Midi 40 CO2 Incubator

Models 3403 and 3404
Service Manual 7993403 Rev. 2

Part of Thermo Scientific

Manual Number 7993403

2	28728	6/18/12	Added full CO2 calibration procedure - Section 7	ccs
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REV	**ECR/ECN**	**DATE**	**DESCRIPTION**	**By**

Important Read this instruction manual. Failure to read, understand and follow the instructions in this manual may result in damage to the unit, injury to operating personnel, and poor equipment performance. ▲

Caution All internal adjustments and maintenance must be performed by qualified service personnel. ▲

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Progressive product changes will be entered into the service manual as it is revised. The manual is intended as an aid to persons qualified in the service of applicable equipment. It is not intended to teach unqualified persons on applicable equipment all procedures necessary to make repairs.

Important operating and/or maintenance instructions. Read the accompanying text carefully.

Potential electrical hazards. Only qualified persons should perform procedures associated with this symbol.

Equipment being maintained or serviced must be turned off and locked off to prevent possible injury.

Hot surface(s) present which may cause burns to unprotected skin, or to materials which may be damaged by elevated temperatures.

Marking of electrical and electronic equipment, which applies to electrical and electronic equipment falling under the Directive 2002/96/EC (WEEE) and the equipment that has been put on the market after 13 August 2005.

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- ✔ Always dissipate extreme cold or heat and wear protective clothing.
- ✔ Always follow good hygiene practices.
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Table of Contents

Section 1 General Information

The purpose of this manual is to provide procedures developed to assist the field refrigeration technician in troubleshooting and repairing certain conditions.

The incubators described in this manual are classified for use as stationary equipment in a Pollution Degree 2 and Overvoltage Category II environment, according to the UL3101-1 and IEC 664 standards.

These units are designed to operate under the following environmental conditions:

• Indoor use

• Altitude up to 2000m

• Maximum relative humidity 80% for temperatures up to 31°C

• Main supply voltage fluctuations not to exceed 10% of the nominal voltage.

Table 1: Typical Dimensions		
Height	Width	Front to Back
18 in.	23.5 in.	18.5 in.
46.7 cm	59.7 cm	47 cm

Symphony incubators are designed to create a stable, reliable environment for cell culture applications. They operate at temperatures ranging from 5°C above ambient temperature to +40°C, accurate to ±0.2°C. The gas system controls within ±0.1% of measurable setpoint.

Each chamber consists of two sections: the cabinet (where the product is stored) and the control section (containing the temperature, CO_2, and humidity control systems). On single-chamber models, the control section is to the side of the cabinet.

Location

Locate the unit in a level area free from vibration with a minimum of three inches (7.6 cm) of space on the sides and rear and 12 inches (30.5 cm) at the top. The table must be able to support 40 PSI. Also, allow enough clearance so that the door can swing open at least 90 degrees, and the power cord can easily be reached to disconnect power. Do not position the equipment in direct sunlight or near any HVAC duct/diffusers. The ambient temperature range at the location must be 59°F to 90°F (15° to 32°C).

Included Parts

The following items are packaged and shipped inside the incubator cabinet:

- The operating manual
- Shelves and shelf brackets
- 1/4 in. (476 mm) ID clear tubing for the gas connection
- Cordset
- 5" round humidity pan
- Additional CO_2 sensor gasket
- CO_2 disposable filter 99.97

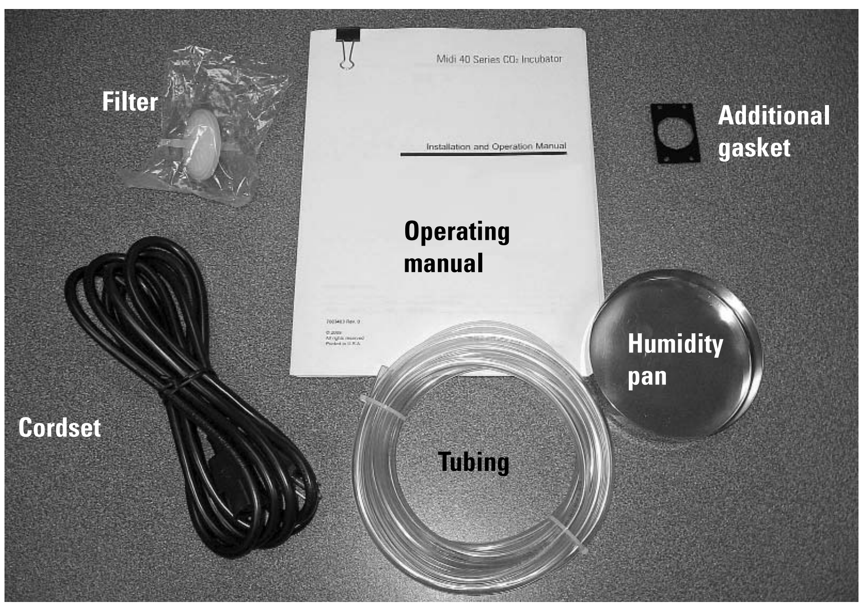


Figure 4-1. Included Components (shelves and brackets not shown)

CO2 Gas Supply

Verify that the incubator gas supply is available near the installation area. The required gas supply pressure is 15 PSI, controlled by a high-quality, two-stage regulator suitable for the connected input gas.

Do not connect the gas at this time.

Wiring Cautions

Caution Connect the equipment to the correct power source. Be sure to operate the incubator at the voltage specified on the dataplate. Incorrect voltage can result in severe damage to the equipment. ▲

Warning Failure to properly ground the equipment may cause personal injury or damage to the equipment. ▲

Caution Always conform to National Electrical Code and local codes. ▲

Warning Do not connect the unit to overloaded power lines. ▲

The incubators described in this manual are rated for supply voltage 115/120VAC, single-phase, 60Hz, 3 amps.

Always connect the unit to a dedicated (separate) circuit. Do not exceed the electrical and temperature ratings printed on the data plate. Electrical codes require fuse or circuit breaker protection for branch circuit conductors.

Model and Serial Number

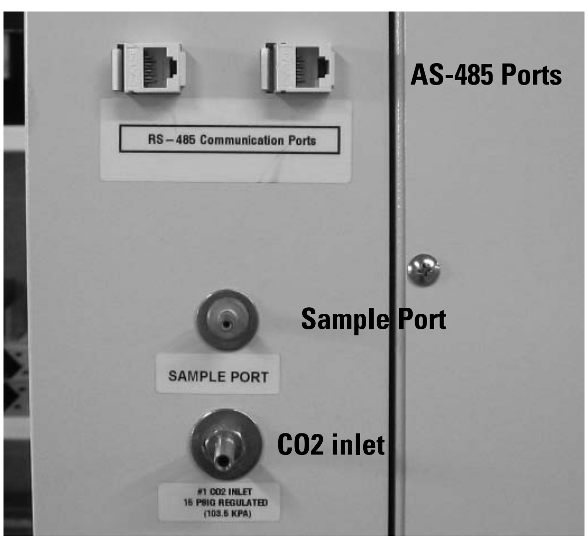
Model numbers are important because they identify the unit for service capability. The serial number is a unique number that identifies the unit as a specific unit. No other unit has that same number.

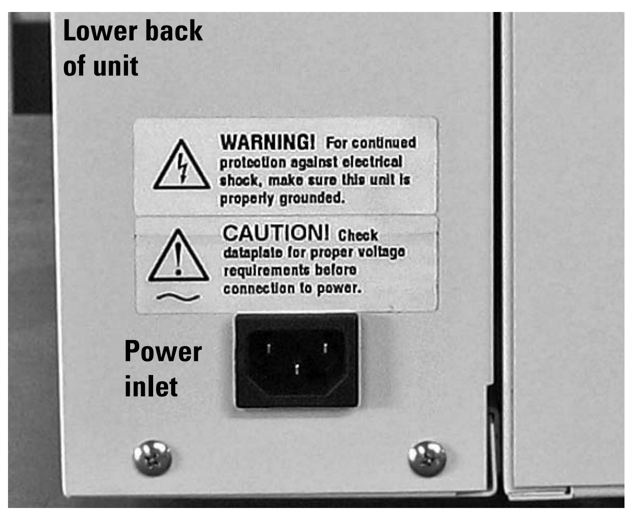
The model and serial numbers of your incubator are printed on a plastic identification plate, commonly referred to as the data plate. The most important information concerning your unit can be gathered from the model number and the serial number identification. Additional information is available on the data plate; such as the voltage, frequency, and current ratings.

The data plate is mounted on the outside of the cabinet, beside the upper door hinge. Some older models may have the plate mounted on the front of the frame, just above the lower door hinge.

Component Locations

Upper back of unit





Section 2 Safety

Incubators are complex equipment. Any attempt to repair a incubator should be done with caution. There can never be too much said or written concerning safety in any area of work, especially when dealing with electricity. Safety should be everyone's concern and responsibility. Personal safety begins with knowledge of the equipment being worked on. Listed below are a few ideas and reminders of safety concerns while working on incubators.

Electrical Safety

In this manual and on labels attached to this product, the words **Note** and **Caution** mean the following:

- **Note** May indicate information that may particularly useful, yet not obvious to someone who is unfamiliar with this particular model.
- **Note** May indicate a situation which could result in failure of the system to function properly unless detailed attention is given to the procedure.
- **Caution** A potentially hazardous situation exists, which may result in personnel injury or damage to the equipment. Before installing, using or maintaining this product, please be sure to read this manual and product warning labels carefully. Failure to follow these instructions may cause this product to malfunction, which could result in injury or damage.

Below are important safety precautions that apply to this product:

- **Caution** When replacing any component, ensure any green ground wires are reconnected securely in their original positions to avoid danger of shock or short circuit.
- **Caution** Never interfere with or bypass the operation of any switch, component or feature of the unit. Interlocks, relays, and switches are designed with a specific purpose and should, therefore, not be altered.
- **Caution** The user is responsible for carrying out appropriate decontamination procedures when hazardous materials are spilled on or inside the incubator.

Electrical Safety (continued)

- **Caution** Be careful when handling access panels, parts, or any components which may have sharp edges which may cause damage to wiring and electrical connections, or personnel injury.

- **Caution** Warranty will not be responsible for damage caused by failure to disconnect the unit from all power sources before cleaning, troubleshooting, or performing other maintenance on the product or its controls. To disconnect power supply to the incubator, unplug the supply cord at the back of the incubator. Note that turning the key switch on the front control panel to the Off position is not sufficient to disconnect power.

- **Caution** Do not modify system components, especially the controller. Use OEM exact replacement equipment or parts.

Before use, confirm that the product has not been altered in any way.

- **Caution** Use only approved replacement parts that are the correct size, rating, and capacity as the original part.

- **Caution** Never interfere with or bypass the operation of any switch, component or feature of the unit.

- **Caution** Before reconnecting the power supply, ensure all uninsulated wires or terminals are not touching the cabinet

- **Caution** Warranty will not be responsible for damage caused by altering a power cord in order to make it fit an electrical outlet. The line cord must be plugged into a grounded, three-prong receptacle. Never cut or remove the third (ground) prong from the power cord connector.

- **Caution** Never substitute ordinary wire for any internal wiring. The internal wiring of these units carry a special rating due to the somewhat high currents that they can be subjected to at times. This heavy current load generates heat, which can melt ordinary wire. It is vitally important that all connections are tight and secure.

- **Caution** To avoid electrical shock, fire, and equipment damage, ensure that any wires or terminals touching the cabinet are insulated before connecting the power supply. Electrical wiring and all grounds must be correctly reconnected and secured away from sharp edges, components and moving parts. All panels and covers should be reinstalled before the incubator is plugged in.

Electrical Safety (continued)

- **Caution** Warranty will not be responsible for damage caused by the use of steel wool, chlorinated products, corrosive agents, formaldehyde, concentrated mineral acids, high pressure steam at over 100°C, benzyl alcohol, Methylene Chloride or other caustic agents.

- **Caution** Warranty will not be responsible for damage caused by disconnecting components with the power cord still plugged into the wall outlet.

- **Caution** Warranty will not be responsible for damage caused by using an improper gas supply, such as a liquid CO2 cylinder with a siphon tube.

- **Caution** Warranty will not be responsible for damage caused by touching gas sensors.

- **Caution** Warranty will not be responsible for damage caused by the use of de-ionized water in the humidity pan.

- **Caution** Warranty will not be responsible for damage caused by gas input pressures exceeding 15 PSIG at the rear of the cabinet.

