CARBPRO v3.5
Users Manual

COPYRIGHT© 2002
MARATHON SENSORS INC

Part # F200004

DISCLAIMER:

Revision Date	Revision Number
03-31-1998	01
04-19-2002	02
06-21-2002	03
10-09-2002	04
10-09-2003	05
02-12-2003	06
07-21-2003	07
10-08-2003	08

Marathon Sensors Inc.

Table of Contents

Description and Applications

The Marathon Sensors Inc. CARBPRO Controller/Programmer represents the latest technology in microprocessor-based process control instrumentation. Through flexible PID (Proportional, Integral, Digital) control along with programmable features, even the most complex, system can be handled. For a thorough explanation of PID please refer to Zeigler and Nichols; "Optimum Settings for Automatic Controllers", Transactions of ASME, Nov. 1942. Or St. Clair, David W.; <u>Controller Tuning and Control Loop Performance, a Primer</u>; Straight-Line Control Company, Newark ,Delaware 1989.

The CARBPRO's control actions are based upon input from a Thermocouple, RTD, Voltage or Current source. The CARBPRO allows Manual, Automatic, or Programmed control of a single loop. Its built-in RS-422 computer interface allows it to be completely supervised by a computer, either on-site or in some remote location within the plant. The Programmer can be used, and is strongly recommended, to allow complete control of temperature or other process cycles.

The following features have been included to allow use of the instrument in a wide variety of applications:

 Fully site-configurable for single point control from one of three (3) fully isolated analog input sources, each separately configurable for thermocouple, RTD, voltage, or current.

 Powerful process/logic programmer that can store up to two-hundred (200) programs, each consisting of nineteen (19) steps, subroutine calls, test and branch capability, and full access to all instrument parameters.

Two (2) control output triacs for use in single or dual control mode.

Two (2) fully isolated analog outputs, each separately configurable for voltage or current output.

Two (2) configurable alarm triacs, assignable as process Alarms, deviation alarms, program alarms, or fault alarms.

Four (4) programmer events, assignable in any combination as either inputs or outputs (expandable to 16 I/O with external event boards).

Three (3) communication ports for talking with host computers, controllers, and discrete digital and / or analog event expansion racks.

This manual provides all of the information required to install, operate and maintain the MSI CARBPRO.

The manual is divided into parts: Installation, Setup and Configuration, Operation, Programming, and Maintenance and Troubleshooting. Installation and Setup and Configuration will be used initially to get the instrument into use. Operation and Programming will be used daily.

Maintenance and Troubleshooting will be used for servicing the instrument periodically or if trouble occurs.

Theory of Process Calculation

Percent Carbon Calculation

Under equilibrium conditions, it is possible to view the carburizing activity in a furnace from the simple equation:

$$CO \; U \; C(g) + \tfrac{1}{2}O2$$
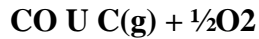
The thermodynamics of this equation are such that when equilibrium between carbon monoxide and oxygen exists (which is a reasonable assumption most of the time), then the carbon potential of the atmosphere is fixed at a value determined by the relative amounts of these two gases. Assuming that the carbon monoxide content of the atmosphere does not vary significantly (again a reasonable assumption if proper atmosphere generation and furnace operation techniques are being employed), then the carbon potential will depend mostly upon the oxygen content of the atmosphere.

The oxygen in the atmosphere is measured by a technique that exposes a simple in-situ zirconia-platinum (or some variation thereof) probe to the gas. The emf (Electromagnetic force measured in millivoltage) generated by this probe is transmitted to the Controller for processing. Also transmitted is the atmosphere temperature by virtue of a thermocouple located in or near the oxygen probe. Again, assuming that the oxygen and carbon monoxide are in equilibrium and that the carbon monoxide level does not vary significantly, we now have all the information required to produce an approximate calculation of %C in the atmosphere.

The equation used as the basis for the Controller's calculation of %C is:

$$\%C = \frac{(5.102)EXP((E-786)/(.0431\ T)))}{(0.2/PcoM)(945.7(af)/PcoA) + EXP((E-786)/(.0431\ T)))}$$

Where:

E = oxygen probe output millivoltage

T = temperature of atmosphere (degrees Kelvin)

PcoA = assumed partial pressure of carbon monoxide in atmosphere (=%CO/100 at 1 atm. pressure)

PcoM = Measured partial pressure of carbon monoxide in atmosphere (=%CO/100 at 1 atm. pressure)

af = alloy factor for a given steel (close to 1 for most carburizing steels); can be calculated from the equation: af (for low alloy steels only)=1+ %Si(.15+.033%Si) + .0365(%Mn) - %Cr(.13-.0055%Cr) + %Ni(.03+.00365%Ni) - %Mo(.025+.01%Mo) - %Al(.03+.002%Al) - %Cu(.016+.0014%Cu) - %V(.22-.01%V)

Note:

PcoM is automatically set to 0.2 if the auxiliary input is not being used for CO measurement.

It should be noted that if the Carbon Monoxide content of the furnace is not known, the term in the equation involving af and Pco can be thought of as a single, overall constant for a given set of furnace and load conditions. It is for this reason that this term was chosen as the location for the "Process Factor" adjustment in the Carbon Controller. Mathematically, the Process Factor adjustment is entered on the front panel for a given case relates to the term in the above equation as follows:

$$29(PF) + 400 = (945.7\ af)/Pco$$

Where PF = Process Factor (0-999)
Adjustment of the Process Factor by the user will allow compensation to be made for a wide range of conditions. Looking at the above equation, it can be seen that for a nominal 20% carbon monoxide atmosphere (as in methane-based endothermic gas), with an assumed alloy factor of 1, the Process Factor should be entered as 149. If a propane-based endothermic (23% carbon monoxide) is used, the Process Factor would be 128. For nitrogen-methanol systems, the Process Factor used will normally be the same as for methane-based endo. However, this will depend entirely on the ratio of methanol to nitrogen, and some experimentation would be required to arrive at a working value. Note that for purse methanol, the theoretical process factor would be 85. Note also that if high nickel steels such as 3115 are to be accurately carburized, an alloy factor (af) will be important in determining the correct Process Factor. A complete chart of process factors for AISI grades at various CO levels appears in Appendix A. Process factors for high alloy steels (such as tool steels) are not directly calculable because of carbide interaction. These must be arrived at experimentally.

Unless configured otherwise (see "Setup and Configuration"), the Controller will use a constant value for CO (PcoM=.2). If the auxiliary input of CO is to be taken into account and assuming the switch setup is correct, the Controller will use that value as PcoM, and the %C calculation will vary as the input of CO to the instruments varies. The nominal input range for interact CO compensation is 0-2 Vdc corresponding to 0-30% CO.

As a practical matter, the exactly-correct Process Factor for a given set of circumstances is best determined from experimentation with shim stock and/or carbon test bars; the above equations may then be used as a basis for correcting the factor from a mathematical standpoint. It is usually easier, however, to correct the Process Factor in real-time by simply changing its value and observing the results in the %C display in relation to a known %C in the furnace. When using this method, care must be taken to gather enough solid data before making adjustments; not allowing for statistical variations between loads can be a potential cause of serious error in setting up a Process Factor.

If a significantly different Process Factor then seems logical must be used to get a correct %C display, a number of things must be investigated. The necessity of using a relatively high Process Factor (for example, a value of 250 in methane-based endo) can possibly be taken to mean (among other things) that soot is present in the furnace, or that the oxygen probe in incorrectly located (a conditions for which the Process Factor can never be reliably adjusted). A low value for Process Factor might indicate a problem with reference air supply to the probe or impending failure of the probe altogether.

Dewpoint
As a convenience for use mainly in the control of endothermic generators, the MSI Carbon Controller may be used to calculate and control Dewpoint, in F, from the probe input and temperature.
The reaction of interest is:

$$H2O \ U \ H2 + \tfrac{1}{2}O2$$

By assuming a hydrogen content in the atmosphere (usually reasonable) and by measuring oxygen and temperature, the Dewpoint (water vapor content) may be calculated.

The method of calculation is much more complex than that for %C, therefore, it will not be explained here.

The Process Factor interacts in the calculation of dewpoint in much the same way as in the carbon calculation, as follows:

$$29(PF) + 400 = (1888.4/pH2)$$

This equation is scaled so that if a Process Factor of 149 is selected for the carbon calculation (indicating 20 %CO), then this same process factor will imply a 40% hydrogen content for the dewpoint calculation. Thus for normal 20/40 endo, the instrument may use the same Process Factor for %C and Dewpoint without a Process Factor adjustment.

The auxiliary input cannot be used in the calculation of dewpoint. The normal method of setting the Process Factor in Dewpoint mode is to adjust it as required until the displayed Dewpoint is equal to the Dewpoint measured by a more direct method (i.e. Alnor). For endo generators where the probe is operating at 200-400 F below the catalyst bed temperature, the Process Factor may have to be set to 250-450 to get agreement with Alnor dewpointer.

The range of Dewpoint as displayed on the instrument is -99 to +212 F. Even when the instrument is run in C, the Dewpoint reading will still be in F.

The setpoint in Dewpoint mode may range from

-99 to +250oF. The process deviation band ALARM, if used, is +10 F around setpoint.

Control Mode Definitions

Time Proportioning (TP)

Time proportioning adjusts the duty cycle of the control device to maintain control. This is usually done with solenoid valves controlling the flow of a critical material to the process. The control loop percent output is the ON time percentage of the value. The cycle time parameter determines the total cycle time, ON time plus OFF time. For example if the control loop percent output is 34% and the cycle time is 10 seconds, then the ON time would be 3.4 seconds and the OFF time would be 6.6 seconds. The selection of the proper cycle time is a trade off between excess wear and tear on the solenoid valve with short cycle times and rough (pulsing) flow of the control material with long cycle times. Only one control output triac is used in this mode.

Time Proportioning with Complement (TC)

This mode is identical to the time proportioning mode except that two control output triacs are used. The second control output is the complement of the first, that is when the first output is ON the second is OFF and vice versa. This mode is used with single action motorized valves that open quickly when a voltage is applied to one terminal and close quickly when voltage is applied to the other terminal.

This mode is used when there is two process materials to control that have complementary effects; like gas and air in a heat treating furnace. If the carbon potential is too low then more gas is required. If the carbon potential is too high then once the gas flow has been shut off air is required. The time proportioning dual mode uses two control output triacs; one for gas and one for air. There is never a time when both outputs are on simultaneously. The control loop computes a percent output from -100 to +100%. When positive, the proportioning action applies to the forward (gas) output. When negative the proportioning action applies to the reverse (air) output.

Motor with slidewire (MS)

This mode is used for motorized valves that have a slidewire feedback. This mode requires a slidewire board for input C of the CARBPRO. The motor slidewire is then wired to this input. This mode uses two control output triacs; one to drive the motor forward (open) and the other to drive it reverse (closed). This mode is effectively a control loop within a control loop. The main control loop computes a desired output percentage. The secondary loop then drives the motor (forward or reverse) until the slidewire indicates that the valve is open the proper percentage. To prevent the motor from "hunting" a deadband can be set using the DIP switches. This value can be set from .2 % to 10%. In most applications the motor with slidewire does not provide any better control than position proportioning (see below).

Position Proportioning (PP)

This mode is used with motorized valves that do not have slidewire feedback. This mode is sometimes referred to as the "bump" mode because it "bumps" the valve slightly more open or closed. This mode uses two control output triacs; one to drive the motor forward (open) and the

other to drive it reverse (closed). For each computation of the control this mode computes the difference between the new percent output and the last percent output. If the difference is positive than the valve motor is driven open for that percentage of the cycle. If negative it is driven closed by that percentage of the cycle time. For example if the new percent out is 60% and the old was 45% then the motor is driven open for 15% of the cycle time. If the cycle time is set to the time that the motor takes to move from fully closed to fully open, then the flow is theoretically increased by 15%. Two special cases exist. If the control output is computed at 100% then the motor is driven continuously in the open direction. Likewise if the control output is computed as 0% then the motor is driven continuously closed.

ON/OFF (OF)

ON/OFF control is exactly what it implies, the control action is either ON or OFF. With true ON/OFF control the control output triac is ON whenever the process is below the setpoint value and OFF when the process is at or above the process value. In many real world applications this simple control method will cause "contact chatter" because of noisy signals which will switch the ON and OFF states rapidly. Also since the control action does not turn OFF until the setpoint is reached, the process will overshoot due to lags in the control action. Marathon controllers incorporate two features that prevent this problems from occurring; Hysteresis and deadband. Hysteresis provides a gap between the process turn on point and the turn off point. With this gap noise will not cause the control output to "chatter". Deadband allows the process to deviate away from the setpoint by the width of the deadband before any control action occurs. The deadband on the CARBPRO is adjusted with the proportion band setup (the reset and rate must be set to 0 for ON/OFF control). For temperature control a proportional band of 10 would represent a deadband of 10 degrees. A proportional band of 5 would represent 5 degrees of deadband, etc. This is accomplished by allowing the PID control loop to calculate in a normal fashion. The percent output is then used to determine when the output should be turned on or off. The output is turned on when the percent output reaches 10%. Hysteresis is added by not turning off the output until the percent output drops to 2%. With the temperature control example where the proportion band is set at 10, the output would turn on when the process dropped to 10 degrees below the setpoint and turn off when the temperature reached 2 degrees below the setpoint. With a proportional band of 1 these points would be 1 degree and 0.2 degrees respectively.

This mode is exactly like ON/OFF control with the addition of a second control output triac. The second triac would be ON when the first is OFF and vice versa.

ON/OFF Dual (OD)

This mode is similar to time proportioning dual in that two control output triac are used such as in a heat/cool application. The forward (heat) output would act as described in the ON/OFF description above. The reverse (cool) output would respond when the process is above the setpoint. To facilitate this process the PID control loop computes a percent output from -100 to +100%. The plus values mean the process is below setpoint and the minus values mean the process is above setpoint. The forward contact would turn on when the percent output reaches 10% or above. It would not turn off until the percent output dropped to 2% or below. In a similar fashion, the reverse contact would turn on when the percent output dropped to -10% or lower (more negative). It would turn off when the percent output rose to -2% or higher (more positive). For the temperature example with a proportional band of 10, the heat contact would

turn on when the temperature was 10 degree or more below the setpoint and would turn off when it came within 2 degrees of the setpoint. Likewise the cool contact would turn on when the temperature rose 10 degrees above the setpoint and would turn off when it dropped to within 2 degrees of the setpoint.

