OPERATING MANUAL

EPC-50
AIR-FUEL CONTROLLER

FORM EPC-50 OM 5-09

WARNING: DEVIATION FROM THESE INSTRUCTIONS MAY LEAD TO IMPROPER OPERATION OF THE ENGINE WHICH COULD CAUSE PERSONAL INJURY TO OPERATORS OR OTHER NEARBY PERSONNEL.

1.0 SYSTEM DESCRIPTION

1.1 The Altronic **EPC-50** is an air/fuel ratio controller designed for use on low-horsepower, carbureted natural gas-fueled engines. It employs microprocessor technology, allowing for a high level of sophistication in control strategy, ease of programming and diagnostic capability. The **EPC-50** is designed for use on engines operating at or near a stoichiometric air/fuel ratio (lambda **.95 - 1.05**) and is ideally suited for application with **3-way** catalytic converters. The **EPC-50** is designed to be mounted in the engine/compressor control panel.

1.2 The single control output of the **EPC-50** allows for its use on any engine application incorporating a single fuel gas regulator. An oxygen sensor is used in the exhaust stream to sense O_2 content, and a thermocouple input signals when proper exhaust temperature has been reached to allow for accurate sensor operation. The system fuel control valve installed in the fuel line to the carburetor is precisely adjusted by a stepper-motor under microprocessor control to maintain the correct O_2 content in the exhaust. The desired air/fuel ratio can be easily adjusted by changing the control target voltages.

1.3 The **EPC-50** has an alphanumeric LCD display showing the target voltage, sensor voltage, operating temperature, stepper motor position and diagnostic information.

1.4 Power requirement is **24 (10–30) VDC, 1 amp**. In remote areas, power can be provided by the **Altronic 24 VDC Alternator Power Package**. Refer to Altronic Form ALT.

1.5 The **EPC-50** also incorporates a thermocouple input and a dedicated output for implementation of catalyst over-temperature protection. A second digital output is available for use as an alarm for diagnostics or uncontrolled operation.

2.0 SYSTEM COMPONENTS

2.1 One part from each group below is required for each installation:

PART NO.	DESCRIPTION	QUANTITY REQUIRED
EPC-50	Air/fuel controller	1 per engine
690153-1	Control Valve, .75" NPT	1 per engine
690154-1	Control Valve, standard 1.5" NPT	1 per engine
690154-2	Control Valve, low HP 1.5" NPT	1 per engine
690154-5	Control Valve, very low HP 1.5" NPT	1 per engine
690220-1	Control Valve, butterfly 2.0" NPT	1 per engine
690225-1	Control Valve, butterfly 2.5" NPT	1 per engine
690230-1	Control Valve, butterfly 3.0" NPT	1 per engine
693013-1	Cable, control valve, 30 ft.	1 per engine
693006-1	Cable, oxygen sensor, 25 ft.	1 per engine
693006-2	Cable, oxygen sensor, 50 ft.	1 per engine
610621	Oxygen sensor	1 per engine
**	"K" Thermocouple Probe (ungrounded w/thermowell)	1 per engine, plus 1 for Catalyst Out
**	"K" Thermocouple Ext. Wire	50 ft. per thermocouple
**	12-16 AWG Hook-up Wire	150 ft. per engine

** Not supplied in Altronic kits.

NOTE: If possible, keep the original shipping container. If future transportation or storage of the controller is necessary, this container will provide the optimum protection.

2.2 ACCESSORY KITS

691305-1 ACCESSORY KIT INCLUDES:

610621	Oxygen Sensor
693013-1	Cable Assembly, Control Valve, 30 ft.
693006-1	Cable Assembly, O2 Sensor, 25 ft.

691305-2 ACCESSORY KIT INCLUDES:

610621	Oxygen Sensor
693013-1	Cable Assembly, Control Valve, 30 ft.
693006-2	Cable Assembly, O2 Sensor, 50 ft.

2.3 REFER TO FIGS. 1 OR 2 for the general layout of components used in the **EPC-50** control systems.

3.0 MOUNTING THE EPC-50

3.1 Operating temperature range is **-40° to 158°F. /-40° to 70°C**. Humidity specification is **0-95%**, non-condensing. Mount the **EPC-50** inside a control panel, preferably off the engine, in such a manner as to minimize exposure to vibration. The Control Module should be mounted so that the display is at a convenient viewing height. **SEE FIGURE 2** for mounting dimensions. A **NEMA 3R** housing **(720004-1)** is also available as an alternative mounting option **SEE FIGURE 3**. Avoid mounting the LCD display and keypad in direct sunlight.

4.0 MOUNTING THE OXYGEN SENSOR

4.1 The sensor should be installed in the exhaust system between the engine and the catalytic converter and/or muffler. The mounting location should be as close to the exhaust manifold of the engine as possible. The tip of the sensor should be exposed to the unobstructed flow of the exhaust gases from all cylinders of the engine. This means that the sensor should be mounted near, but still before the exhaust stack. **DO NOT** locate the sensor in a coupling or in a location where the exhaust gas flow is uneven due to obstructions or sharp bends. The sensor location chosen should allow easy access since sensor replacement may be required as often as every **2000** hours in some applications. The location chosen should not subject the exterior shell of the sensor to an ambient air temperature greater than **350°F**.

NOTE: A weldment boss may be required for sensor installation in soft or thin wall exhaust systems.

4.2 Drill, tap and spot face a hole in the exhaust pipe at the selected location. A flat smooth sealing surface is required to assure accurate readings since air or exhaust leaks will impact sensor operation.

SEE FIG. 5 FOR DETAILS

4.3 New sensors are packaged with an anti-seize compound already applied to the threads. There is no need to apply additional anti-seize unless reinstalling a used sensor. If required, use high temperature anti-seize very sparingly and apply only to the sensor threads. Sensors should be torqued to **28-34 lb.-ft**.

5.0 MOUNTING THE K-TYPE THERMOCOUPLES

5.1 **EXHAUST TEMPERATURE THERMOCOUPLE** is used to monitor the temperature of exhaust gases near the exhaust oxygen sensor and should be mounted as close as possible to the O_2 sensor. As with the O_2 sensor, the location should be easily accessible, and the tip of the probe, which should be enclosed by a thermowell, should be surrounded by unobstructed exhaust flow.

5.3 **CATALYST PROTECTION THERMOCOUPLE** should be installed in the catalyst housing. Provision for thermocouple installation is normally provided for in the design and manufacture of the catalyst. Installation of the thermocouple at the outlet of the catalyst provides two modes of protection: **High Outlet Temp Shutdown** and **High Catalyst Temperature Rise Shutdown**. Consult catalyst manufacturer's recommendations for required overtemp protection.

5.3 **ONLY UNGROUNDED THERMOCOUPLE PROBES** can be used with the **EPC-50**. Grounded type thermocouples will not function correctly. Resistance from either lead of the thermocouple to the probe shell should be **2 megohms** or greater.

6.0 MOUNTING THE FUEL CONTROL VALVE

NOTE: For detailed instructions covering the gas control valve, see form GCV1 OM (690154 series) or GCV2 OM (6902XX series).

6.1 In order to control the air/fuel ratio, an electronically controlled valve is connected in series between each regulator and carburetor. The valve should be installed as close to the fuel inlet of the carburetors as possible. The distance from the valve to the carburetor inlet should not exceed **12** pipe diameters in length. The valve should be installed with the control cable connector facing upward to avoid the collection of condensation in the stepper motor.

6.2 If possible connection piping should be of the same diameter as currently in use. The threaded connection to the valve body may require the use of thread adapters. If adapters are used, proper plumbing procedures must be followed.

6.3 The control valve is connected to the **EPC-50** using the **693013-1** cable. The cable wires are color coded and must be connected to the valve output terminal block of the **EPC-50** according to color. This cable must not be run in the same conduit as the ignition primary or other O_2 Sensor or Thermocouple wires. A distance of **4 to 6 inches** should be maintained between **EPC-50** wiring and other engine wiring.

7.0 ELECTRICAL HOOK-UP

7.1 The power connections to the **EPC-50** must be in accordance with the National Electrical Code. The **EPC-50** is suitable for installation in **Class I, Division 2, Groups C and D** locations.

7.2 Although the input power has an internal protective fuse **(3 amp)**, an external fuse **(5 amp max.)** near the power source is recommended.

7.3 The **EPC-50** can be powered in one of the following ways:

- **24 volt battery with trickle charger (1 amp min. output).**
- **DC power supply capable of furnishing 12-30 VDC, 2 amps.**
- **Altronic 24 VDC Alternator Power Package –see form ALT.**

NOTE: Voltage and current supplied must be sufficient to operate all transducers used in the installation. If a heated Oxygen Sensor is required, the heater current must be added to the requirements shown.

7.4 Power wiring and signal (transducers) wiring must be in separate conduits and conduit entries into the panel containing the **EPC-50** to avoid undesired electrical interaction.

7.5 Input power supply wires **(16 AWG minimum)** should connect to the **24 volt** supply terminals of the main terminal block.

7.6 Oxygen sensor is connected via shielded cable **P/N 693006**. This should be run in conduit only with the **EPC-50** thermocouple connections. These cables should enter the panel containing the **EPC-50** and connect to the main terminal block. The red wire should be connected to the O_2 sensor **(RED)** terminal, and the black wire to the O_2 sensor **(BLACK)** terminal. The shield wire should be cut short and not connected. The cable provided is terminated with weather tight connectors which mate to the O_2 sensors provided by Altronic. The shield wire (green wire at connector end) must be connected to the exhaust piping near to the sensor. This shield will assist in rejecting noise from other wiring which could affect the O_2 sensor signal.

NOTE: Engines using positive ground DC accessories or starter motors will require a separate dedicated ungrounded power supply for the EPC-50.

REFER TO FIGS. 4 AND 5

7.7 The thermocouple **(24 AWG min. type K extension)** wires should be run in a conduit only with the **EPC-50 O_2** sensor wires. The yellow wire should be connected to the T/C (**YELLOW**) terminal and the red wire to the T/C (**RED**) terminal. Again, care should be taken to identify the two thermocouple wires (**TC1 AND TC2**). **REFER TO FIGURE 5**

7.8 The **CATALYST TEMP PROTECTION SHUTDOWN OUTPUT** is configured as a normally closed output signal. Any of three protection shutdown diagnostic temperature thresholds can cause this output to open. Connect this output to the safety shutdown system in combination with a relay to result in an engine shutdown for the purpose of catalyst protection. This output is non-latching and is self-resetting upon the clearing of related protection conditions. **(SOLID STATE SWITCH RATED 30 VOLTS/0.5 AMPS MAX.)** The protection shutdown switch is labeled **SW2** and a red LED indicator located below the terminal will turn on when the switch opens to indicate the shutdown condition.

