Marathon Sensors Inc.
VersaPro Carbon Controller
Installation and Operation Handbook

Marathon
Sensors Inc.

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Safety and Environment Information

Please read this section carefully before installing the controller

This instrument is intended for industrial applications used in conjunction with Marathon Sensors zirconia carbon sensors and standard thermocouple types. It is assumed that any installation meets either CE standards for industrial safety or NEC standard wiring practices. Failure to observe these standards or the installation instructions in this manual may degrade the safety or electrical noise protection provided by this instrument. It is the installer's responsibility to ensure the safety and electrical noise compatibility of any installation.

Service and repair

This controller has user replaceable fuses but no other user serviceable parts. Contact your Marathon Sensors Service (800-547-1055) for repair.

Caution: Charged capacitors

Before removing an instrument from its case, disconnect the supply and wait at least two minutes to allow capacitors to discharge. Failure to observe this precaution will expose capacitors that may be charged with hazardous voltages. In any case, avoid touching the exposed electronics of an instrument when withdrawing it from the case.

Electrostatic Discharge (ESD) Precautions

When the controller is removed from its case, some of the exposed electronic components are vulnerable to damage by electrostatic discharge. Anyone who is not probably ground using an ESD wrist strap or in contact with a ground while handling the controller may damage exposed electronic components.

Installation Safety Requirements

Safety Symbol

Various symbols are used on the instrument, they have the following meaning:

Caution, (refer to the accompanying documents)

Functional earth (ground) terminal

The functional earth connection is required for safety ground add to ground RFI filters.

Personnel

Installation must be carried out by qualified personnel.

Enclosure of live parts

To prevent hands or metal tools touching parts that may be electrically live, the controller should be installed in an enclosure. The contacts on the rear of the instrument case or finger save but it is still possible for loose wiring, or metal objects to come in contact with live terminal connections. It is recommended that power be removed from the instrument connections before they are disconnected. However, instrument's power connector can be removed with power applied. Care should be taken that the connector does not come in contact with any grounded object.

Live sensors

The dc inputs, dc logic, and dc outputs are all electrically isolated from chassis ground. If the temperature sensor is connected directly to an electrical heating element then the inputs will also be live. The controller is designed to operate under these conditions. However you must ensure that this will not damage other equipment connected to these inputs and that service personnel do not touch connections to these terminals while they are live. With a live sensor, all cables, connectors and switches for connecting the sensor and non-isolated inputs and outputs must be mains rated.

Wiring

It is important to connect the controller in accordance with the wiring data given in this handbook. Take particular care not to connect AC supplies to the low voltage sensor input or other low level inputs and outputs. Only use copper conductors for connections (except thermocouple inputs) and ensure that the wiring for installations comply with all local wiring regulations. For example, in the UK, use the latest version of the wiring regulations, BS7671. In the USA use NEC Class 1 wiring methods.

Power Isolation

The installation must include a power isolating switch or circuit breaker. This device should be in close proximity to the control actuator, and within easy reach of the operator. There is no means of disconnecting power from the instrument other than removing the connectors from the rear of the instrument. It is recommended that additional power disconnects are provided in the installation to remove power from these connectors as well.

Earth leakage current

Due to RFI Filtering there is an earth leakage current of less than 0.5mA. This may affect the design of an installation of multiple controllers protected by Residual Current Device, (RCD) or Ground Fault Detector, (GFD) type circuit breakers.

Over Current protection

The instrument has an internal 3.15 Amp fuse (P/N MFU-3.15PCTT) for instrument power and 1 Amp fuses (P/N MFU-1.0PCTT) for the control contacts and alarms. It is recommended that additional protection against excess currents be used for loads exceeding this rating. Fusing and interposing relays should be added to the control circuit if high current or large inductive loads are used.

Voltage rating

The maximum continuous voltage applied between any of the following terminals must not exceed 250VAC:

- line or neutral to any other connection;
- relay output to logic, dc or sensor connections;
- any connection to ground.

The controller should not be wired to a three phase supply with an unearthed star connection. Under fault conditions in this supply could rise above 264VAC with respect to ground and the product would not be safe.

Voltage transients across the power supply connections, and between the power supply and ground, must not exceed 2.5kV. Where occasional voltage transients over 2.5kV are expected or measured, the power installation to both the instrument supply and load circuits should include a transient limiting device.

These units will typically include gas discharge tubes, metal oxide varistors, and constant voltage transformers help suppress voltage transients on the supply line due to lightning strikes or inductive load switching. Devices are available in a range of energy ratings and should be selected to suit conditions at the installation.

Conductive pollution

Electrically conductive pollution must be excluded from the cabinet in which the controller is mounted. For example, carbon dust is a form of electrically conductive pollution. To secure a suitable atmosphere in conditions of conductive pollution, fit an air filter to the air intake of the cabinet. Where condensation is likely, for example at low temperatures, include a thermostatically controlled heater in the cabinet.

Over-temperature protection

When designing any control system it is essential to consider what will happen if any part of the system should fail. In temperature control applications the primary danger is that the heating will remain constantly on. Apart from scrapping the product, this could damage any process machinery being controlled, or even cause a fire.

Reasons why the heating might remain constantly on include:

- the temperature sensor becoming detached from the process;
- thermocouple wiring becoming a short circuit;
- the controller failing with its heating output constantly on;
- an external valve or contactor sticking in the heating condition;
- the controller setpoint set too high.

Where damage or injury is possible, we recommend fitting a separate over-temperature protection unit. Factory Mutual requires that any over temperature device use an independent temperature sensor, which will isolate the heating circuit.

Please note that the alarm relays within the controller will not give protection under all failure conditions. This instrument is not suited for over temperature protection and should not be used as a safety device.

Grounding of the temperature sensor shield

In some installations it is common practice to replace the temperature sensor while the controller is still powered up. Under these conditions, as additional protection against electric shock, we recommend that the shield of the temperature sensor be grounded at one end of the wire. Do not rely on grounding through the framework of the machine.

Installation requirements for EMC

To ensure compliance with European EMC directives certain installation precautions are necessary as follows:

- When using relay outputs it may be necessary to fit a filter suitable for suppressing the emissions. The filter requirements will depend on the type of load. For typical applications such as Schaffner FN321 or FN612 line filters or equivalents.
- If the unit is used in table top equipment which is plugged into a standard power socket, it is likely that compliance to the commercial and light industrial emissions standard is required. In this case, to meet the conducted emissions requirement, a suitable mains filter should be installed. Recommended filters would be Schaffner types FN321 and FN612 or equivalents.

Routing of wires

To minimize the pick-up of electrical noise, the wiring for low voltage dc and particularly the sensor input should be routed away from high-current power cables. Where it is impractical to do this, use shielded cables with the shield grounded at one end.

VersaPro Features

The VersaPro is a single loop process controller / monitor has the following capabilities:

Both Controller

- Two channel 24 bit Sigma-Delta ADC for thermocouple, probe millivolt, with cold junction compensation.
- Two (2) Form A alarm contacts.
- Internal relay for carbon sensor burnoff.
- Internal relay for sensor impedance testing.
- Serial EEPROM stores setup and calibration values.
- Two (2) 4-20 milliamp outputs for control or chart recorder.
- Sixteen character LCD with two four digit LED segment displays.
- RS 485 serial communication port for either MSI protocol or Modus.
- Two (2) Form A control contacts.
- Two (2) Form A user configurable alarm contacts.
- PID control modes.

Installation

The VersaPro instrument is designed for up to 1/8" panel mounting in a DIN standard opening of 3.62" square (adapter panels available by special order). Required rear clearance is 7" to allow for wiring.

As with all solid state equipment, the controller should be located away from excessive heat, humidity, and vibration. Since the unit uses LED and LCD display devices, it should also be located so that direct sunlight will not interfere with the display's visibility. The instrument requires 120/240 VAC 50/60 Hz and should not be on the same circuit with other noise-producing equipment such as induction machines, large electrical motors, etc. Signal wiring must be run separate from control wiring. It is suggested that signal wiring at the rear terminals of the instrument be routed in one direction (up or down) while the AC power wires are routed in the opposite direction.

The following figure shows the rear terminals locations on the rear of the VersaPro.

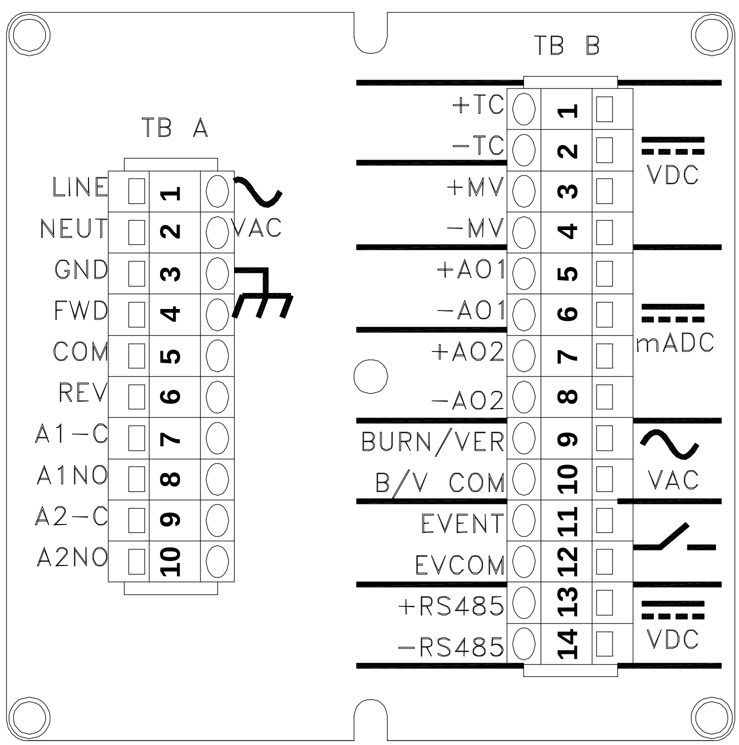


Figure 1 VersaPro Rear Panel

The next figure shows a typical wire schematic for the Versapro carbon controller.

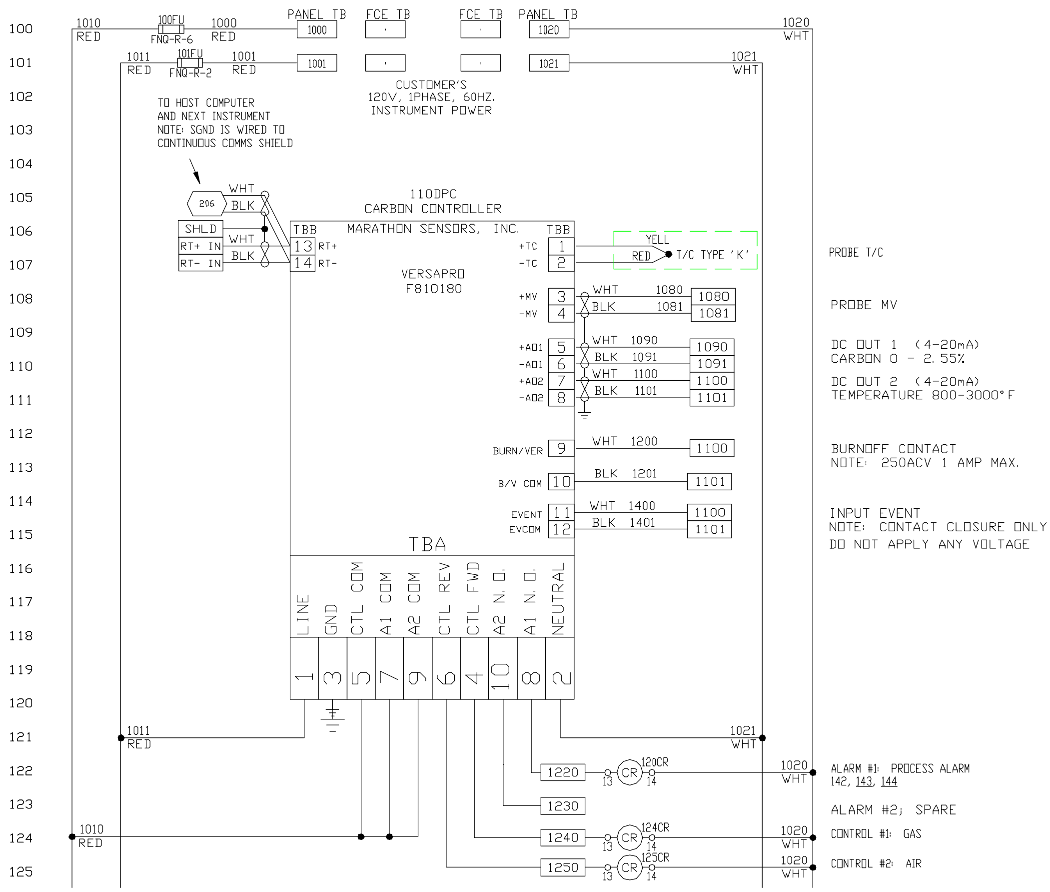


Figure 2 Typical Wiring Schematic

Mounting

To mount the instrument in a control panel, a hole must be cut 3.62" square in the necessary location on the panel. The following procedure should be followed to mount the VersaPro in the panel.

1) Insert the unit into previously cut out 3.62" square hole in panel.

2) While supporting unit, insert one clamping bracket into the groove on the bottom of unit, and then install the 6-32 set screw.

3) Repeat step 2 for the top of the unit.

4) With a HEX KEY wrench, alternately tighten the screw on either side of instrument to a torque of six in.-lbs. Insure rigidity of mounting. DO NOT OVER TIGHTEN. This can wrap the instrument enclosure and make removal difficult.

To remove the instrument from the panel, reverse the above procedures.

Process Control Options

The Versapro can be configured to perform a number of specific control functions. The following table outlines the available process functions for the carbon controller / monitor.

Table 1 Instrument Control Options

Function	Description
Carbon	Uses the millivolt and temperature signals from a zirconia sensor to calculate carbon concentrations and control to a carbon set point.
Linear Input A	Uses the millivolt signal from a linear sensor connected to terminals +TC / -TC
Linear Input B	Uses the millivolt signal from a linear sensor connected to terminals +MV / -MV

Control Modes

The VersaPro controller provides:

- Time Proportional Single (TP)
- Time Proportional Dual (TD)
- Time Proportional Compliment (TC)
- Position Proportioning (PP)
- On/Off (OF)
- On/Off Dual (OD)
- On/Off Compliment (OC)
- Direct Signal Output (4-20mA)

The instrument controls with two control contacts or direct 4-20mA output from two analog output channels. The control function can be set to direct acting or reverse acting.

Direct acting increases the output control signal to increase the process. Reverse acting decreases the output control signal to increase the process.

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 trim gas or addition to the process. The control loop percent output is the ON time percentage of the value relative to total cycle time. The cycle time is the 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 the first control contact is used in this mode.

Time Proportioning Dual (TD)

This mode is used when there are two processes to control that have complementary effects; like gas and air. The time proportioning dual mode uses two control outputs; 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 output (gas). When negative the proportioning action applies to the reverse (air) output.

Time Proportioning with Complement (TC)

This mode is identical to the time proportioning mode except that both control outputs are used. The second control output is the complement of the first. That is when the first output is ON then 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.

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 both control outputs; one to drive the motor forward (open) and the other to drive it reverse (closed). The control output is 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.

There is a built in deadband for this control based on the length of the cycle time. The comparison between the previous and current output values are made at the end of each cycle time. Faster comparisons can be made by shortening the cycle time assuming that a 100% command output is a continuously close control contact.

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 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 these problems from occurring; hysteresis and deadband. Hysteresis provides a delay between the control on point and the off point. Noise will not cause the control output to “chatter” with this gap applied. Hysteresis is ±20% of the deadband value.

Deadband allows the process to deviate away from the setpoint by the width of the deadband before any control action occurs. The deadband is adjusted through the Proportional Band in units of the displayed setpoint value. The reset and rate values have no effect in ON/OFF control.

Let’s assume the process setpoint is 1.00% carbon with a proportional band of 5. This represents a deadband of 0.05% carbon which is a band of ±0.05% carbon around setpoint. The hysteresis is 0.01% of the setpoint or 20% of the deadband. The output is turned on when the process drops below 0.95% carbon and turns off then it reaches 0.99% carbon.

ON/OFF Dual (OD)

This mode is similar to the time proportioning dual mode. The forward output acts as described in the ON/OFF description above. The reverse output responds when the process is above the setpoint.

