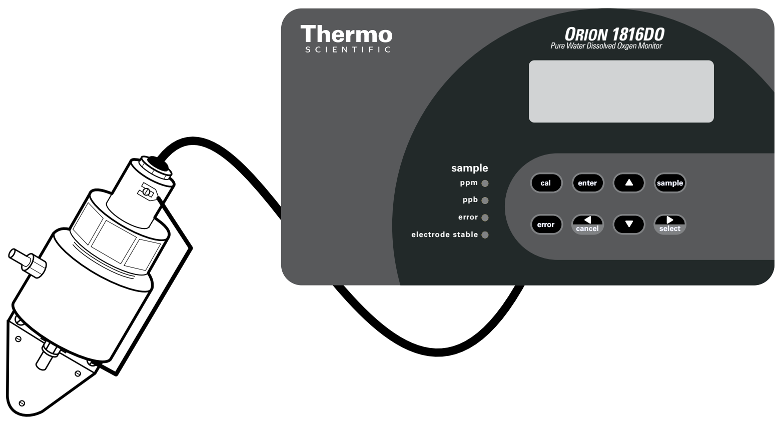
Thermo Scientific Orion 1816DO Dissolved Oxygen Monitor

User Guide



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Chapter 1 General Information

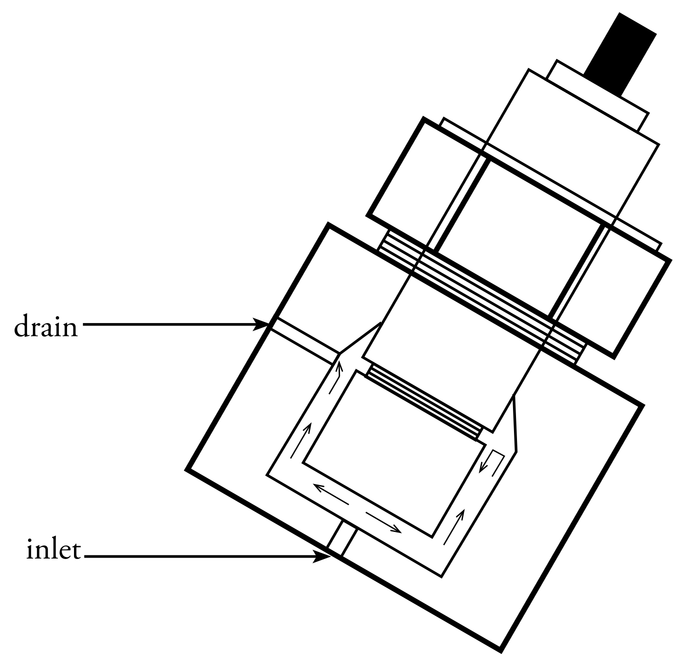
Introduction

Dissolved oxygen is a measure of the amount of oxygen, usually thought of as a gas, that is dissolved in a liquid such as water. Oxygen is essential to life and is the most common element found taking part in corrosion reactions. It is this corrosion reaction that provides the main need for the Thermo Scientific Orion 1816DO dissolved oxygen monitor, which is designed to run normally at trace part per billion (ppb) levels.

Mechanically hard and porous metal oxide deposits have little strength and form rapidly in the presence of water and oxygen. Rapid corrosion will occur inside an industrial utility boiler system unless dissolved oxygen can be virtually eliminated. Corrosion results in expensive repairs or equipment failures and subsequent replacement.