7.9 The **ALARM OUTPUT** is configured as a normally closed output signal. Any diagnostic relating to measured temperatures, **O_2** sensor voltages, or rich or lean limit stepper positions will cause this output to open for identification of possible improper airfuel control system operation. This output is non-latching and is self-resetting upon the clearing of all the alarm conditions. **(SOLID STATE SWITCH RATED 30 VOLTS/0.5 AMPS MAX.)** The Alarm shutdown output is labeled **SW1** and a yellow LED indicator located below the screw terminal will turn on when the switch opens to indicate an alarm or diagnostic condition.

7.10 Although the **EPC-50** does not require a computer to be operated or installed, a serial port has been included which can be used for **MODBUS RTU** slave communications using an **RS-485** connection. The port configuration is accomplished using the display and keypad as described in **SECTIONS 12.12 & 12.13**.

SEE SECTION 20.0 FOR MODBUS REGISTER DETAILS.

SEE FIGURE 6 FOR CONNECTION DETAILS.

8.0 THEORY OF OPERATION

8.1 The primary task of the **EPC-50** is to accurately control the exhaust air fuel ratio **(AFR)** of an engine. Control should be maintained through reasonable load and fuel BTU variations.

8.2 Three-way catalysts are used to oxidize **CO** and **HC** and to reduce **NO_x**. These processes require high temperature and correct **AFR** control. Catalysts perform best for all emissions when operated near the stoichiometric **AFR**.

8.3 The stoichiometric **AFR** is the **AFR** at which exactly the required amount of air **(O_2)** is present to completely burn all of the fuel. Because no engine can perform perfect combustion, typical emission by-products include **O_2, HC, NO and CO** even though the engine is running at stoichiometry. The stoichiometric **AFR** is determined by the chemical composition of the fuel, thus they are different for each fuel, or BTU rating.

(e.g. Methane => 16.09 : 1 and Gasoline => 14.70 : 1)

8.4 Because the fuel type is not always known, it is often easier to specify the **AFR** target in terms of lambda. Lambda is an indicator of **AFR** normalized to the appropriate stoichiometric **AFR**.

(Lambda Actual AFR/Stoichiometric AFR)

Thus lambda for stoichiometric combustion would be **1.0**, no matter what fuel is used.

Lambda > 1 = Lean, Lambda < 1 = Rich.

8.5 An **O_2** sensor (lambda sensor) is used to provide exhaust **AFR** feedback to the **EPC-50**. This type of sensor uses a zirconia element which, when combined with a catalyzing outer surface, creates an output voltage used to indicate lambda. Characteristics of the sensor include: an output range of about **0.1 to 0.9 volts** when above **650°F**, a very high output impedance when cool, a very high sensitivity at stoichiometry and a very low sensitivity away from stoichiometry. The output signal provides a very suitable means of controlling just rich of lambda **1.0** which is the **AFR** range required to obtain best catalyst efficiencies for methane-based fuels.

FIG. 8 describes a typical sensor output voltage curve versus lambda.

8.6 A type K thermocouple is used to assure that exhaust temperatures are high enough for correct operation of the sensor before closed loop control is enabled. An additional thermocouple is used to monitor outlet temperature. The **EPC-50** was designed for use on small engines where the catalyst is assumed to be close to the engine. The engine out temperature is assumed to be representative of the catalyst in temperature. The three shutdown thresholds are **Engine/CatIn temperature too high, CatOut temperature too high, and Catalyst temperature rise too high**. Temperature limit setpoints are provided to create a catalyst protection shutdown capability.

8.7 An electronic valve is used to create a variable restriction between the fuel pressure regulator and the carburetor inlet. This restriction is used to adjust the effective inlet pressure seen by the carburetor and results in a mechanical adjustment of the air/fuel mixture delivered by the carburetor. A stepper motor adjusts the restriction by moving a plunger inside the valve. A stepper motor is a brushless motor consisting of a permanent magnet armature and a four-coil multi-pole stator. The armature is moved by sequentially pulsing the four stator coils. Coupled to a worm screw, the rotating armature of the motor provides very accurate linear positioning capability. The motor used provides **1700** steps of travel at **.0005 inch/step** for a total valve stroke of **0.85 inch**.

8.8 The **EPC-50** adjusts the stepper motor to maintain a specific input voltage from the O_2 sensor. When the sensor voltage is above the O_2 target voltage, the system is richer than desired, and the stepper position is increased to further restrict fuel flow to the carburetor. Conversely, when the sensor voltage is below the O_2 target voltage, the system is leaner than desired, and the stepper position is decreased to reduce the restriction of fuel flow.

8.9 Because the sensor voltage output is not linear with lambda, it would not be practical to adjust the system faster when the error from the set-point is greater. So in order to maximize the control response, the motors are instead adjusted faster as the error persists longer. This method provides rapid response characteristics as well as control stability. Control target voltages must be determined with the use of an exhaust analyzer to locate the operating point of lowest stack emissions. These target values are adjustable in the **EPC-50** through the keypad. The resulting system provides accurate and stable control of air/fuel ratio which results in high catalyst efficiencies and reduced stack emissions.

9.0 PRE-START INSTALLATION CHECKLIST

9.1 BEFORE APPLYING POWER TO THE EPC-50:

A. Measure the power supply voltage to assure voltage is within limits **(12-30 volts)**. Leave unit un-powered.

B. With the terminal block disengaged, measure resistance with an ohm meter between the black **O_2** sensor wire and the earth ground of the panel. This should be less than **1 ohm**. Also measure the resistance between earth ground and the common of the **24v** power supply terminal to verify that it is less than **1 ohm**.

C. With the main terminal block disengaged, measure voltage between yellow and red thermocouple wires. The voltage should be **0.80-1.50 mV** for temperatures **60-100°F**. This verifies that thermocouple wires are terminated. If engine had been running, measurements will be higher, reflecting higher actual temperatures.

D. With the terminal block still disengaged, measure resistance between the red wire and the still-connected earth ground terminal. Resistance should be very high or open circuit. Repeat measurement between yellow wire and earth ground. This verifies that thermocouples are ungrounded and that wires are not shorted in conduit.

9.2 WITH THE EPC-50 POWERED UP AND THE ENGINE NOT RUNNING:

A. Display should follow the power-up sequence **DESCRIBED IN SECTION 11.2.**

B. Display of **O_2** sensor voltage should go to **0.5 volts**. This may require a few minutes. **SECTION 14.0** explains how to view data screens.

NOTE: If engine was running recently, temperature will be higher.

C. Data display screen for exhaust temperatures should indicate ambient temperatures.

D. Control valve operation should be verified during a start position command. This can easily be done if the valves are not yet fully installed in the fuel line. Press **ALARM ACK** if the alarm LED is on. Then press **F1** followed by **START POS**. During the start position activity, the left valve plunger should be fully retracted then positioned near the middle of its travel. No movement, erratic movement, or movement in the wrong direction will result from incorrect wiring of the stepper cables.

NOTE: Ground loops could be more significant when the engine is running. The addition of other electrical devices may affect EPC operation with regard to signal offsets.

F. RETURN THE SET-UP VALUES TO THE FACTORY DEFAULTS:
This can be done by slowly pressing the following keys in order **F1, F3, F2, F4**. Then, once the screen indicates that you are in the set-up mode, press **F2** followed by **F2** again to restore default setup values. Then press **F4** to exit the setup mode. The default values are set as follows:

Gain Value = 0.50
Left O_2 Target = 0.80 volts
Left Default Position = 1000 steps

G. CONFIGURE CATALYST PROTECTION THRESHOLDS:
Reasonable value ranges for protection thresholds are shown below. These max temperature limit values should be configured based on catalyst manufacturer's recommendations. This can be done by slowly pressing the following keys in order **F1, F3, F2, F4,** then **F1** to view each successive set-up parameter:

NOTE: Settings should be established based on catalyst manufacturer's recommendation.

Exh Temp Hi = (1000 to 1250°F)
Cat Out Hi = (1100 to 1250°F)
Cat Rise Hi = (100 to 300°F)

9.3 When all of these checks have been made successfully, move on to the **Start-Up Procedure**.

10.0 START-UP PROCEDURE

10.1 BEFORE STARTING ENGINE:

A. Check for fuel leaks where the fuel line was modified.

B. Verify that catalyst over-temp thermocouples and thresholds are in place and functional according to catalyst provider requirements and recommendations.

C. Press **F1**, then press **START POS** on the **EPC-50** keypad to reset stepper position and enable the warm-up delay.

D. Be sure that the power screw adjustments on carburetors are full open or full rich. If these adjustments are not fully open, then the control range of the stepper control valve will be limited.

E. If the alarm outputs of the **EPC-50** are being used, temporarily disconnect or override these signals so that an alarm indication will not shut down the engine during setup.

F. Verify that the catalyst protection output is wired and functional to cause a shutdown in an overtemp condition.

G. Place **EPC-50** controller in **MANUAL** mode by pressing **LEFT MANUAL** key.

H. Start and warm-up engine.

10.2 WITH THE ENGINE RUNNING:

A. Load engine to desired operating point.

B. Verify that the exhaust temperature data screen is displaying reasonable values, and that the temperatures exceed **650°F**.
REFER TO SECTION 14.0 FOR DISPLAY KEY OPERATION

C. Enable automatic control by pressing the **AUTO OPER** key. The unit should begin adjusting the stepper valves trying to control the engines air/fuel ratio. Use any diagnostic warnings which may occur to trouble-shoot the system. Rich or lean limit errors are a good indication that the pressure regulators need some adjustment.

D. Once the unit has gained control of the engine (**O_2** sensor voltage very near the target voltage), adjust the fuel pressure regulators until the **EPC-50** is controlling with the stepper valve positions near **1000 steps**. This is approximately the middle of the valve's control range.

10.3 FINE TUNE THE CONTROL SETPOINTS:

A. Using an exhaust analyzer, determine the set-point voltage which results in the best emission performance. This can be done by incrementally adjusting the O_2 target voltage in the **Set-Up Mode**. Reference **SECTION 12.0** for an explanation of the setup mode. Alternatively, manual mode can be used to adjust the control valves to the positions which give the best emissions performance. **REFERENCE SECTION 15.0** for an explanation of manual mode operation. Then the O_2 target voltages should be adjusted to match the actual sensor voltages using the **Set-Up Mode**.

B. The control gain rate and default stepper positions can also be adjusted now; however, the default values represent the best typical values for these parameters.

10.4 ONCE THE SYSTEM IS CONTROLLING AT THE BEST EMISSIONS POINT, THE ALARM OUTPUT CAN BE RE-ENABLED.

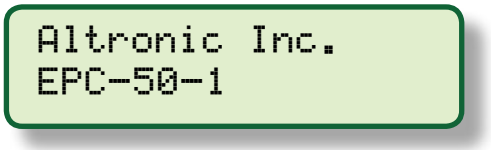
10.5 AT THIS POINT, THE EPC-50 SET-UP IS COMPLETE; THE UNIT SHOULD BE CONTROLLING THE ENGINE.