Using the carbon example with a proportional band (deadband) of 5, the gas contact would turns on when the process is 0.95% carbon and will turn off when it comes to 0.99% carbon. Likewise the air contact would turn on when the process exceeds 1.05% carbon and will turn off when it drops to 1.01% carbon.

ON/OFF with Complement (OC)

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

Direct Current Output

The Versapro has two analog output channels that provide an isolated 4 to 20mA signal proportional to selectable process values. The analog outputs can be configured to control the process by driving actuators with a 4-20mA signal proportional to the calculated percent output of the PID loop. One or both output channels can be used depending on the control mode selected. POUT selection drives the output signal based on the HIPO and LOPO settings. If a Dual Time Proportioning control mode is selected with a HIPO = 100 and a LOPO = -100 then the output will be 4mA for –100%, 12mA for 0%, and 20mA for +100% output. This setting is helpful if one actuator is driving two valves in a split configuration where air is fully opened at –100% and gas is fully opened at +100% or both are closed at 0%.

It is possible to drive two actuators independently by setting on output to PO1 or PO2 where PO1 is the 0 to +100% control output and PO2 is 0 to –100%. In this configuration both outputs are at the maximum (±100%) with an output of 20mA.

It is also possible to drive one actuator with an output channel and a solenoid with a control contact. For example, select PO1 for one analog output channel to drive a gas actuator and connect an air solenoid to the reverse control contact. The percent output for both functions is determined by the PID settings. The cycle time should be set to the stroke time required to fully open the actuator from a fully closed condition. Typical stroke times would be 30 to 45 seconds.

Analog Output Channels

The two analog output channels can also be set to retransmit selectable process values. The Analog Output Offset and Range can be set to correspond to the process range. The default settings for these channels is 0 – 2.55% carbon for channel 1 and 0 to 2000° temperature for channel 2.

The Versapro output channels can drive a chart recorder or PLC input. The remote input should be configured for of 0 - 5 VDC or 4 - 20 mA. If the input device only responds to a DC voltage input, it will be necessary to add a 250 ohm dropping resistor across its input terminals and scale the analog output as 0 – 20mA.

The ideal location of the input device such as a recorder is adjacent to the instrument but it may be located remotely if the connecting wires are properly shielded. For best results, the chart recorder input(s) should be isolated from ground with the cable shield grounded on one end of the cable.

Alarms

The instrument has two types of alarms, process alarms and diagnostic alarms. If an alarm has been selected and conditions are such that the alarm becomes active, the instrument will display this condition on the center LCD display. Alarms can be configured as latched or non-latched and as direct or reverse.

A reverse configuration would be considered a failsafe setting since the alarm contact is closed during normal conditions and opens if power is removed to the instrument or the configured alarm condition occurs.

The alarm message will be displayed on the LCD screen with it occurs. If the LCD screen is written with another message all active alarms can be seen be pressing the up or down arrow keys.

The display can not be cycled to other parameters such as temperature or probe millivolts if an alarm is active.

ALARM DISPLAY	CONDITION	ACTION
HIGH ALARM	Alarm contact assigned to FSHI, dUbd, bdHI, HIPO	Full Scale High, above Deviation Band, or above percent output setting. Contact automatically resets unless latched.
LOW ALARM	Alarm contact assigned to FSLO, dUbd, bdLO, LOPO	Full Scale Low or below Deviation Band, or below percent output setting. Contact automatically resets unless latched.
PROBE CARE FAULT	Alarm contact assigned to PrOb	Probe impedance high or probe recovery time exceeds limit. Contact resets monetarily unless latched.
TIMER END	Alarm contact assigned to TinE, Strt, SOAK	Timer end alarm when the timer counts to zero for Timer, Start, or Soak timer modes. The contact latches until reset by pressing the Enter key or through the Input

		Event.
LLLL	Display only	Displays process value is negative and exceeds display range or exponent setting
HHHH	Display only	Displays process value is positive and exceeds display range or exponent setting
FLASH CSUM	Alarm contact assigned FALt	Reset instrument power. Return to Marathon if error does not clear.
EEPROM CSUM	Alarm contact assigned FALt	Reset instrument power. Return to Marathon if error does not clear.
KEYBOARD	Alarm contact assigned FALt	Reset instrument power. Do not push any keys while instrument is powered on. Return to Marathon if error does not clear.
FLASH ERASE	Alarm contact assigned FALt	Programming error, Reset instrument power, attempt reload.
FLASH / EE SIZE	Alarm contact assigned FALt	Programming error, Reset instrument power, attempt reload.
ADC FAULT	Alarm contact assigned FALt	Reset instrument power. Return to Marathon if error does not clear.
TEMP OPEN	Alarm contact assigned FALt	Check thermocouple for open condition or loose connection.
MV OPEN	Alarm contact assigned FALt	Check probe millivolt signal for open condition or loose connection. This signal can only be tested if the probe temperature is above 1300°F and exposed to

		process gas.
CPU FAULT	Alarm contact assigned FALt	Reset instrument power. Return to Marathon if error does not clear.
CPU IDLE ZERO	Alarm contact assigned FALt	Idle timer of CPU has counted to zero. This means that a CPU process has exceeded an allocated time slot. Possible during extended block transfer requests.

Process Alarms
The process alarms can be setup to activate either or both of the two alarm contacts provide on the VersaPro. Nine user selectable modes are available.

OFF
Disables the alarm function and the alarm contacts.

Full Scale HI
An alarm is generated any time the process value goes above the Full Scale HI alarm value. This alarm is reset if the process falls below the alarm value or acknowledgement from the front panel or through the event input (if configured).

Full Scale LO
An alarm is generated any time the process value drops below the Full Scale LO alarm value. The alarm will arm once the process is measured above the alarm value. This alarm is reset with an acknowledgement from the front panel or through the event input (if configured).

Deviation Band
An alarm is generated any time the process value goes above or below the band alarm setting. The alarm setting is ± value of the band. For example, if a value of 10 is entered as the alarm value, an alarm is generated if the process goes 10 units above or 10 units below the set point. Units are the process units such percent or degrees. This alarm will not arm until the process is in-band of the set point.

Deviation High
An alarm is generated any time the process value goes above the band alarm setting. The alarm setting is number of units allowed above set point. Units are

the process units such percent or degrees. This alarm will not arm until the process is in-band of the set point.

Deviation Low
An alarm is generated any time the process value goes below the band alarm setting. The alarm setting is number of units allowed below the set point. Units are the process units such percent carbon or degrees. This alarm will not arm until the process is in-band of the set point.

Output High
An alarm is generated any time the control percent output exceeds the alarm value. The alarm setting is maximum percent output allowed.

Output Low
An alarm is generated any time the control percent output drops below the alarm value. The alarm setting is minimum percent output allowed.

Fault
An alarm is generated any time an open input occurs on either the T/C or MV inputs. Both inputs are pull up to a maximum value if no input is connected or if the input fails in an open circuit mode. An open T/C input fault is ignored for the Linear configuration. The center display will indicate which of these conditions has caused the alarm. The alarm process will also become active if any of the listed hardware faults occur. The center display will indicate which of these conditions has caused the alarm.

Probe
An alarm is generated any time the probe exceeds the maximum probe impedance setting, or the verification test tolerance. All of the probe values and limits are configured in the Probe Menu. The center display will indicate which of these conditions has caused the alarm.

Time
This alarm setting is necessary for the timer function to work. The timer will only run if it is enabled in the Ctrl Setup menu and a timer setpoint value other than zero has been assigned. This alarm setting allows the timer to start running when it is activated at the Start Timer parameter in the Setpt key menu, when the dual key combination Left Arrow and Enter keys are pressed, or if the Input Event has been configured for Start and a contact closure occurs. The timer will start running as soon as it starts, independent of any process values. See the Timer section for more details.

Start
This alarm setting is necessary for the timer function to work. The timer will only run if it is enabled in the Ctrl Setup menu and a timer setpoint value other than zero has been assigned. This alarm setting allows the timer to be activated

from the Start Timer parameter in the Setpt key menu, when the dual key combination Left Arrow and Enter keys are pressed, or if the Input Event has been configured for Start and a contact closure occurs. The timer will start running as soon as the process level is above the alarm value and will continue to run once it has started. See the Timer section for more details.

Soak
This alarm setting is necessary for the timer function to work. The timer will only run if it is enabled in the Ctrl Setup menu and a timer setpoint value other than zero has been assigned. This alarm setting allows the timer to be activated from the Start Timer parameter in the Setpt key menu, when the dual key combination Left Arrow and Enter keys are pressed, or if the Input Event has been configured for Start and a contact closure occurs. The timer will start running as soon as the process level is with in the band around set point determined by the alarm value. The timer will stop any time the process falls outside the band limit. See the Timer section for more details.

Alarm Action

Each alarm can be configured to operate in several different modes. Each alarm can be configured as a reverse (normally closed) contact. This mode is usually used for failsafe alarms that will open during an alarm condition, fault, or power failure. Each alarm can also be configured as a direct (normally open) contact that closes when an alarm condition occurs. In both cases the alarm will automatically clear if the alarm condition is resolved.

Each alarm can also be configured for either reverse or direct latched conditions. In this mode the alarm contact will remain active until an acknowledgement is received through the configured Event Input terminals or by pressing the ENTER key.

Alarm Delay Times

Each alarm can have delay ON, delay OFF, or both delays applied. Delays can be applied in increments of a second, up to a maximum of 250 seconds. ON delays are helpful if a known upset in the process can be ignored. This avoids nuisance alarms but still maintains an active alarm if the alarm condition persists following the delay. OFF delays will hold the alarm contact active for a determined period of time once the alarm condition has cleared. This can be helpful as an interlock to other process functions that may have to recover following an alarm condition.

Diagnostic Alarms

A diagnostic alarm is shown on the instrument's center display when a fault is detected in the internal hardware during power up. These alarms included:

FLASH CSUM FAULT	A fault has been detected in the Flash memory.

EEPROM CSUM FAULT	A fault has been detected in the EEPROM.
KEYBOARD FAULT	A key is stuck or was held down during power up.
FLSH ERASE FAULT	This error may occur during instrument programming. The Flash memory may be faulty. Retry programming, make sure the communications link to the instrument is working properly.
FLSH SIZE FAULT	This error may occur during instrument programming. The Flash memory may be faulty. Retry programming, make sure the communications link to the instrument is working properly.
ADC FAULT	The analog / digital converter has failed to initialize or failed self calibration.
CPU IDLE ZERO	A CPU process has exceeded the allotted process time. Maybe due to extended serial communications block transfers. Limit the number of parameters requested in a block in this condition occurs.
CPU FAULT	Occurs if the CPU has not initialized correctly. Try resetting power.

If either alarm contact is configured for a fault this alarm will engage if any of the above faults occur. The LCD display will indicate the fault condition.

The front panel display will show LLLL if the process value is below the display resolution, or HHHH if the process value is above the display resolution. It may be necessary to adjust the carbon exponent and/or the carbon decimal point settings if these symbols occur.

Serial Interface

The VersaPro has a single RS-485 half duplex communications port. This port can be configured for either the Marathon protocol of Modbus RTU protocol. Baud rates and parities are selectable. The Modbus protocol only uses a parity of none. See the section on communications for details on both of these protocols.

Front Panel Operation

The instrument has a display/keyboard assembly. This assembly has a 2 x 4 keyboard group, two groups of four LED seven segment displays (upper and lower), and a single line sixteen character LCD display.

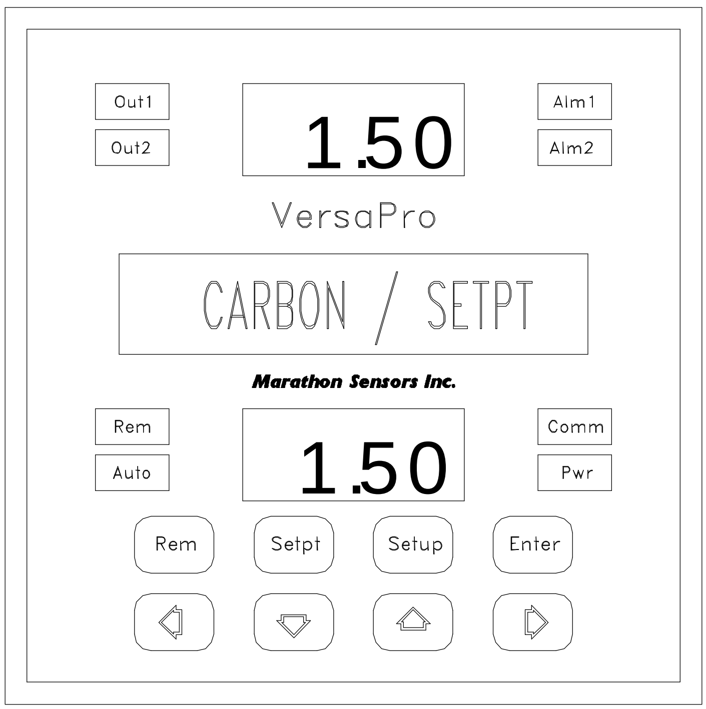


Figure 3 VersaPro Display

The LEDS to either side of the LED segment arrays light when the corresponding function is active.

- COMM flashes when the instrument is properly interrogated over the RS485 port.
- PWR is hard wired to the instrument 5VDC supply
- AUTO is lit when the instrument is controlling to a set point (controller option)
- REM is lit when the instrument is controlling to a remote set point (controller option)

- REM and AUTO flash together if the instrument is in manual mode.
- REM will flash if timer is running.

The upper display indicates the process value or the Setup Menu Heading when the SETUP key has been pressed.

The center display indicates what the measured process calculation is and what the lower display indicates. In figure 2 the instrument is indicating % carbon is being measured. This measurement range is 0 to 2.55%. The lower display shows the set point.

The center display also shows the parameter name in Setup mode or fault and alarm messages if any are active.

The lower display shows the instrument set point if the controller is in automatic or remote mode. The display will switch to control output level when the instrument is changed to manual. The lower display can also be configured to show the probe temperature

Enter Key

If the normal process display is showing on the LED and LCD displays, then pressing the Enter key will cycle the LCD and lower LED through various controller parameters. The display will cycle through

CARBON / SETPT
CARBON / TEMP
CARBON / %OUT
PROBE MILLIVOLT
BOFF MILLIVOLT
PROBE IMPEDANCE
PROBE IMP RECOVERY
NEXT PROBE TEST
REMAINING TIME

The carbon process value will always be displayed in the top LED display. The display can not be cycled if there is an active alarm. If the alarm is not displayed on the LCD screen then the UP or DOWN arrow keys can be pressed to display all of the active alarms.

Remote Key

Pressing the REM key causes the VersaPro to cycle between Remote, Automatic, or Manual control. This key has no function in the monitor version. When switching from Automatic to Manual or Manual to Automatic, the control output remains at the last output value in either mode. This allows for a bumpless control transition between either mode.

When the controller is set to Automatic mode the “Auto” LED lights and the lower display indicates the process setpoint (default).

When the controller is set to Remote mode the “Rem” LED lights and the VersaPro will accept a remote setpoint from a master on the host serial interface. The lower display indicates the process setpoint (default). The Setpt key does not work if the instrument is in remote mode.

When the controller is set to Manual mode both the “Rem” and “Auto” LED’s will flash together and the lower display indicates the power output of the controller. This value can be manually increased or decreased in 1% steps by pressing the UP or DOWN arrow keys. Pressing the RIGHT or LEFT arrow keys changes the output in 10% steps. The output will remain in the last control level if the instrument is switched into manual mode from remote or automatic or back to either setpoint control mode.

Setpt Key

The Setpt key provides access to the instrument process set point. When the key is pressed the center display will show “SET POINT”. The set point value in the lower display can then be manually changed by moving the flashing digit cursor with the RIGHT or LEFT arrow keys and increasing or decreasing the selected digit with the UP or DOWN arrow keys. You can exit the set point function by pressing the Setpt key again. Any changes that are made to the set point are then displayed in the lower window if the instrument is set up of Automatic control.

The following table outlines the options available under the Set Point key.

Table 2 Setpoint Ranges

Parameter Name	Range	Description
SET POINT	0 – 2.55% carbon -999 – 9999	Units for carbon or linear input.
TIMER SETPOINT	0 – 9999	Units in minutes
START TIMER	YES / NO	Starts timer when YES is selected. This is the same as pressing the dual keys LEFT arrow and Enter to start the timer.

Setup Key

The instrument can be placed in setup mode by pressing and holding the SETUP key for 5 seconds. The upper display initially shows the first setup menu while the center and lower displays are blank. At this level you can select different menus by pressing the RIGHT or LEFT arrow keys. The upper display will change accordingly.