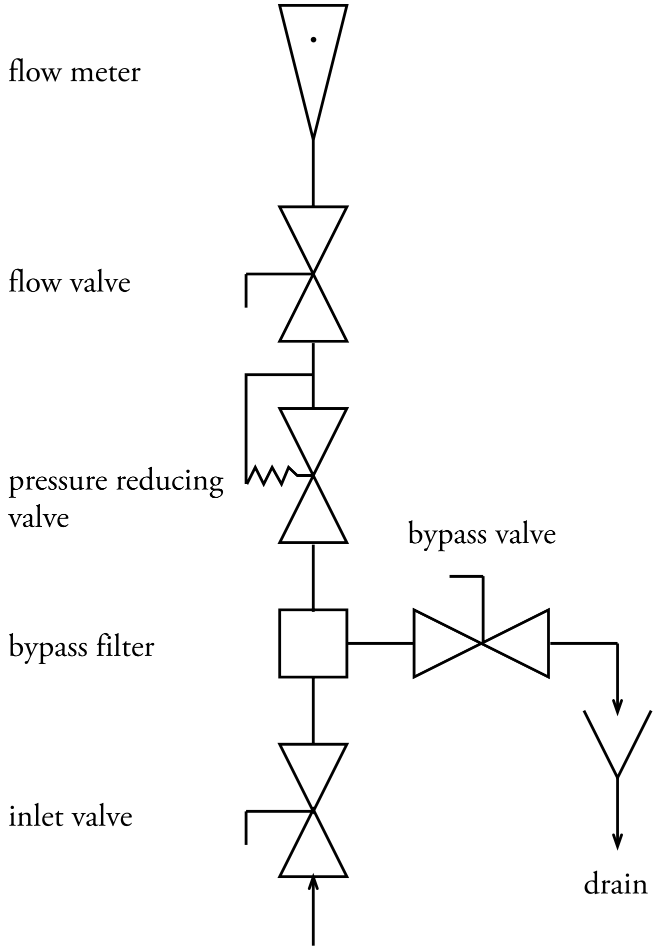
The 1816DO monitor is designed to continuously measure the oxygen in steam and water circuits. The operating range of 0 ppb to 10 ppm allows monitoring of leaks from condensers, valves and fittings, plus very low level precision to clearly show the performance of oxygen removal equipment and chemical scavengers. Design considerations also include an easy-to-use, simple and accurate calibration approach and capability to communicate with DCS systems and evolving technology.

Figure 1
Block Diagram of Sample Flow



Note: Angle mounting is recommended to encourage any bubbles in the sample to rise to the exit and be swept to drain.

Figure 2
Optional Dirty and Pressure Applications



Note: Additional sample stream components are recommended where high pressure or entrained solids may be encountered. A bypass filter helps to protect the electrode membrane, extending its lifetime, by bypassing some rust and other solids to drain.

Principles of Measurement

The 1816DO trace dissolved oxygen monitor measuring sensor is an electrochemical cell similar to a battery that produces a current when oxygen is present. By using carefully selected electrodes, in contact with an appropriate electrolyte, a chemical reaction occurs that uses electrons gained from oxygen modules to produce a galvanic current directly proportional to the concentration of oxygen present. Also, unlike an electrolytic cell in which a flow of current produces the chemical reaction, there is no zero-current as galvanic current naturally is zero when zero oxygen is present. This is a big advantage for trace ppb level operation.

The 1816DO monitor uses a galvanic cell separated from the sample by an oxygen permeable PTFE membrane. The cell has a silver cathode in close contact with the PTFE membrane where oxygen gains electrons (is reduced) to become hydroxyl ions and a lead anode that produces a fixed potential regardless of oxygen concentration, to complete the circuit.

The chemical reactions within the cell are:

At the cathode: $O_2 + 2H_2O + 4e-$

At the anode: $2Pb = 2Pb_2 + 4e-$

Overall: $O_2 + 2H_2O + 2Pb = 2Pb_2OH$

The advanced electrode design permits fast and accurate measurements on both rising and falling dissolved oxygen.