Installation

Installation Location

The CARBPRO instrument is designed for 1/8 inch panel mounting in a DIN standard opening of 5.43 inches square (adapter panels available by special order). Required rear clearance is 10.5 inches to allow for wiring. As with all solid state equipment, the controller should be away from excessive heat, humidity, and vibration (refer to specifications). Since the unit uses red LED display devices, avoid placing it in direct sunlight to reduce interference with the display's visibility. The instrument requires 100/120/200/240 VAC (jumper selectable on power interconnect board inside the rear panel) 50/60 Hz. It should not be on the same circuit with other noise-producing equipment such as induction machines, large electrical motors, etc. All instrument wiring must be run separate from all control wiring.

Panel Mounting/Removal

Because the instrument uses a ventilated enclosure, it is not dust-tight and should therefore always be mounted in a sealed control panel. To mount the CARBPRO in a control panel, a hole must be cut 5.43 inches square in the necessary location on the panel. The following procedure should be followed to mount the CARBPRO in the panel.

1.   Insert the unit into previously cut out 5.43 inches square hole in the panel.

2.   While supporting the unit, insert one slotted clamping bracket, with head of the bolt facing to the rear of the unit, into the 0.62 inch by 0.82 inch cutout on the side of the unit.
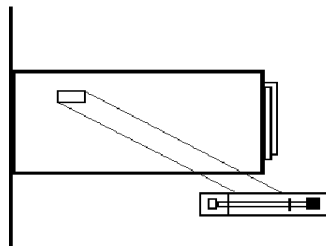
3.   Repeat step 2 for the opposite side of the unit.

4.   With 1/8 inch HEX KEY wrench, alternately tighten bolts on either side of the instrument to a torque of 4 in-lbs. (See warning below). Insure rigidity of mounting.
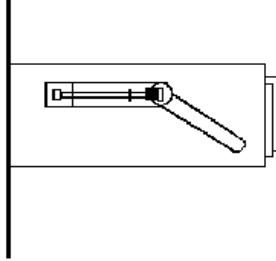
Warning
To prevent warping of the unit's case, do not over tighten the clamp bolts.

To remove the unit, loosen the side clamping brackets and reverse steps 1 through 3 above.

Note
On subsequent removals and installations the rear panel can be removed (4 screws) and the wiring does not have to be disturbed.

Warning
All connections, rear panel installations and removals; plus triac board installations and removals must be done with power removed from TBA and TBB. All PC boards should only be removed or installed with power off via the switch mounted on the triac board. Otherwise, serious personal and/or equipment damage can occur.

Thermocouples and other Signal Wires

The wiring used to connect the signal wires to the instrument should be run in a conduit, separate from any AC lines in the area. This provides noise immunity and physical protection. Thermocouples should be wired with the appropriate alloy extension wire with no termination other than at the instrument. As with all cold-junction compensating instruments, extreme care should be used when an existing thermocouple is to be used for both the Controller and another instrument at the same time.

Control Devices

The CARBPRO provides simple ON/OFF as well as Proportional control through its two contact closure Control Outputs (TBA-7, TBB-7, TBA-8, and TBB-8) and two Analog Outputs (TBD-13 through TBD-16). Refer to the Section on Control Modes for more details on the outputs. This allows control through simple ON/OFF devices or through Proportional control methods.

SIMPLE ON/OFF CONTROL: Set Control Mode for ON/OFF Control. This provides contact closure at Control Output #1 to control absolute heat application/removal for such devices as heating elements, etc.

Three types of Proportional control are:

> 1. Time-Proportioning: Referring to the modulation of the duty cycle. That is, changing the ratio of On Time versus Off Time in systems that use such devices as heating elements, electronically operated/assisted valves, or servo drives that use analog command signals for control.
>
> 2. Position-Proportioning: Referring to the adjustment of a variable positioning device such as a positioning motor with slidewire feedback.
>
> 3. Voltage or Current Output Proportioning: An Analog output's (voltage or current) amplitude is varied based on input from rheostats, thermocouples, ammeters, etc. to control heat applications.

The CARBPRO provides many ways to use the above control methods. Setup has details for setting the Control Modes to determine the method to be used. Some typical applications for the Proportioning method are:

1. GAS/AIR application system: Set Control Modes for Time-Proportioning. This provides that CONTROL OUTPUT #1 (TBA-7, TBB-7) and CONTROL OUTPUT #2 (TBA-8, TBB-8) are in opposite conditions at either extreme of the control range and are both OFF at the midpoint of the control range.

2. ANALOG OUTPUT control: Set Control Modes for Time-Proportioning. This provides a 0 to 5 VDC or 4 to 20 mA output which is selectable on the ANALOG OUTPUT BOARD (TBD-13 through TBD-16, see Section 2.14 and Section 8.0 for more details). The output control is based on 0 to 99% of the output device's control range. For example, 50% control would equal 2.5 VDC out where 5 VDC equals maximum heat output of the drive. This can be used with servo drives that require a voltage or current command signal for controlling heat output or servo positioning.

3. POSITIONING MOTOR with SLIDEWIRE FEEDBACK: Set Control Modes for Single Position-Proportioning with slidewire feedback. CONTROL OUTPUT #1 will drive the motor in the open direction, CONTROL OUTPUT #2 in the close direction.

Remember, the above methods are just examples of the typical applications of the CARBPRO. Please call your MSI representative or application engineer for questions concerning your particular system.

Chart Recorders

If a chart recorder is to be used, it must have input specifications within the following ranges:
> 0 to 5 VDC
> 4 to 20 mA

corresponding to a FRONT PANEL display of 0-2000. The ideal location of the recorder is adjacent to the instrument but it may be located remotely if the connecting wires are properly shielded. Long wiring runs from the chart recorder outputs may require resistive termination (2 K ohms or so) at the chart recorder input(s) should be isolated from ground.

Computer Interface

If you wish to take advantage of the CARBPRO's RS-422 digital communications capabilities, refer to "Communications" for more details.

Alarms

Two user-programmable triac alarm contacts are available for connection in appropriately-engineered systems.

Programmer

The Programmer can run an entire process, depending on how thoroughly the capabilities are set up and used. Refer to "Operation" and "Programming" for further information.

Electrical Connections

Connections to the unit are made via four terminal blocks, on the rear panel, labeled TBA, TBB, TBC, and TBD. (Position 1 is at the top the position 10 (TBA and TBB) or 18 (TBC and TBD) is at the bottom of the terminal strip.) AC power, event, control, and alarm connections are made on TBA and TBB. All communications are on TBC and all analog I/O signals are on TBD. Refer to the Figure below for a complete layout of the CARBPRO rear panel connections.

CARBPRO Rear Panel
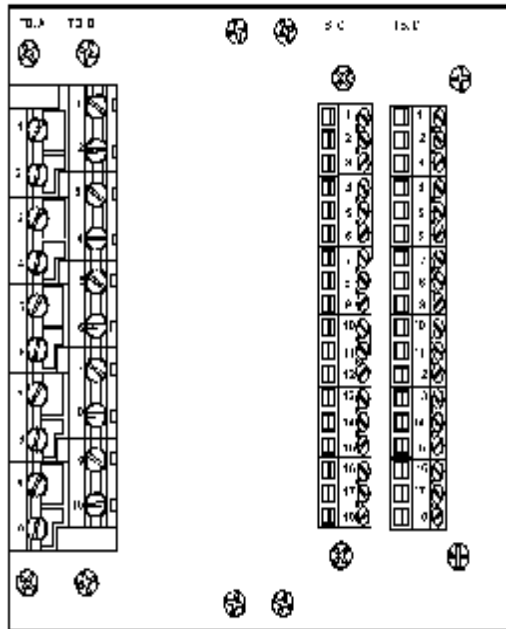
CARBPRO Electrical connections

TB A		TB B		TB C		TB D	
1	LINE	1	NEUTRAL	1	RX +	1	INPUT # 1+
				2	RTX -	2	INPUT # 1-
2	LINE	2	NEUTRAL	3	TX +	3	INPUT # 1 V
				4	TX -	4	INPUT #2+
3	GROUND	3	GROUND	5	RTX +	5	INPUT #2-
				6	RTX -	6	INPUT #2 V
4	EVENT POWER	4	EVENT NEUTRAL	7	TX +	7	INPUT #3+
				8	TX -	8	INPUT #3-
5	EVENT #0	5	EVENT #1	9	RTX +	9	INPUT #3 V
6	EVENT #2	6	EVENT #3	10	RTX -	10	
				11	TX +	11	
7	CONTROL #1-COM	7	CONTROL #1 N.O.	12	TX -	12	
				13	RTX +	13	ANALOG +
8	CONTROL #2 COM	8	CONTROL #2 N.O.	14	RTX -	14	OUT # 1
				15	TX +	15	ANALOG +
9	ALARM #1-COM	9	ALARM #1 N.O.	16	TX +	16	OUT #2
10	ALARM #2 COM	10	ALARM #2 N.O.	17		17	CAL EN +
				18		18	CAL EN -

AC Power

The CARBPRO requires 100/120/200/240 VAC at 1 AMP,

Communications

Three communications busses are at TBC and use RS-422 full or half duplex protocol for all ports. (Refer to "Communications" in Maintenance and Troubleshooting.) Typically, the HOST port will connect to a host computer, the AUXILIARY BUSS to other instruments, and the OPTOMUX PORT to OPTOMUX
I/O devices.

Analog Inputs

The CARBPRO allows for three analog inputs with their individual functions determined by "daughter board" located on the analog input board inside the unit. The standard connection, at TBD, will have the first input as a thermocouple, the second for the oxygen probe, and the third optionally used to input voltage or milliamp signals.

Analog Outputs

Two, separate, isolated analog outputs are provided on TBD and can be selected as 4-20 mV (for maximum accuracy, see Specifications for further details) or 0-10 V output through DIP switch settings on the analog output board. Additionally, outputs can be calibrated by placing a jumper on the two terminals supplied.

DIP Switch Setup

The user may use the CARBPRO in a multi-instrument system by giving the instrument a unique HOST address, specified by using the DIP switches on the Interface Board inside the CARBPRO To get to the DIP switches, loosen the black knurled knob on the front panel by turning in a counterclockwise direction. Carefully remove the front panel but DO NOT remove the ribbon cable connecting the front panel to the Interface Board. Safely support the front panel near the instrument. Adjust the DIP switches per Section 2.16 for the desired operating mode. When switch adjustment is complete, replace the front panel to prevent contamination.

CARBPRO Front Panel Removal
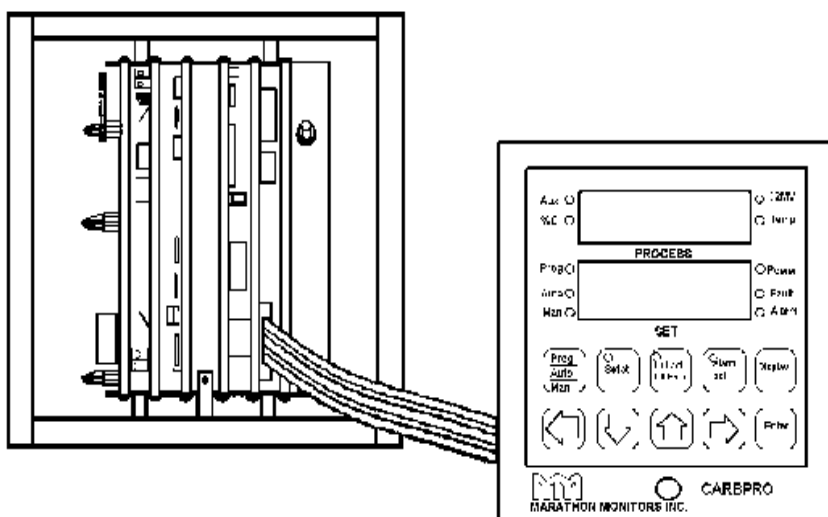
Find the appropriate switches by referring to the figure below.
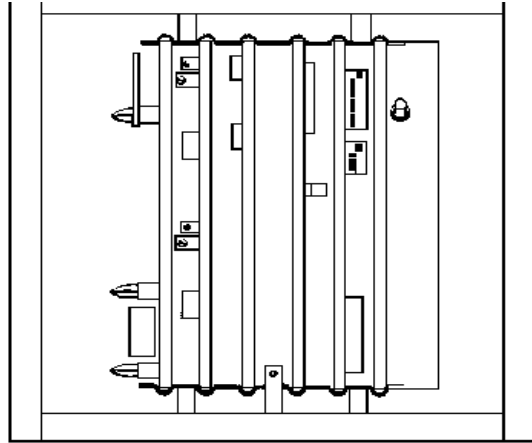
CARBPRO Internal Layout

DIP Switch Assignments

Bank 0

Switch #	Description
1	Probe test Enable
2	Unassigned
3	Slide wire Deadband (see the following table)
4	Slide wire Deadband (see the following table)
5	Slide wire Deadband (see the following table)
6	Unassigned
7	Unassigned
8	Service (Must be OFF)

Selectable deadband for slidewire feedback control.

Slidewire Dead Band Offset			
offset	Switch 3	Switch 4	Switch 5
0.4%	OFF	OFF	OFF
0.8%	ON	OFF	OFF
1.2%	OFF	ON	OFF
1.6%	ON	ON	OFF
2.0%	OFF	OFF	ON
2.4%	ON	OFF	ON
2.8%	OFF	ON	ON
3.2%	ON	ON	ON

Each CARBPRO in a multiple instrument system must have a unique address for proper communications.