11.0 GENERAL: KEYPAD AND DISPLAY OPERATION

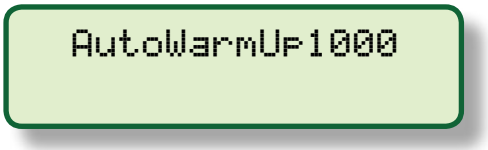
11.1 The **EPC-50** includes a front-mounted keypad and an LCD display which permits the monitoring and adjustment of various parameters and actions.

11.2 The keypad and display function together as the user interface. Only one key on the pad should be pressed at one time. Some commands require a key sequence (a series of key presses, one followed by the next). Whenever possible, special messages indicate what is happening or why a command is not accepted.

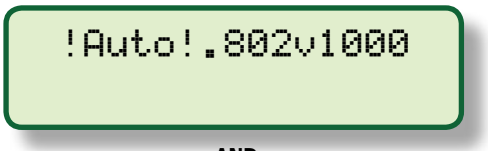
11.3 With the engine not running (cool exhaust), when power is first applied to the **EPC-50**, the display will show an Altronic product description message, then perform an **F1-Start** function.



11.4 After a few seconds the display will indicate that the controller is in warm-up mode. This display indicates that the thermocouples are still reading temperatures too cool for the O_2 sensors to function correctly. The number at the end of the message indicates the current stepper valve position in steps. If the engine is not started this condition will persist for **10 minutes**.



11.5 After **10 minutes** with a cool exhaust, the display will now begin rotating the diagnostic messages for low exhaust temperature. All diagnostic messages include the **!** character for recognition. Diagnostics exist for several functions and are **EXPLAINED IN DETAIL IN SECTION 16**. When any diagnostic condition is present, the status containing **!** will appear, then all of the appropriate descriptions will follow in rotation. O_2 sensor voltage and stepper valve position are also shown.



AND

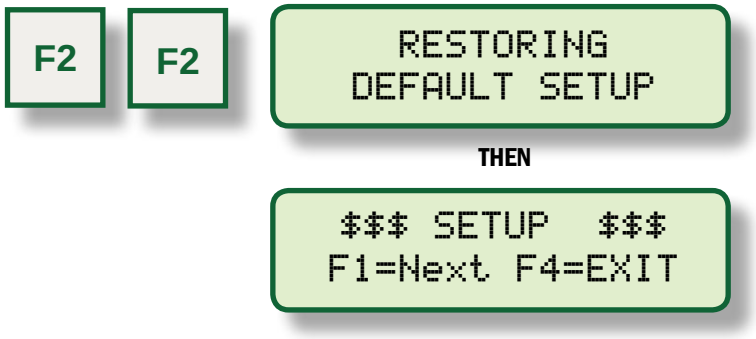
11.6 Press **ALARM ACK** When a new alarm **(ALM)** or protection shutdown condition **(PSD)** is detected, user keypad functions will be restricted until the user acknowledges the new condition. The message **ALARMS MUST BE ACKNOWLEDGED!** will be triggered by keypad presses until the **ALARM ACK** key is pressed to acknowledge the new condition. Pressing **ALARM ACK** does not effect any other indicators or outputs of the **EPC-50**. The display will indicate that the unit is responding to the **ALARM ACK** key press by showing the message **WORKING**.
The low temperature alarm has now been acknowledged and the **EPC-50** will accept other keypad commands. Any time the alarm LED is on steady, no keypad commands will be accepted until the **ALARM ACK** key is pressed. The display will indicate that the unit is responding to this command with message **WORKING**.

12.0 SETUP MODE: KEYPAD AND DISPLAY OPERATION

12.1 Once any alarm is acknowledged, press **F1** followed by **F3** followed by **F2** followed by **F4**. This is the setup mode entry key sequence. The display will indicate that the setup mode is now active.

12.2 Press **F2** then press **F2** again to restore factory default parameters. This special command can be used only from this screen when the user wants to restore factory default values. A message will indicate that the default values have been restored, then will return to the main setup message. **DEFAULT CONTROL VALUES ARE IN SECTION 9.2.** There is a second restore defaults command sequence: **F3**, then **F2**, that will reload all factory defaults with regard to diagnostic and **PSD** thresholds. These are kept separate to avoid changing protection settings for the catalyst.

NOTE: The factory default PSD settings are very conservative and will most likely result in the shutdown of a loaded engine.



12.3 Press **F1** to increment to the control gain setup screen. The factory default value for this parameter is **0.50** as shown on the display. This parameter determines the stepper valve adjustment rate when in automatic mode. The higher the value the faster the controller will move the stepper in response to the O_2 sensor.

12.4 Press **F2** to increase the value for the gain parameter. The display will indicate that the value has been changed. At this point the value is updated and will be used until the value is changed again.

12.5 Press **F3** to decrease the value. Now the value is decreased to the default value again. The range for the gain value is limited to **(0.1 to 2.0)**. The value cannot be moved beyond its limits.

NOTE: All screens in setup mode include the $ character.

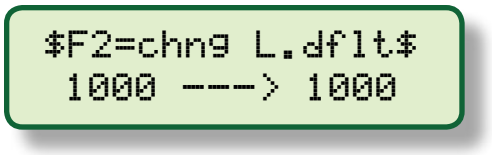
12.6 Press **F1** to increment to the left 0_2 target setup screen. The factory default value for this parameter is **0.80 volts** as shown on the display. Like the gain value, the target can be increased and decreased with the **F2** and **F3** keys. The typical range is near **0.8 volts**. The allowable range is **0.01 to 1.05**; however most sensor's output range is limited to **0.1 to 0.9 volts**.

12.7 Press **F1** to rotate to the left default stepper position screen. The default position is used when any of the 0_2 sensor or thermocouple diagnostics are active. The number on the right is the current default position. Because the temperature diagnostic is still active, the actual stepper position on the left is also **1000**.

12.8 Press **F2** to update the default position (on right) with the value of the current position (on left). Since both values are the same no change was actually made in this example. By using the manual mode which is **DESCRIBED IN SECTION 15.0**, the actual position can be adjusted to the desired position before entering the setup mode.

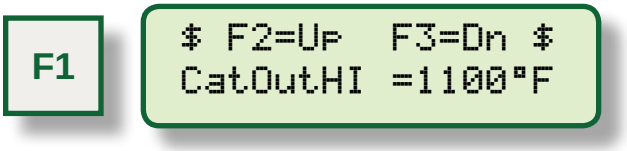
NOTE: Multiple presses of the key are required to continue incrementing the value. If the key is held, the value will be adjusted at a progressively faster rate.

THEN



12.9 Press **F1** to rotate to the first temperature protection setup value. The **EXHAUST TEMPERATURE HI** setpoint represents the maximum permitted engine exhaust temperature as sensed by the left engine out thermocouple mounted near the O_2 sensors. High temperatures at this location may indicate engine overload or engine misfire. The **CATALYST TEMPERATURE PROTECTION SHUTDOWN** output switch will open if this threshold is exceeded to cause a protection shutdown.

12.10 Press **F1** to display the **CATALYST-OUT HI** temperature setpoint threshold. If the outlet temperature of the Catalyst should exceed this setting, then the **CATALYST TEMPERATURE PROTECTION SHUTDOWN** output switch as well as the **ALARM** output switch will open to cause a protection shutdown. Conditions of misfire or overload or improper engine operation may be identified by this test. Extreme temperature at the outlet of the catalyst indicates that the catalyst is being damaged by the operation conditions of the engine. Provision may be provided in the catalyst to mount a temperature probe at the catalyst element. This location may serve as an alternative to catalyst outlet temperature. Consult the catalyst manufacturer for the recommended outlet-temperature shutdown limits.

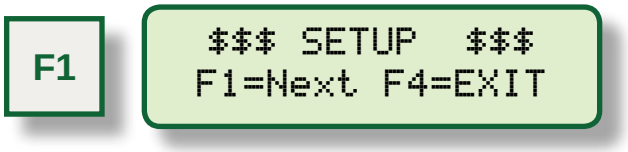


12.11 Press **F1** to display the **CATALYST TEMPERATURE RISE HI** setpoint threshold. The temperature difference outlet–inlet is compared to this setpoint to identify excessive temperature rise across the catalyst. The catalyst inlet temperature is assumed to be the same as the engine out exhaust temperature thermocouple. This condition of temperature rise is an indication that the catalyst is reacting unburned air and fuel that may result from a misfire or poor combustion condition. If the temperature rise across the Catalyst should exceed this setting, then the **CATALYST TEMPERATURE PROTECTION SHUTDOWN** output switch will open to cause a protection shutdown. Consult the catalyst manufacturer for the recommended temperature rise shutdown limits.

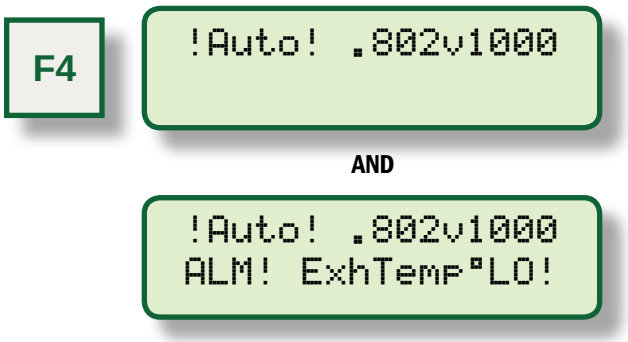
12.12 Press **F1** to display the **MODBUS NODE ID** setup screen. Valid node ID's are **0 to 255** permitting the communication system to incorporate multidrop communications to various ModBus slave devices.

12.13 Press **F1** to display the **MODBUS PORT** setup screen. Various baud rates are supported by the **EPC-50**. The selections include baud rates of **600, 1200, 2400, 4800, 9600, 19200, 38400, 57600**.

12.14 Press **F1** to rotate back to the main screen.



12.15 Press **F4** to exit the setup mode. **F4** can be used from any setup screen. Remember all setup screens have the **$** character on them somewhere. This returns the display to the warning message which was caused by low exhaust temperatures.