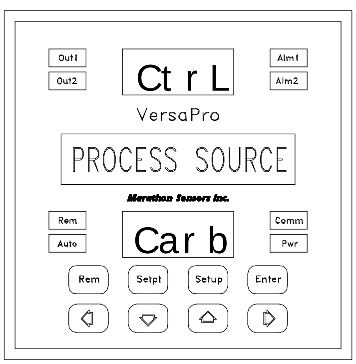
You can enter a menu by pressing the ENTER key when the desired menu heading is being displayed. Pressing the arrow keys can change menu parameters. Value changes can be saved or the next parameter can be selected by pressing the ENTER key. The menu parameters will continue to cycle through the display as long as the ENTER key is pressed. A new menu can be select only when the menu heading is displayed. You can exit from the Setup mode by pressing the SETUP key at any time.

The following tables outline the Setup menus available in the VersaPro Controller and Monitor when the operator presses the SETUP key.

Table 3 Setup Menus

Setup Menu Heading	Description
CtrL	Control functions and PID
Inpt	Thermocouple type and Millivolt setup
CaLc	Carbon process values
Prob	Probe tests and verification parameters
Aout	Analog output selection and parameters
ALr	Alarm contact configurations
Host	Communication protocols and parameters
Info	General information displays
CaL	Input / Output calibration

You have to press the SETUP key for five seconds to activate the setup mode. If a lock level of 1 or higher is set, you may also have to enter a password to proceed. Initially when the setup mode is activated, the LCD display will show the first menu heading, the upper and lower LED displays are blank. Page to the next Menu heading by pressing the RIGHT or LEFT arrow keys. The menu headings will continue to wrap around as the RIGHT or LEFT arrow keys are pressed. Pressing the SETUP key at any point while in the Setup Menus will return the display to the normal process display. See figure 3.



The displayed menu is selected by pressing the ENTER key. The first parameter name in the selected menu list will appear in the center display. The upper LED group continues to display the menu name, the center display shows the parameter name, and the lower LED group shows the parameter value. A flashing cursor in the lower LED display indicates which digit can change if the parameter value is numeric. The UP or DOWN arrows increase or decrease the digit value. The RIGHT or LEFT arrow keys move the cursor to the right or left digit. No wrap-around is provided for the cursor.

If the parameter has a table of choices such as thermocouple types, the various selections can be displayed by pressing the UP or DOWN arrows. No digit flashes in parameter displays that have a choice selection. In either case, the selection is set when the ENTER key is pressed and the display advances to the next parameter.

In the example shown above, the selected menu is Control (CtrL), the selected parameter is Process Source, and the selected source is carbon. Different source selections can be made by pressing the UP or DOWN arrow keys.

Pressing the SETUP key at any time escapes from the menu display and returns to the normal process display. You can only select another menu heading when the display is at a menu heading.

The following figures and tables outline the menu options and parameters under the Setup key.

Figure 4 Setup Menu Tree

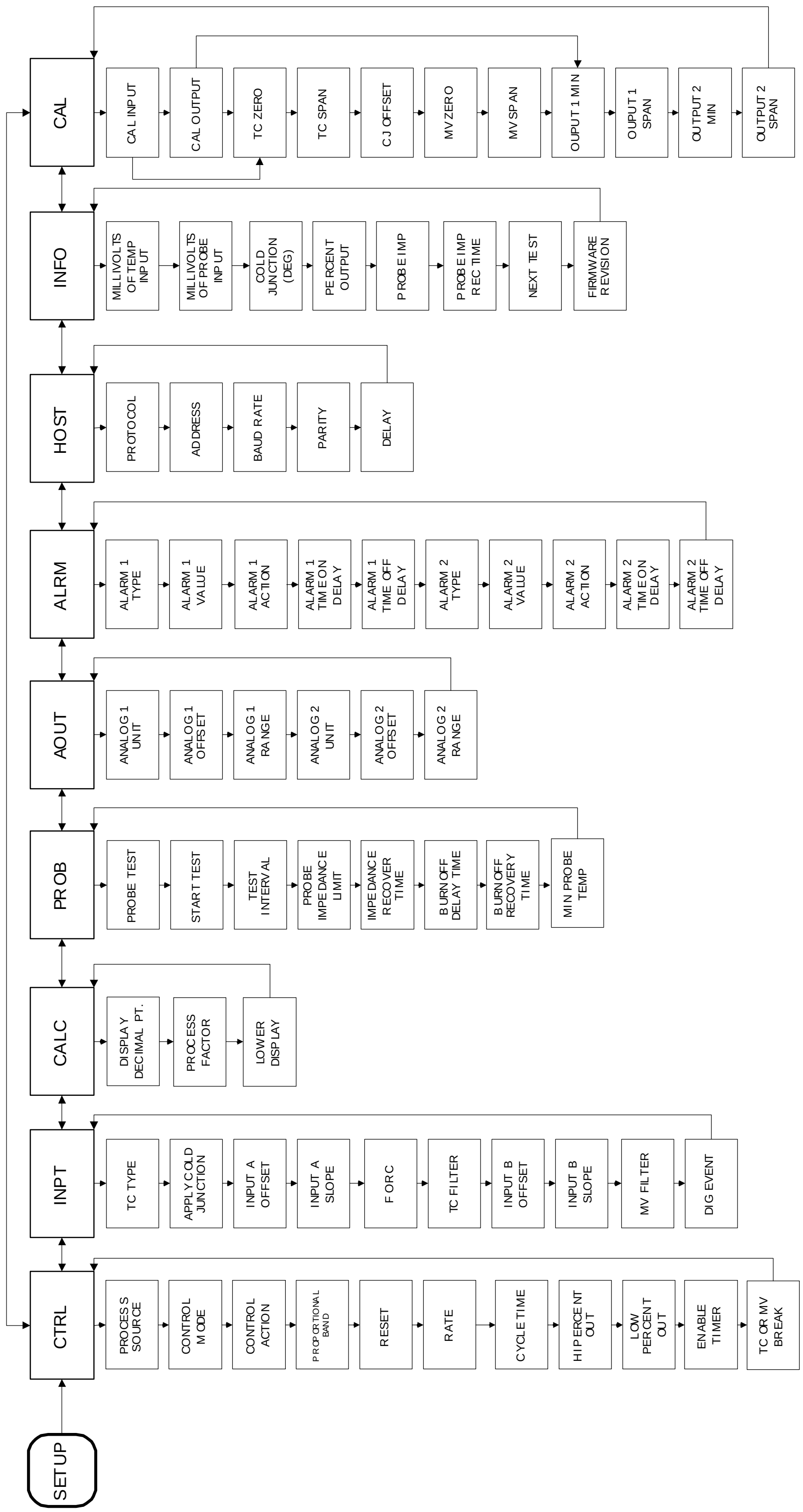


Table 4 Control Menu (CtrL)

Parameter Name	Units or Options	Range	Description
PROCESS SOURCE	CARB, E A, E B	Display range: 00.00 to 02.55 for carbon -999 to 9999 for Input A or Input B	Control type only available on instrument's specific configuration. This selection controls what other parameters will be available. E A is input A (0-50mV), E B is input B (0-2000mV)
TC OR MV BREAK		ZERO, HOLD	ZERO sets the control output to 0 if a thermocouple break and/or an open mV input are detected. HOLD holds the output to the last averaged output prior to a break and/or open input.
The following parameters in this table are only available in the controller			
CONTROL MODE	TP, TC, TD		See Control Modes if configured as a controller, shows NON (MONITOR) only if the instrument is configured as a monitor.
CONTROL ACTION	DIR/REV		Direct or Reverse control action
PROPORTIONAL BAND	Process Value	0 – 9999	Proportional Band value in displayed process units for PID control or Deadband in ON/OFF control
RESET	repeats/min	00.00 – 99.99	Integral control value, no effect in ON/OFF settings
RATE	Minutes	00.00 – 9.99	Derivative control value, no effect in ON/OFF settings
CYCLE TIME	SECONDS	0 – 250	Proportional time period (TP, TC, TD) Motor cycle time (PP) Minimum ON time (OF,OC,OD)
HI PERCENT OUT	MAXIMUM OUTPUT	0 – 100	Sets max. forward control. Output
LOW PERCENT OUT	MINIMUM OUTPUT	-100 to 100	Sets min. reverse control output
TIMER ENABLE	YES / NO		Enables timer function

Table 5 Input Menu (InPt)

Parameter Name	Units or Options	Range	Description
TC TYPE	B, E, J, K, N, R, S, T		See Input calibration for thermocouple ranges. Linear mode allows for input scaling, see IN A OFFSET and IN A SLOPE.
COLD JUNC APPLY	YES or NO		Applies the cold junction correction or not when a thermocouple type is selected. In LINEAR mode the cold junction is never applied. Default is NO.
IN A OFFSET	Only in Linear mode	-999 – 9999	Linear offset to scale Input A to Engineering Units when INPUT A is selected as the process source.
IN A SLOPE	Only in Linear mode	-999 – 999 -99.9 – 99.9 -9.99 – 9.99 -.999 - .999	Linear slope to scale Input A to Engineering Units when INPUT A is selected as the process source. This is the slope number in the linear calculation where: EU = SLOPE(mV) + OFFSET See key
TEMP SCALE	F OR C		Sets temperature scale.
TC FILTER		0 – 3276	Temperature filter time constant. Filters the temperature value with a moving average. 3276 is faster filter time.
IN B OFFSET	Works only in mV Mode	-999 – 9999	Linear offset to scale Input B to Engineering Units when INPUT B is selected at the process source. This is the offset in used in the SLOPE(mV) + OFFSET equation.
IN B SLOPE	Works only in mV Mode	-999 – 999 -99.9 – 99.9 -9.99 – 9.99	Linear slope to scale Input B to Engineering Units when INPUT B is selected

Parameter Name	Units or Options	Range	Description
		-.999 - .999	as the process source. This is the slope number in the linear calculation where: EU = SLOPE(mV) + OFFSET
MV FILTER		0 – 3276	Millivolt filter time constant. Filters the temperature value with a moving average. 3276 is faster filter time.
DIG EVENT	OFF, PrOb, AUtO, rEn, ACK, PrOC, Strt, HOLd, End		See Digital Event section for an explanation of selections. See the Timer section for the Strt, HOLd, and End selections.

Table 6 Calculation Menu (CALC)

Parameter Name	Units or Options	Range	Description
DISPLAY DECML PT	Decimal point	0-4	Sets decimal pt., for Input A and Input B. Carbon defaults to 2.
CARBON PROCESS FACTOR		0 – 1999	Used to correct displayed carbon value when compared to shim stock readings.

Table 7 Probe Setup Menu (PrOb)

Parameter Name	Units or Options	Range	Description
PROBE TEST		NONE RES BOFF BOTH	No test (**NONE**), Impedance (**RES**), Burnoff (**BOFF**), or **BOTH** impedance and burnoff can be selected.
START TEST		YES/NO	If probe test interval is 0, then test only runs once. If probe test interval is set then test run continuously from start point and at each interval time. Test stops when changed back to NO. Probe temp must be >= the minimum probe

Parameter Name	Units or Options	Range	Description
			temperature setting.
TEST INTERVAL	HRS.TENTHS	0 – 99.9	Sets time interval between automatic probe tests, 0 disables automatic testing.
PROBE IMP LIMIT	KOHMS	10 – 100	Sets maximum impedance for Probe alarm
IMP RECVRY TIME	SECONDS	0 – 250	Sets maximum Probe recovery time, timer cut short if probe recovers faster. The Probe alarm is set if the probe signal does not recover while this timer is active.
BURNOFF DELAY	SECONDS	0 – 999	The period of time when air is allowed to flow to the tip of the sensor.
BURNOFF RECOVERY	SECONDS	0 – 999	Recovery time for probe following the burnoff test. The PROBE alarm is set if the probe signal does not recover before this timer expires.
MIN PROBE TEMP	F OR C	1100° – 2000° F 590° – 1090° C	Minimum temperature for probe impedance and verification tests.

Table 8 Analog Output Menu (AOUt)

Parameter Name	Units or Options	Range	Description
ANALOG 1 UNIT	CARB, LInA, TENP, POUT, PO1, PO2, PROG, LInB	4 to 20mA output.	**CARB** – retransmits Carbon if carbon is selected as process source. **LInA** - scaled millivolt value of input A depends on which input selected as process source. **TENP** - probe temperature when carbon is selected as process source and a thermocouple type is selected. **POUT** – Power output is available for the controller, allows for –100% to 100%

			for split actuators. PO1 or PO2 allow for just 0 – 100% output for either control contact. **PROG** - allows the output to be controlled from the DACV1 memory location. **LInB** - scaled millivolt value of input A depends on which input selected as process source.
ANALOG 1 OFFSET	Offset for selected process value or percent output.	-30.0 to 300.0 for CARB, LInA or LInB -300 to 3000 for temperature LOPO for POUT 0 or DAC_OFFSET for PROG	This is the minimum value of the process associated with the 4mA output. The magnitude of this number is based on the display resolution. In POUT mode the offset is fixed to the LOPO value. When PROG is selected the offset is fixed at 0
ANALOG 1 RANGE	Span scaling for selected process value or percent output.	0 to 9999 for CARB, LInA, LInB, and Temp HIPO for POUT 4096 or DAC_SPAN for PROG	This is the maximum value of the process associated with the 20mA output. The magnitude of this number is based on the display resolution.When POUT is selected this value is fixed to the HIPO value. When PROG is selected the range is fixed at 4096
ANALOG 2 UNIT	CARB, LInA, TENP, POUT, PO1, PO2, PROG, LInB		Same as Analog 1
ANALOG 2 OFFSET	Offset for selected process value or percent output.		Same as Analog 1
ANALOG 2 RANGE	Span scaling for selected process value or percent output.		Same as Analog 1

Table 9 Alarm Menu (ALr)

Parameter Name	Units or Options	Range	Description
ALARM 1 TYPE	OFF FSHI, FSLO DUdb dbHI dbLO HIPO LOPO FALT PROB		**OFF** disables alarm contact. **FSHI - Full Scale HI**, active when process is above ALARM 1 VALUE. **FSLO - Full Scale LO**, active when process is below ALARM 1 VALUE. **DUdb – Deviation Band** available for the controller only, active when process is outside of symmetrical band around setpoint. **dbHI – Deviation High**, defines a process band above the process setpoint. The alarm is active if the process moves outside this band. **dbLO – Deviation Low,** defines a process band below the process setpoint. The alarm is active if the process moves outside this band. **HIPO – Output High,** this alarm sets the threshold for the maximum control output allowed which is set by ALARM 1 VALUE. **LOPO – Output Low,** this alarm sets the threshold for the minimum control output allowed which is set by ALARM 1 VALUE. **Falt – Fault**, open inputs for mV, thermocouple or hardware fault. **Prob – Probe**, fault active if impedance or verification are out of range.
ALARM 1 VALUE			Trigger set point value

ALARM 1 ACTION	REV, LREV, DIR, LDIR		**REV** = Reverse (N.C.) can be acknowledged even if the condition still exists. **LREV** = Latched Reverse (N.C.) can not be acknowledged if the condition still exists. **DIR** = Direct (N.O.) can be acknowledged even if the condition still exists. **LDIR** = Latched Direct (N.C.) can not be acknowledged if the condition still exists.
ALRM 1 TM ON DLY	0 – 250 SECONDS		Delay ON time for ALARM1
ALRM 1 TMOFF DLY	0 – 250 SECONDS		Delay OFF time for ALARM1
ALARM 2 TYPE	Same as ALARM 1 TYPE	OFF	Same as ALARM 1 TYPE
ALARM 2 VALUE			Trigger set point value
ALARM 2 ACTION			Same as ALARM 1 ACTION
ALRM 2 TM ON DLY	0 – 250 SECONDS		Delay ON time for ALARM2
ALRM 2 TMOFF DLY	0 – 250 SECONDS		Delay OFF time for ALARM2

Table 10 Communication Menu (HOST)

Parameter Name	Units or Options	Range	Description
PROTOCOL	PROP OR BUSS		PROP is Marathon Sensors, Inc. slave protocol, BUSS is RTU Modbus protocol.
ADDRESS	1 TO 15 (MSI)		
BAUD RATE	NA,600,1200, 2400,4800,9600, 19.2K,38.4K		
PARITY	None/Even/Odd		Modbus uses None parity only.
DELAY	NONE, 10, 20, 30		NONE = 0 Delay, other selections are millisecond delay in response..