HOST address selection switches:
Bank 1 Address

DEC	HEX	SW1	SW2	SW3	SW4
0	0	OFF	OFF	OFF	OFF
1	1	ON	OFF	OFF	OFF
2	2	OFF	ON	OFF	OFF
3	3	ON	ON	OFF	OFF
4	4	OFF	OFF	ON	OFF
5	5	ON	OFF	ON	OFF
6	6	OFF	ON	ON	OFF
7	7	ON	ON	ON	OFF
8	8	OFF	OFF	OFF	ON
9	9	ON	OFF	OFF	ON
10	A	OFF	ON	OFF	ON
11	B	ON	ON	OFF	ON
12	C	OFF	OFF	ON	ON
13	D	ON	OFF	ON	ON
14	E	OFF	ON	ON	ON
15	F	ON	ON	ON	ON

Thermocouple Burnout Jumper Selection
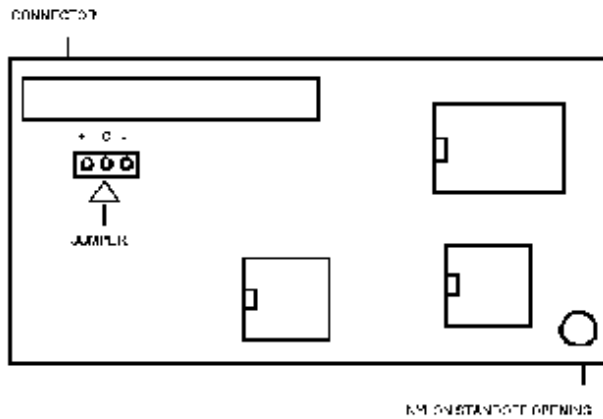
The thermocouple jumper selects either a full upscale or a full down scale reaction to take place when a thermocouple fails or becomes open. The jumper can be found on the thermocouple board, and has two possible settings (see Figure). For full scale upwards, place the jumper from the + to the C, and for full scale downwards, place the jumper from the - to the C.

Setup And Configuration

Front Panel

The front panel of the CARBPRO consists of three main parts, two display windows and a keyboard. Refer to the figure shown below for a layout of the front panel. The display windows each contain four 14-segment digits that are used to display helpful messages and numerical parameter values.
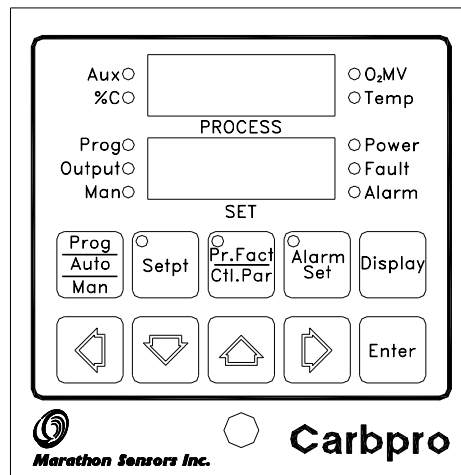
PROCESS Display

This 4 digit 14-segment display provides the value of the current process value, along with messages for ease of operator use when setting up parameters. The PROCESS window displays the step number and OPCODE when in the Program Editor.

SET Display

This 4 digit 14-segment display provides the value of the process setpoint value during Auto and Program operation. In Manual mode the Time-Proportioning % Output value is displayed. During operator input procedures this display shows the data being entered. The SET window displays the corresponding data for the OPCODES displayed in the PROCESS window when in the Program Editor.

LEDs

Several small LEDs indicate operations and functions of the CARBPRO. Ten are on the face and three are in the keys.
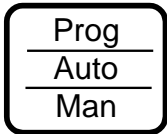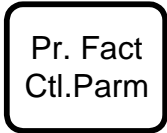
Aux   indicates the PROCESS display is showing the auxiliary input value.

%C   indicates the PROCESS display is showing the percent carbon.

O2 MV   indicates the PROCESS display is showing the probe millivolts.

Temp   indicates the PROCESS display is showing the probe temperature.

Prog   indicates that a program is running and Automatic control is activated. If flashing, the program is in HOLD. Refer to the section "The Programmer".

Auto   indicates that the CARBPRO is in Automatic control mode. If flashing, a program is in HOLD.

Manual   indicates that no control action is being executed by the CARBPRO. If flashing, a program is in HOLD.

Power   indicates that the CARBPRO's 5 volt power supply is functioning.

Fault   indicates that an open circuit is detected at the signal input.

Alarm   indicates when the process value has closed the relay based upon trip point and type of alarm.

Setpt   indicates that the Setpt Enter mode has been selected.

Cntrl Parm   indicates that the Control Parameter Enter mode has been selected.

Alarm Set   indicates that the Alarm Setup mode has been selected or one or both alarm values are non-zero.

Keyboard

The CARBPRO keyboard consists of ten keys for operating and programming the instrument. There are no "hidden" keys on the CARBPRO keyboard.

Various operations with the CARBPRO involve dual-key operations using the [Shift] key in the same way a shift key on a typewriter is used. When activating a dual-key assignment do not try to press both keys simultaneously; rather, follow the sequence below:

1. Press and hold the[Display] key,
2. Press and release the second key,
3. Release the [Display] key.

KEY	DESCRIPTION

Prog / Auto / Man

This key selects the operating mode of the CARBPRO. The mode selected is indicated by the illuminated LED.

Setpt

This key selects the Setpoint Enter mode where the Setpoint, Setpoint Offset and Reference Number can be accessed and altered. When used in the dual-key operation, Display + Setpt, it allows the operator to pull programs into the edit space or decrease the remaining time of a program step if a program is currently running.

Pr. Fact / Ctl.Parm

This key selects the Control Parameter Enter mode where the Proportional Band, Reset, Rate, Cycle Time and Percent Output values (if in solenoid mode) can be accessed and altered. When used in the dual-key operation, Display + PrFact Control Parm, it selects the keyboard Lock Level change mode.

Alarm Set

This key selects the Alarm Setup mode where the Alarm 1 and Alarm 2 conditions can be accessed and altered or Alarm 2 can be used to determine setpoint for auxiliary control loop. When used in the dual-key operation Shift/Alarm Set it selects the Thermocouple Type, Custom Features, and Events Partition. After Shift/Alarm Set the Thermocouple Type is initially displayed, if Enter is pressed the Custom Feature option is available while the second press of Enter allows the Events Partition to be observed and altered if necessary.

Display

This key selects which parameter (Aux, %C, O2MV, Temp) is displayed in the Process display. It is also used as a shift key in two key operations.
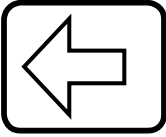
The Right and Left arrow keys are used to select the digit to be modified in a data entry mode. In Manual mode these keys will cause the control output to go to the full reverse or full forward control direction while the value is displayed in the SET window. In Automatic mode pressing "left arrow" causes the % on-time valve position to be displayed in the SET window. (positive-Output 1, negative-Output 2). In the Programmer Status Display it causes the display to move to a new page.**
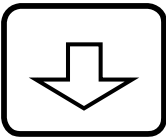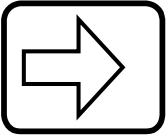
Usually used to decrease the value of a digit in the data entry mode or scroll through various parameter sequences. In Manual mode this key will cause the control action to move toward the Output 2 direction. When used in the dual-key operation Shift/"down arrow" it accesses the Programmer Status Display.
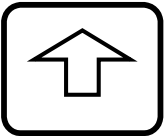
Usually used to increase the value of a digit in the data entry mode or scroll through various parameter sequences. In Manual mode this key will cause the control action to move in the Output 1 direction. When used in the dual-key operation shift/"up arrow" an LED test is activated, where every segment and decimal point should light in both displays. If any segment or decimal point does not light a keyboard problem may exist, contact a qualified MSI representative.

Enter

This key is used to enter data, clear alarms, or cancel programs.

[Control Parameter]Setup Menu

MENU CON	MENU INP	MENU AOUT	MENU CALC	MENU PROB	MENU PROG	MENU COM	MENU EVTS
pb xxxx	in a xxxx	aol xxxx	PFC xxxx	Pt1 xxxx	tco xxxx	host xxxx	ext xxx
res xxxx	cjca xxxx	aolo xxxx	COMP xxxx	Ptrt xxxx	aps xxxx	auxm xxxx	evbd xxxx
rate xxxx	iaof xxxx	aolr xxxx	PFD xxxx	BOT xxxx	asev xxx	aux xxx	ep1 xx
cyc xxxxx	iasp xxxx	ao2 xxxx	DPC xxxx	BORT xxxx	Lock pswd	Ssoa xxx	epxa xx
hipo xxxx	iadp xxxx	ao2o xxxx	DP °X	FDE xxxx	lock X	sso1 xxxx	lina xxxx
lopo xxxx	Inb *	Ao2r xxxx	o20F xxxx	INHB xxxx		: :	
ldln xxxx	inC *					sso8 xxx	
conv xxxx	Tc °X						
Cm xxx							
setp xxxx							

notes:

    * full sequence of "IN A" repeats for inputs B and C.

    : the screen repeats for numbers 0 - 8 decimal and hex and hex numbers 9 - f. This indicates that the repeating screens have been left out between the first and last numbers.

Control Parameter Key Menu Selections

The following shows the order of configuration options set from the [Pr.Fact/CtlParm] key and their range of values. Press [ENTER] to go forward to the next option, or [Display] to back up to a previous option. The arrow keys are used to change the option within its limits see the keys portion of this section for a complete description of how they are used. Pressing [Cntl Parm] at any time will exit from this option setup sequence.

Note

Options are saved as they are changed.

CON menu

Process display	Set display options	Description
Pb	0 to 9999	Proportional band
rEs	0 to 99.99	Reset
rAt	0 to 9.99	Rate
CYC	1 to 250	Cycle time in seconds
HIPO	0 to 100	High limit on percent output
LOPO	-100 to 100	Low limit on percent output
LDLN	-100 to 100	Load Line

CON menu Continued...

Process display	Set display	Description
CONV		This parameter sets the control process (and setpoint) the instrument will use to control to setpoint.

       N/A   Turns off the control process

       TEMP Selects the temperature at input 1, as displayed in the Process window when the TEMP display is selected. Setpoint resolution changes to XXXX (degrees).

       O2MV Selects the probe millivolt at input 2, as displayed in the Process window when the MV display is selected. Setpoint resolution changes to XXXX (mv).

       AUX   Selects the auxiliary signal at input 3, as displayed in the Process window when the AUX display is selected. Setpoint resolution changes to XXXX.

       CARB Selects the carbon process value as displayed in the Process

Marathon Sensors Inc.

window when the CARB display is selected. Setpoint resolution changes to XX.XX (%).

DWPT Selects the dewpoint process value as displayed in the Process window when the CARB display is selected. Setpoint resolution changes to XXX.X (degrees).

CM   XXX   Control mode
Where XXX =
X__ = D or R for direct or reverse.
_XX = tp for time proportioning.
tc for time proportioning with compliment
td for time proportioning dual
ms for motor with slide wire feedback
of for OFF / ON control
oc for OFF / ON with compliment
od for OFF / ON dual
pp for position proportioning

SETP   LOC, IN C   Setpoint source;
local or input C

INP menu

Input A, B, or C values and actions are programmed from this menu. Display choices shown are for input A. The other input choices follow through the same cycle. Exceptions are noted in the table. Thermocouple degree choices for temperature display come at the end of the full menu cycle.

Process display	Set display choices	Description
INA	LIN, Tc, Off, Prog	Linearization for input A: LIN for linear Tc ? For thermocouple type * Off Prog for Programmed.

Input C has three more choices L 30, L50, and L100.

CJCA	YES, NO	Cold junction compensation active for input A
IAOF	-999 to 9999	Input A offset for program mode
IASP	-999 to 999	Input A span value for program mode
IADP	0 to 3	Input A displayed decimal point location for program mode.

tC	deg F, deg C	Temperature display units

Notes:
   * thermocouple types are found in the specifications. Values and types are also found in Maintenance and Troubleshooting.

AOUT menu

Process display	Set display options	Description
AO1	CARB,DWPT, PO, O2MV REFN, PROG, TEMP, AUX	Analog output 1 source *
AO1O	-999 to 9999	Analog output 1 offset
AO1r	0 to 9999	Analog output 1 range

Analog out put 2 choices are the same menu items repeated.

*Analog output source 1 menu items:
PO = percent output
REFN = the reference number
PROG = the program
TEMP = temperature
AUX =Auxiliary output
CARB = Percent Carbon
DWPT = Dewpoint
O2MV = Probe millivolts

CALC menu

Process display	Set display options	Description
PF C	0 to 2000	Process factor carbon
COMP	NO,YES	CO compensation active
PF D	0 to 2000	Process factor dewpoint
DP C	STC,PIC	Dewpoint calculatioon; standard or piccolo
DP	deg F, deg C	Dewpoint display units
O2oF	-999 to 1000	O2mv offset for carbon and dewpoint calculations

COM menu

Process display	Set display	Description
HOST	H or F, E or N	Host communications setup and 0 to 3
AUXM	TEM or UDC	Aux communications port mode; MSI 10Pro or Honeywell UDC3000
AUX	H or F, E or N	Aux communications setup and 0 to 3
SSOA	NO, YES	Slave setpoint offset active
SSOn	-500 to 500	Slave temperature controller setpoint offset The CARBPRO can transfer 7 slave temperatures and have an offset for each. Address 1 is the not offset.

Notes:

communications choices for the CARBPRO are:

H = Half or F = full duplex

E = even or N = no parity

BAUD rate code

0 = 1200, 1 = 4800, 2 = 9600, 3 = 19.2k

PROG menu

Process display	Set display	Description

TCO	-999 to 999	thermocouple offset for Alarm 85
AUTO	NO, YES	Auto start-up
APS	NO, YES	Auto program start
ASEV	NO, YES	Asynchronous event
LOCK	0 to 3	Lock level The most accessible level is 3, the least is 0. To set a password See below.

Password Entry

The password can be entered by pressing the Dual-key sequence [Display] + [Pr.FactCtl. Parm] keys. Any order of keys, except for the [Display] or [ENTER] key, can be entered as a password, up to nine keys maximum. Press [ENTER] to save the password. The number in the set display will count the number of keys entered. Pressing [ENTER] without pressing any other key (i.e. set display=0) will clear the password. So to have no password the sequence [Display] + [Pr.Fact/Ctl Parm], [Enter], [Enter] ,[Enter] must be pressed.

EVTS menu

Process display	Set display options	Description
EXT	NO, YES	External event boards active
EVBD	1200, 4800	Events communications baud rate
EPI	0 to 4	Events partition internal
EPXA	0 to 16	External analog board partition ? Where ? is 0,1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F Representing modules 0 through 15 respectively.
LINA	XXX	External analog board Module linearization.