- **Caution** Remote alarm contacts are rated for a maximum of 3A (amps) at 125VAC.

- **Note** Use this product only in the way described in the product literature and in this manual. Before using it, verify that this product is suitable for its intended use.

- **Note** Know the location of the incubator's circuit breakers or fuses. Ensure all breakers and/or fuses are clearly marked for quick identification and reference.

- **Note** Always use the correct tool for a job and be sure those tools are in good condition. Ensure that tools to be used on electrical devices are well insulated, if applicable.

- **Note** Be sure to reference any applicable wiring diagram(s) when reconnecting and replacing electrical components.

- **Note** Throughout this service manual, additional safety precautions dealing with specific procedures may be presented. This information should be carefully read and observed.

Section 3 Technical Information

This section contains information concerning the unit upon which maintenance is being performed. All numbers given are general in nature and may differ slightly for a particular unit.

Upon start-up, time must be allowed for the interior temperature to stabilize before any adjustments or permanent calibrations are made.

Features and Benefits

- Alarms:

  High and low level CO_2 setpoint alarms, adjustable to within ±1% of setpoint.

  High and low temperature alarms settable by the user.
- Advanced microprocessor controls with large, easy-to-read display. On program request, software steps the user through initial installation and startup procedures.
- Keyed power/alarm switch provides setpoint security.

Microprocessor Control Systems

- Tamper-resistant touchpad data entry with adjustable operating temperature
- Key operated switch for main power and alarm system.
- Extra large digital temperature display, with a resolution to 0.1°C and 0.1% CO_2/RH.
- On-board AC power monitoring with digital read-out of actual line voltage.

Cabinet Construction

- 2” fiberglass insulation
- All-steel cabinet with high-impact epoxy finish for easy cleaning
- Adjustable stainless steel interior shelves
- All the unit exteriors are constructed of painted, cold roll steel.
- One glass inner door with positive latch

Requirements

- A high quality two-stage, low-pressure 30 PSIG pressure regulator is required for proper operation of the CO2 gas supply, 15 PSIG at the incubator.
- CO2 used in the incubator must be at least 99.9% pure.
- Direction-sensitive in-line gas supply filters must be used on the CO2 supply to prevent damage to the solenoid valve. One filter is supplied with the start-up kit:

  Type: Microbiological

  Specification: 0.3 micron

  Location: rear of unit

Alarm Monitoring System

- Built-in safety alarm system with automatic continuous-charge battery back-up.
- Automatic Incident Monitor to advise the user of alarms that may have occurred and cleared while the unit was unattended.
- Low battery indicator
- Touchpad alarm test
- Power failure or temperature deviation outside alarm set limits triggers audible and visual warning.
- Independent high and low alarm setpoints adjustable in 0.1 increments
- RS485 connections for remote monitoring

Section 4 Control Systems Theory

The various control systems theory of operation is described below.

Temperature Control System

Laboratory CO2 Incubators have a “jacket” between the incubator chamber and the exterior wall of the unit. This “jacket” is filled with fiberglass insulation to enhance chamber temperature stability while reducing energy costs.

A temperature sensor located in the chamber air provides a reference point for a closed-loop temperature control system.

CO2 Control Systems

A CO2 sensor constantly detects the level of CO2 in the chamber, and compares the reading with the CO2 setpoint. If the measurement is low, then the CO2 solenoid opens and allows CO2 to be injected until the concentration is within 0.1% of setpoint.

The alarm system constantly monitors the difference between Setpoint and Measured values, and sounds an alarm if the difference is greater than 0.1% above or below setpoint. To prevent false alarms that would otherwise be caused by opening the door, the Low CO2 alarm has a built-in delay of fifteen (15) minutes so that the chamber can stabilize CO2 levels after the door has been opened.

Overtemperature Monitoring System

This system is activated anytime the chamber air sensor detects a temperature above the overtemperature setpoint, which should be set no closer than 0.3°C above the chamber temperature. When the system is activated, the jacket heater is turned off, and both audible and visual alarms are activated. The overtemperature sensor is the chamber air sensor that also provides the signal for the digital display on the control panel.

Door Heat System

Heating the inner surface of the outer door with a low wattage, large area heater provides enough radiant heat to the glass door to control condensation. The microprocessor controls the door heater.

Section 5 Preventive Maintenance and Diagnostics

Preventive maintenance is the best way to ensure that the unit you own or service continues to operate at its optimum level. The following instructions will assist in your preventive maintenance program.

- Cabinet leveling - Check the cabinet to ensure that it is level. Check from the front to the back and then side to side, check the level on a (6) month schedule.
- Cabinet clearance - Locate the unit in a level area free from vibration with a minimum of three inches (7.6 cm) of space on the sides and rear and 12 inches (30.5 cm) at the top. The table must be able to support 40 PSI. Also, allow enough clearance so that the door can swing open at least 90°, and so that the power cord can easily be reached to disconnect power.
- Voltage requirements - Check the voltage requirements every three to six months. Verify that the source voltage is within +10% and -5% of the rated data plate voltage.
- Gasket maintenance - Periodically check the gaskets around the door for punctures or tears. Gasket leaks are indicated by an excessive gas consumption and/or condensation.

  Keep the gaskets clean by wiping gently with a soft cloth.

  To check gaskets for proper sealing, ensure that the cabinet is level. Then use a 2” x 6” piece of paper closed between the gasket and the door at 2” intervals around the perimeter. At each position, pull on the free end of the paper; a slight resistance should be felt. While performing this test, inspect the gasket for cuts or tears. An improperly sealing gasket must be replaced.
- Center Air Temperature Validation - Check the center air temperature using a thermocouple located physically in the geometric center of the cabinet (centered from top-to-bottom, and centered from left-to-right) versus the control panel electronic display. The temperature should match the display within ±0.1°C.
- Electrical wires - Check the electrical control box for any burnt or discolored wires due to lose connections or low voltage conditions.

1. Maintenance should only be performed by trained personnel.

Recommended Tool List

One of the keys to doing a job correctly is using proper tools. The following list is NOT all inclusive of the tools that may be needed to perform the procedures listed in this manual. However, these tools will be needed to perform many of the steps in these procedures.

- Electronic Digital Thermometer (reads ±0.1°C)
- Digital Voltmeter, 4-1/2 digit
- Cordless Screwdriver (reversible)
- Ammeter (4mA – 5A, digital)
- CO2 Gas Analyzer
- Phillips Screwdrivers

Troubleshooting Parameter List

Date of Record:

Model #: Serial #:

Prior Setpoints –

Time at prior Setpoints –

Correct Temperature compared to Setpoint –

Room Temp Changes –

View and record each display:

Current display of temperature “Temp (C)” = ____________

Current display of CO2 “CO2 (%)” = _________________

Press the ‘mode’ and ‘up’ buttons together =

“Ambient Temp” _____________

Press the ‘down’ button = “LOW Temperature” ______________

Press the ‘up’ button = “HIGH Temperature” ______________

Reset the excursions by pressing the ‘up’ and ‘down’ buttons together. Press and HOLD the ‘mode’ button until display changes to “Program Mode” then release ‘mode’ button.

Display = “Set Temp SETPOINT” ____________

Press ‘mode’ button = “Set Temp WARM Alarm” __________

Press ‘mode’ button = “Set Temp COLD Alarm” __________

Press ‘mode’ button = “Set CO2 SETPOINT” __________

Press ‘mode’ button = “Set CO2 HIGH Alarm” __________

Press ‘mode’ button = “Set CO2 LOW Alarm” __________

Press ‘mode’ button = “Set Temp OFFSET” __________ (Actual) and _________ (Offset)

Press ‘mode’ button = “Set CO2 OFFSET” __________ (Actual) and __________ (Offset)

Troubleshooting Guide

Symptom	Solution
General	
No display on control panel.	No power. • The service cord is loose in the outlet or receptacle. • Check the outlet for power. • Check the circuit breaker in the power panel. Ensure the circuit serving the incubator is a dedicated circuit. Reset the circuit breaker. • Check that the keyswitch on the incubator is turned On • Service Tech: Check fuses on Power/Relay Board. • Service Tech: Check other circuits in Technician Diagnostics Guide.
Temperature display disagrees with setpoint.	• Allow sufficient time for stabilization. • Verify temperature setpoint. • Ensure door was not recently opened. If door was opened, allow stabilization time. • Ensure power did not fail recently. If power failed, allow stabilization time after power is restored. • Check door switch operation. • Check chamber fan operation. • Service Tech: Check Temperature sensor resistance (see Appendix)
High temperature alarm flashes.	• Check the incubator location. Keep away from sources of heat: South-facing exterior walls, windows, HVAC duct/diffusers, and other equipment. • Do not open the door more frequently than at five minute intervals. • Set the operating temperature setpoint at least 5°C above the maximum ambient temperature. • Check door switch operation. • Service Tech: Check Temperature sensor resistance (see Appendix)
Oxidation forming on interior surfaces.	• Do not wipe surfaces with a bleach solution greater than 10%. • Always wipe surfaces with mild detergent and water to remove bleach residue. • Never use a steel-wool soap pad on interior surfaces. Use a non-metallic pad (e.g., Scotch-Brite). • Corrosive culture media can cause oxidation.

Section 6 Maintenance & Repair Procedures

Maintaintenance and repair procedures follow.

Replacing the Gas Filter

In order to protect your equipment and cells, each gas supply should an in-line gas filter as shown here ((PN 770001). These filters trap particles as small as 0.3 micron and moisture that could damage the gas solenoids. It is critical to the filter operation that the correct orientation be observed when installing these filters.

1. Locate the gas supply and turn off the supply valve.
2. Pull the gas supply tubing from the end of the filter, and pull the filter from the short length that connects it to the incubator's barbed brass fitting.
3. Discard the old filter.
4. Locate the side of the filter that has the word "IN" molded and connect the gas supply to this side of the filter. Connect the other side of the filter to the incubator's barbed fitting.
5. Turn on gas supply and resume normal operation.

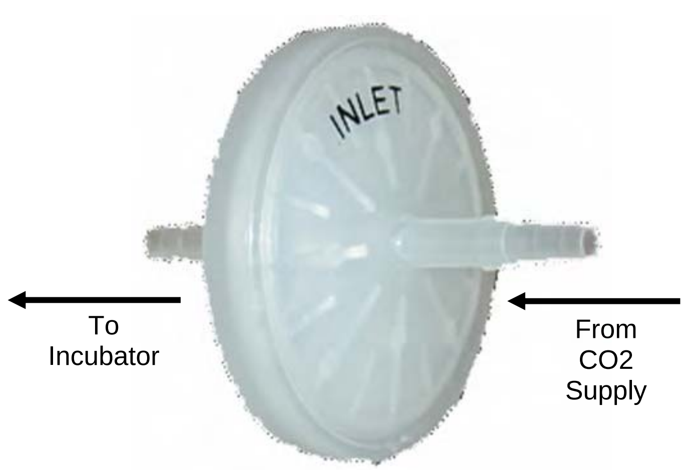


Figure 6-1. Gas Filter

Replacing the Temperature Sensor

The temperature sensor (PN 290194) should be replaced if it no longer matches the Temperature vs. Resistance chart in the Appendix.

1. Turn the Power switch to "Off" and unplug the power cord from the wall outlet.
2. Open the glass door and remove knurled thumb nut securing the sensor bracket.
3. Remove the ten (10) #2 Philips screws that secure the outer rear wall in place, and remove the first layer of insulation.
4. Locate the temperature sensor cable and break the silicone seal where the sensor enters the cabinet. Pull sensor from the chamber.
5. Unplug the sensor from the Main Control PCB connector J6 and withdraw it from the cabinet.
6. Install the new sensor in the reverse order.
7. Use 100% silicone to seal the opening where the sensor enters the chamber.
8. Calibrate the temperature control in accordance with the Temperature Calibration procedure in this section.