Table 11 Info Menu (InFO)

Parameter Name	Units or Options	Range	Description
MILLIVOLT TEMP IN	MILLIVOLTS	-10-100	Displays direct mV of Temperature input
MILLIVOLT PROB IN	MILLIVOLTS	0-2000	Displays direct mV reading of probe input
COLD JUNCTION	DEG (F OR C)	0 – 60°C	Displays actual cold junction temperature
PERCENT OUTPUT	% Output	LOPO to HIPO	Displays actual % output
PROB IMPEDANCE	Kohms	0 – 100	Displays last probe impedance value.
IMP RECVRY TIME	SECONDS	0 – 250	Displays last impedance recovery time.
BURNOFF MV	MILLVOLTS	0 – 2000	Millivolts read at the end of the probe burnoff cycle
BURNOFF TEMP	°F OR °C	0 – 2000	Displays probe temperature read at the end of the probe burnoff cycle
BURNOFF RECVRY TIME	SECONDS	0 – 250	Time taken for probe to return to 98% of pre-test millivolt reading.
NEXT TEST	Hours.tenths		Time to next probe test, shows 00.0 if test automatic test is disabled.
FIRMWARE REV	Version number		

Table 12 Calibration Menu

Parameter Name	Units or Options	Range	Description
CAL INPUT	NO / YES		Default to NO, must be changed to YES to enter input calibration routine.
TC ZERO			Changes calibration value for thermocouple zero
TC SPAN			Changes calibration value for thermocouple span
CJ OFFSET (CAL IN)		0 – 60° C 0 – 140° F	Sets the cold junction offset depending on the temperature range selected
CAL OUTPUT	NO / YES		Default to NO, must be changed to YES to enter output calibration routine.
OUTPUT 1 MIN (CAL OUTPUT)			Sets signal level for the minimum mA output.

OUTPUT 1 SPAN (CAL OUTPUT)			Sets signal level for the maximum mA output.
OUTPUT 2 MIN (CAL OUTPUT)			Sets signal level for the minimum mA output.
OUTPUT 2 SPAN (CAL OUTPUT			Sets signal level for the maximum mA output.

Pressing the Setup key once at any point in the Setup menu will return the instrument to the normal process display.

Dual Key Functions

The VersaPro was three dual key functions as defined below:

RIGHT arrow / Enter	Starts probe test sequence
LEFT arrow / Enter	Starts Timer
DOWN arrow / Enter	Edit Timer
Rem / Enter	Monitor Mode

Starting Probe Tests

Pressing the RIGHT arrow / Enter keys simultaneously will start the probe tests if a probe test function has been selected in the Probe Setup Menu, parameter Probe Test, and the probe temperature is above the minimum probe temperature parameter in the same menu.

If there is a value other than 0 entered in the Probe Test Interval parameter the probe test will be preformed after the selected interval time has elapsed from the time the test was manually started. If the interval time is set to 0 then no additional tests will be preformed until the next manual start. Starting the test through this dual key function is the same as if the Start Test parameter in the Probe menu had been changed from NO to YES.

Start Timer

Pressing the LEFT arrow / Enter keys simultaneously will start the timer if the timer has been enabled in the Control Setup menu, the timer set point is greater then zero, and an alarm contact has been assigned a timer function. Press both keys while the timer is running will stop the timer.

Edit Timer

Pressing the DOWN arrow / Enter keys simultaneously while the timer is running will allow the remaining time to be changed. The remaining time can be increased or decreased. The change in time takes effect when the Enter key is pressed and the display returns to the normal remaining time display.

Monitor Mode

Monitor Mode is used by factory personnel only. Return to operate mode by cycling power or sending the appropriate command word to the instrument.

Digital Input Event

The VersaPro has a single digital input. This input is activated by making an isolated contact closure between terminals TB-B 11 and 12. This input is debounced for a momentary closure of at least 0.6 seconds.

NOTE

Do not connect either terminals TB-B 11 or 12 to any AC or DC potentials. These terminals are internally connected to an isolated 5VDC source. Use only an isolated contact closure across these terminals.

The input event can be set to any one of the following functions: OFF, PrOb (start probe test), AUTO (set to auto), rEn (set to remote), ACK (alarm acknowledge), PrOC (process hold), Strt (timer start), HOLd (timer hold), End (timer end acknowledge). These settings can be selected at the end of the Input Setup menu at the DIG EVENT parameter. The selections can be made by pressing the up or down arrow keys and then pressing the Enter key.

OFF
This selection disables the input event function. This is the default condition of this feature unless another function is selected.

PROB
This selection will start the impedance (10Kohm) test and/or probe burnoff. The various probe tests will run only if they are selected in the Probe Menu. The PrOB input event will have no effect if no probe tests are selected.

If a probe test interval time is set to any value other than zero, activating this function will reset the interval count down timer. If the probe test interval time is set to zero this function will operate only when the contact closure is made across the event input terminals. The contact closure must open and close each time to initiate another probe test.

AUTO (controller only)
This selection will force the instrument from manual mode or remote mode into local automatic mode. No change will occur if the instrument is already in automatic mode.

rEn (controller only)
This selection will force the instrument from local setpoint mode or manual mode into remote setpoint mode. No change will occur if the instrument is already in remote setpoint mode.

ACK
This selection will acknowledge any latched active alarm except the timer end alarm. This function will have no effect if the alarm if the alarm condition persists when the acknowledge signal is issued. This function resets a latched alarm similar to pressing the Enter key.

PrOC (controller only)
This selection will place the process calculation in hold. The control output is also held at the output level when the process hold event was set. This includes all analog output signals as well as control contacts. This is similar to the state the instrument is set to when the probe tests are running.

Strt (controller only)
This selection will start the timer function if the timer is enabled, the set point is greater than 0 and one alarm contact is assigned to a timer function.

HOLd (controller only)
This selection will place the timer in a hold state for as long as the event input is active.

End (controller only)
This selection will acknowledge the end condition of the timer, clear the end state, and reset the timer for another start.

Timer Function

The Versapro timer function is available on all process controller options. The timer can operate independently or it can be dependent on the process based on how either alarm contact is configured. The instrument has three possible functions, timer, guaranteed start timer, and guaranteed soak timer. These functions are set through the mode selection of alarm 1 or alarm 2 in the Setup menu.

For the timer to work, three conditions must be met; the timer function must be enabled by setting a parameter in the Setup Control Menu, an alarm contact must be configured for a timer function, and the timer set point must be greater then zero.

The timer set point is set in the Setpt Key menu. The remaining time is displayed in the display cycle list and can be edited when the timer is running. The timer set point and remaining time are entered and shown as whole minutes. The timer start setting follows the remaining time display in the Setpt Menu.

Setting the Timer

The first step for using the timer is to enable the timer function in Setup Control Menu. This allows the timer to be started in various ways and also allocates a serial port channel for the timer.

The next step is to move to the Alarm menu and select a timer function for one of the alarms. The alarm that is selected will close its alarm contact with the timer counts to zero. Only one alarm should be selected for a timer function and any time.

NOTE

Do not set both alarms to timer functions at the same time.

The final step is to press the Setpt key and the Enter key until the TIMER SETPT parameter appears. Enter the desired value of the timer. This value is the local set point for the timer. This value will be used as the timer value if the instrument is in the local automatic control mode. A remote timer set point value can be loaded into the instrument by a master such as a computer or instrument master. The remote value does not overwrite the local value but is written directly to the count down timer when the instrument is placed in remote mode.

The final step is to start the timer. This can be done in the Setpt menu by pressing the Enter key until the TIMER START parameter appears and selecting ‘YES’. The timer can also be started by pressing a dual key sequence LEFT arrow and Enter, through the serial interface, or through the digital event input.

Timer Dual Key Functions

⇐ + Enter	In Auto or Remote mode this two key combination will activate or deactivate the timer function.
⇓ + Enter	This two key combination allows the timer function remaining time to be edited.

The behavior of the timer is controlled through the selection of the alarm modes. If no timer alarm is selected for either alarm 1 or alarm 2 then the timer will not start. The Time, Start, or Soak modes must be selected before the timer will start.

The Rem LED on the front panel will flash while the timer is active in the RUN, HOLD, or END modes. The timer will go inactive when END is acknowledged or if it is turned off.

The timer can be stopped by pressing the Enter and Right arrow keys during an active RUN state, sending a remote timer set point of –1 when the instrument is in remote mode, or by changing the remaining time to zero.

The Event Input can be configured to start the timer, hold the timer, or acknowledge the End state.

Time

The Time alarm mode it will run continuously once it has started and the alarm contract will close when the remaining time reaches zero. The alarm value has no effect in the simple timer mode and the timer will not stop or hold if the process value changes. The alarm message is 'End' will display on the LCD screen and the appropriate alarm contact will activate.

Guaranteed Start Timer

The guaranteed start timer function works in conjunction with the alarm value. The timer will hold until the process value is greater then the lower band value of the process. The alarm value is the band value. In the figure below the alarm value is 10, which represents a band around set point of ∀10°. The timer will not HOLD once it has met the initial starting conditions. The process can fluctuate outside of the alarm band after the timer has started without placing the timer in a HOLD state. The following figure shows the behavior of the guaranteed start timer.

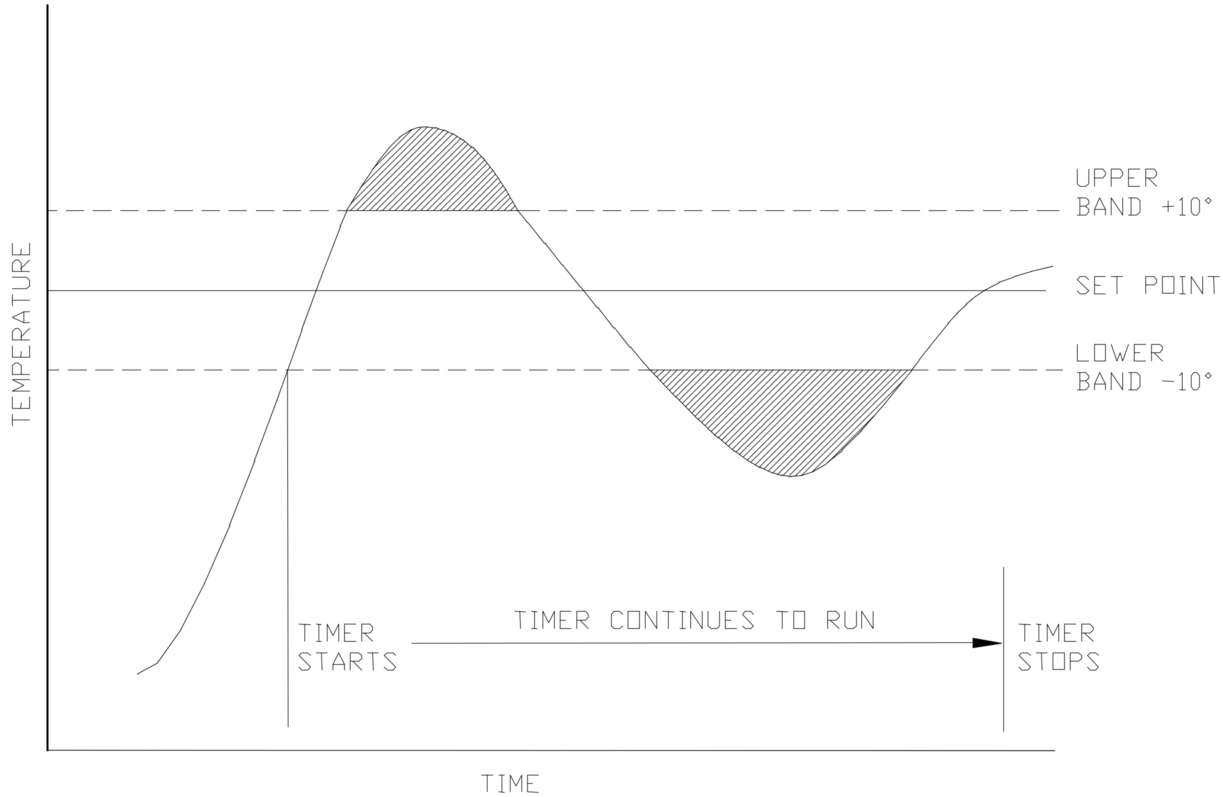


Figure 5 Guaranteed Start

Guaranteed Soak Timer

The guaranteed soak timer works in conjunction with the alarm process value. The alarm value is the valid band around the process set point. The process must be within the band around the process set point to start the timer once it has been activated. If the process passes above or below the alarm band setting, the timer will go to a HOLD state. The timer will be allowed to continue only when the process is within the band setting. In the following figure the alarm value is set to 10 degrees for a temperature process.

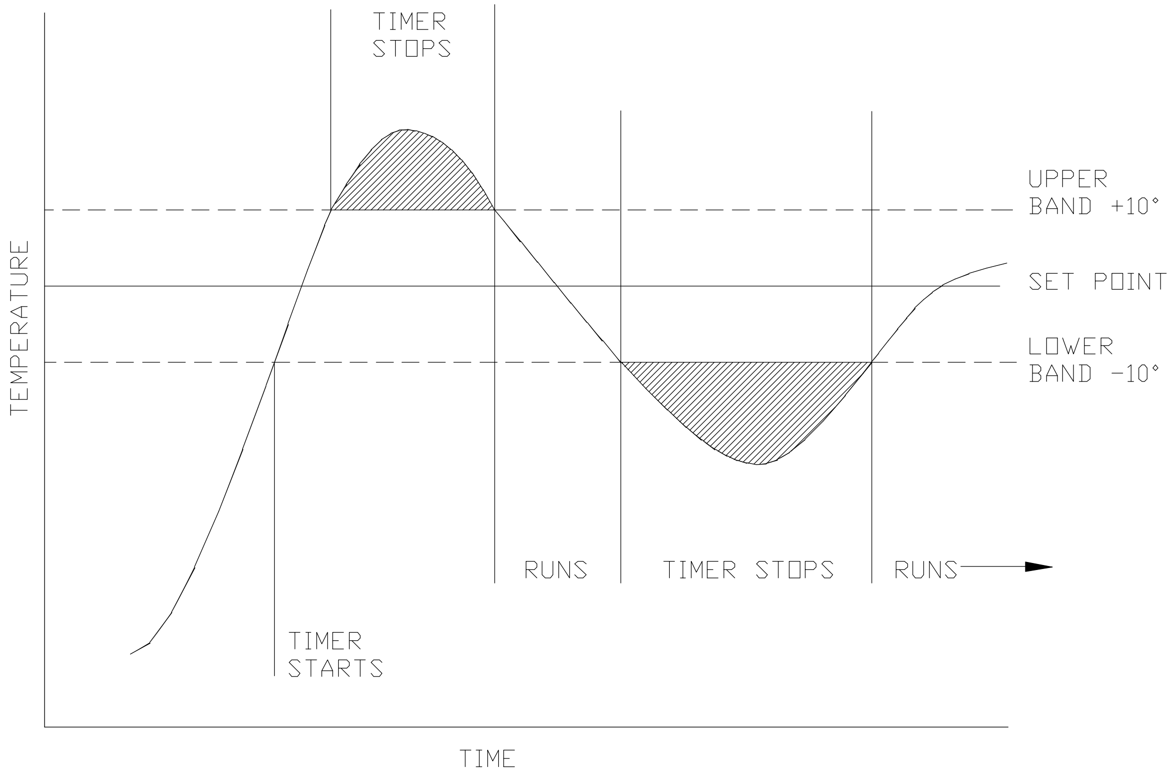


Figure 6 Guaranteed Soak

Timer Alarm Behavior

The alarm contacts do not work like normal process alarms when the timer, soak, or start timer functions are selected. If the alarm is configured for the timer, the contact will only activate when the remaining time counts down to zero and the timer reaches the END state. Once this occurs the END Alarm message will appear on the LCD display. The alarm will stay on until it is acknowledged by pressing the Enter key or closing a contact across the Digital Event terminals assuming the End setting is selected as the Event function. The Rem light stops flashing when the timer returns to the IDLE state.

Timer State Diagram

The following diagram shows the conditions that control the state of the timer function.