Where XXX = lin, prog, n/a

or thermocouple type and value *

Prob menu

Process display	Set display options	Description
PT I	0 to 9999	Probe test interval in minutes
Ptrt	0 to 999	Probe impedance test recovery time in seconds
BOT	0 to 999	Probe burn off time in seconds
BOrt	0 to 3600	Probe burn off recovery time in seconds
FdE	0 to 999	Final delay in seconds
Inhb	NO,YES	Inhibit or cancel tests

All thermocouple displays have TC X format where X = thermocouple type. See the list below

Thermocouple list:

Display	T/c Type
B	B
C	C
E	E
J	J
K	K
N	N
NM	NM
R	R
S	S
T	T

[Alarm Set] key

The [Alarm Set] key also sets some parameters. Its menu is limited to alarm functions. Again [Enter] and [Shift] move forward or back through the selections while setting up, [arrow] keys change values and [Alarm Set] exits. All values are saved as they are changed.

Alarm Set key

Process display	Set display options	Description
AL1M	See notes	Alarm 1 mode. Selects which variable, type of alarm, and whether direct or reverse acting. See notes below.
AL1V	-999 to 9999	Alarm 1 value. Decimal point is automatically set based on control variable and type of alarm.
A1TN	0 to 250	Alarm 1 turn on delay time in seconds.
A1TF	0 to 250	Alarm 1 turn off delay time in seconds.

At this point, if there is no need for ALARM 2 to be set, press [Alarm Set] to exit alarm parameters.

If ALARM 2 does need to be set, press [Enter]. Use the information starting at the top of the table for ALARM 1. The process display will change only from a 1 to a 2. All other information in the table remains accurate for ALARM 2.

Notes:

Variable   Description

D This is DIRECT operation for alarm actuation (i.e. the contact is normally open until it reaches the trigger limit specified in the ALARM VALUE then the contact closes).

R REVERSE operation (opposite of NORMAL) for ALARM actuation (i.e. the alarm contact is normally closed until it reaches the trigger limit specified in the ALARM VALUE then the contact opens).

O2   Alarm actuation is based on the analog signal at Input B inputs exceeding the limit in the Alarm Value. Input B inputs is physically located at TBD-4, TBD-5, and TBD-6 on the unit's rear connectors.

AUX   Alarm actuation is based on the analog signal at Input C exceeding the limit in the ALARM VALUE. Input C is physically located at TBD-7, TBD-8, and TBD-9 on the unit's rear conductors.

BND   Alarm actuation uses BAND WIDTH control above and below a programmed setpoint limit. (i.e. If the band is set by the ALARM VALUE to 0.10 and the programmed setpoint is at 0.80, the alarm will trigger at 0.90 and 0.70.)

DEV   Alarm actuation uses DEVIATION control above or below the programmed setpoint. The + and - symbols determine if the deviation is allowed or if it is above (+) the programmed setpoint or below (-) it. (i.e. If deviation of 0.10 is placed in the ALARM VALUE and 0.80 is the programmed SETPOINT the alarm will trigger at 0.90 or 0.70, for -0.10.)

FLT   An input FAULT, or a program alarm is to be used as basis for the actuation. The ALARM VALUE is ignored.

PRG   An Internal program will actuate the alarm.

PO   Alarm actuation is based on the PERCENT OUTPUT exceeding the limit in the ALARM VALUE .

PV   PROCESS control mode. Alarm actuation is based on the PROCESS VARIABLE exceeding the limit in the ALARM VALUE.

[SETPT] key

Parameter entry under the [Setpt] key is the same procedure as under the other two keys controlling parameters. [Enter] moves forward [Display] moves back and [arrow] keys change the values in a parameter. [Setpt] exits and values are saved when changed.

Setpt key

Process display	Set display options	Description
STPT	-999 to 9999	Control loop setpoint. The location of the setpoint will be automatically set based on the control loop process variable.
REF	0 to 9999	Reference number.
NUM	-999 to 9999	Operator input which can be accessed by the host computer system.

OPERATION

Once installation and setup and configuration are complete, the day to day operation needs of the CARBPRO depend upon the application. The basics are found in the Quick Reference Guide.

To Respond to Alarm Messages :

Note the alarm and determine what caused the alarm.
Press [ENTER] once to deactivate (silence) alarm relay contact and continue program execution.
After acknowledging the alarm, one of the following actions may be appropriate:

 Abort the program by pressing the [Prog/Auto/Man] key.
 In the case of a timed-out LIMIT statement (message #93), it is normally desirable to continue the program by re-executing the offending LIMIT statement to be sure it is satisfied. This is done automatically when the [ENTER] key is pressed to acknowledge the alarm. If you do not want to re-execute the LIMIT statement, pressing the [SETPT] key will cause the LIMIT statement to be skipped and the program to continue to the next STEP.

 Correct the problem or do what the programmed alarm indicates: see "Maintenance and Troubleshooting": the alarm messages for complete information on programmed alarms. Then press [Enter] to continue the program.

If any alarm is only to be acknowledged and the operation is to continue, press [ENTER] to silence the alarm and then press [SETPT] to skip to the next operation.

SETPOINT and the Reference Number

[SETPT] is used to enter the setpoint, the Reference Number, and the Operator Inputs. The first press of [SETPT] will allow the arrow keys to adjust the value of the setpoint. Use the [LEFT ARROW] or [RIGHT ARROW] keys to select the character to be altered. Once the character to be changed is flashing, use the [UP ARROW] or [DOWN ARROW] keys to select the desired number or symbol. After all characters are as desired, press [ENTER] to place the value in nonvolatile memory and to continue paging through the parameters. Pressing [ENTER] again allows the Reference Number to be changed. Pressing [Display] at any time allows the operator to "back up"to the to the step before [ENTER] was pressed. An additional press of [ENTER] allows the operator Input to be changed.   Anytime during the setting of values [SETPT] may be pressed to save the value and exit.

All the parameters in this group have a lock level of 3.

 SETPOINT Parameters

 Display   Parameters   Description

Stpt	Setpoint	The SET display window line represents the basic parameter for the Control Loop that the process needs.
REF	Reference Number	Assigns a number to a program for future reference. These numbers can range from 0 to 9999.
NUM	Operator Input	SET display window line = -999 to 9999. Allows the operator to enter information that may be needed by a program. This input may be used similarly to the reference number.

PROG/AUTO/MAN

The Operation Mode for control of programs is selected by the [Prog/Auto/Man] key. Pressing this key allows access to the operation mode selection controls.

The first selection, after pressing [Prog/Auto/Man], allows for control of the program to be entered. The key presses that follow it depend upon the state of the program. If a program is not running see "Running A Program" below.

Anytime during the selection process [Prog/Auto/Man] may be pressed to exit the selection process. All of the parameters under this key have a Lock Level of 3.

MANual Mode.

In Manual mode the process variable is displayed in the PROCESS display, the SET display shows the appropriate control value, and no control action is computed. The arrow keys can also be used to activate the control output.

Either the percent ON time (time-proportion) or valve position (position proportion) is displayed in the SET window. For single control mode operation this number is always positive (0/50/100). The [UP ARROW] and the [DOWN ARROW] keys increase or decrease the percent ON time or the valve position toward its fully opened or closed positions by approximately 1%. This continues for as long as the key is pressed. The [RIGHT ARROW] and [LEFT ARROW] keys force the CONTROL OUTPUTs to increase or decrease the percent output by approximately 10%.

AUTOmatic Mode

In Automatic Mode the process variable is displayed in the PROCESS display, the SETPOINT is displayed in the SET display, and control action is computed based upon the PID parameters and the input(s). Pressing and holding the [LEFT ARROW] key will cause the SET display to show the control action as described previously in "Manual Mode."

PROGRAM OPERATIONS

Running a Program
1. Press [PROG/AUTO/MAN] until the instrument's Prog LED lights.

2. The Program Number is displayed in the SET display, select the program to be run using the arrow keys.
OPTIONAL: If beginning at a step other than 1 Repeatedly press the [SHIFT] key to select the step upon which the program should start. The step number will appear in the PROCESS display.

3. Press [ENTER] to run the program.
If the Program Number in the SET display begins to flash, there is something wrong with the program (i.e. memory disruption, wrong command, etc.). Press the [PROG/AUTO/MAN] key to escape, or select a new program using the arrow keys. Troubleshoot the program and then restart this procedure.

Stopping a Program
Press [PROG/AUTO/MAN] UNTIL either the Auto or Man LEDs begin to flash, indicating a program is in HOLD. Press [ENTER] to cancel the program (flashing will stop).
  OR
Press the [PROG/AUTO/ MAN] key until the Auto or Man LED is flashing, indicating a program is in HOLD. Return to the program mode by pressing [PROG/AUTO/MAN] and the PROCESS window will display the word HOLd. The SET window indicates the program number that is in hold. Press any of the arrow keys to cancel the program. The hold symbol will be replaced by the run symbol.

Placing a Program in HOLD
Press [PROG/AUTO/MAN] UNTIL the instrument is in either Auto or Man mode as indicated by the LEDs. The flashing LED signifies the program is in HOLD.
  OR
Press [Display]+[LEFT ARROW].

Note
If the instrument is in Manual mode and a program is in HOLD, no automatic control is taking place.
If the instrument is in Automatic mode and a program is in HOLD, automatic control is continuing.

Restarting a Program From HOLD

1. Press [PROG/AUTO/MAN] UNTIL the instrument is in Programmer mode as indicated by the Prog LED. The LED should be flashing signifying a program is in HOLD.
    OR
Press [Display] +[LEFT ARROW].

2. Do not alter the program number, otherwise, the program will start from the first step and not where it had left off.

3. Press [ENTER] and the program will continue executing with the step where the HOLD was initiated.

To Enter Program Editor*

1. Press Display/Setpt
2. Select the program to be edited using the "arrow keys"(Edit / 0001)
3. Press Enter

*   Note that the unit will allow editing of a program that might be running. This editing will not affect the currently-running copy of this program until the program is actually restarted, either manually or by a program jump.

To Edit Program Steps

1. Use the [LEFT ARROW] and [RIGHT ARROW] keys to select digits to be changed (either the OPCODE or the data)

2. Use the [UP ARROW] and [DOWN ARROW] keys to change the selected digit

3. Press [ENTER] to move forward to the next step, or

4. Press [Display] to move backward to the previous step

5. If at any point the program does not advance or back up, and the entire SET display starts flashing, the data in the SET display is invalid for the OPCODE shown. Use the [arrow keys] to enter the correct data and then press [ENTER].

To Insert A Step

1. 1. Go to the step of the desired insertion, using either the [ENTER] or [Display] keys
2. Press [Control Parm]
3. Enter the new step, OPCODE and data
4. Press [ENTER]

To Delete A Step

1. Go to the step to be deleted, using either[Enter] or [Shift]

---

2. Press [Alarm Set]

To Exit the Editor Without Saving the Program

1. Press [Setpt]at any time, the edited program is lost (the copy in non-volatile memory is unchanged)

To Exit the Editor Saving the Program

1. Edit through step 19 as required, inserting NOP's wherever no operation is to be executed

2. Press [ENTER]

3. Select the program number in the SET display using the [arrow keys] until the desired program number is being displayed (SAVE / 0000)

4. Press [ENTER], the program stored in that location previously is now lost (SAVE / Done)

Changing Parameters

All of the CARBPRO parameters, program numbers, OPCODES, and data values can be altered using the following procedure:

Press [Pr. Fact./Ctrl. Param.]. The word MENU will appear in the PROCESS window. The Parameter group will appear in the SET window. Press [ENTER]. The symbol for the parameter is displayed in the PROCESS window while the current alterable data is shown in the SET window. The flashing character is the one that can be altered.

Use the [LEFT ARROW] or [RIGHT ARROW] keys to select the character to be altered.

Once the character to be changed is flashing, use the [UP ARROW] or [DOWN ARROW] keys to select the desired number or symbol.

After all characters are as wanted, press the [ALARM SET] key to place the value in memory and exit,
 OR
press [ENTER] to save the value and continue (forward) editing other parameters,
 OR
[Display] to save the value and continue (back) editing other parameters.

<div align="center">

NOTE
If an entered number value is not within the acceptable data range, the maximum/minimum value will flash in the SET display. Repeat the above procedure until an acceptable value has been entered.

</div>

See "Setup and Configuration" for the Menu table and parameter definitions. The Alarms are also found there.

VIEWING A PROGRAM WHILE IT IS RUNNING
See "Status Display Page" in Maintenance and Troubleshooting

Programmer Operations

Introduction to Programming Techniques

The CARBPRO Programmer uses a step/OPCODE approach rather than a segment approach.
The advantages of using OPCODES (operation code) are:

1) only what is to be changed is entered,

2) features can be added to older instruments, and

3) less information needs to be saved for each step therefore more programs can be stored.

The step approach is very similar to what an operator would do if he were manually controlling the process.

Some of the features in the OPCODEs may not be obvious as to how they would be used until more experience is gained. However, with a little practice and experimentation the Programmer can soon be mastered.

Each program in the CARBPRO consists of nineteen steps (one OPCODE per step). Some OPCODEs allow programs to be linked together. The CARBPRO can store up to 200 programs in non-volatile memory.

Description of OPCODEs

The following "alphabet" lists all of the available OPCODEs for the CARBPRO Programmer.

MNEMONIC/ OPCODE	DATA	DESCRIPTION
ALARM A	0001-0079 80-83*	MESSAGE # Sound and display alarm to summon operator and convey a message.
BRAN b	0000-0019	Specifies an "if true" and "if false" step number to jump to based upon the previous condition (b TT.FF). BRAN 0 branches out of the program.
AUXCN C	0-4000	Set Alarm 2 C Setpoint value if Switch 7, Bank 1 is ON. If Switch 7, Bank 1 is OFF, interpreted as NOP.

ADREF d	-128 to 127	Add to reference number.
EVENT E	1.0-15.1	Turns an output ON/OFF or waits for an input condition. The Programmer waits for an acknowledgment that the change has occurred before advancing to the next step. (.0 for OFF; .1 for ON)
GOSUB G	0-201	Allows one program to execute another program and then continue. Any program can be called a subroutine as long as it does not call another subroutine. When a subroutine ends, the calling program is reloaded and restarted at the step following the G OPCODE. A GOSUB 201 will cause a program to be called whose number is equal to the reference no.
TEMPS H	0-4000	Set the temperature Setpoint.
TEMPI h	0-4000	Check to see if the temperature is above specified value.
DELAY i	2-250 sec	Insert a short delay in seconds.
JUMP J	0-201	Jump to another program and continue executing at the new program. The Programmer never returns to the program with the J OPCODE unless called with the G OPCODE. A JUMP 0000 will reload and execute the currently running program.