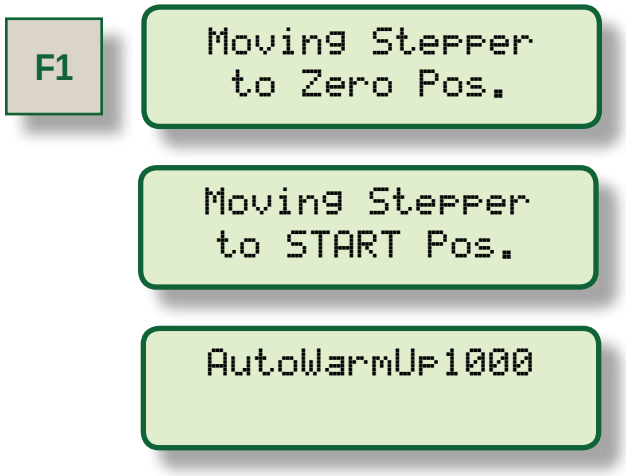


Note: Loading default settings as shown in section 12.2 does not affect settings relating to the Catalyst Temp Alarm Output or ModBus configuration.

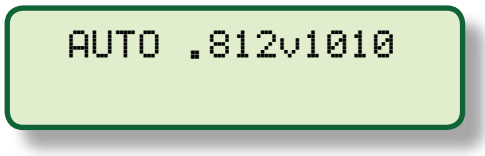
13.0 ENGINE STARTUP: KEYPAD AND DISPLAY OPERATION

13.1 Press **ALARM ACK** to acknowledge alarms if alarm LED is **ON**.

13.2 Press **F1** then press **START POS** to send the steppers to start position (stepper default position) and disable the alarm warnings due to a cold engine for **10** minutes. The controller will return each stepper to its start position and then display the warm-up screen. This procedure should **ALWAYS** be used when starting the engine.



13.3 Now the engine should be started, warmed up and loaded. Temperature requirements would be met before the **10 minute** delay expires and the controller would go into automatic control. Both the current $\mathbf{O_2}$ sensor voltage, and the current stepper valve position are provided on the automatic display screen.



14.0 DATA VIEWING: KEYPAD AND DISPLAY OPERATION

14.1 Press **DSPL SEL** to display the first data view screen. The first data screen displays the current O_2 sensor voltages.

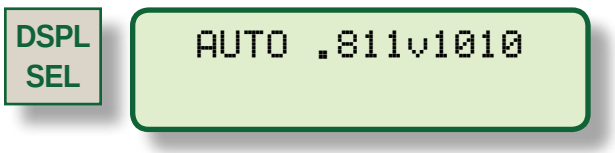
14.2 Press **DSPL SEL** again to display current O_2 target voltages.

14.3 Press **DSPL SEL** again to display the engine out exhaust temperature reading from thermocouple **TC1** which is located near the O_2 sensor.

SINGLE BANK TC1

14.4 Press **DSPL SEL** again to display the Catalyst inlet temperature is assumed to be the same as engine out exhaust temperature as measured by **TC1**.

14.5 Press **DSPL SEL** again to loop back to the automatic screen.

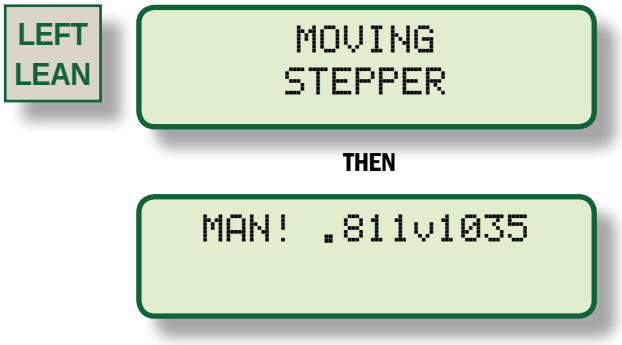


15.0 MANUAL MODE: KEYPAD AND DISPLAY OPERATION

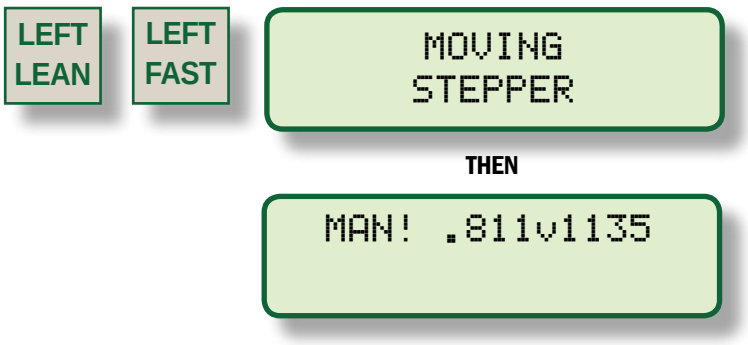
15.1 Press **MAN** to enter the manual mode. The display will indicate **WORKING** and then return to manual mode. This mode can be used to help setup the controller, and to diagnose problems. Because no diagnostic alarms are present, it was not necessary to acknowledge alarms. Also, once in manual mode, diagnostic alarms are disabled. In manual mode, the alarm output **SW1** will be open and the yellow LED will be on to indicate system is not in automatic control.

NOTE: Both the ALARM LED and the ALARM output return to the normal condition when the system fault is corrected.

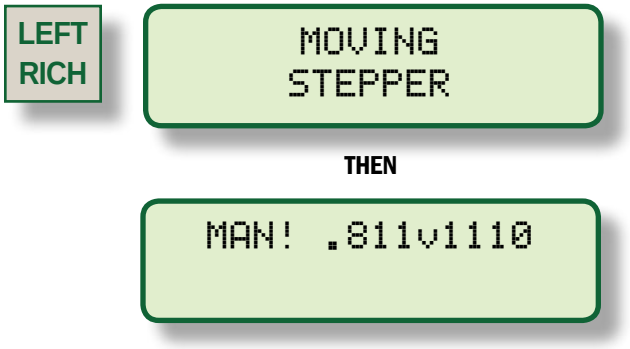
15.2 Press **LEFT LEAN** to increase the stepper position by **25 steps**. A descriptive message will be displayed and then the modified position will be returned. Increasing the position causes the valve to close and the mixture to change in the lean direction.



15.3 Press **LEFT FAST**, then press **LEFT LEAN** to increase the stepper position by **100 steps**.

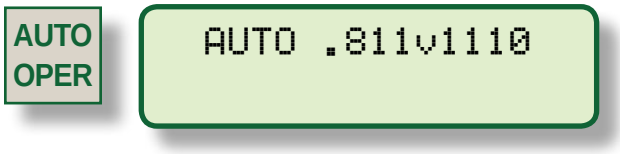


15.4 Press **LEFT RICH** to decrease the stepper position by **25 steps**. Decreasing the position causes the valve to open and the mixture to change in the rich direction.



NOTE: When F1 then START are pressed before starting the engine, the exhaust temperature diagnostic will be delayed 10 minutes displaying the warm-up screen.

15.5 Press **AUTO OPER** to return to automatic mode. Any time this key is pressed, automatic mode will be enabled for both banks.



15.6 POSITION UNCERTAIN

If power to the **EPC-50** is interrupted, the display reads ***Pos.UnCertain*** and may or may not blink. This occured because the position was not saved automatically at the moment of power loss/interruption. Typically this would occur if the **EPC-50** were powered up while the engine was running.

It is important to note that this is a temporary and resolvable condition. The **EPC-50** is functioning properly and, if it is in **AUTOMATIC** mode, it will correct itself. If the **EPC-50** is in **MANUAL** mode, the proper display setting can be restored by performing an **F1** start.

16.0 DIAGNOSTIC DISPLAYS AND OPERATION

16.1 ALARM OUTPUT

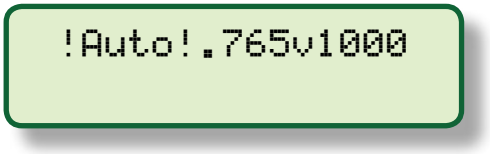
The **ALARM** output is configured as a **NORMALLY CLOSED** output signal. Any system fault will open the alarm circuit. including loss of power, diagnostic warnings, etc. As described above, the alarm output would be in its fault condition (open) any time that an unacknowledged alarm or shutdown is present.

16.2 SYSTEM DIAGNOSTICS

The system diagnostics included in the **EPC-50** are designed to identify conditions which are not considered normal operation. These diagnostic tests are performed continuously while the controller is in automatic mode. Each of the diagnostics will display a descriptive message and place the alarm output in the fault condition **(OPEN)**.

16.3 DIAGNOSTIC WARNING MESSAGES

Active diagnostic warning messages include the **!** character and are displayed in rotation, each message being displayed for about **1 second**. The home screen uses the **!** character to indicate the status and that other diagnostics will follow in rotation.



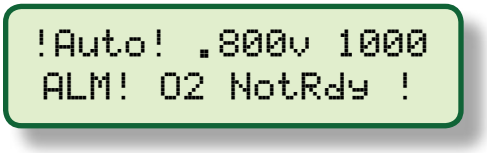
16.4 EXHAUST TEMPERATURE

The **Exhaust Temperature** diagnostic monitors the exhaust temperatures near the O_2 sensors as measured with the thermocouples. If the temperature is below **650°F** or above **1400°F**, then the **EPC-50** displays the appropriate low or high message and activates the **ALARM** LED and **ALARM** output. Automatic control is also disabled and the stepper valves are positioned at the default stepper position. Thermocouple probe or thermocouple connection failures will also activate this diagnostic.

OR

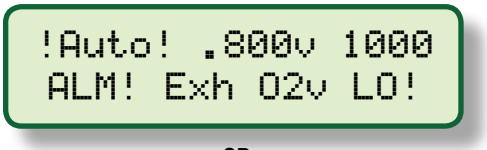
16.5 SENSOR NOT READY

The **Sensor Not Ready** diagnostic is designed to identify problems with the O_2 sensor. The controller has a very high impedance pull up resistor to **0.5 volts** in parallel with each exhaust sensor input. When the sensor is too cool or disconnected this will force the input to read **0.5 volts**. If the controller sees that the sensor output is **0.5 volts** for **10** or more seconds the **EPC-50** will display the sensor not ready message and activate the **ALARM** LED and **ALARM** output. Automatic control is also disabled and the stepper valves are moved to the default stepper position. The sensor ready test is only performed if the exhaust temperature requirements of **16.5** are satisfied. Failure of this test indicates a cold, disconnected or failed sensor.



16.6 SENSOR INPUT VOLTAGE

The **Sensor Input Voltage** diagnostic is also designed to identify problems with the O_2 sensor. Normal input voltages should be between **0.1 and 0.9 volts**. If the sensor input voltage is less than **0.1 volts** or more than **1.1 volts**, the **EPC-50** will display the appropriate low or high message and activate the **ALARM** LED and **ALARM** output. Automatic control is also disabled, and the stepper valves are moved to the default stepper position. Failure of this diagnostic test indicates shorted wiring or a failed sensor.