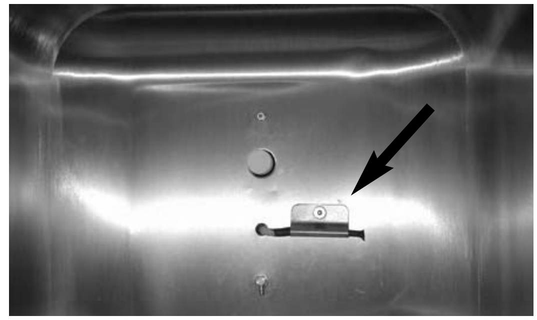


Figure 6-2. Temp Sensor (viewed from inside the chamber)

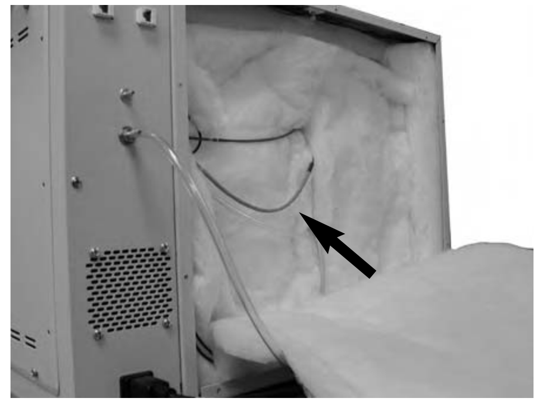
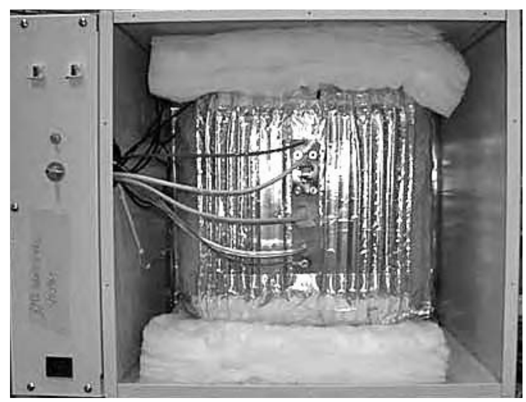


Figure 6-3. Outer Rear Wall Removed



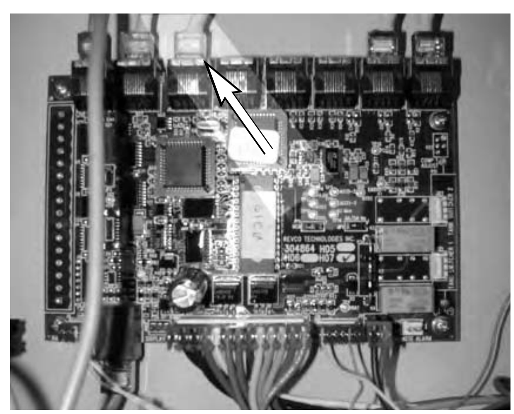


Figure 6-4. Temp Sensor Connector

Replacing CO2 Sensor and Interface PCB

1. Turn the Power switch to “Off” and unplug the power cord from the wall outlet.

2. Remove the ten (10) #2 Philips screws that secure the outer rear wall in place, and remove the first layer of insulation (see Figure 6).

3. Remove the four nuts that secure the CO2 sensor mounting plate and unplug it from the harness.

4. Install the new sensor (PN 290195) in the reverse order.

5. Access the CO2 Sensor Interface PCB by removing the twelve (12) screws that secure the side access cover.

6. Label and disconnect the wiring interface PCB wiring harnesses.

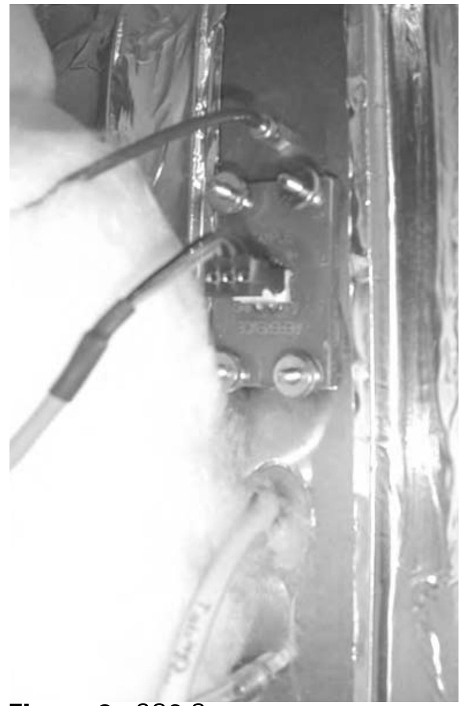


Figure 6. CO2 Sensor

7. Remove the four #2 Phillips mounting screws and remove the interface PCB

8. Install the new PCB in the reverse order.

9. Install both covers and all mounting screws.

10. Plug in unit and turn on the main power switch.

11. Allow temperature to stabilize and calibrate the CO2 control

Replacing Printed Circuit Boards

Caution When replacing any component, ensure any green ground wires are reconnected securely in their original positions to avoid danger of shock or short circuit. ▲

Caution Never bypass, nor interfere with, the operation of any switch, component or feature of the unit. Interlocks, relays, and switches are designed with a specific purpose and should, therefore, not be altered. ▲

Caution All printed circuit boards are susceptible to electrostatic discharge damage. Technician should always wear an ESD wrist strap when working on these components. ▲

Caution Warranty will not be responsible for damage caused by failure to disconnect the unit from all power sources before cleaning, troubleshooting, or performing other maintenance on the product or its controls. To disconnect power supply to the incubator, unplug the supply cord at the back of the incubator. Note that turning the key switch on the front control panel to the Off position is not sufficient to disconnect power. ▲

Caution Use only approved replacement parts that are the correct size, rating, and capacity as the original part. ▲

Caution A short thin ribbon cable connects the mylar buttons to the display board behind it. Use caution that neither the cable nor the connector is damaged when removing the bezel. ▲

Note If replacing the Main Control board, perform Steps 1-3 of the TC CO2 Calibration Procedure in this section before turning power switch to "Off". ▲

Replacing Printed Circuit Boards (cont.)

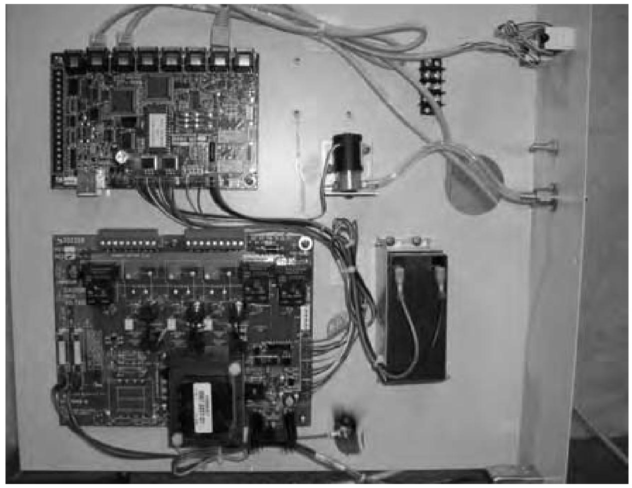


Figure 6-7. Circuit Boards

1. Turn the Power switch to "Off" and unplug the power cord from the wall outlet.
2. Label and then disconnect all necessary harnesses and sensors.
3. Remove the Philips mounting screws. Remove the PCB and install replacement in the reverse order.
4. Plug the power cord into the wall outlet and turn the Power switch to "On".
5. Calibrate in accordance with the respective procedure.

Testing the Outer Door Heater

1. Turn the power switch to "Off" and unplug the unit.
2. Access the Power PCB by removing the twelve (12) screws that secure the side access cover.
3. Disconnect the wires from Terminal #8 on connectors J9 & J10.
4. Measure the resistance between these two wires and compare with the below table; if different, replace the heater.

	Minimum	Maximum
115V	188 Ω	208 Ω
230V	635 Ω	776 Ω

5. Measure the resistance from each wire to chassis ground. Replace the heater if the meter does not indicate "open" or infinite resistance.
6. If the resistance is good, replace the wires and cover/tray. Turn power switch to "On" and resume normal operation. If the resistance is incorrect, replace the door.

Replacing the Outer Door Heater

1. Turn the power switch to "Off" and unplug the unit.

2. Remove the two Phillips screws that secure the door upper hinge cover.

Caution The outer door heater is still connected. Do not allow the door to drop or be pulled away from the cabinet more than 4" (15cm). ▲

3. Remove the two #2 Phillips upper hinge mounting screws and lift the door off of the lower hinge. Carefully lay the door on top of the incubator, gasket-side up.

4. Without tearing the gasket, carefully remove the ten (10) #2 Phillips screws that secure the gasket and inner liner to the outer door.

5. Lift the inner liner and cut the heater wires next to the foil tape.

Caution The inner panel can be easily warped if the adhesive-backed heater is pulled off too quickly or with too much "up" motion. ▲

6. Carefully peel the heater off of the inner panel, using care not to distort the panel. Discard the old heater.

7. Peel the backing off of the heater. Carefully align the heater with the inner panel and apply.

Note To ensure maximum surface area contact for maximum heat transfer, rub the exposed surface of the heater to ensure all air bubbles have been removed. ▲

Caution The heater panel has 2 heaters built in. On 115V units, these two heaters should be wired in Parallel. ▲

8. Cut the wires of the new heater as short as possible, but still long enough to connect with wire nuts.

9. Connect the new heater with wire nuts and install the new inner liner and door in the reverse order.

Replacing CO2 Solenoid Assembly

1. Turn the power switch to “Off” and unplug the unit.

2. Access the solenoid (PN 1900437) by removing the twelve #2 Phillips screws from the side access panel.

Caution The solenoid outlet is a red tube secured to an easily-broken thin-walled orifice by a free-sliding collar. Carefully slide the collar away from the solenoid, then use a knife blade to carefully PUSH the tubing off the orifice. ▲

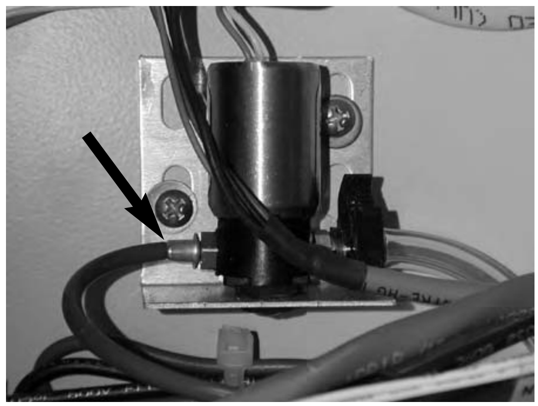


Figure 6-8. CO2 Solenoid

3. Carefully remove the collar and red tubing from the solenoid outlet.

4. Release the clip securing the inlet tube to the solenoid, and pull off the tube.

5. Cut the plastic wire ties securing the harness to the CPU PCB and unplug the solenoid connector.

6. Remove the 2 mounting bracket screws and remove the solenoid from the control housing.

7. Remove the bracket from the solenoid.

8. Install the replacement solenoid in the reverse order.

Section 7 Calibration

The Midi-40 Incubator utilizes a Thermal Conductivity (TC) CO2 sensor. This style of CO2 sensor is adversely affected by changes in temperature and relative humidity (RH). Therefore it is necessary to verify the temperature calibration first and then wait for the passive RH inside the chamber to stabilize, after any adjustment is made to temperature settings.

It is recommended that a full CO2 calibration procedure be performed:

- After replacing the CO2 sensor or main micro board.
- If, after re-setting a CO2 calibration offset and the offset calibration does not improve the true measured accuracy.
- If the interior RH condition is changed by adding or removing the RH water pan to convert from a wet to dry condition.

Caution The full zero/span calibration procedure requires the user to access the Program and Service Mode menu. ▲

Access Program or Service Menu

To access the Service Mode, you first must enter Program mode. Press and hold the Mode key for approximately five seconds until "Program Mode:" is displayed. Release the key.

Next press and hold the Mode key again for approximately six seconds until "Service Mode;" is displayed. Release the key.

Note If user does not push any keys after approximately thirty seconds, the display will revert back to the normal Run mode . If a value was changed, whatever value was last displayed will be stored as the new setting. ▲

Temperature Calibration

1. Ensure shelf support system and empty shelves are in place

2. Fill humidity pan approximately halfway full with distilled water and position the RH pan on the incubator chamber floor and centered.

3. Install reference temperature sensor into the geometric center of the chamber ensuring the sensor is not touching any shelves and is measuring air temp only.