MNEMONIC/ OPCODE	DATA	DESCRIPTION
LIMIT L	.05-40.00 hrs	Limit the amount of time the Programmer should wait for something to happen before sounding an alarm. The L OPCODE performs no operation by itself, it only performs a function when used with another OPCODE. The data in a LIMIT statement may also be interpreted as Temperature. (Refer to "Effect of Limit Statement")
REF#S n	0-255	Set the reference number.
OUTPUT O	0000 to 0255	Set a value to be used for the selected Analog Output (XXXX).
OXINQ o	000.0 to 100.0	Test input b.
PID P	0-999	Allows the Proportional Band to be altered by the Programmer. It is used in conjunction with = OPCODE.*
REF#I Q	0-4000	Test to see if the reference number is above the specified value.
RAMP r	05-40.00 hrs	Specifies the time (.05-40 hours) to ramp from the current temperature Setpoint to the new temperature setpoint. Must be followed by an H OPCODE.
SOAK S	.05-40.00 hrs.	Soak for specified period of time.

TIMES0-40.00 hrs T		Set the master timer to the specified value for count down. If the set value is 0, the timer will count up to a maximum of 99.99 hours and HOLD.
TIMEI0-40.00 hrs t		Check to see if the timer is above the specified value.
UNTIL-99 to 99 u		Causes the Programmer to wait until the percent output reaches the specified value. This OPCODE is used when it is desired to know when a load is up to temperature. Since the percent output needed to maintain the furnace at a given temperature can be determined, the load will be up to temperature when the percent output returns to that value.
AUXI Y	0000 to 4000	Check to see if the auxiliary input is above the specified value.
PIDEQ0-99.99 =		Allows the Reset, Rate, LOPO and HIPO parameters to be changed by the Programmer. *Only if preceded by P OPCODE.
NOP -	0000	No operation. (Data is forced to 0)

* Refer to NOTE at the end of this section for further information.

Note:
The P and = OPCODEs are used together as shown in the following example which
enters values for the Pb=150, Reset=.3, Rate=.05, LOPO=20 and HIPO=95

01	P	0150	Pb=150
02	=	0030	Reset=.30
03	=	0005	Rate=.05
04	=	0020	Minimum %Output=20%*
05	=	0095	Maximum %Output=95%*
			cycle Time=16

When altering the above parameters, note that no decimal point appears.

Note:
The execution of a JUMP or a GOSUB statement always loads the program into working memory whereas an unconditional BRANCH statement does not reload the program.
Note that the Programmer counts time in hours, tenths of hours (=6 minutes) and hundredths of hours (=36 seconds) rather that in hours, minutes, and seconds.

Symbol Table of OPCODEs
DISPLAY SYMBOL   PROGRAMMER OPCODE

A	**A-ALARM**
b	**b-BRAN**
C	**C-AUXCN**
d	**d-ADREF**
E	**E-EVENT**
F	**F-FSOAK**

DISPLAY SYMBOL   PROGRAMMER OPCODE

G	**G-GOSUB**
H	**H-TEMPS**
h	**h-TEMPI**
I	**I-DELAY**
J	**J-JUMP**
L	**L-LIMIT**
n	**n-REF#S**
O	**O-OUTPUT**
o	**o-OXINQ**
P	**P-PID**
Q	

q-REF#I

`r`	**r-RAMP**
`S`	**S-SOAK**
`T`	**T-TIMES**
`t`	**t-TIMEI**
`U`	**U-TOUTI**
`Y`	**Y-AUXI**
`=`	**=-PIDEQ**
`--`	**--NOP**

Limit Statements

There are various ways to force a program to wait for something to happen. Although it may seem that the specified condition should be easily satisfied, it is still wise to put realistic time limits on how long the wait should be.

The following chart summarizes the effect the LIMIT statement has on each OPCODE.

Effect of Limit Statement on OPCODES

OPCODE	Effect of Limit Statement
A	Effective with alarm codes 80 and 81. An 80 or 81 -- limit statement sets deviation band in degrees, decimal point is ignored (i.e. 1.00 is 100 degrees)
b	No Effect*
C	No Effect*
d	No Effect*
E	No effect on event output. On event input, sets the maximum amount of time to wait for that event to occur. An alarm 93 is displayed or sounded.**
G	No Effect*
H	Forces a wait and sets the maximum amount of time to wait for the temperature to reachsetpoint +10 F(+5 C).**
h	Sets maximum time to wait for a condition to be met.**
I	No Effect*
J	No Effect*
L	No Effect*
n	No Effect*

o	Sets the maximum time to wait for a condition to be met.*
P	No Effect*
q	No Effect*
r	ILLEGAL! An r OPCODE must always be followed by an H OPCODE.
S	No Effect*
T	No Effect*
t	Sets maximum time to wait for a condition to be met.**
U	Sets maximum time to wait for a condition to be met.**
Y	Sets the maximum time allowed to wait for a condition to be met.*
=	No Effect*
-	No Effect*

*   When a LIMIT statement follows this OPCODE it is interpreted as a NOP.

** An alarm 93 is displayed and/or sounded only if the limit statement is not followed by a branch. If the condition is not met by the time listed in the data statement, the unit will display and/or sound an Alarm #93. If the alarm need only be acknowledged and operation is to continue, press Enter once to silence the alarm and then press Setpt to skip the LIMIT OPCODE and resume operation.

The operation of a limit statement after the following OPCODEs is described in more detail below:

E (EVENT) (INPUT)   - A limit statement here will cause the program to wait for the specified event INPUT (normally event numbers 8-15) to switch to the specified state (ON OR OFF, 1 OR 0), before proceeding. If this does not occur within the specified limit time, a limit time-out alarm will occur.
Note: The event INPUT must be held in the trip state for at least 30 seconds to make sure that the Programmer will acknowledge it. Thus, a momentary push button could not be used as an event INPUT unless some type of latching scheme is employed. If a limit statement is not used, the program may wait indefinitely.

H (TEMPS)   A limit statement here will cause the program to wait for the measured temperature to come to within +10 F (or +10 C) of the specified Setpoint. If this does not occur within the specified limit time, a limit time-out alarm will occur. If no limit statement is used, the Programmer simply sets the specified Setpoint and goes on to the next step. The maximum time that a limit statement will accept is 40 hours. Use the Programmer Status Display during a wait operation to reveal the time left before a limit time-out alarm will occur.

Branch Statements

Branch statements are best utilized when placed after inquiry statements. If neither a branch

nor a limit statement is placed after an inquiry the Programmer will sit at the inquiry line indefinitely. A branch statement can immediately follow an inquiry or it can placed after the limit statement, for example:

INQUIRY	or	**INQUIRY**
BRANCH		**LIMIT**
		BRANCH

The effect of a branch after an inquiry is to jump to a specific line in the program based upon the outcome of the inquiry. The format of the branch OPCODE is b TT.FF; therefore if the outcome is true the program jumps to the step number listed first. Whereas , if the outcome is false, the program jumps to the second step.

A limit statement between an inquiry and a branch just sets a definite time to wait for the inquiry to become true. It has no effect on the outcome of the inquiry or where the program branches to. It only effects the length of the time delay.

If a branch statement is not preceded by an inquiry, or any conditional statement, the branch is automatically assumed TRUE.

An unconditional branch is one in which the steps specified for true and false are the same. An unconditional branch to step 1 (b 01.01) will cause a program to loop back to the beginning of the program every time the above statement is encountered. The difference between a b 01.01 and a J 0000 is that the jump reloads the program and would therefore pick up any changes edited into the program after it was initially started.

Writing and Editing a Program

Writing

Before a program can ever be written into the CARBPRO, the author must understand and perform the following process:

1. Determine what the program is to do.
2. Write, revise, and rewrite an algorithm (program in words) until part 1 works.
3. Construct the program for the CARBPRO using the OPCODEs listed in "Programmer Alphabet".

The Programmer Editor can be used to create a new program or modify an already existing program. While in Program Edit mode, the unit continues to control the furnace (as long as the Auto LED is on), and a running program continues if the program LED is on.

The Editor Mode:

To get the unit into the editor mode, perform the dual-key operation [Display][Setpt.] The PROCESS window will have the message EDIT displayed and the SET window will have a XXXX displayed signifying the program number to be edited. At this point any of the 200 programs can be called into the edit space using the arrow keys to change the necessary

digits. That is, the [left arrow] or [right arrow] keys can be used to select the digit to be changed and the [up arrow] or [down arrow] keys can be used to select 0 through 9. Next, press the [Enter] key once more to begin entering or modifying the program. The PROCESS display will show step 01. The OPCODE character is also displayed in the PROCESS display while the SET display will show the DATA line in various formats depending on the OPCODE character. To advance through each step of the program use the [Enter] key; to move backwards in the program use the [Display] key.

At any point, a step can be inserted or deleted. To insert a step, press Control Parm, this forces the OPCODE at step 19 to be lost and a -(NOP) will appear. To delete a step, press [Alarm Set key], this causes a - NOP to be pulled in at step 19.

Use the [left arrow] or [right arrow] keys to determine whether the OPCODE or DATA is to be changed. If a data character is flashing move left or right in the data by using the arrows. If the OPCODE needs to flash press the [left arrow] until the OPCODE character flashes the [right arrow] does not allow access to the OPCODE. If the OPCODE is to be changed, the [up arrow] or [down arrow] keys can be used to scroll through the OPCODES alphabetically. If either the "up arrow" or "down arrow" keys are held down, the OPCODEs will automatically be displayed with each flash of the display. When entering data, the "up arrow" and "down arrow" keys can be used to select 0 through 9 (or negative sign, if applicable).

If at any point [Enter] or [Shift] is pressed and the SET display starts flashing, the data is not valid for the OPCODE shown. Use the arrow keys to alter the data as required and press [Enter] or [Display] to continue entering or editing the program.

Exiting

Once all 19 steps have been entered or modified as needed and the editor is sitting at step 19, press [Enter] one more time to get the message SAVE displayed in the PROCESS window. The program number, the number of the program originally pulled into the edit space, will appear in the SET display but can be changed using the arrow keys.
If the program number is changed at this point, however, the edited program will be stored as the new number. For example, it is possible to call up program #29, edit it, and store it back as program #4. The original #29 is still intact, and whatever was in program #4 is now replaced with the edited #29.
If, while entering data an error is made, or it is desired to exit the editing routine without making any changes, press Setpt and the unit will continue normal operation. The edited information will be lost.

<div align="center">

NOTE:

</div>

It is recommended that program #200 be kept as a "garbage" program location to temporarily store programs as required.

Programmer messages are displayed when inputting data and using the Editor, refer to the table shown below:

Explanation of Programmer Messages

DISPLAY	MESSAGE
EDIT	Pull the program into the editor
SAVE	Save the edited program
RUN	Run the program
HOLD	Place the running program into Hold

Effect of Start-up Sequence on Programmer

The two start-up options described in "Start-Up Procedures" affect the Programmer significantly.

If a Shift-Shift-Enter start-up was used, the program running at the time of power was lost will pick up where it left off. This includes events and soak times.

If a simple Enter-Enter start-up sequence was used, the program is canceled. All events will return to the rest position (OFF) and the setpoint is lost.

Alarm Messages

Programmer alarms interrupt Manual display, as discussed in "Keyboard Operations". This prevents important error messages from being lost while the Manual display is activated.

Once any of the following alarms are displayed and/or sounded, the dual-key operation Shift/"down arrow" cannot be used until the alarm is silenced by pressing Enter. This does not clear the alarm, however.

Programmer Alarms appear at Event 0 on the Optomux board.

To respond to alarm displays (#01-#98)

1. Press Enter one time to deactivate alarm relay contact (silence).
2. Examine the display to determine the origin of the system alarm:

Messages #01-79:

Indicate a programmed alarm (from an "A-ALARM" OPCODE in the program) has occurred. The response should be to carry out whatever task the message code indicates. For example, Message #37 might mean put test pins in furnace, while #28 might mean to manually change the temperature setpoint to 1550`F. These codes should be assigned for the particular installation involved.

Message #80-#81:

Used, in conjunction with the Programmer, for the following purpose:

    81   TURN ON A TEMPERATURE DEVIATION BAND ALARM (COMMUNICATING TEMPERATURE CONTROLLER REQUIRED)

    80   TURN OFF SAME

The A(Alarm) OPCODE in this case should be followed by the L(Limit) OPCODE that sets

the width of the particular deviation band
(i.e. +10`,+25` or +12%C, etc.). If no LIMIT statement is used, the previous deviation value
will be used. Both the turn ON and turn OFF statements can set the deviation. The alarms
are said to be "smart" in the sense that they are not armed until the process is actually at the
required setpoint. If tripped, the alarms produce the standard programmer ALARM display
and pulsing alarm. The program remains in HOLD until action is taken.

Also, after the Deviation Alarm 81 occurs, clearing the alarm also clears the inb and flag;
therefore, the process must reach setpoint before the alarm can sound again. The alarm is
automatically disarmed at the end of a program.

Message #82-90:

Not assigned.

Message #91:

Reserved

Message #92:

Indicates a problem on the Events Buss. This error may occur at any point in a program
that attempts to use events statements.

One of the following conditions possibly exists:

a.   The OPTOMUX board of interest is not present, is disconnected, or is turned off.

b.   The jumpers on the events board are improperly set.

Should be configured for:

                    -2 pass format
                    -1200 baud
                    -Address #1
                    -Multidrop Mode

c.   There is severe disruption of communication due to the use of wrong cable, too
        long a cable run, routing of cable in non-recommended termination schemes (i.e.
        WYE), or improper or missing termination resistor connections.

Message #93:

Indicates a limit statement has timed out. This must be interpreted in the particular situation,
but if the limit time specified in the program was realistic, then a flaw in the system is
indicated, or an instrumentation or operator error has occurred.

Message #94:

Not assigned.

Message #95:

Indicates an illegal ramp, the r OPCODE is not followed by the H OPCODE in the currently
running program.

Message #96:

Indicates that a power failure has occurred and the CARBPRO started up again in the AUTO

RESTART mode as determined by DIP Switch 5 on Bank 1.

Message #97:

Indicates that a subroutine is calling a subroutine which is illegal with the MSI Programmer.

