. There must be free air movement within the clearance volume; packing the volume immediately behind the board with loose-fill insulation or the like may lead to localized over-heating on the main board and is to be avoided.

Thermal Issues

The power supply on the main board dissipates so little heat that self-heating should not be an issue if the 1 inch back side clearance is maintained. The main board should be located so that it is not heated to over 50 degrees Celsius by energy dissipated by other heat sources.

Front Panel Trim

The preferred method of trimming the front panel is a lexan overlay with a clear window through which the LED display can be read. A frosted window will noticeably blur the display digits, though not usually enough to make them unreadable.

The area on the overlay above the two switches can be marked with just a button shaped graphic to indicate where to press, or a raised button can be embossed. In any case the front panel hole through which the switch shafts protrude should be at least a half inch in diameter and burr free to allow the overlay to travel the required (up to) .027 inch into the front panel to actuate the switch without chafing the overlay material.

Be sure to specify no adhesive on the back of the overlay in the button area.

Mechanical dimensions of the main ECB are shown in Figure 6.

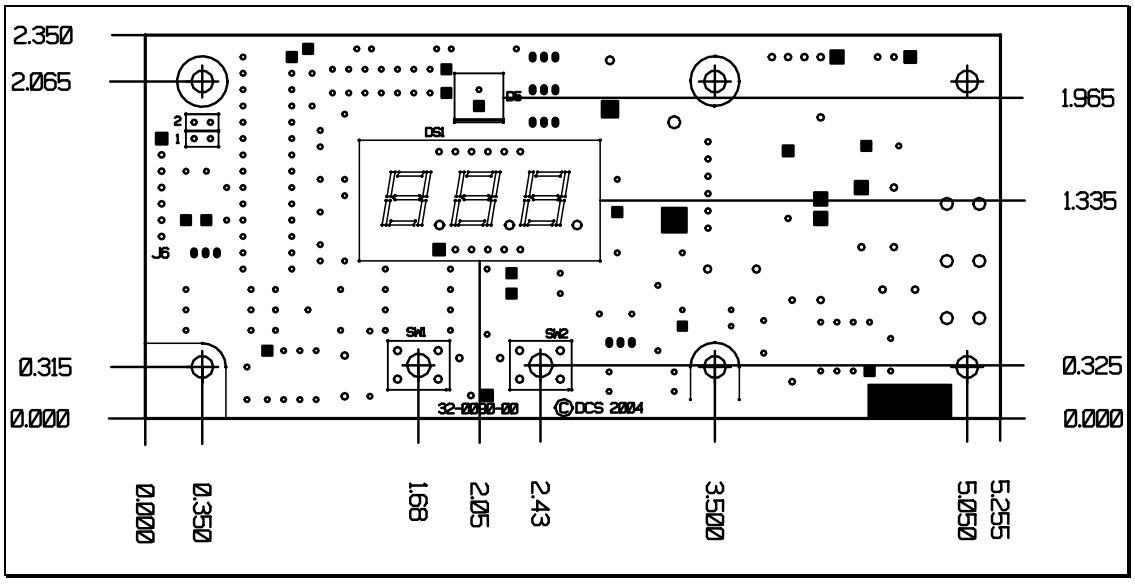

Figure 6: Main ECB Mechanical Dimensions (in inches)

Power Board Mounting

This section discusses various issues related to mechanically mounting the power board in the equipment to be controlled.

Mechanical Attachment

The power ECBs are intended to be attached to their mounting surface with the metal flange that forms the bottom of the triac assembly. The mounting flange is electrically isolated and can be directly attached to any surface.

There are two mounting holes in the flange. One is on the portion of the mounting flange that extends past the perimeter of the circuit board, the other is accessible through a large hole in the circuit board near the power connection tabs. Use of #6 hardware (or equivalent) is recommended for mounting the power ECB, though #4 can be used for low to moderate current applications.

Thermal Considerations

The surface to which the power ECB is attached acts as the heat sink for the triac which must dissipate 1.4 Watts per Amp of load current. Depending on the load current profile, the local heating that results can be significant and must be accounted-for. In any case the power board should be mounted in a location where it is not being heated by outside sources.

Because the excess heat from the triac is conducted into the surface onto which the power board is mounted, only minimal air circulation is required. At least one inch (2.54 cm) of clearance is recommended above the power board.

The actual triac case temperature at full load and maximum rated ambient temperature must be verified during the design-in engineering phase to ensure that it does not exceed 85 °C. Case temperature of the triac is measured at the exposed portion of the mounting flange immediately adjacent to the mounting screw's head. See the section on load considerations starting on page 12 for other important thermal considerations.

The power ECB(s) must be positioned so that it is inaccessible to the end user and the interconnect cable is not under mechanical tension.

Mounting dimensions are shown in Figure 7.

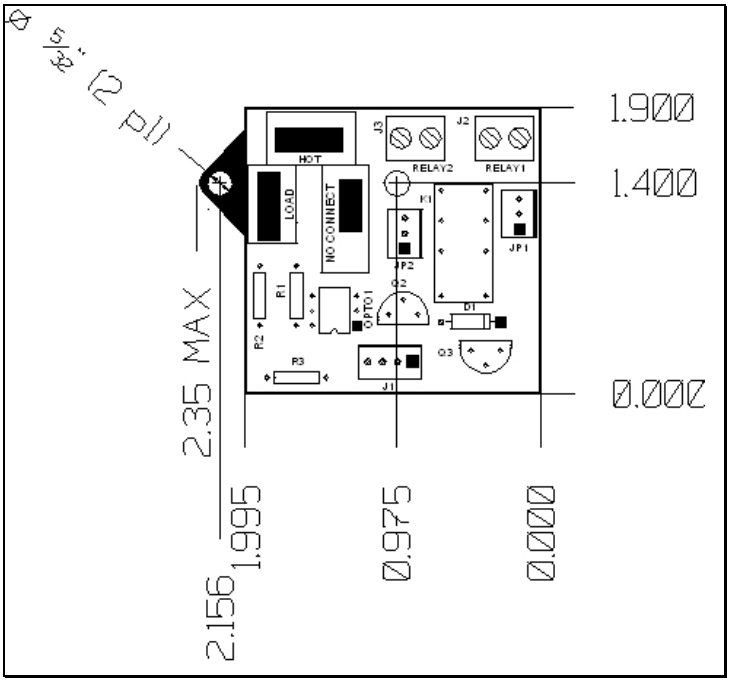

Figure 7: Power ECB Mechanical Dimensions (in inches)