OR

16.7 LEAN AND RICH LIMIT

The **Lean and Rich Limit** diagnostic monitors the stepper positions. If the position of a stepper valve is at the minimum **(0)** or maximum **(1700)** travel limit, the **EPC-50** displays the appropriate message and activates the **ALARM** LED and **ALARM** output. The rich limit warning indicates that the engine is too lean and the controller cannot open the valve any farther to enrich the mixture. The lean limit warning indicates that the engine is too rich and the controller cannot close the valve any farther.

OR

16.8 ENGINE OUT EXHAUST OVER-TEMPERATURE

When the left or right bank exhaust temperature exceeds the setup threshold, the alarm output will open, the alarm LED will turn on, the **Catalyst Protection Alarm** output **(PSD)** will open, and the messages below may be displayed.

16.9 CATALYST OUTLET OVER-TEMPERATURE

When the outlet temperature of the catalyst exceeds the setup threshold, the alarm output will open, the alarm LED will turn on, the **Catalyst Protection Alarm** output **(PSD)** will open and the message below is displayed.

16.10 CATALYST TEMPERATURE RISE

When the temperature from the inlet to the outlet of the catalyst exceeds the setup threshold, the alarm output will open, the alarm LED will turn on, the **Catalyst Protection Alarm** output **(PSD)** will open and the message below is displayed.

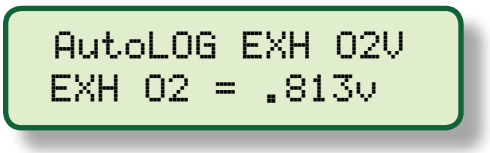
17.0 AUTOLOG FEATURE

17.1 Press **F3** to display the first out **Autolog** screen which provides the first most recent detected cause for leaving normal automatic operation. The cause is logged to a modbus register and also presented as below on the screen using a text string. The example below indicates that, while the engine was running in automatic mode, the measured catalyst output temperature exceeded the PSD shutdown triggering the snapshot of the auto log values as the engine was shutdown. The auto log values are updated on every transition out of fully automatic control without alarms. The table of auto log causes is shown below.

ALM! Exhtemp°LO!
ALM! ExhTemp°HI!
ALM! Exh O2v LO!
ALM! Exh O2v HI!
ALM! O2 NotRdy !
ALM! Lean Limit!
ALM! Rich Limit!
PSD! ExhTemp°HI!
PSD! CatTemp°HI!
PSD! CatTmpRise!
USER Left MANUAL

17.2 The following screens are viewed in rotation, displaying the next screen on each press of **F3.**

Identifies the temperature at auto log event.



Identifies O2 voltage measurement at auto log event trigger.

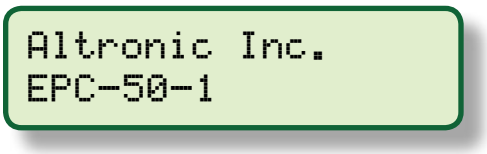
Identifies stepper position at auto log event trigger.

Identifies internal and supply voltage at auto log event trigger.

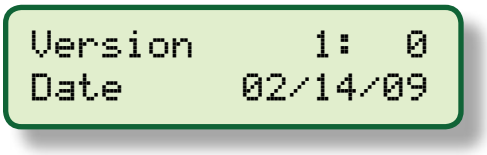
18.0 ADDITIONAL DISPLAY SCREENS

18.1 Three additional screens exist which can be helpful in obtaining information about the version and supply voltage and temperature of the **EPC-50**. They can be viewed as follows.

Press **F1** then **DISP-SEL**, to view the product description screen.



Press **F2** then **DISP-SEL**, to view the version and date information.



Press **F1** then **F2** then **DISP-SEL** to view the supply voltage and temperature.

19.0 TROUBLE-SHOOTING THE EPC-50 SYSTEM

19.1 GREEN PWR LED AND LCD DISPLAY BACKLIGHT ARE DARK; POWER IS INTERRUPTED.

A. Check power supply voltage at **EPC** terminal block **(10-30 volts)**, while still connected.

B. Replace **EPC-50** unit.

19.2 LCD DISPLAY BACKLIGHT IS LIT, BUT BLANK OR NOT FUNCTIONING PROPERLY.

A. Power-down unit for **1 minute**. Re-power and check status of **LCD** display and green **PWR LED**.

B. **LCD BACKLIGHT ON, WITH BLINKING PWR LED, INDICATES:**
Internal problem with terminal program.
Replace **EPC-50** unit.

19.3 KEY PAD ENTRIES CAUSE NO DISPLAY RESPONSE.

A. Verify connection of keypad ribbon connector at bottom of board inside unit.

B. Replace enclosure and keypad assembly.

19.4 EPC-50 WILL NOT MOVE STEPPER VALVES DURING F1 THEN START POS. COMMAND.

A. Check stepper cable connections at **EPC-50** and at stepper valve.

B. Test **EPC-50** with a spare stepper valve assembly.

C. Test **EPC-50** and stepper valve assembly, with a spare stepper cable. (Verify cable connections pin-to-pin.)

D. Replace **EPC-50** unit.

19.5 HIGH OR LOW EXHAUST TEMP WARNINGS PERSIST.

A. Observe thermocouple readings for reasonable values using display select screens in **SECTION 14.**

B. Compare observed readings to—and verify feasibility of—catalyst protection setpoints as described in **SECTION 9.2 (G)**.

C. If engine is not running, start and warm up engine.

D. Test the disconnected thermocouple reading at **EPC-50** with an alternate thermocouple reading device.

E. Replace thermocouple or correct wiring if temperatures are incorrect. The life of thermocouple probes is highly dependent on the use of a thermowell and on corrosives in exhaust.

F. If low temperature is a problem during first installation, an alternate sensor and probe location may be required. Please contact the factory before pursuing any other action to raise sensor temperatures.

G. Replace **EPC-50** unit.

19.6 RICH OR LEAN LIMIT WARNINGS PERSIST.

A. A misfiring engine can cause the system to shift in the rich direction. Check the engine for misfiring cylinders using a timing light or exhaust pyrometer.

B. Use an exhaust analyzer and the **EPC-50** manual mode to adjust the **%O_2** before the converter to around **1.0%**. If the **%O_2** cannot be manipulated in the manual mode, then test to make sure the stepper valve is functioning as was done during installation.

C. If manual mode moves the **%O_2** but cannot attain **1.0%**, then the fuel system may need to be readjusted. First verify that the load screw adjustments on the carburetors are full rich or full open. If they are not full open, the control range of the stepper valves will be limited. Second, adjust the fuel pressure regulators so that when in automatic mode, the stepper valves are controlling near **1000 steps**.

D. If the fuel system appears to be adjusting correctly, use an exhaust analyzer and the **EPC-50** manual mode to sweep the **%O_2** from around **3%** down to **0.2%** while watching the **O_2** sensor voltage on the display. The voltage should move from around **0.2 volts** toward **0.8 volts** as the **%O_2** is changed. If this is not the case, a new sensor should be tested.

E. If **EPC-50 O_2** sensor voltage display does not match actual sensor voltage, test for ground loop problems.
DESCRIBED IN SECTION 9.1B.

F. Replace **EPC-50** unit.

19.7 SETUP VALUES ARE LOST AT POWER-DOWN; EEPROM MEMORY HAS FAILED.

A. Replace **EPC-50** unit.

20.0 EPC-50 MODBUS REGISTER LIST

The **EPC-50** incorporates a half-duplex **RS-485** port which is Modbus RTU slave compliant. The protocol used follows the Modicon Modbus RTU standard. The default configuration for the port is **BaudRate 9600n81** with a node ID of **50**. The Modbus communications could allow the **EPC-50** to meet the needs of continuous emissions monitoring should it be required.

The **10xxx** registers are read-only binary, and support Modbus standard function **1**. These registers are read in multiples of **8 (1 byte)** addressed at each **8 bit** boundary **(10001-10008, etc.)**. A single Boolean read from registers **10001 to 10064** can be made which will return all **64** values as a group of **8 bytes.** These registers also support an Altronic custom function **101** which will return a descriptive label for each specific register. The custom label function can be used to reduce the need for the Modbus master to maintain a current listing of all of the register labels for each unit.

REGISTER	16-BIT BINARY REGISTER VALUE
00017	L-Manual
00018	Reserved Coil
00019	Reserved Coil
00020	Reserved Coil
00021	Reserved Coil
00022	Reserved Coil
00023	Reserved Coil
00024	Reserved Coil
10001	Reserved Status
10002	Reserved Status
10003	Warmup Mode
10004	Reserved Status
10005	Stepper Resetting Now
10006	Reserved Status
10007	Reserved Status
10008	Unacknowledged Alarm Preset
10009	Exh Temp Low
10010	Exh Temp High
10011	O2 Signal Low
10012	O2 Signal High
10013	Reserved Status
10014	O2 Sensor Not Ready
10015	Stepper Lean Limit
10016	Stepper Rich Limit

REGISTER	16-BIT BINARY REGISTER VALUE	
10025	Reserved Status	
10026	Reserved Status	
10027	Reserved Status	
10028	Reserved Status	
10029	Left Bank Step Coil Open A	
10030	Left Bank Step Coil Open B	
10031	Left Bank Step Coil Open C	
10032	Left Bank Step Coil Open F	
10033	Auto Control is Active	
10034	Getting Richer	
10035	Very Rich	>512mv
10036	Rich	
10037	----ONTARGET----	+/-5mv
10038	Lean	
10039	Very Lean	>512mv
10040	Getting Leaner	
10049	Reserved Status	
10050	Reserved Status	
10051	Reserved Status	
10052	Reserved Status	
10053	Step Coil Drive A	
10054	Step Coil Drive B	
10055	Step Coil Drive C	
10056	Step Coil Drive F	
10057	Left Valve Position Uncertain	
10058	Reserved Status	
10059	Reserved Status	
10060	Reserved Status	
10061	Reserved Status	
10062	Reserved Status	
10063	Reserved Status	
10064	Reserved Status	

REGISTER	16-BIT BINARY REGISTER VALUE
10065	TC ENG LEFT HiTemp PSD
10066	Reserved Status
10067	Reserved Status
10068	Reserved Status
10069	TC CAT OUT HiTemp PSD
10070	TC CAT DELTA HiDelta PSD
10071	Reserved Status
10072	Reserved Status

10089	Reserved Status
10090	Reserved Status
10091	DIGOUT1 0=NORM 1=ALM=YELLOW
10092	DIGOUT2 0=NORM 1=SHUTDOWN=RED
10093	Reserved Status
10094	Reserved Status
10095	Reserved Status
10096	Reserved Status

The **30xxx** registers are read-only, **16 bit**, analog values. The Modbus standard function **4** is supported. Multiple register reads are supported up to **32** registers per request. These registers also support an Altronic custom function **104** which will return a descriptive label for each specific register.