Message #98:

Indicates that a jump from one program to another was attempted but not implemented due to memory disruption or a J201 to reference number too large.

Message #99:

Not assigned.

Message #101:

Indicates that a recipe has attempted to change the instrument set point when the remote setpoint selection (SETP) has been changed from LOC (local) to IN C (input C).

3. After taking the required action based upon the alarm message, there are several possible courses of action:

    a.   Press Enter again to continue with the program (after either correcting the problem with the temperature or events buss in the case of error message #92, or taking the prescribed action in the case of programmable messages 01 through 89).

    b.   Abort the program by pressing PROG/AUTO/MAN.

    c.   In the case of a timed-out limit statement, (message #93), it is normally desirable to continue the program by re-executing the offending limit statement to be sure it is satisfied. To do this, simply press Enter. A setpoint will cause the LIMIT statement to be skipped and the program to continue on the next step.

STATUS DISPLAY PAGE

The status display is broken into "pages" and "paragraphs" the "pages" are represented here by columns and the" paragraphs", by the individual cells. See "Setup And Configuration" for the values displayed here most of the status pages correspond to the setup menus.

Press [Display]+[Down Arrow] to enter the page display table. Press [Right Arrow] or [Left Arrow] to move from one column to the next in the display. Press [Up Arrow] or [Down Arrow] to move down a column.

3.5 c r ??	PROG	EVNT	DATA	EXT ALOG	CONT	(generic)	SLVE INST	PROB CARE
	R ? P???	SP 1 ////	CJ ????	EA 0 ????	PO ????	00 = 0 C11C	HSP1 ????	DATE M.DD
	G ? p???	ACT 1 ////	TC ????	EA 1 ????	PB ????	: :	HAC1 ????	TIME HH.MM
	- ????	PAR 1 ////	O2 ????	EA -- ????	RES ????		HPO1 ????	IMP X.X kohm
	RT ????	ST 1 B 10	AUX ????	----	RAT ????		**	I RT .SSS
	MT ????		CARB ????	----	CYC ????		**	BOMV ????
	PAL		DWPT ????	----	LOPO ????		**	BOTC ????
				----	HIPO ????		HST1 G ??	BORT .SSS
				EA 15 ????	LDLN ????		----	
				ST A X ??	SW ????		HST 8	

NOTES:

----   The item displayed in the box above this repeats through the full cycle of options. For example:

Exterior Analog has 16 displays and Slave Instrument has 8.

**   Items displayed above this repeat in sequence through the full cycle of options. For example: Slave Instrument will display data for HSP, HAC, And HPO for each option in the cycle before going to the next option.

:   The Generic table (the title of this page does not display) displays the parameters in hex for all the programs loaded into the CARBPRO 3.5 .   These are for engineering troubleshooting purposes only. The operator should not try to use these.

Status Display Column 1 – Firmware version

The first column displays the firmware version number. The 3.5 c indicates that the instrument is a version 3.5 Carbpro. The number following the 'r' is the actual frimware version.

Status Display Column 2 – Program

PROG	Program Menu
R ? P???	**R = Line number of running recipe, P = Running program number**
G ? P???	**G = Line number of running gosub routine (if called), P = running gosub program number**
- ????	**Display of current running line op code and data**
RT ????	**Remaining time (soak timer) if running.**
MT ????	**Remaining time of master timer if set.**
PAL	**Program alarm number (if active)**

Status Display Column 3 – Event

EVNT	Events
SP 1 ////	**Displays the event setpoints for all 16 possible events. An event is active if it's corresponding tick mark is lit. The top row represents events 0 through 7, from left to right. The lower row of tick marks represents events 8 through 15. All the events can be turned off by pressing the [Disp] and [Setpt] keys at the same time while displaying the SP1 page. Events 0 through 3 are valid if only the instrument's internal events are being used. If an external event board is used, the first four external events and the internal events will turn on/off at the same time when event 0 through 3 are addressed by the 'E' recipe op code.**

ACT 1 ////	Displays the actual on/off state of each of 16 events. Each tick mark represents an event.
PAR 1 ////	Displays the partition setting of the events. A tick mark indicates that the corresponding event is set as an ouput.
ST 1 B 10	Status of external event board communications, B 10 = bad comms, G 00 = good comms

Status Display Column 4 – Data

DATA	Data Display
CJ ????	Cold Junction temperature in degrees (F or C)
TC ????	Thermocouple temperature in degrees (F or C)
O2 ????	Millivolt input level applied to Carbpro's probe millivolt input.
AUX ????	Scaled Auxillary input value.
CARB ????	Calculated Carbon value based on temperature and probe millivolts.
DWPT ????	Calculated Dewpoint value based on temperature and probe millivolts.

Status Display Column 5 – External Analog
The external analog events pages shows the values of the active analog events depending on what type of opto module is used in each event location.

EXT ALOG	External Analog Events
EA X ????	Input value of analog event X, where X is event inputs 0 through 15.
ST A G 00	Status of analog board communications, B10 = bad comms, G00 = good comms

Status Display Column 6 – Control

CONT	Control Display, this are displayed values only. These parameters can be changed in the Process Factor / Control key menu.
PO ????	Actual percent output
PB ????	Actual proportional band
RES ????	Actual reset setting.
RAT ????	Actual rate setting.
CYC ????	Actual cycle time setting.
LOPO ????	Actual low power output setting.
HIPO ????	Actual high power output setting.
LDLN ????	Actual load line setting.
SW ????	Actual slide wire input value.

Status Display Column 7 – Memory Map

This display should be used by advanced users and Marathon service personnel. The memory map or generic display shows values as they are stored in various memory locations. Both value and memory location addresses are in hexadecimal notation. In the upper row the display shows XX=Y, where XX is the memory address and Y is the memory table. The memory addresses range from 00 to FF. The table is fixed at 0. The lower row shows the data stored in the memory location shown.

Pressing the [Enter] key advances the address by x10 memory locations. Pressing the [Enter] and [Setpt] keys at the same time will allow changes to the lower value for the displayed memory location.

Status Display Column 8 – Slave Instruments

SLVE INST	Slave Temperature controller menu
HSP1 ????	Temperature setpoint of first temperature slave.

HAC1 ????	Actual temperature being measured by temperature slave 1.
HPO1 ????	Actual percent output of temperature slave 1.
HSP**	Repeats setpoint for slave controllers 2 – 8.
HAC**	Repeats actual temperature for slave controllers 2 – 8.
HPO**	Repeats actual temperature percent output for slave controllers 2 – 8.
HST1 G ??	Repeats communication status for temperature slave controllers 1 – 8.

Status Display Column 9 – Probe Care

PROB CARE	Probe Care data display menu
DATE M.DD	Date of last probe care test M = month, DD = day.
TIME HH.MM	Time of last probe care test, Hours.minutes.
IMP X.X kohm	Measured probe impedance shown in kilo-ohms.
I RT .SSS	Impedance recovery time in seconds.
BOMV ????	Burnoff millivolts. Should be lower than process millivolts.
BOTC ????	Burnoff temperature. Should be higher than process temperature.
BORT .SSS	Burnoff recovery time in seconds.

CALIBRATION PROCEDURES

The CARBPRO instrument is shipped completely pre-calibrated. The drift characteristics of the input circuits are excellent but from time to time adjustment may be necessary in order to maintain high accuracy.

Analog Input Calibration.

There are three analog inputs and a cold junction compensation sensor on the CARBPRO. The input level and input features for each input are determined by changeable daughter boards that are mounted piggy back on the analog input board. There are several types of input daughter boards: thermocouple input, auxiliary input, 4 to 20 mA input, 0 to 10 V linear, RTD, and slide wire input.

The standard factory configuration is for input A to be a thermocouple input, input B to be an Oxygen probe input(auxiliary input) board, and input C to be a slidewire feedback input. If the instrument to be calibrated does not have the standard factory configuration, then identifying the configuration is necessary so that the proper procedure for each input board can be followed.

Displays And Keyboard

When operating in the calibration mode, the displays and front panel keys take on special assignments. The PROCESS display shows the value of the input being calibrated with a flashing digit. This flashing digit shows the relative sensitivity of the arrow keys, as described following the key descriptions. The SET display shows which input is being calibrated and whether the zero value or the span value is being modified.

The SET display messages are shown below:

Message	Description
Z-A	Zero input A
Z-B	Zero input B
Z-C	Zero input C
Z-SW	Zero slide wire (from input C)
S-A	Span input A
S-B	Span input B
S-C	Span input C
S-SW	Span slide wire (from input C)

NOTE
It is very important to be sure the SET display is showing the proper mode before making an adjustment or the wrong value will be changed.

Adjustment Sensitivity

The adjustment sensitivity works in the following manner. If the digit farthest right in the process display is flashing, then each press of the [Up Arrow] or [Down Arrow] key will change the calibration value shown by one unit. This is the least sensitive position. If the digit farthest left is flashing, then each press of the [Up Arrow] or [Down Arrow] key will change the calibration value by a thousand units. The middle digits will show sensitivities of a hundred and ten units respectively. It is not important to know the relative worth of one calibration unit. Understanding that the location of the flashing digit affects change that one key press will make on the calibration value is necessary. By observing the degree of sensitivity one key press makes at each flashing digit location, you can quickly see how to use this feature.

Preparing For Calibration

Before placing the CARBPRO into calibration mode, check to be sure that for each input:
The proper thermocouple type has been selected, and
Cold Junction compensation has been selected, if required. Cold Junction compensation can be selected by using the [Setup] key. The option is below the corresponding input type selection.

The CARBPRO is placed into calibration mode by connecting a jumper from TBD-17 to TBD-18. To make sure of the integrity of the calibration factors, power should be applied to the CARBPRO before this jumper is installed and not removed until after this jumper has been removed. The CARBPRO should be operating for at least 30 minutes before calibration to make sure that input circuits have stabilized.
For each input of the CARBPRO, follow the calibration procedure by the type of input board installed for that input. Once an input has been calibrated, be sure to press the [Enter] key to make sure that the latest calibration factors are stored.

Calibration Of The Thermocouple Board

This calibration procedure assumes that a thermocouple has been selected and internal cold junction compensation is being used. If this is not true, follow the procedure for the auxiliary board using a 0 to 40 millivolt signal. The calibration procedure is as follows:

Connect the input to be calibrated to a junction compensated calibrator (IE: Biddle Instrument Co. Versa-Cal Calibrator) using the proper extension wire for the thermocouple type selected.

Using the [Display] key, select the proper input to be calibrated (input A, if standard configuration).

Using the [Enter] key, select the zero mode (IE: if for input A, Z-A).

Set the calibrator output to the recommended zero value for the thermocouple type selected. See the table below.

Using the Arrow keys, adjust the process value to equal the calibrator output.

Press the [Enter] key to select the span mode (IE: S-A, for input A).

Set the calibrator output to the recommended span value in   for the thermocouple type selected.

Using the arrow keys, adjust the process value to equal the calibrator output.
Repeat steps f. through j. until no additional change is needed.

Press the [Enter] key one more time to be sure the calibration factors are stored. Go to the next input to be calibrated or exit calibration mode by removing the calibration jumper or pressing [Setup] .

Thermocouple type	Zero ºF(ºC)	SpanºF (C)
B	200 (90)	3000 (1800)
C	32 (0)	3000 (1800)
E	32 (0)	1300 (900)
J	32 (0)	1300 (900)
K	32 (0)	2300 (1200)
N	32 (0)	2300 (1200)
NNM	32 (0)	2000 (1100)
R	300 (150)	3000 (1800)
S	300 (150)	3000 (1800)
T	32 (0)	700 (350)

The usable ranges of the thermocouple types are shown in The table above. If having a high accuracy over a specific operating range is desirable then the input should be calibrated over that range. Follow the calibration procedure for normal calibration with the following changes. Use the low end of the desired range as the zero value and the high end as the span value. There will be more interaction between zero and span with this method. The desired operating range must fit with the limits of the table.

Oxygen /Auxiliary Board Calibration

To Zero the board Calibration

Turn off the power at the simulator.

Short the input by putting a banana plug shorting block into the simulator. Short the jumper (switch) wired into 17 and 18 to calibration mode.

This will produce some value in the PROCESS window and Z-A in the SET window. Use the left and right arrow keys to change the adjustment from coarse to fine in the PROCESS window, and the up and down arrow keys to change the value. Adjust the PROCESS window value to zero (0), or as close as possible.

Press the [Enter] key twice to store the value.

Press the [Display] key to change the SET window to Z-B or Z-C and repeat steps 4 and 5 for inputs B and C.

After all the values are stored, press the [Display] key to return the SET window to Z-A

and press the [Enter] key to change it to S-A (span).

To set the span
Put the meter leads into the banana plug to measure mV (300----).

Remove the jumper block from the simulator.

Using a meter to check your input voltage on the O2 side, enter 1400 or 1500 mV from the simulator, and turn ON the simulator.

Set the span values at 1400 or 1500 (depending on what the simulator generated) using the arrow keys to adjust the values.

Press the [Enter] key twice to save the values and press the [Display] key to change the input type.

Repeat steps 1-5 for each input (A, B, and C), pressing [Enter] twice to save the values each time. Wait 5 to 10 seconds to allow the reading to record, then take it out of calibration mode by throwing the switch.

Remove the banana plugs from the simulator (remove the load from the line) and wait for the instrument to "max out" at 3500.

Let the reading settle at maximum (another 5 to 10 seconds) hen reinsert the banana plug into the simulator to see if the instrument returns to a steady 1500 at all inputs.

Vary the input millivoltage down and verify that 1500 reduces to 1000 at a steady level for each input setting.

Check the reference voltage on TBD-5 and 6 (for input B) and 8 and 9 (for input C). Should read around +2 mV (between 1.8 and 2.2 is considered good).

Linear (0-10VDC) Board Calibration

Initial Settings
The following steps set up the parameters necessary to calibrate the Linear board. Verify these settings before proceeding with this calibration.

1. Press the [Pr. Fact / Ctl. Parm] key once.
2. Use the [Right] or [Left] arrow keys to display **MENU INP**
3. Press the [Enter] key until **IN C** is displayed in the process window
4. Set **IN C** to **PROG** by using the [Up] or [Down] arrow keys.
5. Press the [Enter] key to move to **CJCC** (cold junction compensation – C)
6. Change **CJCC** to **NO**
7. Press the [Enter] key to display **ICOF** (input C offset)
8. Set **ICOF** to **0000**
9. Press the [Enter] key to display **ICSP** (input C span)

10. Set **ICSP** to **01.00**
11. Press the [Enter] key to display **ICDP** (input C decimal point)
12. Set **ICDP** to **2**

Zero
Turn off the power at the simulator.