Note There is no access port located on a Midi-40 incubator to permit passing cables through. Therefore a user must pass their independent calibration temperature sensor cable through the inner and outer door gasket seal. If access to a flat or thin style cable is not available, this may lead to humidity escaping the inner chamber thus causing condensation to form on the glass door or between the inner and outer doors surfaces. If a thin style cable is not available, attempt to seal around the cable using some perma-gum style putty (part # 13014) to help seal the passing of the cable through the door gasket seal. ▲

4. With power connected to the unit, turn on the key switch from (0) to the (I) ON position.

5.) To set or adjust the Temp setpoint, enter Program mode. The first menu is "Set Temp Setpoint", using the increment up arrow or the decrement down arrow, adjust setting to desired temperature. Continue to press the Mode button to advance from menu to menu to exit, or wait 30 seconds and system will default back to normal Run menu.

6. Set CO2 control set point in Program mode to 0.0% to keep CO2 injection solenoid off. It is highly recommended NOT to connect the CO2 supply at this time.

7. Allow for temperature to stabilize;

   a. <u>Start-Up</u> - Allow 12 hours for the temperature in the cabinet to stabilize before proceeding.

   b. <u>Operating Unit</u> - Allow at least two hours after the display reaches setpoint for the temperature to stabilize before proceeding.

8. Enter Program Mode, go to "Set Temp OFFSET" option and press the up/down arrow to match the display to a calibrated instrument.

9. For any offset adjustments made, allow at least 1 hour between adjustments to permit the unit to stabilize again.

Temperature Calibration (cont.)

10. After the temperature has been calibrated it is recommended to remove the temp sensor from the inner chamber to ensure the humidity inside the chamber is not passing thru the door seal. TC CO_2 sensors require a stable temp and RH environment to ensure they are accurately calibrated!

CO2 Calibration

1. After performing the Temperature calibration first, ensuring the unit has stabilized and the outer and inner door has not been opened for at least two hours, proceed to zero the CO2 sensor.

2. Enter the Program mode, press Mode key until “Set CO2 OFFSET” is displayed. Using the increment or decrement keys, make offset read 0.0%. Exit Program mode back to normal Run mode.

3a. Enter the “Service Mode”, press Mode key until “Zero CO2TC Sensor” is displayed. Press the decrement key to zero, then press the increment key to accept. The display should read zero micro-volts (0uV). **IMPORTANT NOTE** You must complete the next step to fully zero the CO2 sensor! ▲

3b. Press the increment key to set the new zero micro-volt (uV) value and then press the decrement key to accept. Repeat this step until you get repeating micro-volt values that are within ±50uV of each other. If the uV values are greater than 50 digits, this indicates that the Temp/RH has not fully stabilized inside the chamber and you should wait longer for the Temp/RH to stabilize.

4. In “Service Mode”, press the Mode key again to display “Span CO2TC Sensor”. Adjust CO2 span to read 975uV.

5. Press Mode key to exit Service mode, or wait 30 seconds for auto exit.

6. Connect CO2 supply and ensure CO2 gas pressure is set at 15psig, set CO2 setpoint to desired setpoint, e.g. 5.0%.

7. Allow system to stabilize at least 1 hour after unit display shows set point. Ensure that no door openings occur during this stabilization period.

8. Just before taking a CO2 gas sample with your CO2 calibration hand-held meter or FYRITE, lower the CO2 control set point in Program mode 1.0% below your current set point, e.g. from 5% to 4%. This step is necessary to prevent CO2 gas injection during the calibration of the unit.

CO2 Calibration (continued)

IMPORTANT NOTE During the sampling of the chamber with your FYRITE or hand-held calibration meter, the CO2 value shown on the unit display will most likely drop a few tenths of a percent from e.g. 5% CO2 to maybe 4.5%, depending on how many FYRITE measurements/ aspirations you take, or depending on how long you leave your hand-held calibration meter aspiration pump running. It is recommended that you take 2-3 FYRITE measurements and or leave your CO2 hand-held meter sampling the interior chamber for approx 1.5 to 2 minutes but no greater than 3 minutes. After obtaining your calibration readings, remove the tubing from CO2 sample port and cap the port. Allow the unit CO2 displayed value to stabilize, waiting approximately 3 minutes before proceeding with the CO2 calibration offset in the next step!

9. Enter Service Mode, press Mode key until “Span CO2TC Sensor” is displayed. Using the increment or decrement keys, adjust the span until the correct CO2 % level is indicated.

10. Press Mode key to exit Service Mode, or wait 30 seconds for auto exit.

11. To verify if the new CO2 calibration works correctly, open both outer and inner doors for at least 30 seconds, close the doors and wait a minimum of two hours permitting the temperature and RH to stabilize.

12. After two hours, sample the CO2 via the sample port with calibration instrument; remember to reduce CO2 set point 1.0% below your actual set point to avoid injecting gas during your measurement check.

13. If a small offset adjustment between (0.1 to 0.5%) is necessary, enter Program mode, press Mode key until “Set CO2 OFFSET” is displayed. Using the increment or decrement keys, enter a corresponding offset to match the displayed value with your calibration instrument. Press Mode key to exit Program mode, or wait 30 seconds for auto exit.

CO2 OFFSET NOTE If a CO2 offset value was entered, after exiting Program mode back to the normal Run mode; wait at least 2 to 3 minutes for the displayed value to auto-correct using the new offset value entered. The delay in the update is due to how the system microprocessor averages CO2 measurements, the displayed value will not update immediately! ▲

Section 8 Appendices

IntrLogic Power/Key On Modes

All power/key on modes require that the keypad pattern be selected by the time the logo stops scrolling, and that the pattern be maintained for the approximate three seconds in which the logo is stationary in the center of the display until the logo disappears. It should also be noted that on a first time power up sequence for a CPU board (defined as the Battery Check Interval variable upon restoration from the non-volatile memory being something other that 4, 12, or 20), all keypad patterns are ignored and an automatic start-up sequence ensues. In addition, normal start-up will occur with no keypad pattern.

Abbreviations:

Decrement Pad - Dec

Increment Pad - Inc

Mode/Mute Pad - Mode

Table 7-1. Keypad Patterns

Keypad Pattern	Description
	Incubator
Dec	Adjust the Water Adj (ADJ Delta H2O variable)
Inc	Plug-N-Play mode
Mode	N/A
Mode + Inc	Override serial number requirement or permit serial number reprogram (code must be compiled with SN Init And Test)
Mode + Dec	N/A
Inc + Dec	Restore Defaults / Manual Reset
Mode + Inc + Dec	Board Test Mode (if compiled with UL Testing, then UL Test Mode)

Common Diagnostics

- If all displayed values show "Err" on the display in the main loop, ensure there are no out-of-range voltages at the ADC input (see Test Points on the CPU board). Specifically, if the unit utilizes TC CO_2 control, ensure the sensor harness to the sensor is connected properly. If this sensor becomes disconnected the TC input on ADC channels 0 and 1 are ~5.4 to 5.5 VDC and will cause all ADC channels to fail. Technically, this violates an absolute maximum rating for the LTC2408 ADC of Vcc +0.3 VDC (5.3 VDC). To date, no permanent ADC failure due to this problem has been identified; however, this situation should be avoided.

- If the CO_2 display is not stable and for example displaying 4.0%, 5.2%, and then 6.0% and it cycles through this display cycle (or similar) every display update (16 seconds), ensure the fan is rotating. If not, check the door switch, AC fan signal, and any obstruction that may prevent the fan from rotating.

- If the water RTD display is showing an extremely high value and the cabinet probe RTD is displaying a normal value, ensure that the water RTD and the cabinet RTD are not switched.

IntrLogic Test Points and Jumpers

Table 7-2. Test Points

Test Point	Description
CPU TP1	ADC Ch 0: CO_2 (+) Sensor 2.3-2.4VDC Typical
CPU TP7	ADC Ch 1: CO_2 (-) Sensor TC only; IR=N/C
CPU TP9	ADC Ch 2: Rh Sensor 3.677VDC Typical
CPU TP10	ADC Ch 3: Water Temperature Sensor 105mVDC Typical
CPU TP11	ADC Ch 4: Ambient Temperature Sensor 105mVDC Typical
CPU TP12	ADC Ch 5: Chamber Temperature Sensor 105mVDC Typical
CPU TP13	ADC Ch 6: Tank Switcher
CPU TP14	ADC Ch 7: nc / line voltage / O_2 Sensor 8mv Typical
CPU TP2	5 VDC (regulated from line or battery)
CPU TP6	4.5 VDC Reference
CPU TP15	-1.6 VDC Offset (H05 version only)
CPU TP4	Battery Voltage 15.3VDC typical
CPU TP5	-5 VDC (H05 version only)

IntrLogic Test Points and Jumpers (cont.)

Table 7-3. Jumpers

Jumper	Position	Description
JP1	1-2 Short: 50Hz filter 2-3 Short: 60 Hz Filter	ADC LTC2408 Filter
JP2	1-2 Short: 256k EPROM in U19 2-3 Short: 512k EPROM in U19	U19 chip size
JP3	1-2 Short: Telemetry Mode 2-3 Short (OR NO JUMPER) : RS485 Mode	Communications mode

IntrLogic: Board Test Function

The interface looks the same between display types. For example, a 7219 based display and the Noritake vacuum fluorescent display have the same common output for feedback to the user. There may be up to 16 different tests numbered 0 to 15 and will be output as (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, b, c, d, E, F) OR (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15). There are three types of messages: 1) Test Passed, 2) Test Failed, and 3) User Intervention required. The message format is as follows: Test Passed: Step # P Example: "1 P" Test Failed: Step # F. Example: "A F" User Intervention: Step # U. Example: "7 U".

How to Enter Test Mode

Board test mode may be entered by simultaneously holding down the increment (up arrow), decrement (down arrow), and mode/mute button, then turning the key to one of the On positions. The user should hold these buttons for approximately 10 seconds, then release.

Note This changes slightly as on some displays it is indicated by the screen going blank. ▲

After releasing the buttons, the user will see the result of Test 0. The tests progress as the user presses the mode/mute button and upon reaching the last test, the first test is re-executed.

Note Normal operation will NEVER return until the key is cycled OFF again. ▲

Test 0 (9356 Test)

This test simply writes a byte of data (0xA5) to a non-volatile memory address (0xF0) within the 9356 IC. Next, the location is read to a local RAM to ensure proper operation of the 9356. On success, the display shows "0 P"; on fail, "0 F."

Test 1 (5891, Power Board, Relay 0XAA Test)

Note May not be available with ±40V buck-boost system. ▲

This test simply communicates with the 5891 and sends a relay, data pattern of 0xAA. Once the relays are set, the user intervention message appears "1 U" so the user can look at the LEDs on the power board to verify the correct on-off pattern (LEDs 5, 3, and 1 should be active and the remaining LEDs inactive). Additional troubleshooting with a DMM and/or ammeter may be required to determine if signal is operating properly.

Test 2 (5891, Power Board, Relay 0X55 Test)

Note May not be available with ±40V buck-boost system. ▲

This test simply communicates with the 5891 and sends a relay, data pattern of 0x55. Once the relays are set the user intervention message appears "2 U" so the user can look at the LEDs on the power board to verify the correct on-off pattern (LEDs 6, 4, and 2 should be active and the remaining LEDs inactive). Note that LED 6 will only be active when the high-pressure cutout is functioning properly or manually shorted; i.e., J6-4 and J6-5 connected on the power board. Additional troubleshooting with a DMM and/or ammeter may be required to determine if signal is operating properly.

Test 3 -10/A (ADC Read Test)

This test reads channels 0 to 7 of the ADC. When the test first initiates, a Step# U will be displayed signaling the user to install the plug. Once the plug is installed, then the user needs to press the mode/mute button again to read the voltage. It will return a Test Pass message whenever the voltage is between 0 V and 4.5 V. Eventually, we need to construct dummy, resistance plugs/jacks to put into applicable channels per unit type and code an appropriate voltage window in order to distinguish between CPU board failure (conditioning circuit or otherwise) and sensor failure.

Test 11/B (Display Test)

This test will light up all segments, icons, pixels, or otherwise of the given display for 3 seconds to verify proper operation.

Test 12/C(Battery Test)

This test forces a battery test by loading the battery for approximately 500 ms and determining that a minimum voltage was maintained. It does NOT effect the normal battery test frequency.

Test 13/D (Audible Test)

This test activates the beeper for 3 seconds to ensure proper operation.

Test 14/E (Communications Test)

This test sends "COMM TEST\r\n\r\n" to the serial port to verify correct operation of the communications interface. If multiple "daisy-chain" jacks are on the unit, all should be tested.