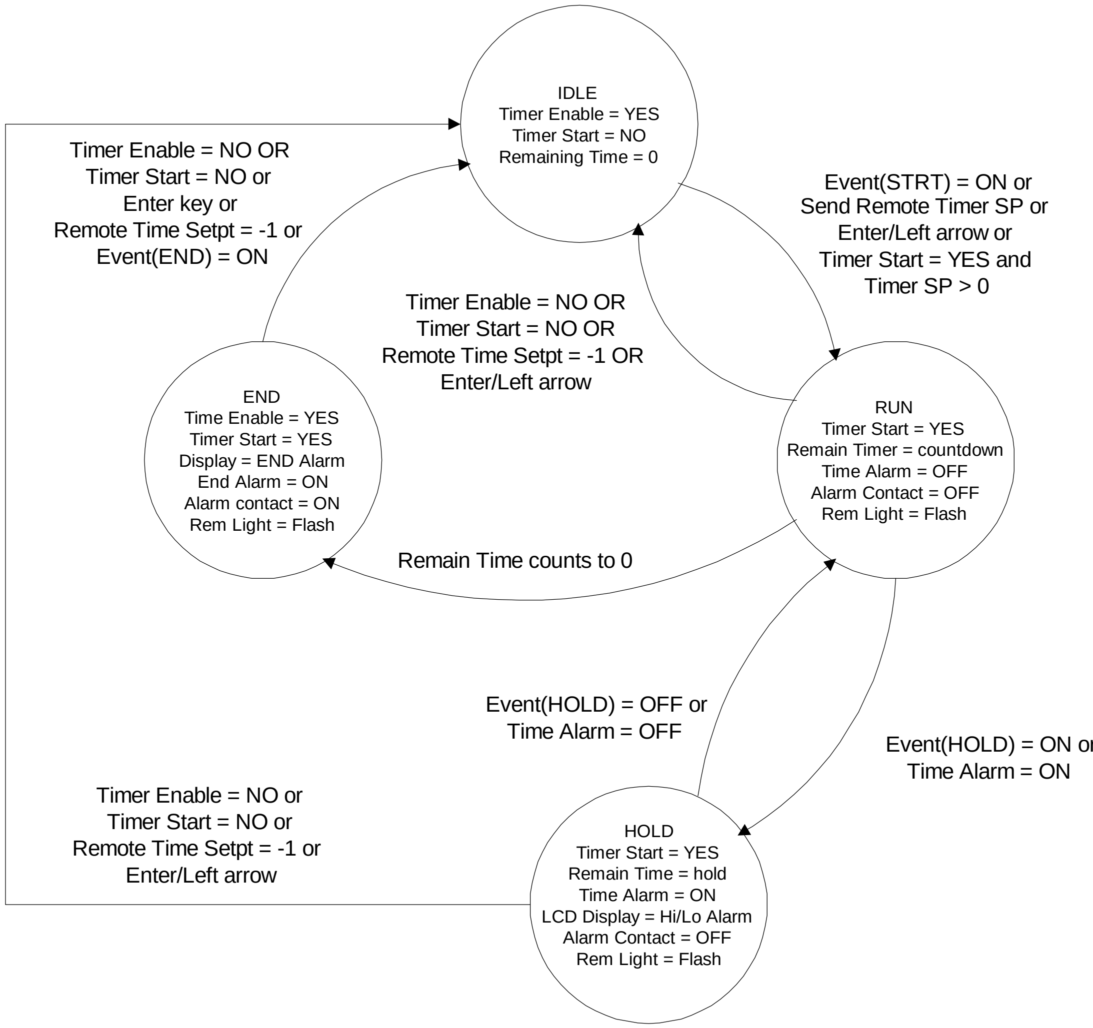


Figure 7 Versapro Timer State Diagram

The timer has four states. The IDLE state is the inactive condition. The RUN state is the active state when the timer is counting down. The HOLD state is when counting is paused due to either digital event = HOLD or a configured alarm is active. The END state is when the timer has timed-out and has not been acknowledged. The configured alarm contact will activate when the END state is entered.

The following is a summary of ways to change the state of the Timer. These assume the standard setups are in effect. It is assumed that the Timer is enabled for it to start or run.

Timer will start if:

1. Timer Enable = YES and
2. Digital STRT event = ON or

3. Master writes a remote setpoint or
4. Enter/Left keys = CLOSE or
5. Timer Start = YES

Timer will hold if:

1. Digital HOLD event = ON
2. Alarm Soak or Run deviation is active

Timer will run if:

1. Timer Enable = YES and
2. Timer Start = YES and
3. Timer Setpoint > 0 and
4. Digital HOLD event = OFF and
5. Remaining Time > 0

Timer will reset to IDLE without activating END if:

1. Enable = NO or
2. Timer Start = NO or
3. Communications sends a -1 for the timer setpoint or
4. Enter/Left keys = CLOSE

Timer goes to END state if:

1. Timer count down reaches 0

Timer returns to IDLE state from END when:

1. Enable = NO or
2. Timer Start = NO or
3. Operator presses Enter key or
4. Communications sends a -1 for the dwell setpoint or
5. Digital END input = ON

Timer SIO Operations

The Versapro allocates two communication addresses if the timer function is enabled and the host port protocol is set to PRoP (Marathon). The first address is the primary address set by the Address parameter setting in the Setup HOST menu. The second address is assigned as Address +1 and will respond to 10Pro type commands. The setpoint commands affect the timer set point. The timer will be enabled if a master writes a new setpoint to the instrument. The initial state conditions must be met for the timer to run.

The remaining timer value will be transmitted as the process value. The timer values and process values are available at the host address if the instrument is responding to Marathon block transfer commands or Modbus. The Address + 1 address is always active while the timer is enabled and the serial port protocol selection is MSI and inactive when Modbus is selected. It is important to consider this extra address allocation if multiple slaves with timers are going to be connected to a master. Only eight addresses are possible when the 10Pro command mode is used. See the section on serial communication for details on these differences.

In the MSI 10Pro protocol, the value returned for the percent output command is the timer control byte. The bits in the control byte are defined in the following table.

Timer Control Byte

Bit	Description	Purpose
0	Timer Enabled	Indicates that the timer is enabled in the setup menu.
1	Timer Running	Indicates that the timer has started.
2	End	Indicates that the timer has timed out and not acknowledged.
3	Hold	Indicates that the timer is in hold mode.
4 & 6	N/A	Not used.
7	Control	Set when the timer is started. Reset when timer has stopped. Is toggled by the Enter + Left Arrow or set by the SIO sending a time setpoint.

Controlling the Timer Remotely

Control of the timer via the serial port has limited capabilities since the only value that can be written to the instrument is the time setpoint. If the 10pro is in remote and the host sends a positive setpoint to the timer, the timer will start and the control bit is set. If the host sends a -1 setpoint then any active time will stop and the timer remote setpoint will clear. The host can not set the timer enable bit, alarm types, or the alarm on delay times. These parameters must be setup manually.

Probe Impedance Test

The probe impedance test is performed by measuring the open circuit voltage of the probe, applying a known shunt resistor across it and measuring the shunted voltage output. The value of the shunt resistor is 10kohm for carbon sensors.

To run a probe impedance test it is necessary setup the probe testing parameter in the SETUP Probe Menu. Please refer to Probe parameters table for an explanation of these setup parameters. It is necessary to have the impedance (RES) test or both (BOTH) selected at the PROBE TEST parameter in order to run the impedance test. You may choose to accept the defaults for the other parameters in this menu or change them to suit your applications.

NOTE

It is necessary that the sensor be above the MIN PROBE TEMP parameter setting for this test to run. It is also necessary that the probe is measuring a stable process gas during this test.

There are two ways to start this test. From the Probe Setup menu at the START TEST parameter, you can change this parameter from NO to YES and then press the ENTER key. The instrument will exit the Setup mode and display the test name and sequence number on the front display. The LCD display will indicate "IMPEDANCE TEST" while the lower LED display will show the test sequence number as listed in the following table.

It is also possible to start the test in the process display mode by pressing the ENTER and RIGHT ARROW keys at the same time. The test can be stopped by returning to the START TEST parameter and changing YES to NO and then pressing ENTER or by pressing the ENTER and RIGHT ARROW keys again.

If the TEST INTEVAL parameter has a number other than 00.0 then the test will continue to run each time the test interval timer counts down to 0. This test interval can be stopped by setting the interval timer to 00.0.

The following table explains the various operations of the impedance test.

Table 13 Probe Impedance Sequence

Sequence #	Description
1	Inhibit process variable calculations. Freeze all process controls and outputs.
	Freeze alarms at last state except clear any previous probe test failure alarm.
	Store present probe millivolt reading
	Apply shunt resistor across probe

Sequence #	Description
2	Wait for impedance test timer, fixed time of 30 seconds
	Compute impedance of probe and remove shunt resistor. Save measured impedance as PROBE IMPEDANCE in INFO menu.
	If impedance is greater than PROBE IMP LIMIT then set probe test failure alarm.
3	Wait for probe to recover to >=99% of original millivolts.
	Evaluate actual recovery time to IMP RECVRY TIME
	If recovery time is greater than IMP RECVRY TIME then set probe test failure alarm.
	Store recovery time (or max value) as IMP RECVRY TIME in INFO menu
4	If verification is to be performed then go to step 1 of verification sequence
	Otherwise wait 30 seconds and resume normal operation of all instrument functions.

Why Measure Sensor Impedance?

It is important to track sensor impedance over a period of time to help determine the replacement schedule for the sensor. A high impedance (>50 KΩ) indicates that the electrode contact on the probe zirconia has deteriorate to a level that probably warrants replacement. High sensor impedance results in a lower signal output from the sensor and an eventual failure of the electrode connection on the process side of the zirconia ceramic. This deterioration is more of a factor in highly reducing atmospheres. In such applications, it may be necessary to check the impedance at least once a month. Under light reducing, annealing, or brazing operations, the impedance may not have to be check unless there is a question about the probe's performance.

A typical impedance for a new probe is less than 1 KΩ. As the probe starts to age the impedance will increase. Past 20 KOHM the sensor should be monitored more closely. Above 50 KΩ, the sensor should be replaced. If it is necessary to replace the sensor, remove it carefully, following the instructions supplied with the sensor. Do not discard a sensor with a high impedance. It may be possible to rebuild the sensor if the ceramic parts are intact. Contact Marathon Sensors, Inc. for information on rebuilding your sensor.

An impedance test can only be performed if the probe temperature is at or above 1300°F with stable atmosphere present. The instrument freezes all control functions and process signals during the test.

A 10Ω resistor is shunted across the sensor output. The sensor impedance is calculated as:

$$Rx = [(Eo/Es)-1]*Rs$$

Where Rx = sensor impedance, Eo = sensor's open circuit voltage, Es = shunted sensor's voltage, and Rs = shunt resistor. The units of Rx are the same as Rs.

Probe Burnoff

Probe burnoff is performed by flowing air into and around the oxygen sensor internal ceramic substrate. This air creates a flame at the tip of the sensor that burns off any accumulated carbon or soot. A ¼" CPI compression fitting at the mounting hub of Marathon Sensors sensor is provided for the air connection. This air floods the probe sheath and flows out and around the sensor. The sensor does have to be above the MIN PROBE TEMP parameter found in the PROBE setup menu. This value is typically 1300°F or higher.

To run a probe burnoff it is necessary setup the probe test parameters in the SETUP Probe Menu. Please refer to Probe parameters table for an explanation of these setup parameters. It is necessary to have the burnoff (BOFF) test or both (BOTH) selected at the PROBE TEST parameter in order to run the burnoff. You may choose to accept the defaults for the other parameters in this menu or change them to suit your application. It is necessary that the sensor be above the MIN PROBE TEMP parameter setting for this test to run. It is not necessary for the probe to be measuring a stable process gas during this test.

There are two ways to start this test. From the Probe Setup menu at the START TEST parameter, you can change this parameter from NO to YES and then press the ENTER key. The instrument will exit the Setup mode and display the test name and sequence number on the front display. The LCD display will indicate "BURNOFF TEST" while the lower LED display will show the test sequence number as listed in the following Table.

It is also possible to start the test in the process display mode by pressing the ENTER and RIGHT ARROW keys at the same time. The test can be stopped by returning to the START TEST parameter and changing YES to NO and then pressing ENTER.

If the TEST INTEVAL parameter has a number other than 00.0 then the test will continue to run each time the test interval timer counts down to 0. This test interval can be stopped by setting the interval timer to 00.0.

Readings are averaged to eliminate variations in measurement due to initial flow conditions. There are three operator inputs for verification time periods;

- TEST INTERVAL is an interval timer that sets the time between automatic verifications in hours and tenths. The verification can be manually initiating by pressing and holding the Enter key and then the Right Arrow key. Setting the test interval time to zero disables automatic testing.
- BURNOFF TIME is the period in seconds burnoff air is flowing to the sensor.
- BURNOFF RECOVERY is the time period in seconds that allows the probe to recover and return to the process level.

The following table outlines the actions the instrument takes at each sequence step.

Table 14 Probe Burnoff Sequence

Sequence #	Description
1	Inhibit process variable calculations. Freeze all process controls and outputs.
	Freeze alarms at last state except clear any previous probe test failure alarm.
	Close burnoff contact and wait the BURNOFF time period.
2	Release the burnoff contact and wait the BURNOFF RECOVERY time period.
	Save the mV reading as in INFO menu.
3	Resume normal operation of all instrument functions.

Tuning

Before attempting to tune the instrument make sure you understand the *Operation and Setup* part of the instrument.

What is tuning?

Tuning the controller means that the control characteristics of the controller are matched to those of the process in order to obtain hold the process to setpoint. Good control means:

- Stable, 'straight-line' control of the process variable at setpoint without fluctuation
- No (minimum) overshoot, or undershoot, of the process variable relative to setpoint
- Quick response to deviations from the setpoint caused by external disturbances, thereby rapidly restoring the process variable to the setpoint value.

Tuning involves calculating and setting the value of the parameters listed the following table. These parameters appear in the Control Setup menu.

Table 15

Parameter	Meaning or Function
Proportional band	The bandwidth, in display units, over which the output power is proportioned between minimum and maximum.
Integral time (Reset)	Determines the time taken by the controller to remove steady-state error signals.
Derivative time (Rate)	Determines how strongly the controller will react to the rate-of-change of the measured value.
Cycle Time	The total amount of time used to calculate the combination of percent on and percent off periods of the control function.

The Versapro uses the Proportional Band as a representation of the Proportion section of PID, the Reset as a representation of the Integral section of PID, and the Rate as a representation of the Derivative section of PID. Thus by following a simple procedure, PID tuning can easily be implemented in any control situation. A suggested procedure is diagramed in the next figure.

All of the PID parameters may be altered by changing these parameters in the Setup / Ctrl menu. The following procedure assumes the initial PID values for a typical batch furnace. You may be able to start with a proportional band setting of 10 or less for a smaller box or temper furnace.

You must determine want the initial cycle time should be. If you are using control motors or continuous motors, set the cycle time to the time it takes the control motor or actuator to fully open and fully close. If you are using quick acting solenoids to control the process the cycle time setting is a compromise between longer times to limiting contact cycles and extend the life of the actuator or shorter times to maintain good control. A good rule is to watch to process value and turn on the solenoid. Measure the time it takes for the process to react with a 5% change. Double this time and enter it as the cycle time. Decrease the cycle time to get a smoother control.

If, after following the procedure, the process continues to oscillate, it may be necessary to change the HIPO or LOPO parameters. Make sure that the control output is linear through the full range from LOPO to HIPO. In situations where the system is difficult to tune, it is most likely the output is not linear or there is too much lag time between the control command and measurable changes in the process. Test the system in manual mode to verify the output is linear.

A much higher proportional band may be necessary for extreme lag in the process response. In most cases, the derivative part of the control equation is not necessary. Generally, furnace control can be maintained using only the proportional band and the reset parameters.

Make sure you record all operating parameters and keep them in a secure place for later reference.