Short the input by putting a banana plug shorting block into the simulator. Short the jumper (switch) wired into 17 and 18 to calibration mode.

This will produce some value in the PROCESS window and Z-A in the SET window. Change Z-A to Z-C by pressing the [Display] key.

Use the left and right arrow keys to change the adjustment from coarse to fine in the PROCESS window, and the up and down arrow keys to change the value. Adjust the PROCESS window value to zero (0), or as close as possible.

Press the [Enter] key twice to store the value.

Press the [Enter] key to change Z-C to S-C (span).

Span

Put the meter leads into the banana plugs to measure Volts.

Remove the jumper block from the simulator.

Using a meter to check your input voltage on the O2 side, enter 10V for the simulator, and turn ON the simulator.

Set the span values at 10.00 (depending on what the simulator generated) using the arrow keys to adjust the values.

Press the [Enter] key twice to save the values and press the [Display] key to change the input type (if required).

Wait 5 to 10 seconds to allow the readings to record, then take it out of calibration mode by throwing the switch.

Remove the banana plugs from the simulator (remove the load from the line).

It may be necessary to change the ICOF and ICSP values to scale the input C signal to a particular process value. For example it would be necessary to change ICSP to 2.00 if input C was going to used as a carbon setpoint source. A 0V to 10V input would indicate a 0% to 2% carbon.

It is possible to change the scale value without changing the calibration if an input level other than 10V is going to be used. For example, if a 5V input will represent a 2.00% carbon setpoint, then just change ICSP to 4.00.

Slidewire Board Calibration

Zero
Turn off the power at the simulator.

Short the input by putting a banana plug shorting block into the simulator. Short the jumper (switch) wired into 17 and 18 to calibration mode.

This will produce some value in the PROCESS window and Z-A in the SET window.

Use the left and right arrow keys to change the adjustment from coarse to fine in the PROCESS window, and the up and down arrow keys to change the value. Adjust the PROCESS window value to zero (0), or as close as possible.

Press the [Enter] key twice to store the value.

Press the [Display] key to change the SET window to Z-B or Z-C and repeat steps 4 and 5 for inputs B and C.

After all the values are stored, press the [Display] key to return the SET window to Z-A and press the [Enter] key to change it to S-A (span).
Span

Put the meter leads into the banana plug to measure mV (300----).

Remove the jumper block from the simulator.

Using a meter to check your input voltage on the O2 side, enter 1.4 or 1.5 mV from the simulator, and turn ON the simulator.

Set the span values at 1400 or 1500 (depending on what the simulator generated) using the arrow keys to adjust the values.

Press the [Enter] key twice to save the values and press the [Display] key to change the input type.

Repeat steps 1-5 for each input (A, B, and C), pressing [Enter] twice to save the values each time. Wait 5 to 10 seconds to allow the readings to record, then take it out of calibration mode by throwing the switch.

Remove the banana plugs from the simulator (remove the load from the line) and wait for the instrument to "max out" at 3500.

Let the reading settle at maximum (another 5 to 10 seconds) then reinsert the banana plug into the simulator to see if the instrument returns to a steady 1500 at all inputs.

Vary the input millivoltage down and verify that 1500 reduces to 1000 at a steady level for each input setting.

Check the reference voltage on TBD-5 and 6 (for input B) and 8 and 9 (for input C). Should read around +2 mV (between 1.8 and 2.2 is considered good).

Analog Output Calibration

The two Analog Output signals can be configured for the following ranges: 0 to 5 V or 4 to 20 mA. The output modes for each of the Analog Outputs are determined by the two separate DIP switches on the ANALOG OUTPUT board.

Any time the mode of operation is switched between current and voltage, the outputs must be re-calibrated. The outputs do not have to be re-calibrated when switching between output mode i.e.: if the output is calibrated for 0 to 5 volts, and it is necessary to change from Process Variable to Proportional Output 1, then no re-calibration is necessary (5 volts will be equal to 100%).

Preparing for Calibration
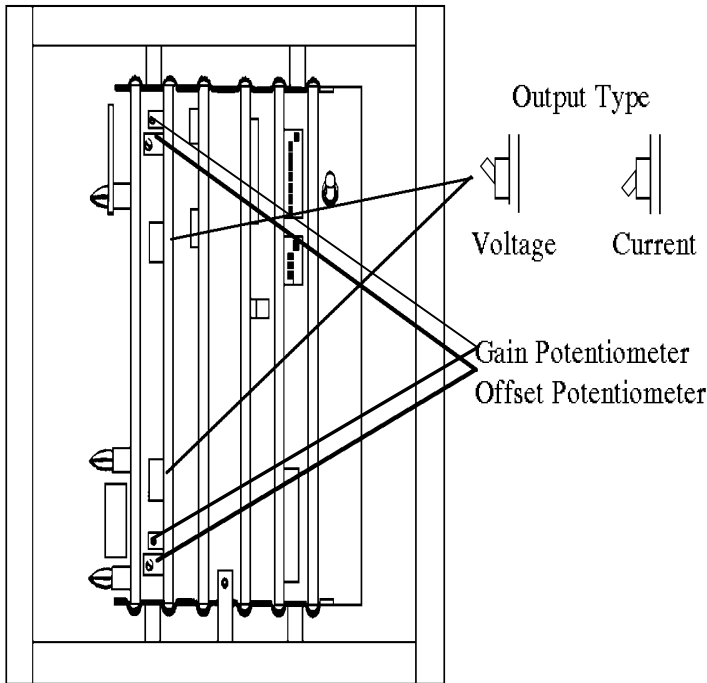
To set the desired mode, find the proper switch that corresponds to the output to be used. Select the voltage mode by pushing the rocker switch down at the bottom edge of the switch. Select the current mode by pushing the rocker switch down at the top of the switch. Repeat procedure for the other output.

Calibrating the Outputs

To calibrate the Analog Outputs:

- Consideration must be made at this time about which type of output, current or voltage, is to be used. Check the two rocker switches on the Analog Output board to confirm that the desired mode is selected for each output.

The easiest way to adjust the current output for 4 mA, is to put the instrument in Manual Mode by using the [Prog/Auto/Man] key.

- Remove the FRONT PANEL by loosening the black knurled knob in the counterclockwise direction. Remove the panel from the chassis and support it near the instrument.
- To calibrate the outputs using the following method, both Analog Outputs must be set to the Proportional Output (PO) control mode. This is done by:

1. Pressing [Pr. Fact / Ctl. Parm] and selecting AOUT from the menu. Press [Enter] to move forward through the menu.
2. At the AO 1 display, change the control mode in the lower window to PO.
3. Press [Enter] repeatedly.
4. At the AO 2 display, change the control mode in the lower window to PO.
5. Press [Setup] to exit the menu.

- *Remove any wires at the Analog Output terminals (TBD-13, TBD-14, TBD-15 and TBD-16).
- *Attach the leads of a digital multi-meter (DMM) to the terminals that correspond to the output to be calibrated (TBD-13(+) and TBD-14(-) for Analog Output #1. TBD-15 (+) and TBD-16(-) for Analog Output #2).
- *Set the Percent Output to 0% using the [Left Arrow] key.
- *Find the OFFSET POT for the output to be adjusted. Adjust the pot until the DMM reads 4 mA current output or 0 V.

NOTE: Make sure your meter is setup for the appropriate measurement. If you are reading >20VDC then the output is probably setup for current output and the meter should be configured to read DC Current.

NOTE: Repeat * steps for the other output.

- To get the full SPAN output value, press the [right arrow] until 100 is displayed in the PROCESS Window indicating 100 percent is being applied.
- With the DMM connected at the proper output terminal connection, adjust the GAIN pot of the corresponding output until the DMM reads the required output (5 V max) or 20 mA).
- Move the meter leads to the other Analog Output and repeat the previous step for the SPAN output.
- Repeat the Zero and Span process until no further adjustments are required.
- Reset PO1 to its original setting, if it was changed in the *l offset pot step above, to their desired values. Reattach any wires removed from the Analog Output terminals.
- Reattach the FRONT PANEL to the chassis. The Analog Output Calibration procedure is now complete.

DIGITAL INTERFACES

Host Communications

The Host communications are able to be set from the front panel: see "Setup and Configuration". The CARBPRO is suitable for connection to a host computer for intelligent overall process monitoring or supervision. Terminal connections are made on the rear panel: See the connections label on the instrument. Twisted pair wire with or without a shield must be used for all communications wiring. Conventional RS-232 cable is required along with a half-duplex RS-232/422 convertor (P/N FG/500-0501). With a 9-Pin or 25-Pin female connector depending on Host Computers connector, some of the pins on the computer end of the connector should be jumpered together as follows: 9-Pin: 1,4,6,8 or 25-Pin: 5,6,8,20. The CARBPRO never initiates communications, and is always in receive mode unless responding to a question.

"X" Protocol

The "X" protocol software involves a Parameter Table, a Program Run Buffer, a Program Edit Buffer, and a Serial I/O Program Buffer. The CARBPRO can be written to using a "1TXparameternumber$data" format. This entry would place the data value in the proper location as determined by the parameter number. Any parameter can be read back from the CARBPRO using the following format "1Txparameternumber". Therefore, to write a value to the CARBPRO for a specific parameter use an "X" or to read a specific parameter from the CARBPRO, use an "x".

All of the parameters are listed below along with a short description. The numbers in the parenthesis are in Hexadecimal.*

Parameter Table
(0H-2FH) & (72H-79H)
CHSTAT   (0) -Status Word
SETPT(1) -Setpoint of Process Variable
SETPTOS   (2) -Setpoint Offset
GAIN   (3) -PID Proportional Band
RESET   (4) -PID Reset
RATE   (5) -PID Rate
CYCTIM   (6) -PID Cycle Time
ALARM1   (9) -ALARM1 Value and Type
ALARM2   (0AH) -ALARM2 Value and Type
                 (0H-2FH) & (72H-79H)
REFNUM   (0CH) -Reference Number
PRGNUM   (0DH) -Program Number and Step
PRGSTK   (0EH) - Program Stack (Number and Step)
PRGMT   (0FH) -Master Timer Bit 15 is DIR Flag
PRGRTIM   (10H) -Programmer Course Remaining

	Time	
EVSETPT	(11H)	-Events Buss Setpoint
PTDALM	(14H)	-Programmer Temperature Deviation Alarm Value and Condition
RAMPTIM	(15H)	-Programmer Ramp Time
RAMPST	(16H)	-Programmer Ramp Starting Temperature
RAMPDIF	(17H)	-Programmer Difference and Direction
TEMP	(19H)	-Temperature
COLDJCT	(1AH)	-Temperature Compensation Value
AUXIN	(1BH)	-Auxiliary Input
DIPSW	(1EH)	-DIP Switch Image, bit map
ALRMCON	(1FH)	-Alarm Conditions

Parameter Table (continued)

PERRCUR	(21H)	-Current Process Error
PERRNO	(22H)	-Process Error (N)
PERRN1	(23H)	-Process Error (N-1)
PERRN2	(24H)	-Process Error (N-2)
CONACC	(25H)	-Control Action Accumulator
RLYTIM	(26H)	-Relay ON Time and OFF Time
RLYCON	(27H)	-Control Action
CONACTIM	(28H)	-Control Action Timer
EVPAR	(29H)	-Events Partition Bit Map
EVSTAT	(2AH)	-Events Buss Status
EVACT	(2BH)	-Actual Events Buss
CONSUM	(72H)	-Control Summers
DACV1	(73H)	-DAC1 Data
DACV2	(74H)	-DAC2 Data
ALRMQ	(75H)	-Programmer Alarm
HPOUT	(76H)	-Temperature Percent Output

PROGRAM RUN BUFFER (30H-45H)
PRUNPRG   Program Number and Step, Remaining Time, First Through Last
Steps of Program Along With Opcodes, and Checksum and
PROGRAM EDIT BUFFER (46H-5BH)
PEDPRG   Program Number and Step, First Through Last Steps of Program
Along With Opcodes, and Checksum and Allow Byte
**Location 91 is not used
SERIAL I/O PROGRAM BUFFER (5CH-71H)
PSIOPRG (50)   Program Number and Step, First Through Last Steps of Program
Along With Opcodes, and Checksum and Allow Byte

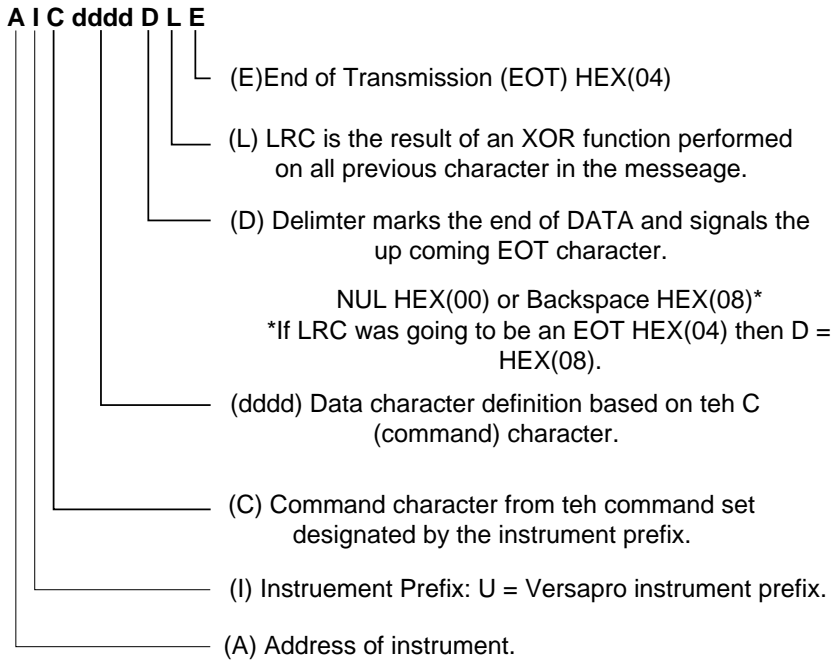* Refer to Appendix A for further information on Hexadecimal Code.