Note The "\r\n\r\n" are carriage returns and will not come out as text. ▲

Test 15/F (External RAM Test)

This test sends vectors to the external RAM chip. It exercises the parallel interface and integrity of the external RAM interface on the CPU board. Test duration depends on the oscillator frequency, typically 15-30 minutes.

Note After the last test, a mode/mute button press will result in cycling back to the first test. This mode will never reenter the Main Loop. ▲

Telemetry Tables

Telemetry mode is meant to be a point-to-point communications mode that easily interfaces with a serial communications program (ex. HyperTerminal). The underlying hardware uses a TI75176 (or similar) transceiver to communicate to an RS485 specification. Thus, to connect to a PC, a converter (RS232 to RS485) is required. In the preferred embodiment, the converter selected is powered from the PC UART (see B&B Electronics Model: 485SD9TB). The communications settings that are required are as follows: 9600-8-S-1-NONE:

Communications Parameters:

Bits per second: Settable in Service Mode (9600, 14400, 19200 *Default*, 38400)

Data bits: 8

Parity: Space

Stop bits: 1

Flow control: None

Once these settings are correct for the terminal program, communications with the embedded controller can commence. To communicate, simply send a command from the terminal program and await the response. Commands are a simple ASCII character and some repeat with a set frequency and some merely output data one time. Date may be text, integer, floating point, or hexadecimal values.

The following list comprises all available IntrLogic Incubator telemetry command streams:

'?' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE…different views though

Description: This command simply outputs a list of available commands. The list will vary depending on what type of device and its options.

'#' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE

Description: This command erases all non-volatile memory (9356 chip) on the IntrLogic CPU board.

'0', '1', '2', '3', '4', '5', '6', '7' COMMANDS

Repeat: YES

Frequency: Every two seconds

Compile Dependencies: NONE

Description: This command outputs the voltage of the ADC channel specified by the command in uV.

'A' COMMAND

Repeat: YES

Frequency: Every two seconds

Compile Dependencies: Available in all code…effected by Incubator and O2Control

Description: This command lists the actuals.

Param 1: Cabinet Probe including TempOffset (divide by 10 to convert to °C)

Param 2: Incubator only - water RTD (divide by 10 to convert to °C)

Param 3: Incubator only - CO2 concentration (divide by 10 to convert to %)

Param 4: O2 Control only…O2 concentration (divide by 10 to convert to %)

Param 5: Relative humidity (divide by 10 to convert to %)

'B' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE

Description: This command displays the hour count of the next scheduled battery check.

'C' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE

Description: This command displays the eight hexadecimal value of the checksum (does not actually calculate the checksum, it just reads it from non-volatile memory.

'e' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE

Description: This command dumps the defined ranges of internal and external RAM that is stored in the non-volatile memory (the same range that is dumped every 24 hours) to the non-volatile memory.

'E' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE

Description: This command will output a stream composed of the entire non-volatile memory contents in the following fashion:

"9356 (0-255 decimal) (0x00-0xFF hexadecimal) (value in hexadecimal)"

'F' COMMAND

Repeat: YES

Frequency: Every two seconds

Compile Dependencies: NONE

Description: This command dumps the variable FlagBank which is specific to each version of code. Requires understanding of memory map to be useful.

'M' COMMAND

Repeat: N/A

Frequency: N/A

Compile Dependencies: NONE

Description: The defined way to stop telemetry output. It will not stop error messages, just the telemetry table data. To guarantee that no telemetry messages are sent, set JP3-TELE jumper on the CPU board to RS485 mode (short pins 2 & 3).

'O' COMMAND

Repeat: YES

Frequency: Every two seconds.

Compile Dependencies: Available in all code - effected by Incubator and O2 Control

Description: This command lists the offsets.

Param 1: Temperature offset (divide by 10 to convert to °C)

Param 2: Relative humidity offset (divide by 10 to convert to %)

Param 3: Incubator only…CO2 offset (divide by 10 to convert to %)

Param 4: O2 Control only…O2 offset (divide by 10 to convert to %)

'p' COMMAND

Repeat: YES

Frequency: Every two seconds.

Compile Dependencies: Env Chamber, Incubator, CO2 Control, O2 Control, RH Control

Description: This command displays PWMs and timers for various control sets.

INCUBATORS:

Param 1: Door Heater PWM

Param 2: Water Heater PWM

Param 3: CO2 injection PWM

Param 4: CO2 rapid recovery time (used only in rapid recovery mode)

Param 5: O2 Control only - O2 injection PWM

Param 6: O2 Control only - O2 rapid recovery time (used only in rapid recovery mode)

Param 7: RH Control only - Relative humidity heater PWM

Param 8: RH Control only - Relative humidity water source PWM

'P' COMMAND

Repeat: YES

Frequency: Every two seconds

Compile Dependencies: NONE

Description: This command displays the Ports of the 8051 microcontroller in the following fashion: "P0-XX P1-XX P2-XX P3-XX" (the XX are hexadecimal values)

'R' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE

Description: This command displays the contents of the 8051 internal RAM in the following fashion: "RAM (0-255 decimal) (0x00-0xFF hexadecimal) (value in hexadecimal)".

'S' COMMAND

Repeat: NO

Frequency: N/A

Compile Dependencies: NONE

Description: This command reads the serial number (if the unit does not have one, it reads the locations where the serial number would be stored) in the following fashion: "SN Ext RAM (0-15 decimal) (0x00-0x0F hexadecimal) (value in hexadecimal)".

't' COMMAND

Repeat: YES

Frequency: Every two seconds

Compile Dependencies: Env Chamber, Incubator

Description: This command display miscellaneous temp information.

INCUBATORS:
Param 1: Temperature setpoint (divide by 10 to convert to °C)
Param 2: Temperature warm alarm setpoint (divide by 10 to convert to °C)
Param 3: Temperature cold alarm setpoint (divide by 10 to convert to °C)
Param 4: Cabinet Probe RTD including TempOffset (divide by 10 to convert to °C)
Param 5: Water RTD (divide by 10 to convert to °C)
Param 6: Door integral
Param 7: Water integral
Param 8: High temperature excursion (divide by 10 to convert to °C)
Param 9: Low temperature excursion (divide by 10 to convert to °C)

T' COMMAND

Repeat: YES

Frequency: Every two seconds

Compile Dependencies: NONE

Description: This command displays the internal cumulative clock count as follows: "Seconds Minutes Hours Days Months Years" All data is in decimal format.

'U' COMMAND

Repeat: YES

Frequency: Every two seconds

Compile Dependencies: NONE

Description: This command displays the 8255 ports by outputting the ports mirrors in the 8051 local RAM and the 5891 driver to all "high-voltage" outputs on the power board. All data is hexadecimal.

Param 1: Port A (local RAM image of 8255 port)

Param 2: Port B (local RAM image of 8255 port)

Param 3: Port C (local RAM image of 8255 port)

Param 4: Relay Register (local RAM image of 5891 data)

Detailed Descriptions of IntrLogic PCBs

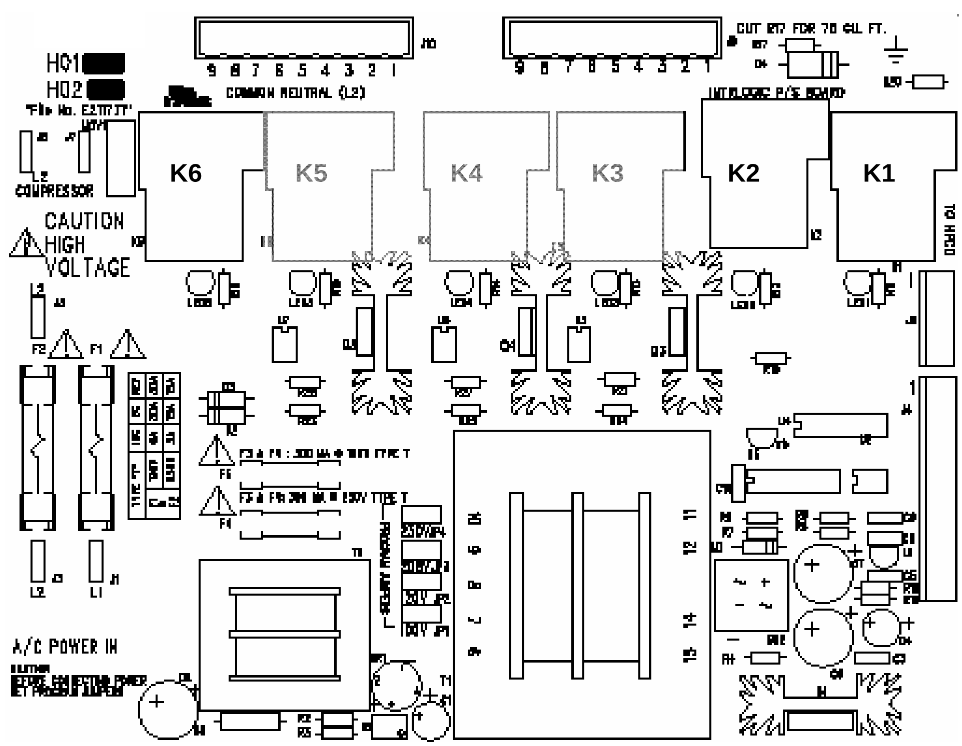


Figure 7-1. Power Printed Circuit Board (PCB)

Relay and Triac Allocation on Power PCB

Behavior under normal operation, possible modes of failure, and troubleshooting of failure, and troubleshooting in general

K1 Fan Relay

Under proper operation, this relay will cycle power to the fan during door openings. LED1 should be on whenever the door is closed (fan on). If the door is closed and LED1 is not illuminated, one of three failures could have occurred: the door switch is not fully engaged, no continuity through the door switch harness, or a 5891 communication failure.

Test if the door switch is fully engaged. Open the doors of the unit and manually cycle the switch. If LED1 now cycles, the switch is not getting fully engaged by the glass door. Units are shipped with a 'fish eye' attached to the glass. This is intended to further engage the switch from the surface of the glass. It can sometimes come off during normal use – such as when the glass is cleaned. This should be the first item to check for. If this is present, then a plastic cap (available from the factory) can be placed over the end of the switch plunger to ensure plunger actuation.

If the LED1 does not illuminate during the manual cycling of the switch, the harness should be tested next. Disconnect J9 on the CPU, located in the very front left corner of the electrical tray. Short pin 1 to pin 2 (pin 1 is marked) with a pocketknife, screwdriver, etc. to simulate a door switch closure to the CPU. LED1 should cycle on; if it does not, then replace the control PCB.

5891 communications should be the last item to suspect. If general 5891 communication failure were occurring, there typically would be more significant system problems. Serial communications to the 5891 device can easily be tested via the power up test mode. Turn the unit off, press all three buttons and turn the power on: continue holding the buttons for approximately 10 seconds. After releasing, the results of the first test will be displayed. The 'Mode/Mute' button will sequence through the tests. Test 1 and 2 pertain to communications to the power board. After test 1, '1U' will be displayed and LED's 2 and 4 should be illuminated. Although not pertinent to the incubator application, LED 6 can be tested at this point by shorting pins 4 and 5 together on J6. After test 2, '2U' will be displayed and LED's 1, 3, and 5 should be illuminated. If the results do not match those described and the system is working correctly otherwise, replace the power board.

K2 No Connection

This output is not used in the current design.

K6 No Connection

This output is not used in the current design.