REGISTER	16-BIT BINARY REGISTER VALUE
30001	Input Bit Mirror 10016-10001
30002	Input Bit Mirror 10032-10017
30003	Input Bit Mirror 10048-10033
30004	Input Bit Mirror 10064-10049
30005	Input Bit Mirror 10080-10065
30006	Input Bit Mirror 10096-10081
30007	Input Bit Mirror 10112-10097
30008	Input Bit Mirror 10128-10113

30009	SUPPLY INPUT VOLTAGE	.1v/cnt
30010	CJT DEG C	signed 0.01degc/cnt
30011	EXH TEMP ENG-OUT	1degf/cnt
30012	reserved	
30013	EXH TEMP CAT-IN	1degf/cnt
30014	EXH TEMP CAT-OUT	1degf/cnt
30015	EXH O2 VOLTAGE-1	1mv/cnt
30016	reserved	
30017	SMP1C Stepper Position	

REGISTER	16-BIT BINARY REGISTER VALUE
30031	CATALYST TEMP RISE (CATOUT-IN)
30038	CONTROL GAIN VALUE

The **40xxx** registers are read/write, **16-bit**, analog values and they support the Modbus standard functions **3, 6 and 16**. Multiple register reads and writes are supported up to **32** registers per request. These registers may have new values written to them in order to make setpoint adjustments from a remote location. They also support a custom function **103** which will return a label describing each specific register.

REGISTER	16-BIT BINARY REGISTER VALUE	
40001	REG40001=CoilBits 00016-00001	
40002	REG40002=CoilBits 00032-00017	
40003	REG40003=CoilBits 00048-00033	
40004	REG40004=CoilBits 00064-00049	
40005	REG40005=CoilBits 00080-00065	
40006	REG40006=CoilBits 00096-00081	
40007	REG40007=CoilBits 00112-00097	
40008	REG40008=CoilBits 00128-00113	
40009	O2 SENSOR BASE TARGET	mV
40010	reserved	
40011	DEFAULT VALVE START POS	
40012	reserved	
40013	CONTROL GAIN RATE	value/40
40014	EXH TEMP HI ALARM SETTING	degF
40015	EXH TEMP LO ALARM SETTING	degF
40016	EXH O2 HI ALARM SETTING	mV
40017	EXH O2 LO ALARM SETTING	mV
40018	EXH O2 READY HI SETTING	mV
40019	EXH O2 READY LO SETTING	mV
40020	TC ENGOUT HI PSD	degF
40021	TC CAT OUT HI PSD	degF
40022	TC CAT DELTA HI PSD	degF
40023	reserved	
40024	reserved	
40025	reserved	

40082-40089 are Autolog values – a snapshot of parameters upon Alarm Event

REGISTER	16-BIT BINARY REGISTER VALUE	
40082	ENUMERATED CAUSE OF NOT AUTO	
40083	SUPPLY INPUT VOLTAGE	.1v/cnt
40084	CJT DEG C	signed 0.01degc/cnt
40085	EXH TEMP ENGINE OUT	1degf/cnt
40086	reserved	
40087	EXH TEMP CAT IN	1degf/cnt
40088	EXH TEMP CAT OUT	1degf/cnt
40089	EXH O2 VOLTAGE-L	1mv/cnt
40090	reserved	
40091	STEPPER POSITION-L	
40092	reserved	

40120	REG40126 MSB=BAUD LSB=NODEID
40121	Warm Boot (reset) Count
40122	Cold Boot (powerup) Count
40128	MODBUS KEY COMMAND REGISTER

Detailed below are the command values which can be written to the Modbus **Key Command Register (40128)**.

1.	Reg(40128)	00510	Select auto mode for both banks
2.	Reg(40128)	00765	Select manual mode for left bank
3.	Reg(40128)	01275	F1-Start stepper reset
5.	Reg(40128)	01530	Alarm acknowledge
6.	Reg(40128)	01785	Decrement left O2 target
7.	Reg(40128)	02040	Increment left O2 target
10.	Reg(40128)	02805	Decrement control gain rate
11.	Reg(40128)	03060	Increment control gain rate
12.	Reg(40128)	03315	Reload calibration defaults
13.	Reg(40128)	03570	Update left start position with current pos
20.	Reg(40128)	05355	Manual move left stepper rich (- 25)
21.	Reg(40128)	05610	Manual move left stepper lean (+ 25)
22.	Reg(40128)	05865	Manual move left stepper rich (-100)
23.	Reg(40128)	06120	Manual move left stepper lean (+100)

The **EPC-50** units also support a Modbus function **17** which will return the unit information including the **Version, Date and Name**.

30.	Reg(40128)	07905	decrement Hi Exhaust Temp Threshold
31.	Reg(40128)	08160	increment Hi Exhaust Temp Threshold
32.	Reg(40128)	09435	decrement Hi Catalyst Temp Out Threshold
33.	Reg(40128)	09690	increment Hi Catalyst Temp Out Threshold
34.	Reg(40128)	09945	decrement Hi Catalyst Rise Temp Threshold
35.	Reg(40128)	10200	increment Hi Catalyst Rise Temp Threshold
199.	Reg(40128)	51118	autolog reset

FIGURES SECTION:

FIG. 1 EPC-50, GENERAL INSTALLATION LAYOUT: SINGLE BANK

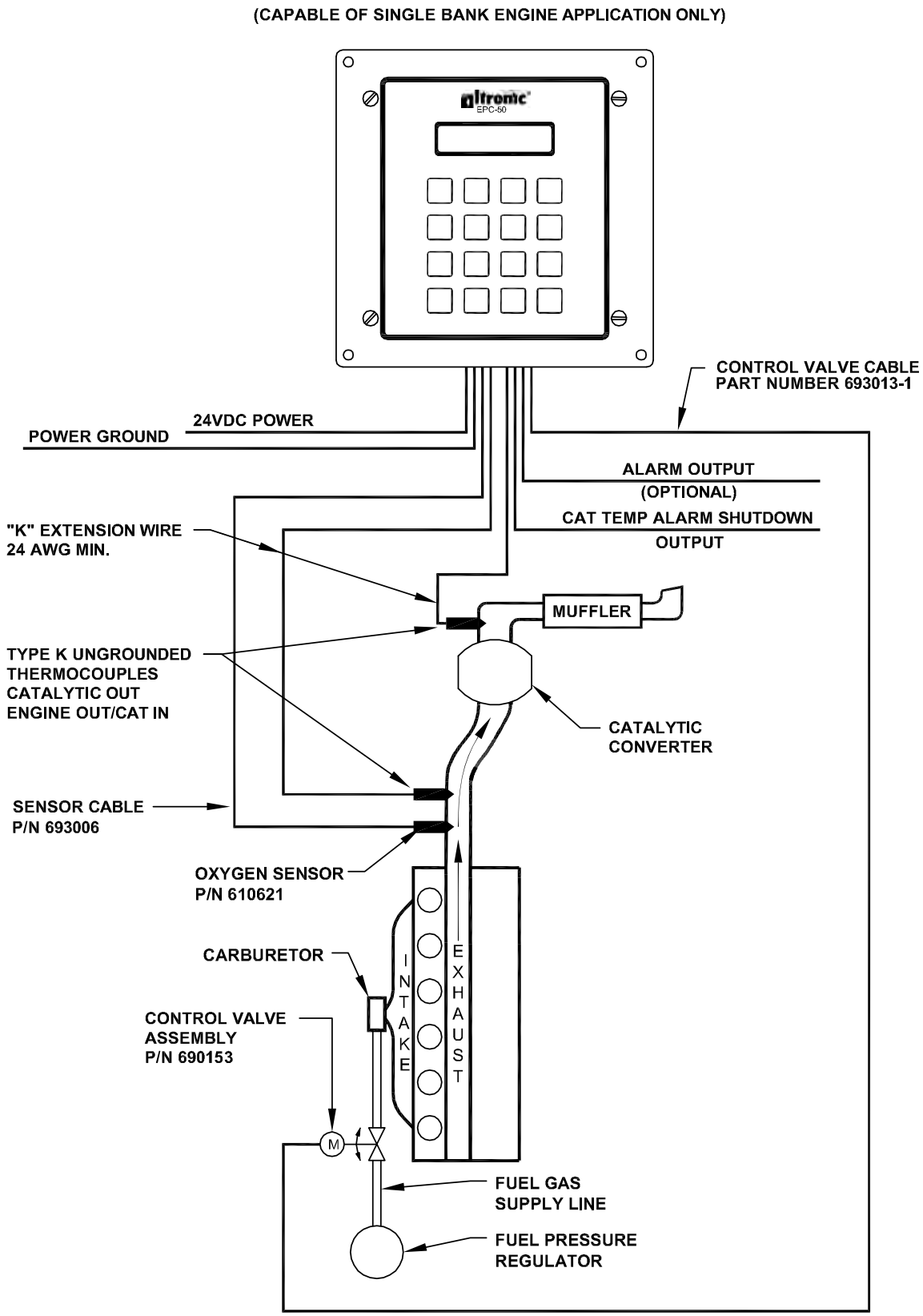


FIG. 2 EPC-50, MOUNTING DETAIL

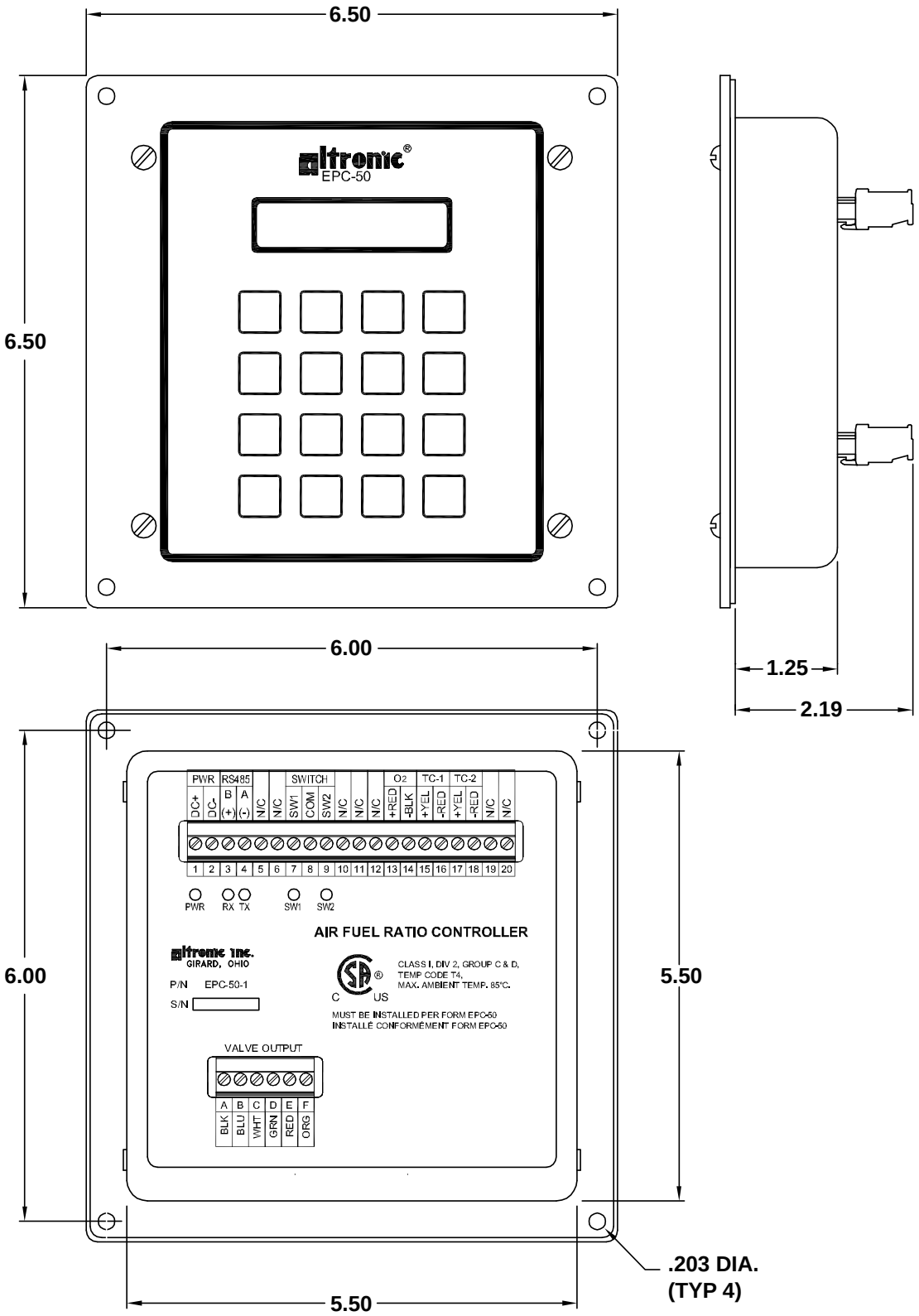


FIG. 3 NEMA 3R ENCLOSURE MOUNTING DIMENSIONS

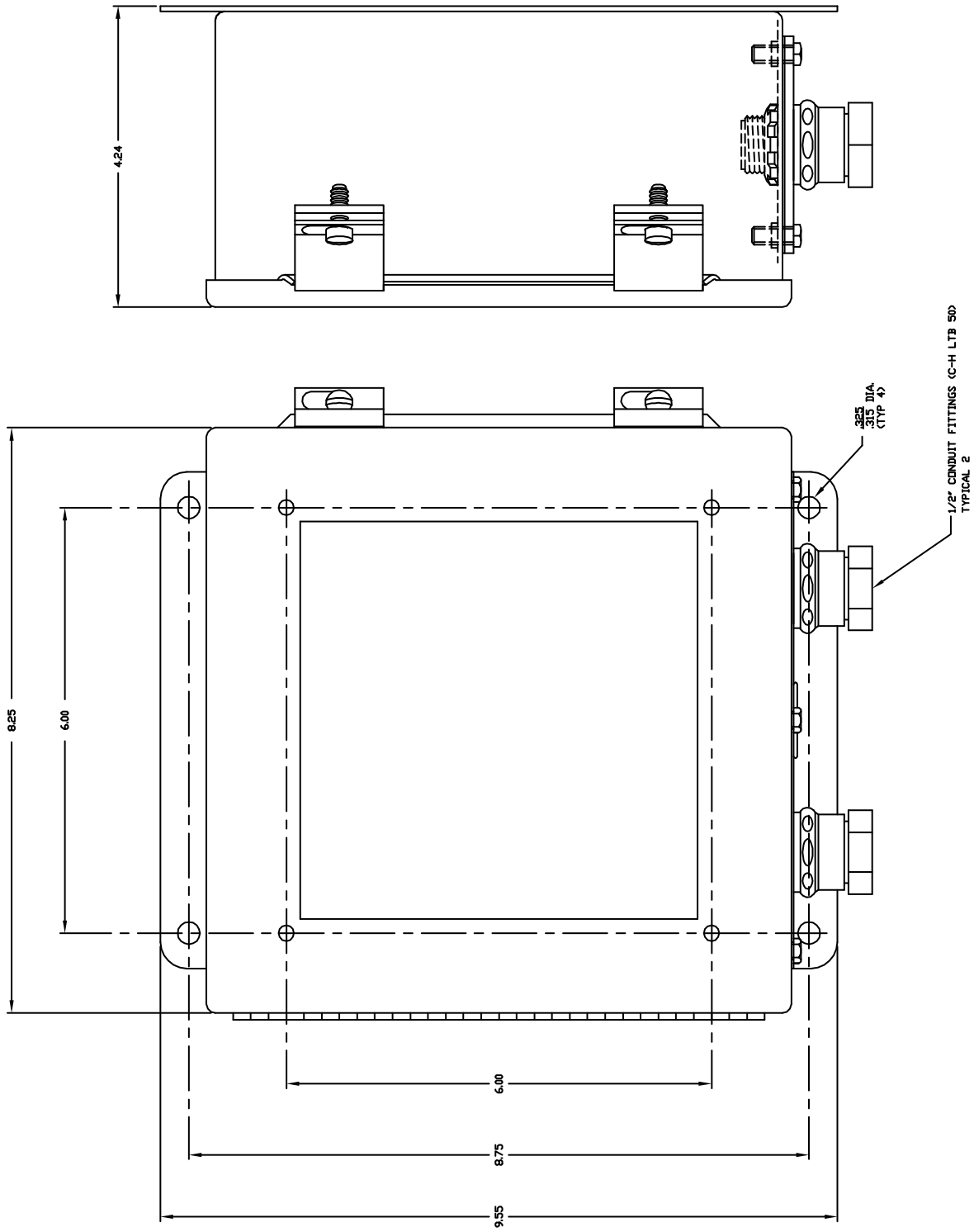
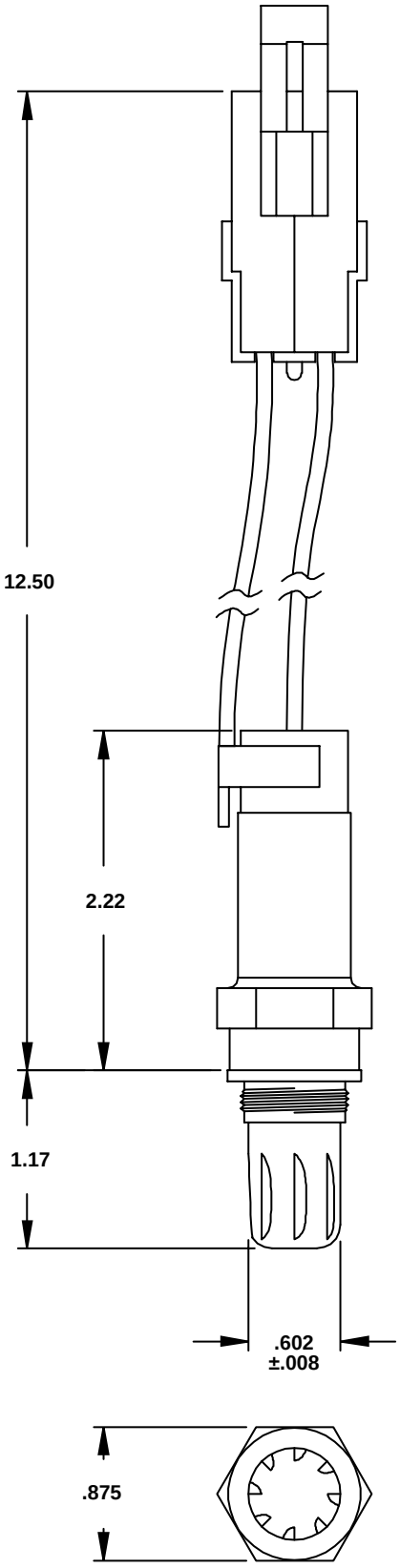
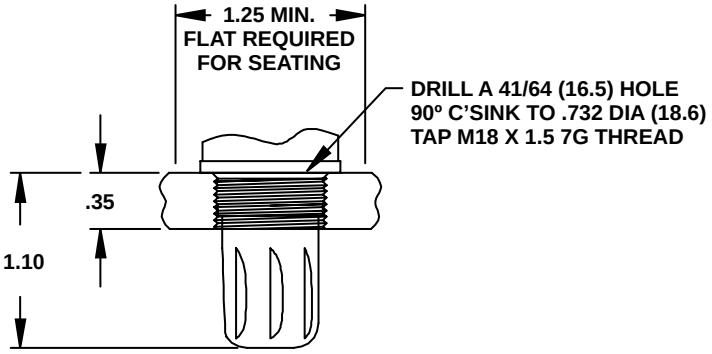