** An Alarm Queue is included in the host communications capabilities of the instruments.

The Alarm Queue is simply a block of storage locations for the programmer alarms that occur within the instrument and works similar to the idea of FIFOs (first in, first out). The queue was added because various programmer alarms can occur and be acknowledged and/or corrected before the Host Software ever has the chance to "see" them. Therefore, the alarms had to be passed on to the Host Software even if they were already acknowledged and/or corrected. The Alarm Queue was created to meet this need.

The Alarm Queue works on a READ & CLEAR basis. If the Alarm Queue is read with the "x" parameter FF (Hex), the storage location will return a word comprised of a HI byte and a LO byte. The LO byte is the first alarm appearing in memory while the HI byte is the second alarm appearing in memory (thus creating the FIFO effect). If both bytes are non-zero, then the Host will look again to see if any non-zero values have been stored. Once the bytes are read from the Queue, they are cleared out of the memory block.

If there is no Host Software used, the Alarm Queue is never read, but the Queue is still written to by the instrument. Once the Queue is filled, it cannot be written to until a location has been cleared. Considering the fact that Host Software is not used, the Queue will never be cleared and will never store any of the alarms that occur after the Queue has been filled. This does not cause a problem considering the fact that the Queue is only used with Host Software and if the software is not used, we do not care if it is filled or not. Message Protocol Format

A I C dddd D L E

(E)End of Transmission (EOT) HEX(04)

(L) LRC is the result of an XOR function performed on all previous character in the messeage.

(D) Delimter marks the end of DATA and signals the up coming EOT character.

NUL HEX(00) or Backspace HEX(08)*
*If LRC was going to be an EOT HEX(04) then D = HEX(08).

(dddd) Data character definition based on teh C (command) character.

(C) Command character from teh command set designated by the instrument prefix.

(I) Instruement Prefix: U = Versapro instrument prefix.

(A) Address of instrument.

	ASCII	or	BROADCAST MODE
	0 – F (15)		? character
			or
			@ character

HOST SOFTWARE

10PRO Emulation Mode

The CARBPRO will emulate the 10PRO temperature controller command set. The commands which are emulated are:

10PRO Temperature Controller Command Set

Command Letter	Description
p	Read Auto/Manual mode
o	Read Remote/Local
I	Read Remote Setpoint
h	Read Local Setpoint
I	Update Remote Setpoint
J	Update Remote Setpoint
l	Read Temperature
m	Read % Output
P	Update Auto/Manual mode

Command Set

The MSI command set supports the extensive capabilities of the CARBPRO when used with a supervisory computer software system such as MMI's Process Master. The command set consists of the following characters:

MSI Command Set

Update	Read	Description
A	a	Alarms
D	d	Derivative
E	e	Memory
*	g	Auxiliary Input
I	I	Integral (Reset)
*	j	Event Inputs

MSI Command Set (Continued)

Update	Read	Description
K	k	Event Outputs
L	l	Program Number
M	m	Mode
N	n	Program Step Number
P	p	Proportional Band
Q	q	Memory Update
R	r	Remote Program Access
S	s	Setpoint
*	t	Temperature
U	u	Status
V	v	% Output
X	x	Parameters**

Z	z	Communications mode
*	w	Read DIP Switches

*   Update Not Allowed
**   See X Protocol Section

OPTOMUX Protocol

The OPTO 22 format is RS-422, Full-Duplex, 1200 BAUD, 8 bit, no parity, and 1 stop bit. The message format follows the OPTOMUX two pass protocol. The CARBPRO sends messages to set up the events board per the events partition, activate the appropriate outputs, and reads the input conditions. The CARBPRO initiates messages on this buss and waits ½ second for a reply.

The Events Buss allows the Controller to receive and/or transmit discrete events in time. The XMT and REC LEDs indicate whether the OPTOMUX is transmitting or receiving data. (These LEDs should never be on at the same time.) This actual input/output switching is executed by the OPTOMUX board: see "Setup and Configuration" or "Programmer Operations" or the OPTO22 manual for specific details.

Slave Buss
The slave buss is a broadcast only communications buss.

Broadcast Mode
The slave buss broadcasts the CARBPRO setpoint using the 10PRO broadcast protocol. The broadcast protocol format is similar to the message protocol format. Its form is

        ?AIddddDLE
      where   ?= 10PRO address symbol
              A= Using 10PRO
              I= Sending Setpoint
              dddd= Data for Setpoint

Passwords

In "Setup and Configuration" the Password is introduced. Password protection for certain operator functions is provided for security. We do not preset passwords at the factory.

To set the password:
         [Display]+[Cntl.Parm] will produce PWEN/PSWD in the Process and Set displays. Press the sequence that you wish to use as the password then press [Enter]. Any combination of keys, up to nine strokes, except [Shift] or [Enter] can be used as the password.

To bypass the password if the old one is known:
         Press [Cntl parm] press the old Password and then press [Enter] press the new password and press [Enter]. "See Setup and Configuration" for the location of the

password.

To change an operating function when lock level = 1:
> [Display] [Alarm Set] [Cntl Parm] [Alarm Set]

To bypass the password there is none:
> Press [Enter].

If you are locked out because you forgot the password, you will have to
> Remove the front panel.
> Find DIP switch 8 in the top bank. Turn it to ON.
> Find the 4 switch (bottom) bank and set them all to OFF. This resets the address to 0.
> Press [Display],[Cntl Parm] and [Enter][Enter] to create "enter" as a new password. Return the bottom bank to its original address setting. Turn switch 8 in the top bank OFF. Replace the front panel. The new password is in effect. See "Setup and Configuration" for more details.

SPECIFICATIONS

Alarm Outputs	**Two solid state relay contacts for the process alarms -300 to 4000. Programmer alarm provided by optional OPTOMUX interface.**
Ambient Temperature	**0 to 130 F**
Analog Outputs	**0 to 5 volts for 0-4000 F** **0 to 5 volts for -99 to +99 control output**
Auxiliary Input Impedance	**10K ohm**
Auxiliary Input Range	**0 to 2 Vdc**
Control Outputs	**Two solid state relay contacts selectable for Time-Proportioning or Position-Proportioning.**
Serial Interface	
Host	**RS-422, 1200 BAUD, Half Duplex MMI protocol and 10PRO emulation**
Events	**RS-422, 1200 BAUD, Full Duplex OPTOMUX protocol**
Slave	**RS-422, 1200 BAUD, Half Duplex BC-560 broadcast mode**
Dimensions	**5.63 in. wide by 5.63 in. high by 8.38 in. deep**
Humidity	**0 to 85%**
Line Voltage	**85 to 140 VAC, 50/60 Hz**
Panel Cutout Requirements	**5.43 in. square**
Programs	**200, l9 steps each**
PID Constants	
Proportional Band	**1 to 999% of Range**

Reset	**0 to 99.99 RPM**
Rate	**0 to 9.99 minutes**
Cycle Time	**0 to 250 seconds**
Relays	**Solid state, triacs, Mechanical, dry contact, 1 ampere, 125 VAC maximum (fused at 1 amp)**
Setpoint	**-300 to 4000**
	-999 to +999 setpoint offset for receipt of master broadcast
Signal Input Impedance	**100K ohm**
Signal Input Range	**-10 to +64 mV**
Signal Display Range Depends on thermocouple type	**-300 to 4000 (+4)**

Thermocouple

L:	**Linear**
E:	**Chromel-Constantan**
J:	**Iron-Constantan**
K:	**Chromel-Alumel**
	Tungsten 5% Rhenium vs.
C:	**Tungsten 26% Rhenium**
	Platinum vs. Platinum l3%
R:	**Rhodium**
	Platinum vs. Platinum 10%
S:	**Rhodium**
T:	**Copper-Constantan**

Weight	**Approximately 11 pounds**

GLOSSARY

Load Line
Load line (LdLn) is a manual offset to the control output (manual reset). The load line can be set from 0 to 100%. Load line must be set to zero when using ON/OFF control.

ON/OFF control
In ON/OFF control Output l is turned ON whenever the percent output exceeds l0% and Output 2 is turned ON whenever the percent output goes below -l0%. Therefore the proportional band is used to set the deadband. If the proportional band is set at 5% then an error of 5 will produce a l0% output; therefore, the deadband is 5. Reset and Rate would normally be set to zero; however, experimentation could improve the control response. Load Line must be set to zero.

Position with Feedback
This mode is used with slidewire feedback. Output l is used to drive for more feedback and Output 2 is used to drive for a smaller feedback. The percent output is used as a setpoint for the slidewire feedback. A deadband of .5% is used to prevent hunting.

Position without Feedback
This mode is used with a motorized valve with no feedback. The change in percent output is used to compute a drive time as a percent of the cycle time. For example, if the cycle time is 30 seconds and the percent output changes from 40% to 60% then Output l will be ON for 6 seconds (20% of 30 seconds). If the change was in the opposite direction then Output 2 is turned ON. If the percent output is at its limits (0 or l00 for single, and l00 or -l00 for dual) then the appropriate output will remain ON continuously.

Proportional Band
The proportional band is based upon a range of l000. Therefore, if the proportional band is set at 10% and the error is 100 (10% of range) then the output would be 100% (presuming reset=0).

Rate
The rate setting is in minutes and is settable from 0 to 9.99 minutes in .0l steps.

Reset
The reset setting is in repeats per minute. The range is 0 to 99.99 repeats per minute in .0l steps.

Time Proportion
In time proportion mode Output l is ON for the percent of the cycle time when the percent output is plus. When the percent output is minus, Output 2 is ON for the percent of the cycle time.

Marathon Sensors Inc.

Appendix A
Hexadecimal Code

Hexadecimal code is a functional, compact method of representing certain parameters within the binary computer framework. Hexadecimal code uses four binary bits to make one hexadecimal digit.* The number range for the hexadecimal system is 0 to F where the corresponding base numbers are as follows:

Decimal System	Binary System	Hexadecimal System
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

To convert a binary number to the equivalent hexadecimal number, follow the procedure listed below:

1.   Group the binary representation into sets of four.
     i.e. 1100 1111 0011 1101

2.   Analyze each set of four separately for the equivalent hexadecimal digit determined from the chart above.
     i.e.   1100   1111   0011   1101
             C   F   3   D

*   For further explanation, consult any college digital systems text, such as Microcomputer-Based Design by John B. Peatman.

3.   Put all of the separate HEX digits together to form the numerical word.
     i.e. CF3DH*

4.   Therefore, the HEX representation CF3DH is numerically equivalent to the Binary representation 0101110011110011101 or the Decimal number 53,053. Hexadecimal code is an extremely helpful number representation when coding computer systems. Recall that most addressing systems for microprocessors involve 16 binary bits which convert to four HEX digits and 8 binary data bits that convert to two HEX digits. The HEX system allows very long binary numbers to be represented in a must shorter way.

Many of the responses to the MSI Controller's Serial Communications questions are in HEX. Therefore, in order for the user to correctly interpret an answer, a clear understanding of the Hexadecimal number system must be attained.

*   An H is written after hexadecimal numbers to signify that the number is hexadecimal, it is not part of the actual number value.

Version 3.5 CARBPRO setup sheet
Furnace #_____

[Ctrl Parm]	Unit #1	Unit #2	Unit #3	Unit #4
PB	_____	_____	_____	_____
RES	_____	_____	_____	_____
RAT	_____	_____	_____	_____
CYC	_____	_____	_____	_____
LOPO	_____	_____	_____	_____
HIPO	_____	_____	_____	_____
LDLN	_____	_____	_____	_____
[Alarm set]				
A1__	_____	_____	_____	_____
A1XX	_____	_____	_____	_____
A2__	_____	_____	_____	_____
A2xx	_____	_____	_____	_____
TON1	_____	_____	_____	_____
TOF1	_____	_____	_____	_____
TON2	_____	_____	_____	_____
TOF2	_____	_____	_____	_____
[Setpt]				
STPT	_____	_____	_____	_____
REF	_____	_____	_____	_____
TCO	_____	_____	_____	_____
[Shift\Alarm set]				
AO1	_____	_____	_____	_____
AO2	_____	_____	_____	_____
AO1O	_____	_____	_____	_____
AO1R	_____	_____	_____	_____
AO2O	_____	_____	_____	_____
AO2R	_____	_____	_____	_____
AI A	_____	_____	_____	_____
AI B	_____	_____	_____	_____
AI C	_____	_____	_____	_____
CONV	_____	_____	_____	_____
COMD	_____	_____	_____	_____
HOST	_____	_____	_____	_____
AUX	_____	_____	_____	_____
AXMD	_____	_____	_____	_____
[Shift\ Ctrlparm]				
LL	_____	_____	_____	_____
degC	_____	_____	_____	_____

STRT	_____	_____	_____	_____
APS	_____	_____	_____	_____
ASEV	_____	_____	_____	_____
CJCA	_____	_____	_____	_____
CJCB	_____	_____	_____	_____
CJCC	_____	_____	_____	_____
EXEV	_____	_____	_____	_____
EVBD	_____	_____	_____	_____
EP 1	_____	_____	_____ _	_____
EP A	_____	_____	_____	_____
EAL0	_____	_____	_____	_____
EAL1	_____	_____	_____	_____
EAL2	_____	_____	_____	_____
EAL3	_____	_____	_____	_____
EAL4	_____	_____	_____	_____
EAL5	_____	_____	_____	_____
EAL6	_____	_____	_____	_____
EAL7	_____	_____	_____	_____
EAL8	_____	_____	_____	_____
EAL9	_____	_____	_____	_____
EALA	_____	_____	_____	_____
EALB	_____	_____	_____	_____
EALC	_____	_____	_____	_____
EALD	_____	_____	_____	_____
EALE	_____	_____	_____	_____
EALF	_____	_____	_____	_____

**DIP switch settings
(circle ON)**

UNIT #1
　　BANK 1　　　　1 2 3 4　　　　5 6 7 8

　　BANK 2　　　　1 2 3 4

UNIT #2
　　BANK 1　　　　1 2 3 4　　　　5 6 7 8

　　BANK 2　　　　1 2 3 4

UNIT #3
　　BANK 1　　　　1 2 3 4　　　　5 6 7 8

　　BANK 2　　　　1 2 3 4

UNIT #4
　　BANK 1　　　　1 2 3 4　　　　5 6 7 8

　　BANK 2　　　　1 2 3 4

Index