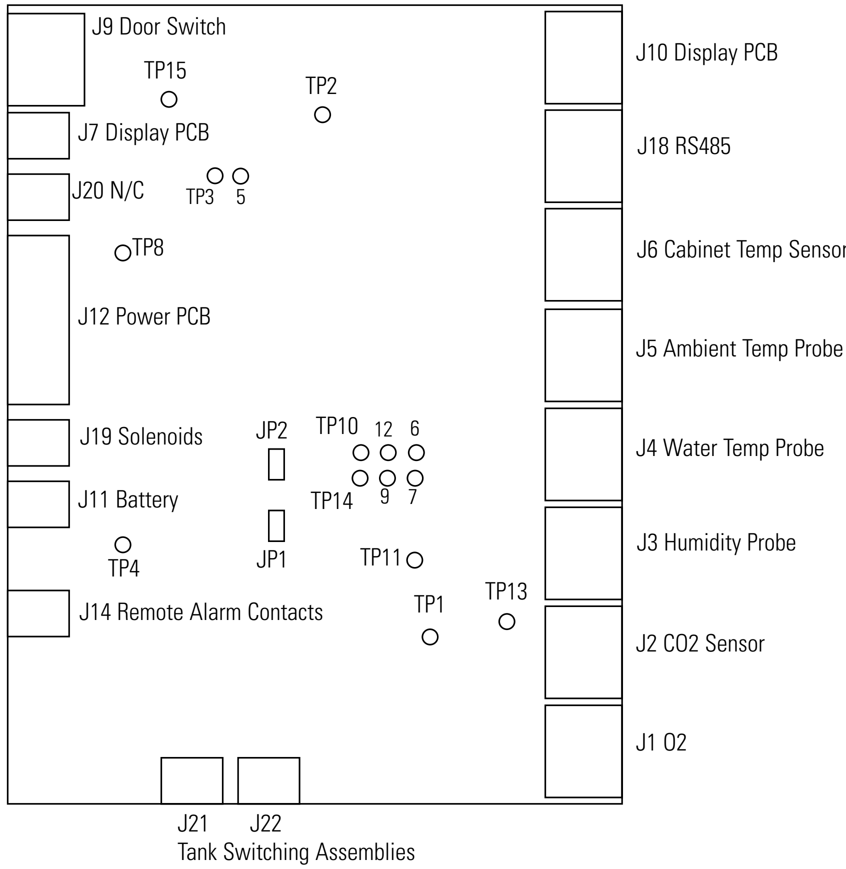


Figure 7-2. CPU Board PN 192040

JP1 50/60 Hz

JP2 Memory

Test Points (as labeled on the silkscreen)

TP1 "LM335-1"	TP6 "+4.5V"	TP11 "RTD2"
TP2 "+5V"	TP7 "LM335-2"	TP12 "RTD3"
TP3 "GND"	TP8 "+12V"	TP13 "TC"
TP4 "VBAT"	TP9 "LM335-3"	TP14 "AC Mon"
TP5 "-5V"	TP10 "RTD1"	TP15 "-1.6 Adj"

General Overview

Test Point	Generic Description	H07 Application
TP1 "LM335-1"	Voltage @ input to the A/D converter (channel 0).	TC CO2 Input (Resistors, V_m^+)
TP2 "5V"	5 VDC, regulator output.	5 VDC
TP3 "GND"	Ground plane.	Gnd
TP4 "VBAT"	Positive terminal of the battery. Charging voltage under normal operation; battery voltage in backup.	VBAT
TP5 "-5V"	-5 VDC, regulator output.	Not Used
TP6 "+4.5V"	+4.5VDC, regulator output.	+4.5 VDC
TP7 "LM335-2"	Voltage @ input to the A/D converter (channel 1).	TC/IR CO2 Input (Thermistors, V_m^-)
TP8 "+12V"	Input to the 5 VDC regulator	Input to the 5 VDC regulator
TP9 "LM335-3"	Voltage @ input to the A/D converter (channel 2).	Humidity
TP10 "RTD1"	Voltage @ input to the A/D converter (channel 3).	H20 / Tank RTD
TP11 "RTD2"	Voltage @ input to the A/D converter (channel 4).	Ambient RTD
TP12 "RTD3"	Voltage @ input to the A/D converter (channel 5).	Cabinet RTD
TP13 "TC"	Voltage @ input to the A/D converter (channel 6).	Tank Switcher
TP14 "AC Mon"	Voltage @ input to the A/D converter (channel 7).	O2 Input
TP15 "-1.6 Adj"	Offset voltage adjustment specific to ULT T/C circuitry.	Not Used

Note When observing the voltage on any A/D channel inputs, there will be a voltage 'pulse' that occurs. This is normal and should not cause alarm.

If any channel is found to be outside the limits of normal operation, 0 to 4.5 VDC, the reading of all channels will become suspect. For instance, if channel 0 is found to be 5.4 VDC, the readings on channels 1-7 may be corrupt.

Because TC sensor readings are adjusted or compensated due to the presence of RH, an erroneous RH reading can cause incorrect CO2 results.

TP1 "LM335-1"

Only used for units with a TC CO2 Sensor. TC CO2 application requires the use of two A/D channels and the differential is used for CO2 calculation. TP1, A/D channel 0, is referred to as V_{m+} and is basically the voltage produced by a precision voltage divider. Typically, this will measure approximately 2.4 VDC under normal operation. With nothing attached to this location, 0 VDC should be present. If the TC board and sensor are in circuit and greater than 5 VDC is measured here (i.e. approximately 5.4 VDC), the sensor or interconnectivity should be suspect. Under this condition, "Err" will be displayed at the front of the unit. An easy way to demonstrate this condition is to disconnect the TC sensor, at the sensor or at JP3 on the 192040 board. The table below covers some additional TC fault conditions.

Table 7-4. Additional TC Fault Conditions

Condition	TP1	TP7
Sensor - no connection	~5.4 VDC	Toggles 0 & ~5.4 VDC
J1 - bad connection	0	~2.4 VDC
J2 - bad connection	~2.4 VDC	0
JP4 - bad connection	0	0

TP7 "LM335-2"

TP7, A/D channel 1, is referred to as Vm- and is the actual voltage produced by the TC Sensor. The sensor is comprised of two thermistors. One is sealed – only influenced by temperature; one is open – influenced by temperature as well as other environmental factors. In simple terms, Vm- is the voltage produced by another resistive voltage divider. Under normal operation the voltage at TP7 will fluctuate in the ~2.4 VDC range. Refer to TP1 for addition observations on TP7.

TP9 "LM335-3"

All applications – humidity channel. In proper operation, TP9 will be in the range of 1.0 to approximately 3.9 VDC. If no sensor is connected, 0 VDC will be present at TP9. Pressing all three buttons (increment, mute/mode, and decrement) can access the current RH reading. This value, the voltage at TP9, and the current temperature (offset removed), should correlate via the following expressions:

V_{OUT} [TP9] = V_{SUPPLY} (0.0062 (Sensor RH) + 0.16) = 5 (0.0062 (Sensor RH) + 0.16)

Sensor RH = (-1.919E-09*V_{OUT}3 + 1.335E-05*V_{OUT}2 + 9.607E-03*V_{OUT} - 21.75) / (1 + (T - 23)*2.4E-03) [V_{OUT} in mV, RH in %, T in °C]

$RH_{TEMP. COMP.}$ = Sensor RH/(1.0546 – 0.00216T), T in °C

$RH_{TEMP. COMP.}$ is ultimately the value to be displayed. If the values correlate but the RH reading does not make sense or agree with an independent reading, confirm that there is 5 VDC being supplied to the sensor then check for condensation in the vicinity of the sensor. 5 VDC can be measured by checking the leftmost conductor of J3, as viewed from the front of the incubator. If this is not 5 VDC, disconnect the sensor and see if 5 VDC returns. If it does not, confirm that the conductor is in fact in contact with the probe – maybe check the second conductor (~10.3VDC); if these values are not present on the CPU, there should be more severe symptoms than erroneous RH. If unplugging the sensor restores 5VDC, proceed to check for condensation. Condensation will cause adverse results. If condensation is present on the sensor, it should be allowed to dry off.

Caution RH elements used before July 2002 should not be touched by bare hands; doing so can cause damage and erroneous results. ▲

The element can be allowed to dry off passively or a fan, blow dryer, or similar device can be used to speed things up. The sensor should operate correctly when dry, however, the root cause of the condensation should be assessed to avoid a repeat scenario.

TP10 "RTD1"

H2O / Tank RTD located in a well at the top left rear of the incubator. Under normal operation, TP10 will be ~107 mV (see Table 7-5 after **TP12** "RTD3"). If you are getting a reasonable value from the RTD, i.e. 20-40°C, count on this information being correct. A failed sensor will typically be shorted or open, rarely in between. If **TP10** agrees with what is being displayed but is not agreeing with an independent measurement, look into sources of conditioning.

Conditioning refers to a situation where the RTD probe is being adversely affected by a source other than the medium it is intended to be measuring or tracking. In this case, conditioning of two different probes can cause abnormal water temperature reads: the H2O / Tank RTD or the cabinet RTD. Conditioning is typically found to fall into the following categories, along with possible sources:

- The H2O / Tank RTD probe is indicating a temperature read higher than independently measured water temperature (from the fill tube).
- The H2O / Tank RTD probe is not inserted all the way into the well.
- The RTD element in the H2O / Tank RTD probe is not at the very end of the heat shrink.
- A poorly insulated steam generator.
- Heat source near the left rear of the incubator.

TP10 “RTD1” (continued)

- The H2O / Tank RTD probe is indicating a temperature significantly below set point (typically results in condensation on the walls).
- Large cabinet temperature offset (single loop operation).
- Heat source near top of the unit.
- A poorly insulated steam generator (conditioning cabinet probe).

It should be remembered that the H2O / Tank RTD probe plays a new role in the control of the water temperature from previous designs. In single loop mode (default), The H2O / Tank heater PWM is determined by the Cabinet RTD probe. If the H2O / Tank RTD exceeds the set point be 0.1°C, the PWM will be clipped to zero. In dual loop mode, the H2O / Tank RTD probe determines the PWM for the H2O / Tank heater. In this case, the temperature that will be controlled to, will be the set point minus the H20 Adjust variable (“ADJDeltaH2O”).

TP11 “RTD2”

Ambient RTD located at the top rear of the incubator. **TP11** will typically be in the ~100-103mV range (reference Table 7.5 after **TP12** “RTD3”). There are no control implications with this sensor. This sensor is useful if environmental conditions are suspect. Also useful for swapping RTD’s if a CPU A/D channel is suspect.

TP12 “RTD3”

Cabinet RTD located in top center of the interior of the incubator. With a set point of 37.0°C and 0.0°C offset, **TP12** should be in the 107 mV range. Keep in mind that most DMM’s are not that accurate when reading millivolts. In a reciprocal fashion, if set point is 37.0°C and the offset is 0.0°C, then approximately 106.9 mV is present at **TP12**. In most cases, the accuracy of the DMM can be gauged by how closely it reflects this value. As discussed earlier, if you are getting a reasonable value from the RTD, i.e. 20-40°C, count on this information being correct. Again, the issue most likely to be encountered with this sensor is conditioning. Conditioning typically leads to greater than desired probe to center air offsets, which in turn can lead to condensation. Conditioning of the cabinet probe can usually be traced to an improperly isolated steam generator or another source of heat on top of the incubator.

Table 7-5. Probe Temperatures

Probe Temperature *	RTD Value	Test Point
20°C	1077.928 ˜	100.89 mV
25°C	1097.337 ˜	102.67 mV
30°C	1116.718 ˜	104.44 mV
35°C	1136.069 ˜	106.21 mV
37°C	1143.802 ˜	106.91 mV
40°C	1155.392 ˜	107.97 mV

* **1000Ω Platinum Resistance Temperature Detector (PRTD)**

IEC 751, DIN EN 60751 grade platinum (α = 0.00385 Ω/Ω/°C)
Tolerance IEC standard 751 class B, $\Delta t = \pm [(0.30) + 0.005 \times |t|]$

TP14 “AC Mon”

Only used on units with an O2 sensor. O2 sensors used in this application utilize a capillary technology to quantify O2 concentrations. In very simplified terms, this sensor is analogous to a battery whose charge level is dependent on the presence of O2. The more O2, the higher the charge or voltage produced. In ambient conditions, the concentration of O2 is 20.9%. Off the shelf, the O2 sensor will produce 7-14mV. This off the shelf value is particular to each sensor and will be tied to 20.9%. The slope for the sensor is thereby determined by the off the shelf value and 0mV equating to 0%. For instance, if a sensor produces 10.45mV off the shelf, it will have a slope of 0.5mV / % O2 (10.45mV/20.9%). This value can be viewed and/or reset in the service loop of the incubator. With this value it is straightforward to check a measurement at TP14 against the displayed percentage. In addition, the sensor is a stand-alone device - the voltage can be checked at the sensor’s molex connector with it completely out of circuit.