FIG. 4 OXYGEN SENSOR DETAIL



CONNECTOR PIN	WIRE COLOR	PIN AND WIRE CONNECTION
A	TAN	SENSOR (GROUND)
B	BLACK	OUTPUT

MATING CONNECTOR:
PACKARD ELECTRIC DIV. PART NO. 12010501

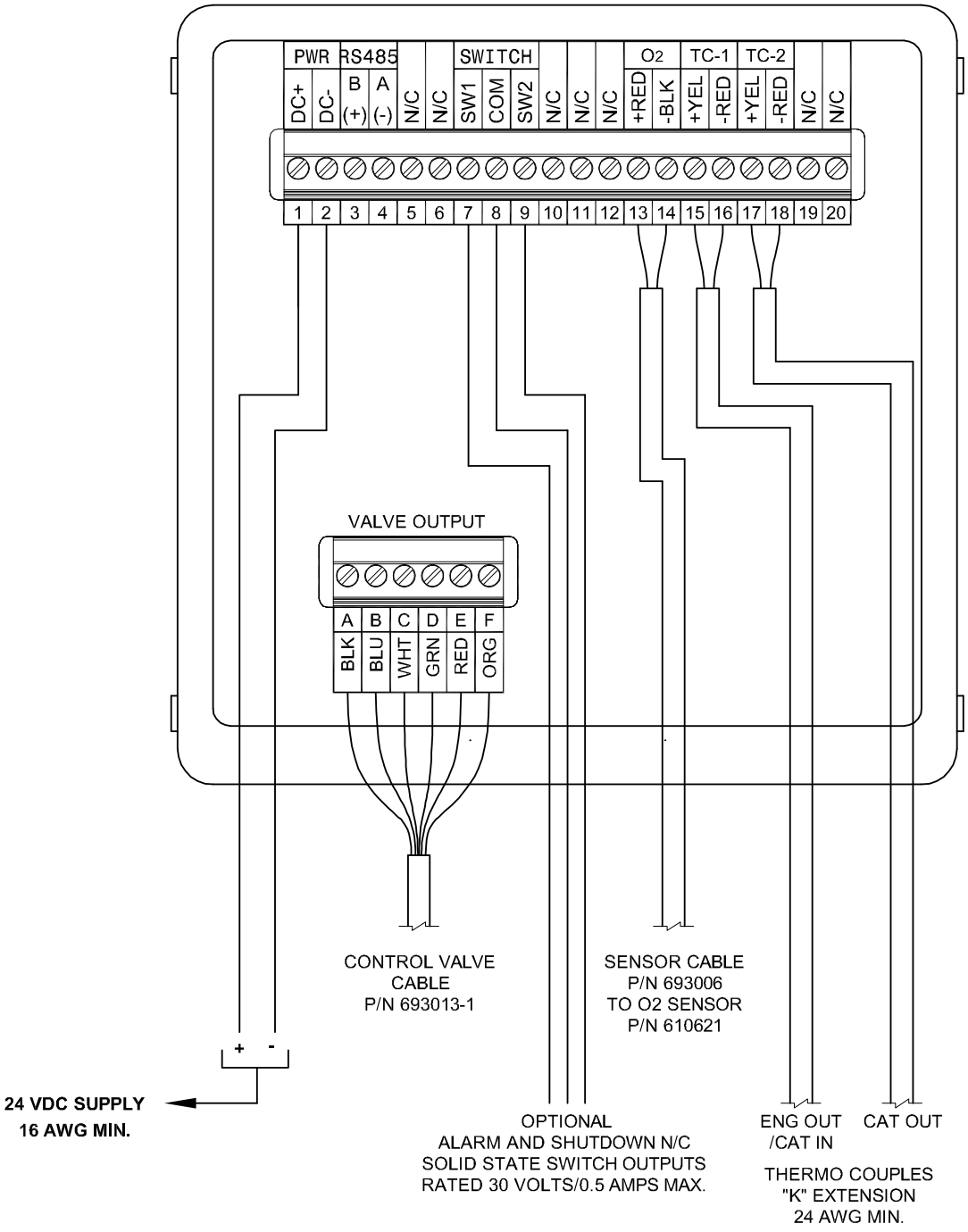


RECOMMENDED INSTALLATION DIMENSIONS

INSTALLATION INSTRUCTIONS:

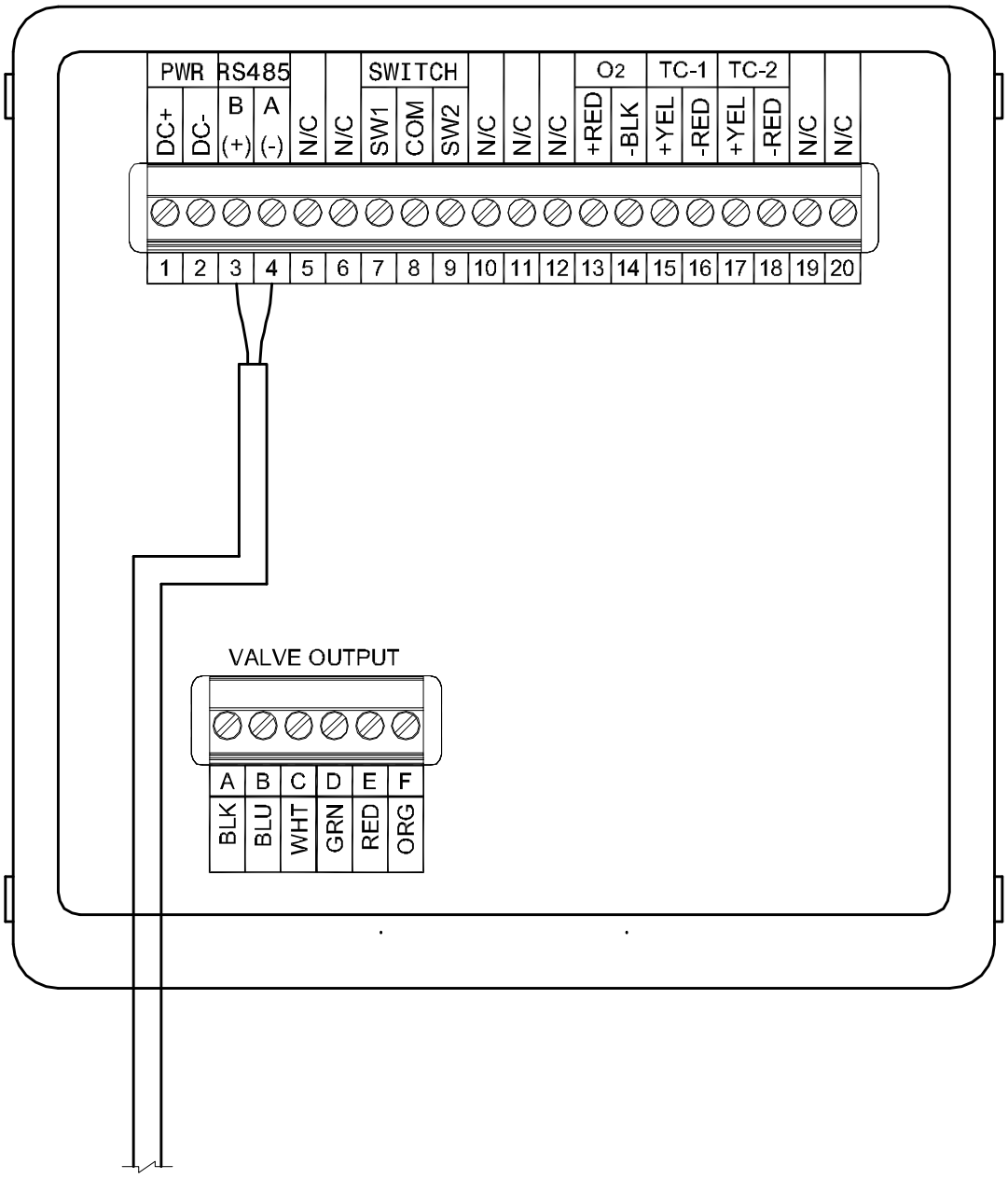
1. INSTALL IN THE APPROPRIATE MOUNTING HOLE TO A TORQUE OF 28-34 LB. FT.
2. USE A 7/8" WRENCH SIZE.
3. SENSORS ARE TO BE SUPPLIED WITH THREADS COATED WITH MS-0572 ANTISEIZE COMPOUND.
   CAUTION: DO NOT APPLY ANTISEIZE COMPOUND TO AREAS OTHER THAN THE MOUNTING THREADS.
4. FOR OPTIMUM RESISTANCE TO WATER INTRUSION, AC RECOMMENDS MOUNTING SENSORS SUCH THAT THE EXPOSED END (WIRE END) OF THE SENSOR IS ORIENTED AT OR ABOVE HORIZONTAL.
5. THIS SENSOR IS DESIGNED FOR WATER SPLASH RESISTANCE.

FIG. 5 EPC-50, WIRE ROUTING DETAIL



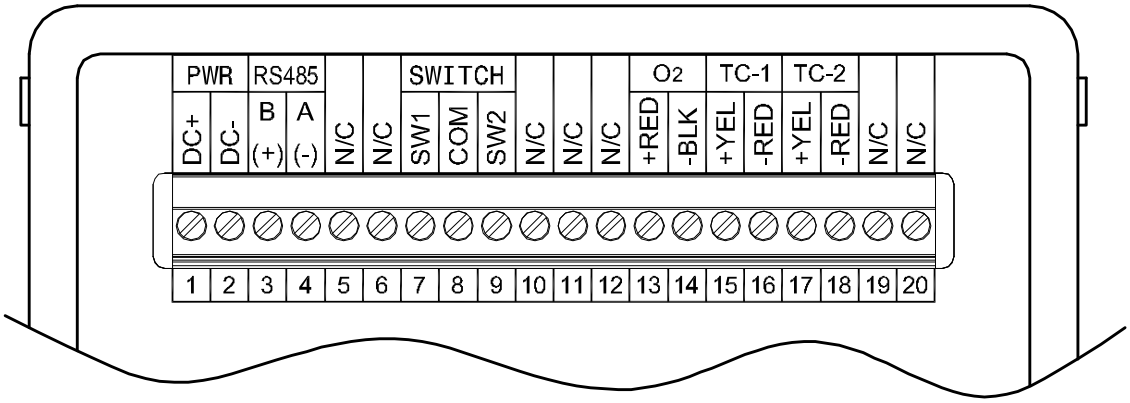
NOTE: ROUTE WIRES SUCH THAT POWER INPUT AND VALVE OUTPUT SIGNALS ARE NOT IN COMMON CONDUIT WITH O_2 AND THERMOCOUPLE SIGNALS.

FIG. 6 EPC-50, MODBUS COMMUNICATION CONNECTIONS



MODBUS RTU COMMUNICATION
RS-485 (NON ISOLATED) (NO TERMINATION LOAD)

FIG. 7 EPC-50, TERMINAL LAYOUT



PIN 1 POWER SUPPLY +24 NOMINAL

PIN 2 POWER SUPPLY COMMON (ALSO ENGINE GROUND)

PIN 3 MODBUS RS485 SERIAL CONNECTION (+, B) SIGNAL

PIN 4 MODBUS RS485 SERIAL CONNECTION (-, A) SIGNAL

PIN 5 NOT USED

PIN 6 NOT USED

PIN 7 ALARM SWITCH OUTPUT (NORMALLY CLOSED)

PIN 8 COMMON/ENG. GND.

PIN 9 PROTECTION SHUTDOWN SWITCH (NORMALLY CLOSED)

PIN 10 NOT USED

PIN 11 NOT USED

PIN 12 NOT USED

PIN 13 ENGINE OUT OXYGEN SENSOR INPUT (0-1.25 V) (RED)

PIN 14 ENGINE OUT OXYGEN SENSOR INPUT (COMMON/ENG. GND.) (BLK)

PIN 15 ENGINE OUT/CATALYST IN EXHAUST TEMP INPUT (TYPE K TC) (YEL)

PIN 16 ENGINE OUT/CATALYST IN EXHAUST TEMP INPUT (TYPE K TC) (RED)

PIN 17 CATALYST OUT EXHAUST TEMP INPUT (TYPE K TC) (YEL)

PIN 18 CATALYST OUT EXHAUST TEMP INPUT (TYPE K TC) (RED)

PIN 19 NOT USED

PIN 20 NOT USED

FIG. 8 TYPICAL O_2 SENSOR RESPONSE (ESTIMATED DATA)