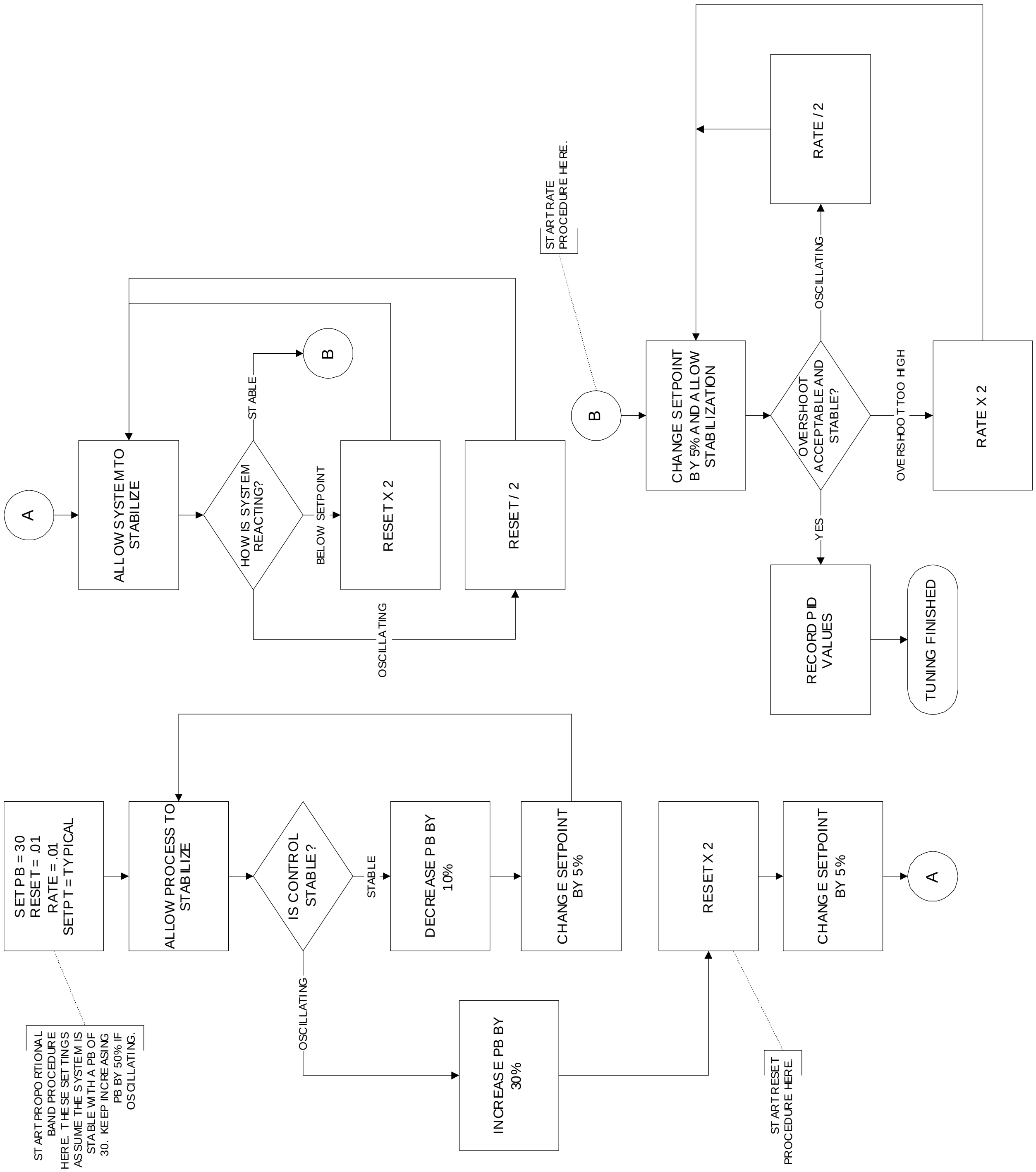


Figure 8 PID Manual Tuning Procedure

Scaling Analog Inputs

If either input is set to Linear mode the displayed value for that input can be scaled to desired engineering units. This is helpful if the measured linear value has to be scaled and re-transmitted on one of two analog output channels.

Using the equation y = mx + b, where
- Y is the desired engineering unit to be displayed
- X is the linear millivolt value
- M is the Slope of the y/x relationship
- B is the y intercept

Linear A example

Let us use Input A as a linear input for a linear carbon cell that outputs a 0mV to 53.2mV signal over a 0% to 100% carbon range. Since both the signal output and the process minimum are both 0, the Input A offset will be 0. The slope can be calculated by dividing the maximum process value (100) by the maximum input level (53.2mV). The gives a slope value of 1.879. Since the slope parameter only has three digits, the actual number to be entered is 1.88. The decimal point has to be shifted twice to the left.

These scaling values will produce a process value of 100.0160% carbon for a maximum sensor input of 53.2mV. The process display can be configured to display either 100 or 100.0. This process value can then be retransmitted to other control devices are a recorder. The control model of the Versapro will be able to control to a set point for the new process value.

Keyboard Function during Input Slope

The three left digits in the slope display can be change from 0 to 9. The most significant digit position allows you to shift the decimal point by pressing the LEFT arrow key. The decimal point will loop from first digit to the third digit as the LEFT arrow key is pressed. The RIGHT arrow key moves the display cursor back to the numbered digits.

Scaling Analog Outputs

The analog outputs are scaled to simple offset and span values. For example if analog output 1 is to be scaled for a 0 to 100% carbon value, the offset value would be 0 and the span value would be 100. This assumes that the process carbon value is also scaled for percent carbon where the carbon exponent is set to 2.

For ppm values the analog output would be scaled to the display resolution of the process. For example, if the process display is 6.5 ppm, with a carbon exponent of 6, the full scale display resolution would be any number between 000.0 and 999.9. The analog output can be scaled to a reasonable range of 0 to 10, which would drive the 4 – 20mA output over a 0 to 10ppm range and the 6.5 ppm process value would result in an output of 14.4mA.

The same rules apply to analog output 2. The range of the offset and span numbers depends on the range of the process value that has been selected for either analog output.

Additional selections for Power Output and Program mode have fixed offset and span values. The power output offset and span values are fixed to the LOPO and HIPO values selected for the control outputs under the Setup Control menu.

The Program mode selection has a fixed offset of 0 and a fixed span of 4096. When this output mode is selected the analog output can only be changed by writing a value to either the DACV1 or DACV2 registers.

Calibration

There are two analog inputs, a cold junction compensation sensor, and two analog outputs on the VersaPro. The input level is determined by which terminals are used for the input signal. There are two pairs of input terminals: TB-B 1, 2 for the thermocouple (T/C) input and TB-B 3, 4 for the probe millivolt input.

The 4 – 20mA analog outputs are at TB-B 5, 6 and TB-B 7, 8.

The following is a brief description of input/output and its specifications.

a) T/C Input

Input range	-10 to +70 millivolts ± 2 μV
TC burnout	>full scale

b) Probe mV Input

Input range	-50 to +2000 millivolts ± .1 mV, linear
Input impedance	40 megohm
Open input	>full scale

c) Output 1

Output range	0 to 20 milliamps
Max. Load	650 ohms

d) Output 2

Output range	0 to 20 milliamps
Max. Load	650 ohms

Calibration Displays and Keyboard Operation

When entering the Calibration Menu, the operator has to answer one of two questions depending on which I/O functions have to be calibrated. If the CALIBRATION IN prompt is answered with a YES, then the parameters related to the thermocouple input, millivolt input, and cold junction can be changed. If this prompt is skipped by pressing the Enter key, then a second prompt, CALIBRATION OUT is displayed. If this prompt is answered with a YES, then the zero and span values for both analog outputs can be changed.

In the Calibration Menu the displays and front panel keys take on special assignments. The LCD display shows the input and calibration point being calibrated. The upper LED display indicates that the instrument is in CAL mode. The lower LED display indicates the actual input level for the input channels or the calibration factor for the output channels.

It is very important that the display is indicating the proper I/O parameter before making an adjustment or the wrong value will be changed.

For the CAL INPUT calibration mode, the following keys perform the described functions:

Key	Function
UP ARROW	Increases the displayed value.
DOWN ARROW	Decreases the displayed value.
RIGHT ARROW	Shifts the flashing digit to the right and decreases the amount of adjustment or sensitivity of the adjustment.
LEFT ARROW	Shifts the flashing digit to the left and increases the amount of adjustment or sensitivity of the adjustment.
ENTER	Advances to next input value and saves the calibration changes.
SETUP	Exits the calibration mode.

Preparing for Input Calibration

The following is required to calibrate thermocouple and millivolt inputs:

Calibrated millivolt source, 0 – 2000mV with a 0.1 mV resolution
Calibrated microvolt source, -10mV to 50mV with a 0.1 uV resolution.
Copper wire to connect the millivolt source to the instrument.
Calibrated thermocouple simulator with internal cold junction compensation
Thermocouple extension wire for the type of thermocouple to be used.

In the Input Setup menu, select the thermocouple type to be used in the process.
Enable Cold Junction Compensation.

The first part of the calibration is in linear mode first. The thermocouple setting has no effect on the millivolt readings in the first part of the input calibration but will effect the reading during the cold junction adjustment.

Calibration of the Thermocouple Input

Calibration procedure:

1. Connect terminals TB-B 1, 2 to an isolated, stable millivolt source calibrator using standard copper wire, 20 AWG is sufficient.
2. Set the calibrator output to 0.00 mV.
3. Activate the calibration mode by entering the SETUP menus, selecting the Calibration menu and changing Calibration IN - NO to YES.
4. Use the Enter key to select the TC ZERO mode.
5. Using the arrow keys, adjust the displayed value to equal the calibrator input.
6. Press the Enter key to select the TC SPAN mode.
7. Set the calibrator output to 50.0mV (70mV maximum).
8. Using the arrow keys, adjust the displayed value to equal the calibrator output.

Calibration of the Cold Junction Temperature

Calibration procedure:

1. Change the millivolt source calibrator to thermocouple mode with internal cold junction compensation. Change the copper wire with the correct thermocouple extension wire
2. Set the calibrator to a typical temperature level.
3. Use the Versapro Enter key to advance to the CJ Adjustment display.
4. Using the arrow keys, adjust the displayed value to equal the calibrator input.

Ref to the following tables for the valid range of thermocouple inputs that can be used to calibrate the cold junction compensation.

Table 16 Thermocouple **Calibration Values**

T/C type	Minimum Value °F (°C)	Maximum Value °F (°C)
B	800 (426)	3000 (1800)
E	-454 (-270)	1832 (1000)
J	32 (0)	1300 (900)
K	32 (0)	2300 (1200)
N	32 (0)	2300 (1200)
R	300 (150)	3000 (1800)
S	300 (150)	3000 (1800)
T	32 (0)	700 (350)

The usable ranges for the thermocouple types are shown in the following table. If it is desirable to have a higher accuracy over a specific operating range then the input should be calibrated over that range.

Table 17 Usable Thermocouple Range (°F)

T/C type	Minimum Value (°F)	Maximum Value (°F)
B	800	3270
E	-440	1830
J	-335	1400
K	-340	2505
N	-325	2395
R	300 *	3210
S	300 *	3210
T	-380	755

* Due to the extreme non-linearity of low level signals, using type R and S below 300° F is not recommended.

Calibration of the Probe Millivolt Input

Calibration procedure:

1. Connect terminals TB-B 3, 4 to an isolated, stable millivolt source calibrator using standard copper wire, 20 AWG is sufficient. A maximum output of 2000 mV is required.
2. Set the calibrator output to 0.00 mV.
3. Activate the calibration mode by entering the SETUP menus, selecting the Calibration menu and changing Calibration IN - NO to YES.
4. Use the Enter key to select the MV ZERO mode.
5. Using the arrow keys, adjust the process value to equal the calibrator input.
6. Press the Enter key to select the MV SPAN mode.
7. Set the calibrator output to the required millivolt span (2000 mV maximum).
8. NOTE: The displayed number will change in resolution. The millivolt value will show the tenths digit if the measured value is less than 1000 mV. Above 999.9 mV the display will shift to whole numbers. Use the arrow keys to adjust the process value to equal the calibrator output.

Preparing for Analog Output Calibration

The same calibration procedure can be used for either output channel. For the CAL OUTPUT mode, the following keys perform the described functions:

Key	Function
UP ARROW	Increases the value of the flashing digit.

DOWN ARROW	Decreases the value of the flashing digit.
RIGHT ARROW	Shifts the flashing digit to the right.
LEFT ARROW	Shifts the flashing digit to the left.
ENTER	Advances to next calibration value and saves the calibration changes.
SETUP	Exits the calibration mode.

Calibration procedure:

1. Connect terminals TB-B 5, 6 (or 7, 8) to a multimeter such as a Fluke 77. Select the milliamp measurement range and verify that the test leads are plugged into the milliamp jack and common on the multimeter.
2. Activate the calibration mode by entering the SETUP menu, selecting the Calibration menu, press the ENTER key until CAL OUTPUT - NO is displayed.
3. Change the NO prompt to YES using the UP arrow key.
4. Press the ENTER key to select the OUTPUT 1 MIN mode. If OUTPUT 2 is required, continue pressing the ENTER key until OUT 2 MIN is displayed.
5. Using the UP or DOWN arrow keys, adjust the displayed number from 0 to 9. Press the RIGHT or LEFT arrow keys to select the adjustment sensitivity. Adjust the displayed value until the multimeter indicates the desired minimum output. This is typically set for 4 mA (cal factor ~ 800), but this level can be adjusted to 0mA (cal factor ~ 0).
6. Press the ENTER key to select the OUTPUT 1 SPAN mode. If OUTPUT 2 is required, continue pressing the ENTER key until OUTPUT 2 SPAN is displayed.
7. Using the arrow keys as explained in step 5, adjust the output to read 20mA on the multimeter. A typical cal factor for 20mA is 3200. The maximum cal factor is 4095.
8. Press the SETUP key to save the calibration values and exit the calibration routine.

Communications

Modbus

The MODBUS protocol describes an industrial communications and distributed control system (DCS) that integrates PLCs computers, terminals, and other monitoring, sensing, and control devices. MODBUS is a Master/Slave communications protocol, whereby one device, (the Master), controls all serial activity by selectively polling one or more slave devices. The protocol provides for one master device and up to 247 slave devices on a half duplex twisted pair line. Each device is assigned an address to distinguish it from all other connected devices.

The VersaPro recognizes three Modbus RTU (Remote Terminal Unit) commands. These are: read single I registers (command 4), read a single H register (command 3), and preset a single H register (command 6)

In the RTU protocol sends data in 8-bit binary characters. Message characters are transmitted in a continuous stream. The message stream is setup based on the following structure:

Number of bits per character:	
Start bits	1
Data bits (least significant first)	8
Parity	0 (no bits for no parity)
Stop bits	1 or 2
Error Checking	CRC (Cyclical Redundancy Check)

In Modbus mode, the VersaPro can be only be configured for the 'none' parity option.

The instrument never initiate communications and is always in the receive mode unless responding to a query.

RTU Framing

Frame synchronization can be maintained in RTU transmission mode only by simulating a synchronous message. The instrument monitors the elapsed time between receipt of characters. If three and one-half character times elapse without a new character or completion of the frame, then the instrument flushes the frame and assumes that the next byte received will be an address. The follow command message structure is used, where T is the required character delay. Response from the instrument is based on the command.

T1,T2,T3 ADDRESS FUNCTION DATA CHECK
T1,T2,T3

8-BITS	8-BITS	N X 8-BITS	16-BITS

Address Field

The address field immediately follows the beginning of the frame and consists of 8-bits. These bits indicate the user assigned address of the slave device that is to receive the message sent by the attached master.

Each slave must be assigned a unique address and only the addressed slave will respond to a query that contains its address. When the slave sends a response, the slave address informs the master which slave is communicating.

Function Field

The Function Code field tells the addressed slave what function to perform. MODBUS function codes are specifically designed for interacting with a PLC on the MODBUS industrial communications system. Command codes were established to manipulate PLC registers and coils. As far as the VersaPro is concerned, they are all just memory locations, but the response to each command is consistent with Modbus specifications.

The high order bit in this field is set by the slave device to indicate an exception condition in the response message. If no exceptions exist, the high-order bit is maintained as zero in the response message.

Data Field

The data field contains information needed by the slave to perform the specific function or it contains data collected by the slave in response to a query. This information may be values, address references, or limits. For example, the function code tells the slave to read a holding register, and the data field is needed to indicate which register to start at and how many to read.

Error Check Field (CRC)

This field allows the master and slave devices to check a message for errors in transmission. Sometimes, because of electrical noise or other interference, a message may be changed slightly while it is on its way from one device to another. The error checking assures that the slave or master does not react to messages that have changed during transmission. This increases the safety and the efficiency of the MODBUS system.

The error check field uses a CRC-16 check in the RTU mode.

The following is an example of a function 03 call for timer setpoint value (TSETPT) at memory location 03. The value returned by the instrument is the hex value 1E (30 seconds).

Transmit from Host or Master

Address	Cmd	Reg HI	Reg LO	Count HI	Count LO	CRC HI	CRC LO
01	03	00	03	00	01	74	0A

Response from Versapro

Address	Cmd	Byte Count HI	Byte Count LO	Data HI	Data LO	CRC HI	CRC Lo
01	03	00	02	00	1E	38	4C

Note that all the values are interpreted as hexadecimal values. The CRC calculation is based on the A001 polynomial for RTU Modbus. The function 04 command structure is similar to the 03 structure.

The following is an example of a function 06 call to change the remote setpoint (RSETPT) to 200 (2.00%). The response from the instrument confirms the new value as being set.