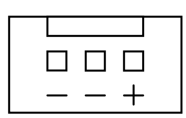


Table 7-6. O2 Sensor Pin Out

TP13 - "TC" Tank Switcher Status & Voltages				
Tank 1	**Tank 2**	**Tank 3**	**Tank 4**	**Ideal Voltage**
(CO2 Primary)	**(CO2 Backup)**	**(O2/N2 Primary)**	**(O2/N2 Backup)**	**(VDC)**
				0.000
			Empty	1.716
		Empty		1.447
		Empty	Empty	2.347
	Empty			0.962
	Empty		Empty	2.117
	Empty	Empty		1.922
	Empty	Empty	Empty	2.595
Empty				2.243
Empty			Empty	2.776
Empty		Empty		2.676
Empty		Empty	Empty	3.041
Empty	Empty			2.513
Empty	Empty		Empty	2.938
Empty	Empty	Empty		2.857
Empty	Empty	Empty	Empty	3.159

The tank switcher circuit is a simple circuit comprised of pressure switches in parallel with resistors. These in turn are connected in a serial fashion to a voltage supply. With the presence of gas pressure, the associated switch closes and shorts out the corresponding resistors. This results in different voltage levels at **TP13** (A/D channel 6 input). The table above outlines the 16 possible scenarios along with the expected voltage level at **TP13**. The simplest manner to troubleshoot the tank switcher circuit is to disconnect it at the CPU and enter the 'Plug N Play' Mode. Turning the unit off and powering it up while pressing the up arrow enters PNP mode. Then scroll to the tank set up screen – this screen is updated in real time – no delays. Shorting between the following pins on the CPU board should result in a full indication (F) for the corresponding tank. Note that pin 1 is closest to the component designator label (J21 or J22).

J22 pin 1 to 2	T3
J22 pin 3 to 4	T4
J21 pin 1 to 2	T1
J21 pin 3 to 4	T2

If the display does not reflect the correct status, check the corresponding voltage at **TP13** and confirm the presence or absence of the correct voltage. If an erroneous voltage is being measured by the A/D converter (outside ±50mV of the anticipated value), 'Error' will be displayed. If this is the case, check the levels at all other A/D inputs. If all are within range, 0 to 4.5 VDC, the CPU board is most likely to blame.

Conversely, to test the tank switcher assembly, turn on the supply tanks one at a time and confirm a short on the corresponding pins of the J21 and J22 connectors.

TP4 "VBAT"

When operating correctly, ~14 - 16 VDC is typically present when loaded with a battery. ~17 - 19 VDC will be present when unloaded. This will vary with line voltage.

MISC.

J14 Remote Alarm

Pin out is as follows:

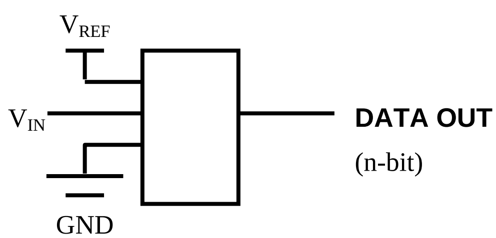
Pin 1 – NC

Pin 2 – NO

Pin 3 - Common

A/D Converter Refresher

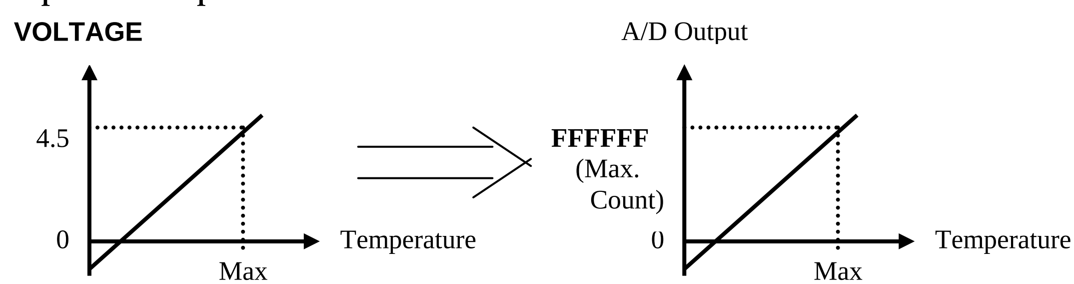
Fundamental purpose of an A/D converter is to convert an analog voltage to a digital number.



$$\frac{(V_{IN} - GND)}{(V_{REF} - GND)} \times \text{(Max Count)}$$

Result is basically a ratio of VIN to VREF, normalized to VREF in binary format.

Simplified example:



A/D converter is typically specified by the binary output length desired ('n-bit' output).

i.e.

4 bit ➨ 0000 to 1111 (0 to 15 decimal)

8 bit ➨ 00000000 to 11111111 (0 to 255 decimal)

12 bit ➨ 000000000000 to 111111111111 (0 to 4095 decimal) etc.

Maximum Count = 2^n - 1

Resolution = (V_{REF} – V_{GND}) / (2^n - 1)

Resolution ≡ Smallest discernable unit

304864 Assembly: Linear Tech 24 bit 2408 A/D Converter

n = 24

Maximum Count = 16777215

V_{REF} = 4.5 V

Resolution = 0.0000002682209174765 Volts

≅ 0.000000268 Volts 2.68 x 10^{-7} (¼ µV)

Interface PCB

I/O SUMMARY

J1 – N/A Used only for ULT application

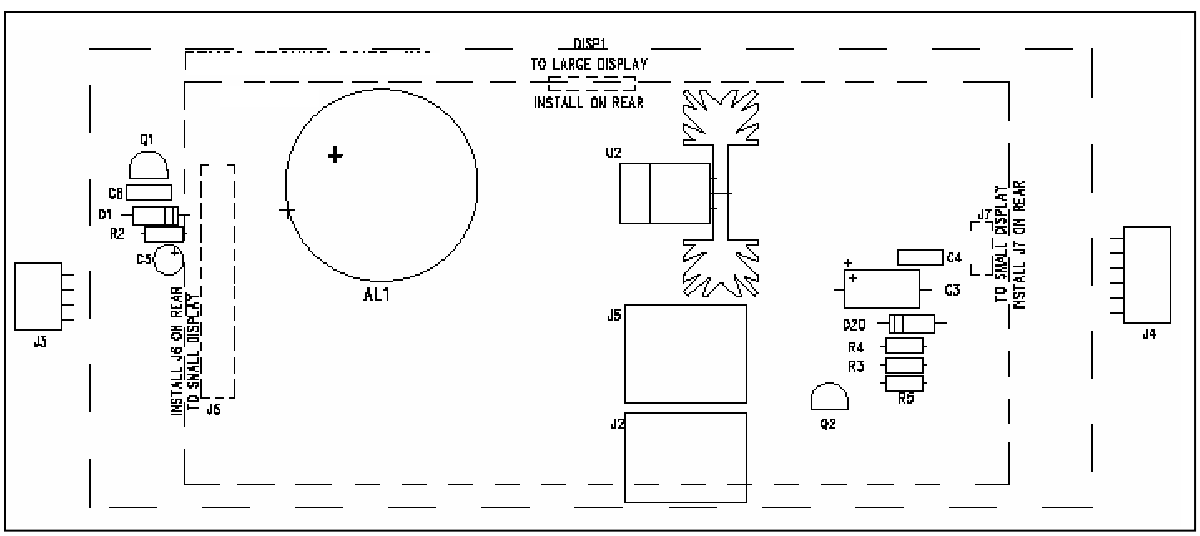


Figure 7-5. Interface PCB (P/N 192039)

Interface PCB (continued)

J2 – General I/O with CPU

J2 is not a good place to measure anything. In general, most of these signals should be checked at other access locations. Better points for measurement are listed after a brief description.

Pin 1 – "PS15" DC voltage supplied out to key switch. Refer to J4 for troubleshooting.
Pin 2 – "+12V" DC voltage supplied to audio transducer (AL1), 5 volt regulator (U2), and the VFD in ULT applications. The voltage level at "+12V" should be one diode drop down from "+DC" (CPU and Power board). Typically, these will be ~10.5 VDC and ~11.3 VDC, respectively. Easiest access point is J1 pin 1: can also be check at '+' side of AL1 or U2 pin 1 (toward J5 & J2).
Pin 3 – "SW-DOWN" Keypad status passed to CPU. See J3 for troubleshooting.
Pin 4 – "SW-SELECT" Keypad status passed to CPU. See J3 for troubleshooting.
Pin 5 – "SW-UP" Keypad status passed to CPU. See J3 for troubleshooting.
Pin 6 – Ground
Pin 7 – "BEEPER" Signal from CPU to activate an audible alarm. +5 VDC when active, measure at the anode (+) of D1 (pin away from audio transducer - AL1). Anode is also the side of the diode without a bar.
Pin 8 – "ALARM-EN" Output supplied to CPU indicating that the key switch is in position 3. +5 VDC when active, measure at J4 pin 3.
Pin 9 – "BAT-EN" Output supplied to battery charging circuit. Refer to J4 pin 2 & 3 for troubleshooting.
Pin 10 – "PS15R" Secondary side of key switch. Refer to J4 for troubleshooting.

J3 – Switch *Input* from Keypad

Pressing a keypad simply shorts it to ground. For instance, pressing the UP pad will cause pin 1 to short to pin 4. Pin 1 is toward the top of the board or R2/D1. **NOTE Pin 1 on a connector can frequently be identified by a square pad on the PCB.**

Pin 1 – "SW-UP" Input from UP keypad. Grounding this pin will simulate the 'up' pad being pressed.
Pin 2 – "SW-SELECT" Input from Mode/Mute/Select keypad. Grounding this pin will simulate the 'Mode/Mute/Select' pad being pressed.
Pin 3 – "SW-DOWN" Input from DOWN keypad. Grounding this pin will simulate the 'down' pad being pressed.
Pin 4 - Ground – common to one side of each of the keypads.

J4 – *Input* from Key Switch

For reference, wiring diagram 3403-70-1 provides a schematic depiction of the key switch and J4. Pin 1 is toward the top of the board, away from "J4" label.

Pin 1 – "+5V" Output to key switch

Pin 2 – *no label* Enables battery charging circuit. When key is in position 2 (|), +5 VDC will be present. Approximately +4.3 VDC (diode drop from +5) will be present on this pin when the key switch is in position 3.

Pin 3 – "ALARM-EN" Signal to CPU that the key switch is in position 3 (🔈). Also enables battery charging circuit via a diode to Pin 2. +5 VDC will be present on this pin when active.

Pin 4 – "PS15" Primary DC voltage supplied to key switch. Typically, this will measure ~11.7 VDC. During normal operation, as long as line voltage is supplied to the unit, this should always be present. See additional information below.

Pin 5 & 6 – "PS15R" This is the signal that initiates a power up. When the key is in position 2 or 3 (| or 🔈), the DC voltage measured at pin 1 should be present here. See additional information below. The PS15 signal passes from the power board through the CPU and Interface board to its final destination – the key switch. Likewise, PS15R travels back through these boards to trigger a power up. Thus, there are several points available to check these signals and troubleshoot a power up problem through the process of elimination.

The following is a summary of key points to check.

- If the display is blank, the PS15/PS15R circuit can actually be working correctly. If a unit appears not to be working, the first thing to check is for activity on the power board. With the key in position 2, wait for a few seconds and check for illuminated LED's on the power board. If LED's are illuminated, serial communications to the display should become suspect. Begin troubleshooting the CPU J10 to Interface J5 connectivity. Check the CPU J10 connection first & wire tie if necessary. If LED's do not illuminate, begin troubleshooting PS15 & PS15R.
- To confirm that a break in the PS15(R) circuit has occurred, with power to the unit & the key switch on, check for PS15R at J4 pin 9 on the power board (302268H02). If present, troubleshoot elsewhere, i.e. check for 5 VDC on the CPU. If not, check for the presence of PS15 at J4 pin 8. If PS15 is not present, check the fuses and power coming in.

- The next step would be to check for the presence of the PS15 & PS15R signal at the CPU board. Easiest point to check these will be J12 pin 8 (PS15) and J12 pin 9 (PS15R). If PS15 is not present, check the harness assembly between the power and CPU board. If PS15 is present while PS15R is missing, proceed to the interface board.
- Jumper J4 pin 4 to J4 pin 5 on the interface board. If the unit powers up, the key switch assembly is the probable cause. If not, troubleshoot the connectivity between CPU J7 and Interface J2. Another verification that there is a breakdown in connectivity here is to short J12 pin 8 & 9 on the CPU. If the CPU J7 or Interface J2 connection is the issue, the unit should power up.

J5 - Serial Communications In from CPU

None of the signals at J5 or J6 can be accurately measured with a typical DMM. Some activity maybe discerned with a DMM but an oscilloscope is really required to capture these signals. Plus, measuring points on the 305172H01 are essentially inaccessible. Troubleshooting is basically limited to swapping harnesses or assemblies. A strong indicator of a serial communication problem with the display is when there is LED activity on the power board yet the display is blank. On other occasions, a unit may have been running and then the information on the display becomes static. It is also common for erroneous dots to be illuminated on the display in this scenario. This is indicative of a successful communication link being broken. Reseat J10 on the CPU as well as J5 on the interface board. A wire tie around the J10 connection is recommended.

Pin 1 – Serial Data

Pin 2 – Latch

Pin 3 – Blank

Pin 4 – Ground

Pin 5 – Serial Clock Pin 6 - Ground

J6 – Serial Communications Out to VFD Display

Pins 1, 3, 5, 7, 9, 11, 13, 17, 25 – No Connect

Pins 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24 - Ground

Pin 15 – Serial Data

Pin 19 – Blank

Pin 21 – Serial Clock

Pin 23 – Latch Pin 26 - +5V

J7 - Ground and 5 VDC Out to VFD Display

Pin 1 – "+5V'" If not present, check for "+12V" signal at J1 pin 1. If "+12V" is present while "+5V" is missing, U2 circuitry would be suspect and the 192039 assembly should be replaced. If both signals are absent, troubleshoot "+12V" back to the CPU board.

Pin 2 – No Connection

Pin 3 - Ground

CO2 Sensor PCB

This circuit is simply comprised of a regulator supplying constant voltage to a resistive bridge. One leg of the bridge (R1 & R4) consists of precision resistors; the other leg is the TC sensor itself, also made up of two resistive elements. Each of these is a basic voltage divider circuit. The voltage produced at the center of each divider is provided to the CPU board A/D converter via JP1 and JP2. These values are then used to calculate CO2.

Test Points

JP4 Pin 1 – "RAW"

Pin 1 is closest to the "JP4" label. "RAW" is the main supply voltage to the board and the regulator. A specific voltage level here is not important: it will vary with line voltage. Just determining that there is a voltage here is the important item (15-20 VDC, typically ~18 VDC). If this is not present, yet the system is running in all other respects, the harness to JP4 is probably the problem. In most cases, if "RAW" is not present, there will be more significant system problems.

R2 Pin 1 – +12V

Regulator output, measure at leg of R2 closest to JP2. If +12VDC is not measured, unplug JP1, JP2, and JP3 then recheck. If still not present, assuming "RAW" has been confirmed, replace the board. Else, reconnect harnesses one at a time and troubleshoot the problematic connection.

JP3 Pin 3 – TC Supply

This is the voltage supplied out to the TC sensor. This should typically measure ~4.8 VDC with the sensor connected; ~11.7 VDC without. Pin 1 is closest to the "JP3" label.

JP3 Pin 4 or JP1 Pin 3 – TC Sensor (V_m-)

This is the voltage produced by the TC sensor and supplied to the CPU board. Under proper operation, this will measure in the ~2.4 VDC range. If the sensor is open circuit, this point will toggle 0 & ~5.4VDC. Pin 1 is closest to the "JP3" & "JP1" label.

JP2 Pin 3 – V_m+

This is the voltage produced by the R1/R4 voltage divider. Under proper operation, this will measure in the ~2.4VDC range. If the sensor is open circuit, this point will measure ~5.4VDC. Pin 1 is closest to the "JP2" label.

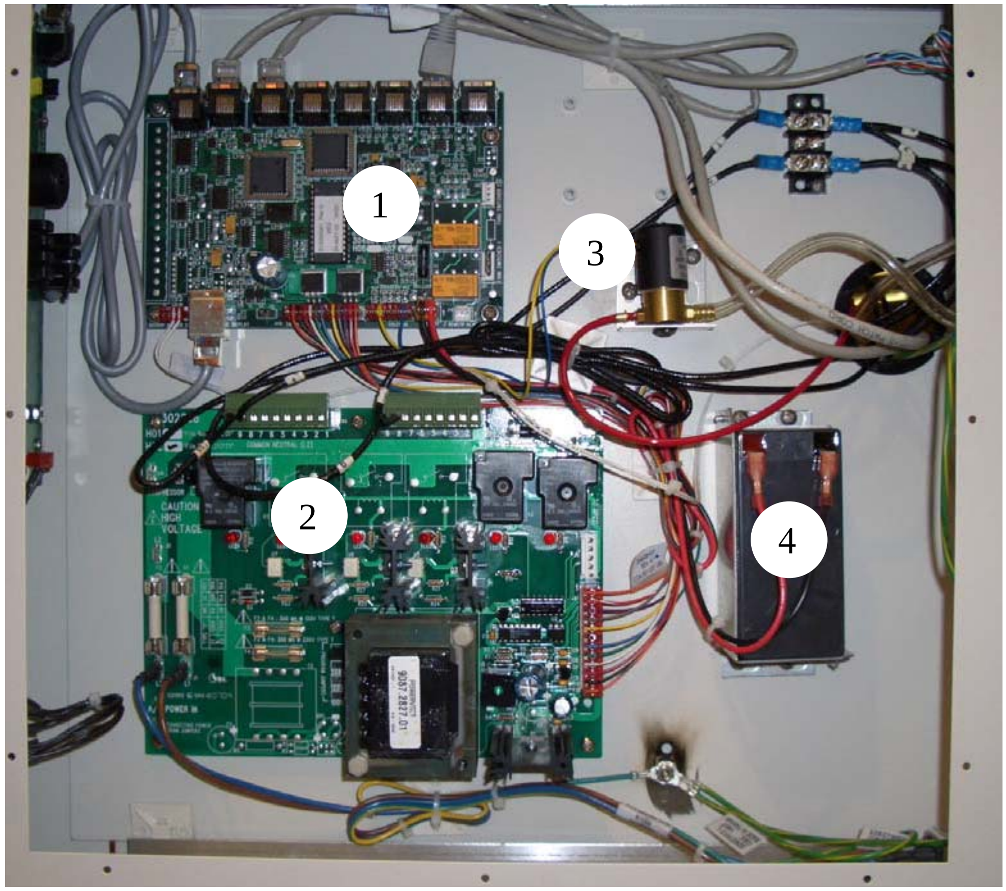
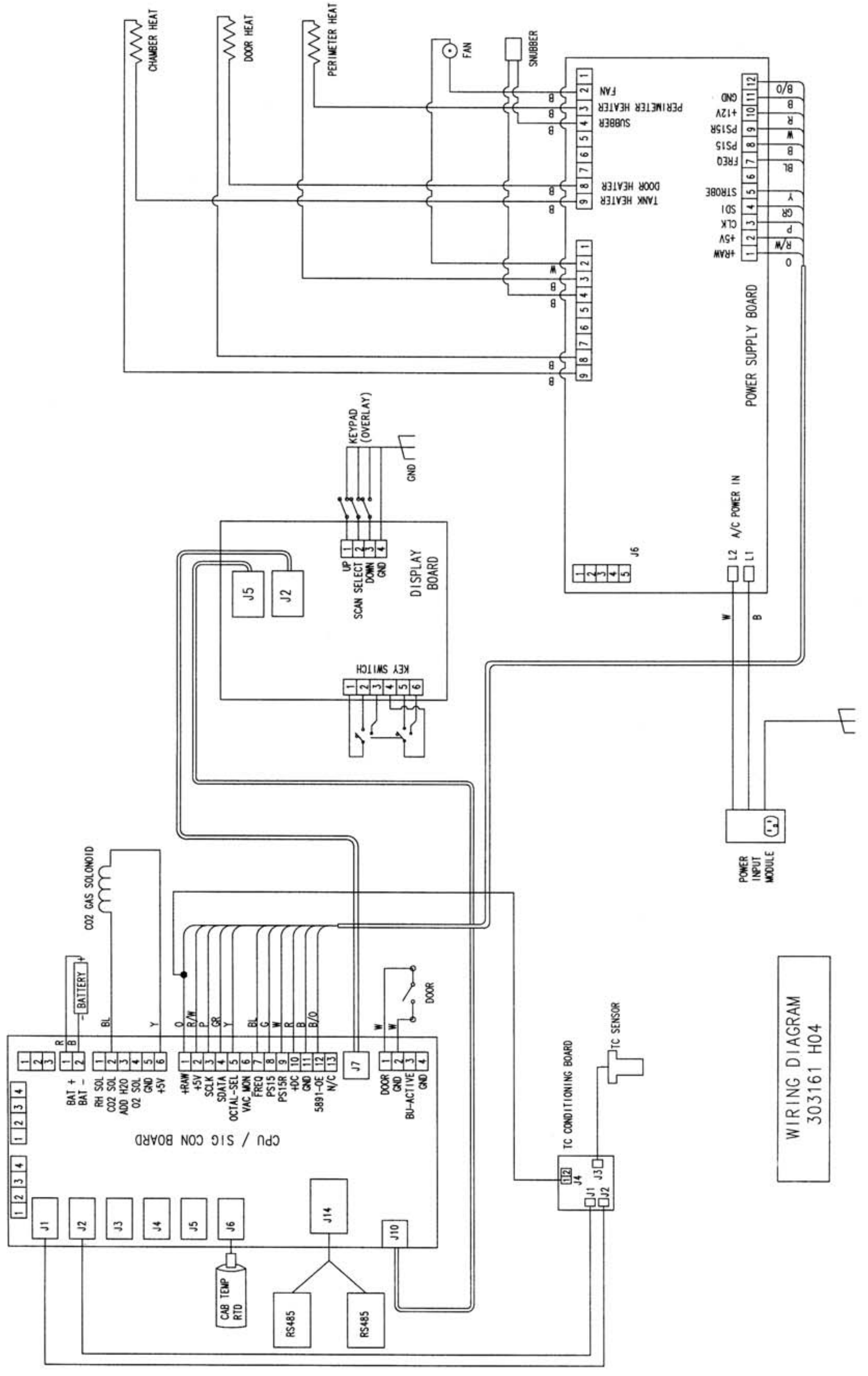


Figure 7-6. Control Housing, Main Components

1. CPU PCB
2. Power PCB
3. CO2 Solenoid
4. 12V Gel Celll battery

Table 7-8. 1K Ohm Temperature Sensor Temperature/Resistance

Temp (Centigrade)	Resistance (Ohms)		Temp (Centigrade)	Resistance (Ohms)		Temp (Centigrade)	Resistance (Ohms)
15	1058.49		34	1132.20		53	1205.49
16	1062.38		35	1136.07		54	1209.34
17	1066.27		36	1139.94		55	1213.18
18	1070.16		37	1143.80		56	1217.03
19	1074.04		38	1147.67		57	1220.87
20	1077.93		39	1151.53		58	1224.71
21	1081.81		40	1155.39		59	1228.55
22	1085.70		41	1159.25		60	1232.39
23	1089.58		42	1163.11		61	1236.23
24	1093.46		43	1166.97		62	1240.07
25	1097.34		44	1170.83		63	1243.90
26	1101.22		45	1174.69		64	1247.74
27	1105.09		46	1178.54		65	1251.57
28	1108.97		47	1182.39		66	1255.40
29	1112.84		48	1186.25		67	1259.23
30	1116.72		49	1190.10		68	1263.06
31	1120.59		50	1193.95		69	1266.89
32	1124.46		51	1197.80		70	1270.72
33	1128.33		52	1201.65			


WIRING DIAGRAM
303161 H04
CPU / SIG CON BOARD
POWER SUPPLY BOARD
DISPLAY BOARD
TC CONDITIONING BOARD
TC SENSOR
POWER INPUT MODULE
A/C POWER IN
CHAMBER HEAT
DOOR HEAT
PERIMETER HEAT
FAN
SNUBBER
KEYPAD (OVERLAY)
KEY SWITCH
CO2 GAS SOLONOID
BATTERY
DOOR
CAB TEMP RTD
RS485
RS485
GND

Parts List

Description	Part Number
In-Line Gas Filter	770001
Temperature Sensor	290194
(TC) CO2 Sensor	290195
CPU PCB	192040
Display PCB	192039
Power/Relay PCB	192041
Chamber Heater 230V	132121
Heater, Door, 115V	132073
Heater Door 230V	132113
Valve Assy, CO2 Inject w/.024	1900437
12V Alarm Battery	400194
Foot 1/4 Hole, w/Washer	505180
Power/Alarm Key Switch w/Harness	350061
Door Gasket, Inner Assy	103140
Door, Glass Assy	1900435
Latch, Glass Door Assy	1900436
Outer Door Gasket	990044
Door Switch Harness	350062
Power Cord 125V USA	430108
Pwer Cord 250V European	430109
E-PROM Assy	320546

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