Transmit from Host or Master

Address	Cmd	Reg HI	Reg LO	Data HI	Data LO	CRC HI	CRC LO
01	06	00	01	00	C8	D9	9C

Response from Versapro

Address	Cmd	Reg HI	Reg LO	Data HI	Data LO	CRC HI	CRC LO
01	06	00	01	00	C8	D9	9C

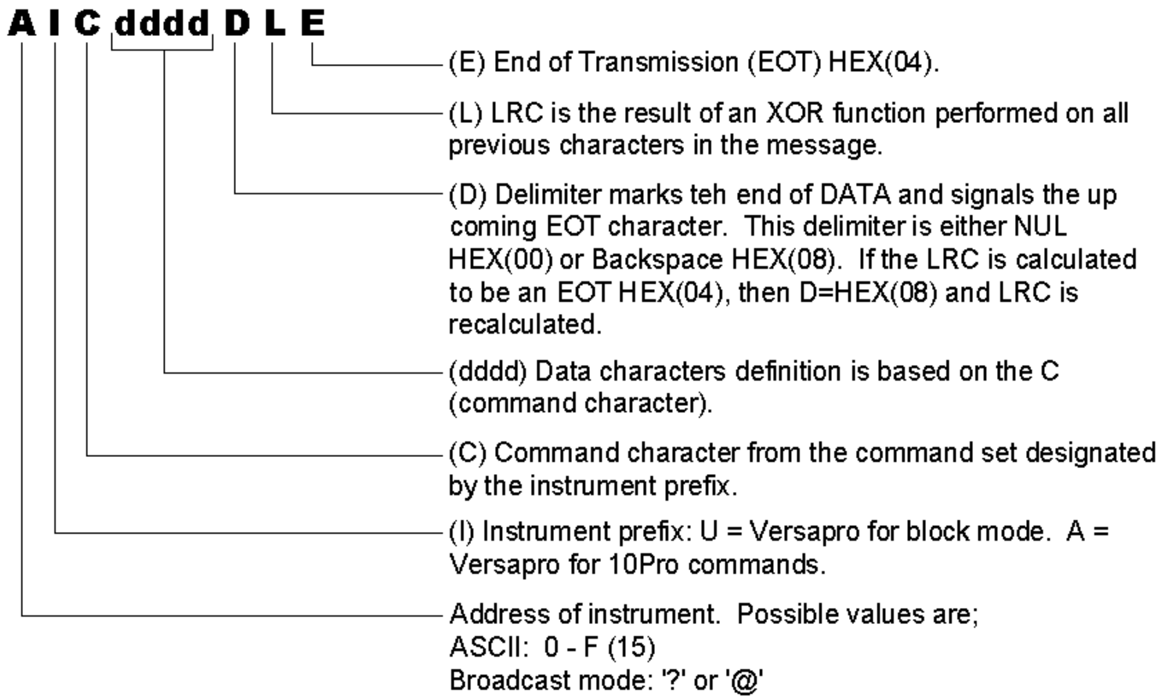
The Versapro will respond to several error conditions. The three exception codes that will generate a response from the instrument are:

01 – Illegal Function
02 - Illegal Data Address
03 – Illegal Data Value
04 – Slave Device Failure

The response from the Versapro with an exception code will have the most significant bit of the requested function set followed by the exception code and the high and low CRC bytes.

MSI Message Protocol

The Marathon Sensors message protocol format is shown below.



The currently implemented MSI or proprietary mode allows communication using the 10PRO ‘A’ command protocol.
The following command set is used for the Versapro and other 10PRO type instruments such as temperature controller slaves. The command set is sent by a master to a 10PRO slave instrument. These commands can also be used by any device such as a computer communicating with instruments via an instrument network. The commands that are supported are shown in the following table.

Table 18 10Pro / 10Pro-T / Versapro Command Set

COMMAND LETTER	**Process (temperature)**	**Timer**	**Returned Value**
p (low case)	Read Auto / Manual mode	Same	A = auto, B = manual
o (low case)	Read Remote / Local	Same	A = local, B = remote
i (low case)	Read Remote Process Setpoint	Read Remote Time Setpoint	integer decimal number
h (low case)	Read Auto Process Setpoint	Read Auto Time Setpoint	integer decimal number
I (upper case as in Instrument)	Update Process Setpoint Temporarily	Update Time Setpoint Temporarily	integer decimal number
J (upper case)	Update Process Setpoint Permanently	Update Time setpoint Permanently	integer decimal number
l (lower case as in limits)	Read Actual Process	Read Remaining Time	integer decimal number
m (low case)	Read % Output	Read Time control byte	integer decimal number
P (upper case)	Update Auto/Manual mode	Same	A = auto, B = manual

The following are examples of commands and responses using the 10Pro type command set. The first row in each table shows the ASCII characters of the command as they would appear if monitored on the serial port. The second row in each table is the hexadecimal translation of the characters transmitted on the serial port. These values must be known to calculate the checksum.

This is the command and response for reading the actual process value of a 10Pro type slave instrument. In this example the instrument address is 2 and the return value is 0071. This could be 71 degrees. 0.71% carbon, 7.1 degrees dewpoint, or 0.71% oxygen depending on the process and the instrument settings. Other parameters and scaling are available if the linear inputs are selected. In general the number that is returned is the number displayed on the instrument. Decimal point information is assumed.

Transmit from Host or Master

Add	Prefix	Cmd	Delim	LRC	
2	A	l	<NULL>	<HEX 1F>	<EOT>
0x32	0x41	0x6C	0x00	0x1F	0x04

Response from Versapro

	Add	Prefix	Cmd	D1	D2	D3	D4	Delim	LRC	
<ACK>	2	A	l	0	0	7	1	<NULL>	<HEX 1F>	<EOT>
0x06	0x32	0x41	0x6C	0x30	0x30	0x37	0x31	0x00	0x1F	0x04

Here is an example of a request and response for the local setpoint of the instrument in Automatic mode. The response indicates that the instrument's address is 2 and the local setpoint is 1500.

Transmit from Host or Master

Add	Prefix	Cmd	Delim	LRC	
2	A	h	<NULL>	<HEX 1B>	<EOT>
0x32	0x41	0x68	0x00	0x1B	0x04

Response from Versapro

	Add	Prefix	Cmd	D1	D2	D3	D4	Delim	LRC	
<ACK>	2	A	h	1	5	0	0	<NULL>	<HEX 19>	<EOT>
0x06	0x32	0x41	0x68	0x31	0x35	0x30	0x30	0x00	0x19	0x04

Here is an example that shows how the HOST changes the instrument's remote set point. The instrument's address is 15. The HOST has sent a command to update the remote setpoint with 1450. The instrument responds by echoing the command.

Transmit from Host or Master

Add	Prefix	Cmd	D1	D2	D3	D4	Delim	LRC	
F	A	I	1	4	5	0	<NULL>	N	<EOT>
0x46	0x41	0x49	0x31	0x34	0x35	0x30	0x00	0x4E	0x04

Response from Versapro

	Add	Prefix	Cmd	D1	D2	D3	D4	Delim	LRC	
<ACK>	F	A	I	1	5	0	0	<NULL>	H	<EOT>
0x06	0x46	0x41	0x49	0x31	0x34	0x35	0x30	0x00	0x48	0x04

Process Calculation

Percent Carbon in an Endothermic Atmosphere

The carburizing activity in a furnace are such that when equilibrium between carbon monoxide and oxygen exists, 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, 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 an in-situ zirconia-platinum sensor to the gas. A millivolt signal generated by this sensor is transmitted to a controller for processing. Also transmitted is the atmosphere temperature by virtue of a thermocouple located in or near the oxygen sensor. 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:

$$\%C = \frac{(5.102)\,EXP\left[\dfrac{E - 786}{.0431\ T}\right]}{\dfrac{.2}{PcoM} \times \dfrac{945.7(af)}{PcoA} + EXP\left[\dfrac{E - 786}{.0431\ T}\right]}$$

Where:

E = oxygen probe output millivoltage
T = temperature of atmosphere (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)

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 as entered on the front panel for a given case relates to the term in the above equation as follows:

$$29(PF) + 400 = \frac{945.7\ af}{Pco}$$

Where:

PF = Process Factor (0-999) and
Pco = partial pressure of carbon monoxide in atmosphere (= %CO/100 at 1 atm. pressure)

Adjustment of the Process Factor by the user will allow compensation to be made for a wide range of conditions. A nominal 20% carbon monoxide methane-based endothermic gas atmosphere, with an assumed alloy factor of 1 would require a Process Factor of 149. If a propane-based endothermic (23% carbon monoxide), would require a Process Factor of 128. For nitrogen-methanol systems, the Process Factor used will be the same as for methane-based endo atmosphere. 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 pure 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. Process factors for high alloy steels such as tool steels are not directly calculable because of carbide interaction. These must be arrived at experimentally.

As a practical matter, the 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 than 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 can possibly be taken to mean that soot is present in the furnace, or that the oxygen probe is incorrectly located, or that the probe is sooted. A low value for Process Factor might indicate a problem with reference air supply to the probe or impending failure of the probe altogether.

Technical Specification

Environmental ratings

Panel sealing: Instruments are intended to be panel mounted. The rating of panel sealing is IP64.

Operating temperature: 0 to 55°C. Ensure the enclosure provides adequate ventilation.

Relative humidity: 5 to 95%, non condensing.

Atmosphere: The instrument is not suitable for use above 2000m or in explosive or corrosive atmospheres.

Equipment ratings

Supply voltage: 100 to 240Vac -15%, +10%, or optionally:

Supply frequency: 48 to 62Hz.

Power consumption: 15 Watts maximum.

Relay 2-pin (isolated): Maximum: 264Vac, 2A resistive. Minimum: 12Vdc, 100mA.

Relay changeover (isolated): Maximum: 264Vac, 2A resistive. Minimum: 6Vdc, 1mA.

Over current protection: External over current protection devices are required that match the wiring of the installation. A minimum of 0.5mm^2 or 16awg wire is recommended. Use independent fuses for the instrument supply and each relay output. Instrument supply: 2A.
Relay outputs: Triac outputs: 1A.

Low level I/O: All analog input and output connections are intended for low level signals less than 5VDC.

DC output (Isolated): 0 to 20mA (650Ω max), 0 to 10V (using a 500Ω dropping resistor).

Fixed digital inputs: Contact closure. (common to internal 5VDC source.)

DC or PV input: As main input plus 0-1.6Vdc, Impedance, >100MΩ. (isolated.)

Transmitter supply: 30Vdc at 20mA. (isolated.)

Digital Comms: EIA-485 half duplex. (isolated).

General

Thermocouple input: Type B, K, R, and S accuracy after linearization +/- 1 deg F

Millivolt input : 0 to 2000 millivolts +/- 0.1 millivolt

Cold junction compensation: 0 to 60°C +/- 1 deg F

Calibration accuracy: The greater of ±0.2% of reading, ±1 LSD or ±1°C.

Isolation: 1000V DC/AC
Power input to signal inputs
Power input to communications

Calculations: Percent carbon 0 – 2.55% with Process Factor adjustment (no CO compensation)

Accuracy: +/- 1% of LSD of process value.
Probe Care: Probe burnoff and impedance for oxygen probes.

Communications port: RS-485 Half Duplex Only
Protocol: 10Pro, MMI block transfer, or Modbus RTU
Baud rates: 1200, 2400, 4800, 9600, 19.2K
Parity: Even, odd, or None

Control Mode
Time Proportioning Single Contact Direct
Time Proportioning Single Contact Reverse
Time Proportioning Dual Contact Direct
Time Proportioning Dual Contact Reverse

Alarm Type (both Alarm 1 and 2)
High Limit Temp
Low Limit Temp
Process Deviation Band
Process Deviation High
Process Deviation Low
Control Percent Out
Input Fault (mV or Thermocouple)

Electrical safety (pending approval)

Standards: EN 61010, Installation category II, pollution degree 2.
Installation category II: Voltage transients on any mains power connected to the instrument must not exceed 2.0 kV.
Pollution degree 2: Conductive pollution must be excluded from the cabinet in which the instrument is mounted.

Environmental Conditions
Operating Temperature -20 °C to 65 °C (-4 to 176 F)
Storage Temperature -40 °C to 85 °C (-40 to 185 F)
Operating and Storage Humidity
85% max relative humidity, noncondensing, from –20 to 65°C

Electromagnetic Compatibility (pending approval)

Immunity

Electrostatic discharge	EN 61000-4-2	Level 2: ±8 kV air Level 2: ±4 kV contact
Electromagnetic RF fields	EN 61000-4-3	Level 3: 10 V/m

		80 MHz – 1000 MHz
Fast Transients	EN 61000-4-4	Level 3: ±1 kV I/O
		Level 3: ±2 kV power
RF conducted interference	EN 61000-4-6	Level 3: 10 V/rms
		150 KHz – 80 MHz
Power Freq Magnetic Fields	EN 61000-4-8	30 A/m, x y z planes
Surge	EN 61000-4-5	±1kV L-L, ±2kV L-PE
		5 / min at 0°, 90°, 270°
Voltage Variations	EN 61000-4-11	70% of operating voltage
		0.5 cycles/10ms

Emissions

RF Emissions	CSIPR Class B
Conducted Emissions	CISPR Class B
Harmonic Current Emissions	EN 61000-3-2
Voltage Fluctuation	EN 61000-3-3

Note: Specifications may change without notification.

Versapro Memory Map

NOTE: Modbus refers to the hexadecimal address location

BLOCK 0				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
00	0	Not used		READ ONLY
01	1	RSETPT	Remote setpoint sent to the instrument from the Host port. This number has to be scaled to the range of the displayed process value based on the decimal point and exponent settings of the instrument. Range = -999 to 9999 Default = 0.000 For example: If the process = oxygen, display decimal point = 2, and exponent = 6, as remote setpoint of 1234 would be interpreted and displayed as 12.34 ppm.	READ/WRITE
02	2	LSETPT	Process setpoint set by the operator through the Setpoint menu. This number is scaled to the range of the displayed process value based on the decimal point and exponent settings of the instrument. Range = -999 to 9999 Default = 0.000	READ ONLY
03	3	TSETPT	Timer setpoint set via the Host port or locally. Range = 0 to 999 minutes Default = 0	READ/WRITE
04	4	PROC	This value is the calculated process value shown as an integer. The decimal point and exponent values are required to determine the actual scaled value. Range = -999 to 9999. For example: If the process = oxygen, display decimal point = 2, and exponent = 6, and PROC = 1234, then the actual value and displayed as 12.34 ppm.	READ ONLY

BLOCK 0				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
05	5	TIME	This is the remaining time on the timer as it counts down from Time Setpoint. Zero indicates timer has stopped. Range = 0 to 999 minutes Default = 0	READ ONLY
06	6	ALARM1	Alarm value is based on process value display decimal point and exponent. Both are required to determine the real alarm value. Range = -999 to 9999. Default = 0000	READ/WRITE
07	7	ALARM2	Alarm value is based on process value display decimal point and exponent. Both are required to determine the real alarm value. Range = -999 to 9999. Default = 0000	READ/WRITE
08	8	ALRMMD1	**Alarm 1 configuration** BITS 0 – 3 0000 = OFF (DEFAULT) 0001 = DEVIATION BAND 0010 = BAND LOW 0011 = BAND HIGH 0100 = PERCENT OUT LOW 0101 = PERCENT OUT HIGH 0110 = FULL SCALE LOW 0111 = FULL SCALE HIGH 1000 = PROBE IMPEDANCE / VERIFY 1001 = SPARE 1010 = SPARE 1011 = SPARE 1100 = SPARE 1101 = SPARE 1110 = SPARE 1111 = FAULT BIT 4 ACTION CONTROL 0 = DIRECT 1 = REVERSE BIT 5 NO LATCH = 0, LATCHED = 1	READ ONLY

BLOCK 0				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			BIT 6 – 15 SPARE	
09	9	ALRMMD2	**Alarm 2 configuration** BITS 0 – 3 0000 = OFF (DEFAULT) 0001 = DEVIATION BAND 0010 = BAND LOW 0011 = BAND HIGH 0100 = PERCENT OUT LOW 0101 = PERCENT OUT HIGH 0110 = FULL SCALE LOW 0111 = FULL SCALE HIGH 1000 = PROBE IMPEDANCE / VERIFY 1001 = SPARE 1010 = SPARE 1011 = SPARE 1100 = SPARE 1101 = SPARE 1110 = SPARE 1111 = FAULT BIT 4 ACTION CONTROL 0 = DIRECT 1 = REVERSE BIT 5 NO LATCH = 0 LATCHED = 1 BIT 6 – 15 SPARE	READ ONLY
0A	10	PB	Proportional Band – Based on display units Range = 1 to 9999 Default = 20	READ/WRITE
0B	11	RESET	Reset – Based on seconds Range = OFF to 9999 Where 0020 is assumed to be 00.20 seconds Default = OFF (reset value = 0)	READ/WRITE
0C	12	RATE	Rate – Based on seconds Range = OFF to 9999 Where 0020 is assumed to be 00.20 seconds	READ/WRITE

BLOCK 0				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			Default = OFF (rate value = 0)	
0D	13	CYCTIM	Cycle Time – Based on seconds Range = 0.2 to 9999 Where 0002 is assumed to be 0002 seconds Default = 30	READ/WRITE
0E	14	LDLN	Load Line – Range = -100 to 100 Default = 0	READ/WRITE
0F	15	HIPO	Control Output High Limit Range = -100 to 100 where HIPO is always greater than LOPO. Default = 100	READ ONLY
10	16	LOPO	Control Output Low Limit Range = -100 to 100 where LOPO is always less than HIPO. Default = 0	READ ONLY
11	17	CONMD	Control Type setting BITS 0 – 2 = CONTROL PARAMETER 000 = SPARE 001 = Temperature 010 = Millivolt INPUT B 011 = Carbon 100 = Dewpoint 101 = Oxygen 110 = Redox 111 = Millivolt INPUT A BIT 3 = NORMAL (0) FREEZE CONTROL OUTPUT (1) BITS 4 – 6 = MODE 000 = TIME PROPORTIONING 001 = TIME PROP W/ COMPLEMENT 010 = TIME PROP, DUAL 011 = SPARE 100 = ON/OFF 101 = ON/OFF W/ COMPLEMENT 110 = ON/OFF, DUAL 111 = VALVE POSITIONING W/ FEEDBACK BIT 7 = DIRECT (0) OR REVERSE (1)	READ ONLY

BLOCK 0				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			ACTING BIT 8 = MANUAL (0) OR AUTO (1) BIT 9 = SETPT LOCAL (0) OR SETPT REMOTE (1) BIT 10 = MONITOR (0), CONTROLLER (1) BITS 11 = SENSOR BREAK OUTPUT 0 (0), OUTPUT HOLD (1) BITS 12 – 15 NOT USED	
12	18	CONFIG0	Input Configuration **BITS 0-3 TC Input TYPE** 0000 = B (DEFAULT) 0001 = C 0010 = E 0011 = J 0100 = K 0101 = N 0110 = NNM 0111 = R 1000 = S 1001 = T 1010 = SPARE 1011 = SPARE 1100 = SPARE 1101 = SPARE 1110 = SPARE 1111 = SPARE BIT 4 = SPARE BIT 5 0 = NO CJ APPLIED, 1 = CJ APPLIED BIT 6 0 = °F, 1 = °C BIT 7 0 = 60HZ FILTER **BIT 8 – 11 Millivolt Input TYPE** 0000 = LINEAR (DEFAULT) All other bit combinations are spare BITS 12 – 15 are spare	READ ONLY
13	19	CTRLOUT	Control Output Actual control output where:	READ ONLY

BLOCK 0				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			1000 = 100.0% and –1000 = -100.0%	
14	20	ALRMT1	ALARM 1 ON/OFF TIMES RANGE = 0 – 255 SECONDS DEFAULTS = 0 BIT 0-7 = ON TIME BIT 8-15 = OFF TIME	READ/WRITE
15	21	ALRMT2	ALARM 2 ON/OFF TIMES RANGE = 0 – 255 SECONDS DEFAULTS = 0 BIT 0-7 = ON TIME BIT 8-15 = OFF TIME	READ/WRITE
16	22	FAULT	FAULT BIT MAP BIT 0 = CPU Fault BIT 1 = Min Idle counter = 0 BIT 2 = Keyboard failure, stuck key or a key was pressed during power up. BIT 3 = Flash Erase Failed BIT 4 = Flash Checksum Failed BIT 5 = EEPROM Checksum Failed BIT 6 = Flash/EEPROM Size Fault BIT 7 = ADC Fault BIT 8 = Temperature Input Open BIT 9 = MV Input Open BIT 10 = Range of input is low BIT 11 = Range of input is high BIT 12 = Monitor/Controller failed BITS 13= Probe Care Fault BITS 14 – 15 = SPARE	READ ONLY
17	23	CJTRM AND COMP	LOW BYTE – COLD JUNCTION TRIM COLD JUNCTION TRIM RANGE = –128 TO +127 WHERE 1 COUNT = 1 DEG (C or F) HIGH BYTE – CO / H COMPENSATION LOWER BYTE = CO COMP RANGE 0 – 255 DEFAULT = 20 (% CO FOR CARBON) DEFAULT = 40 (% H2 FOR DEWPOINT)	READ/WRITE

BLOCK 1				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
18	24	ASRC	ANALOG OUT SOURCES **LOW BYTE, ANALOG OUTPUT 1** BITS 0 – 3 0000 = N/A 0001 = Temperature 0010 = Input A or B 0011 = Carbon value 0100 = Dewpoint value 0101 = Oxygen value 0110 = Redox value 0111 = Output Power 1000 = Control Output 1 1001 = Control Output 2 1010 = Reference Number* 1011 = Programmable* *For Reference Number and Programmable, write required output value into DACV1, where DACV1 = 0 is minimum output and DACV1 = 4096 is maximum output. BITS 4 – 7 SPARE **HIGH BYTE, ANALOG OUTPUT 2** BITS 8 – 12 0000 = N/A 0001 = Temperature 0010 = Input A or B 0011 = Carbon value 0100 = Dewpoint value 0101 = Oxygen value 0110 = Redox value 0111 = Output Power 1000 = Control Output 1 1001 = Control Output 2 1010 = Reference Number* 1011 = Programmable* *For Reference Number and Programmable , write required output value into DACV2, where DACV2 = 0 is minimum output and	READ ONLY

BLOCK 1				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			DACV2 = 4096 is maximum output. BITS 13 – 15 SPARE Special case: If Analog Output 1 = CONTROL OUTPUT 1 and Analog Output 2 = CONTROL OUTPUT 2 and the Control Mode is dual, then Analog Output 1 is 4-20ma for 0 to +100% PO and Analog Output 2 is 4-20ma for 0 to -100% PO.	
19	25	AOUTOF1	ANALOG OUTPUT 1 OFFSET Minimum source value that correlates to minimum Analog Output of 4 mA. The source value is based on the selection in ASRC lower byte	READ/WRITE
1A	26	AOUTRN1	ANALOG OUTPUT 1 RANGE Maximum source value that correlates to maximum Analog Output of 20 mA. The source value is based on the selection in ASRC lower byte where	READ/WRITE
1B	27	AOUTOF2	ANALOG OUTPUT 2 OFFSET Minimum source value that correlates to minimum Analog Output of 4 mA. The source value is based on the selection in ASRC upper byte	READ/WRITE
1C	28	AOUTRN2	ANALOG OUTPUT 2 RANGE Maximum source value that correlates to maximum Analog Output of 20 mA. The source value is based on the selection in ASRC upper byte where	READ/WRITE
1D	29	TEMPFIL	Temperature Input Filter in seconds Range = 0 to 3276. The higher the number the faster the reading update. DEFAULT = 1000	READ ONLY
1E	30	MVFIL	Millivolt Input Filter in seconds Range = 0 to 3276. The higher the number the faster the reading update. DEFAULT = 1000	READ ONLY
1F	31	CONFIG2	SETUP VALUES	READ/WRI

BLOCK 1				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			BITS 0 - 4 OXYGEN EXPONENT RANGE = 0 to 31, where 2 = % and 6 = ppm DEFAULT = 2 **BITS 5 - 6 DISPLAY DECIMAL PLACE** where: 0 = no decimal point in display 1 = Display XXX.X 2 = Display XX.XX 3 = Display X.XXX DEFAULT = 0 **BITS 8 – 12 REDOX METAL NUMBER** RANGE = 0 – 14 DEFAULT = 0 **BITS 13 – 15 SPARE**	TE
20	32	COLDJCT	COLD JUNCTION Where 1 COUNT = 1°F (°C) RANGE = -99 TO 255°F (°C)	READ ONLY
21	33	TEMP	MEASURED TEMPERATURE Where temperature is presented in degrees C or F, based on the C/F setting. This value is scaled in 1/8 degree increments, i.e. -2721 = -341.38. Range = max / min range of selected thermocouple.	READ ONLY
22	34	MV	MEASURED MILLIVOLT Where this value is scaled in 1/8 mV increments, i.e. 2721 = 341.38. Range = 0 to 2000 mV.	READ ONLY
23	35	HADR AND SIOSET	LOW BYTE – HOST ADDRESS BITS 0-7 RANGE = 0 – 255 HIGH BYTE – SIO SETUP BITS 8 – 9 00 = Even Parity, 7 bits, 1 Stop bit 01 = No Parity, 8 bits, 1 Stop bit 10 = Odd Parity, 7 bits, 1 Stop bit BIT 10	READ/WRITE

BLOCK 1				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			0 = Non delay applied to response 1 = 10ms delay applied to response BITS 11 SPARE BITS 12 – 14 BAUD SELECT 000 = 76.8K 001 = 38.4K 010 = 19.2K (DEFAULT) 011 = 9600 100 = 4800 101 = 2400 110 = 1200 111 = 600 BIT 15 HOST FORMAT 0 = MSI (PROP) 1 = MODBUS (DEFAULT)	
24	36	PF	PROCESS FACTOR FOR CARBON OR DEWPOINT RANGE = 0 to 4095 DEFAULT = 150	READ/WRITE
25	37	DACV1	ANALOG OUTPUT 1 0 to 4095 is 4 to 20 mA In dual mode 4mA = -100, 12mA = 0, 20mA = +100	READ/WRITE
26	38	DACV2	ANALOG OUTPUT 2 0 to 4095 is 4 to 20 ma In dual mode 4mA = -100, 12mA = 0, 20mA = +100	READ/WRITE
27	39	LOCK AND PLIM	LOW BYTE – LOCK LEVEL BITS 0 – 2 LOCK LEVEL; 0-3 0 is full lock, 3 is wide open BITS 3 – 7 SPARE HIGH BYTE – PROBE IMPEDANCE LIMIT 0 – 255 KOHMS, DEFAULT VALUE = 20K	READ/WRITE
28	40	PIMP	LAST PROBE IMPEDANCE VALUE (KOHMS X 10) i.e. 25 = 2.5 KOHMS	READ ONLY
29	41	PRTM	LAST PROBE RECOVERY TIME	READ

BLOCK 1				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			FROM IMPEDANCE TEST (SECONDS) RANGE = 0 to 255 Available for Redox, Carbon, and Dewpoint.	ONLY
2A	42	PBOMV	LAST MILLIVOLTS DURING PROBE BURN OFF RANGE = -99 TO 2048 i.e. 1018 = 1018 mV Available for Redox, Carbon, and Dewpoint.	READ ONLY
2B	43	PBOTC	LAST TEMPERATURE DURING PROBE BURNOFF RANGE = 0 to 3000 i.e. 1715 = 1715° (F or C based on CONFIG0 BIT 6) Available for Redox, Carbon, and Dewpoint.	READ ONLY
2C	44	PBORT	LAST PROBE BURNOFF RECOVERY TIME RANGE = 0 – 255 SECONDS Available for Redox, Carbon, and Dewpoint.	READ ONLY
2D	45	PREMT	REMAINING TIME TO NEXT PROBE TEST RANGE = 0 – 999 Where 999 = 99.9 hours	READ ONLY
2E	46	VGAS	MEASURED VERIFY GAS VALUE Value / 8 = Actual measured % oxygen Verify function available for Oxygen.	READ ONLY
2F	47	PMC	PROBE MAINTENANCE CONTROL WORD BITS 0 – 1 00 = START FULL MAINTENANCE 01 = START BURNOFF (VERIFY) ONLY 10 = START PROBE IMP ONLY 11 = NONE BITS 2 – 6 UNDEFINED BIT 7 = NORMAL (0), CANCEL (1) BITS 8 – 15 = PROBE MAINTENANCE SEQUENCE	READ/WRITE

BLOCK 1				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			NUMBER	

BLOCK 2				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
30	48	PTINT	PROBE TEST INTERVAL SETTING (HRS) Operator input for interval setting RANGE = 0 – 999 Where 999 = 99.9 hours DEFAULT = 0 (Disable Probe test)	READ/WRITE
31	49	PTRECT	PROBE TEST RECOVERY TIME SETTING (SECONDS) RANGE = 0 to 999 DEFAULT = 30	READ/WRITE
32	50	BOTM	BURN OFF TIME SETTING (SECONDS) RANGE = 0 to 999 DEFAULT = 30 Burnoff function available for Redox, Carbon, and Dewpoint.	READ/WRITE
33	51	BOREC	BURN OFF RECOVERY TIME SETTING (SECONDS) RANGE = 0 to 999 DEFAULT = 30 Burnoff function available for Redox, Carbon, and Dewpoint.	READ/WRITE
34	52	VSTD	VERIFY TEST GAS STANDARD This is the test standard value used to verify the probe. RANGE = 0 to 999 Where the value 999 = 99.9% oxygen DEFAULT = 30 (3.0%) Verify function available for Oxygen.	READ/WRITE
35	53	VTOL	VERIFY TEST TOLERANCE SETTING This setting establishes the limit as VSTD ± VTOL when comparing to the measured value VGAS Range = 0 to 999 Where 0005 = 00.5%	READ/WRITE

BLOCK 2				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			DEFAULT = 0005 Verify function available for Oxygen.	
36	54	TAVE	VERIFICATION SAMPLE AVERAGING SETTING (SECONDS) RANGE = 0 to 999 DEFAULT = 2 Verify function available for Oxygen.	READ/WRITE
37	55	TDEL1	VERIFY DELAY 1 SETTING (SECONDS) RANGE = 0 to 999 DEFAULT = 30 Verify function available for Oxygen.	READ/WRITE
38	56	TDEL2	VERIFY DELAY 2 SETTING (SECONDS) RANGE = 0 to 999 DEFAULT = 30 Verify function available for Oxygen.	READ/WRITE
39	57	TMIN	MINIMUM TEMPERATURE FOR PROBE CARE TEST This setting establishes the lowest process temperature allowed for a probe test to proceed. RANGE = 500°F to 2000°F (260°C to 1090°C) DEFAULT = 1400°F (760°C)	READ/WRITE
3A	58	UAZERO	OFFSET CALIBRATION VALUE FOR T/C (IN A)	READ/WRITE
3B	59	UASPAN	SPAN CALIBRATION VALUE FOR T/C (IN A)	READ/WRITE
3C	60	UBZERO	OFFSET CALIBRATION VALUE FOR MV (IN B)	READ/WRITE
3D	61	UBSPAN	SPAN CALIBRATION VALUE FOR MV (IN B)	READ/WRITE
3E	62	DAC_OFFSET_1	DAC 1 OFFSET CALIBRATION	READ/WRITE
3F	63	DAC_SPAN_1	DAC 1 SPAN CALIBRATION	READ/WRITE
40	64	DAC_OFFSET_2	DAC2 OFFSET CALIBRATION	READ/WRITE
41	65	DAC_SPAN_2	DAC2 SPAN CALIBRATION	READ/WRITE
42	66	AZERO	LINEAR OFFSET, Y INTERCEPT	READ/WRI

BLOCK 2				
HEX	DEC	PARAMETER	DESCRIPTION	READ/WRITE
			LINEAR SCALING FOR INPUT A	TE
43	67	ANUM	LINEAR SPAN VALUE FOR INPUT A	READ/WRITE
44	68	BZERO	LINEAR OFFSET, Y INTERCEPT LINEAR SCALING FOR INPUT B	READ/WRITE
45	69	BNUM	LINEAR SPAN VALUE FOR INPUT B	READ/WRITE
46	70	TIME CONTROL AND EVNT	LOW BYTE – INPUT EVENT CONFIGURATION Bits 0 – 3 0000 = None 0001 = Auto Mode Selected 0010 = Remote Setpoint Selected 0011 = Acknowledge alarms 0100 = Timer hold 0101 = Timer reset 0110 = Timer standby 0111 = Start probe test 1000 = Process hold Bits 4 – 7 not used. HIGH BYTE - TIMER CONTROL BIT 0 = Timer Disabled (0), Timer Enabled (1) BIT 8 – 15 SPARE	READ/WRITE
47	71	SPARE		READ ONLY