Figure 3
Galvanic Dissolved Oxygen Sensor

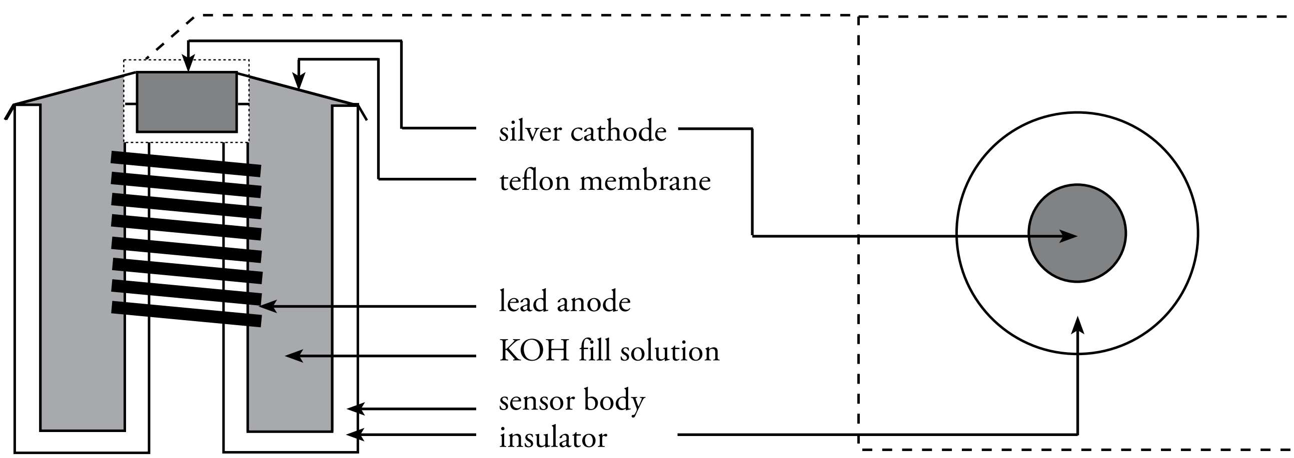
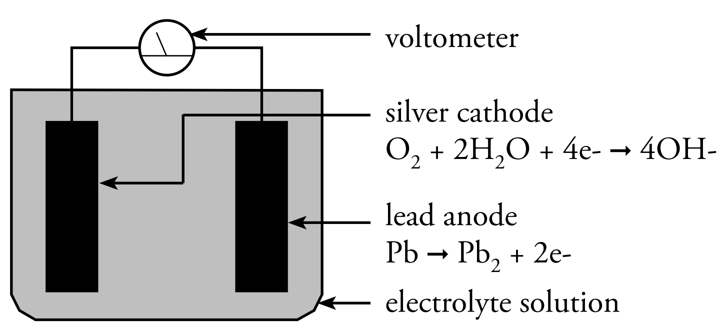


Figure 4
Basic Galvanic Cell



Principles of Calibration

At any given temperature and barometric pressure the partial pressure of oxygen in water-saturated air is exactly the same as it is in air-saturated water. Thus a sensor can be calibrated in water-saturated air, using the 20.9% oxygen available in air as the full-scale standard and it will correctly read dissolved oxygen in water samples. Both temperature and barometric pressure affect the partial pressure of oxygen in air saturated with water vapor. The 1816DO monitor has microprocessor memory programmed with all the values, plus automatic temperature sensor, so it can automatically obtain the correct data, look up the dissolved oxygen table, compute the correct gain and calibrate the monitor. The operator need only remove the cell and suspend it over a beaker of water. This calibration technique will give a 100 % saturation reading for the temperature and pressure, which the 1816DO monitor will display as ppm dissolved oxygen.

To calibrate the sensor, simply suspend the probe above water and let the monitor auto-calibrate.

Sample Requirements

The Thermo Scientific Orion ppb dissolved oxygen sensor has been designed to give fast stable readings at low levels of dissolved oxygen. It is able to return to service quickly after sample interruptions, such as encountered on swing service units.

Sample inlet connection – recommended sample delivery tubing is 316SS with quality tube fittings to eliminate diffusion of oxygen through the sample system tube walls and leaks at fittings.

Upstream sample system components should have as few components and chambers as possible to limit dissolved oxygen hideout locations with accompanying long rinse down times. However, if the sample will contain rust or hydrocarbons, a filter should be installed upstream of the sensor to protect the membrane from puncture or plugging and to prolong life. See Figure 2.

Flow rate – 100 to 200 mL/minute is recommended with a minimum of 50 mL/minute. Lower sample flows will result in slower response to ppb dissolved oxygen changes.

Temperature – Sample should be cooled to between 10 and 35 °C, maximum 45 °C and minimum +1 °C.

Pressure – Should be low, as the flow cell effluent should discharge to atmospheric drain. Sample supply at 5 to 15 psig works well and with 100 to 200 mL/minute flow the sensor exhibits no response to flow changes. With low supply pressure, the large nut on the flow cell can be hand tightened to provide an airtight seal.

Description of 1816DO Monitor Components

Note: The numbers in the description refer to Figure 5.

Dissolved oxygen sensor and lead (1) – Senses ppb oxygen in sample stream and produces a current dependent on sample concentrations. Equipped with attached 10 ft cable.

Stainless steel sensor housing (2) – Provides total shielding for stable low-level ppb signals included with each electrode.

Hand seal gland nut (3) – Offers easy removal of sensor and pressure seal.

Stainless steel flow cell (4) – Contains dissolved oxygen sensor and close contact sample flow paths.

30 degree angle mounting bracket (5) – Securely mounts flow cell at 30 degrees to easily let bubbles pass.

O-ring seal (6) – Inlet fitting, special 1/4" tube fitting to for oxygen-tight inlet seal.

Ground/shield lead (7) – Ensures no electrical potential from static that would affect low ppb level readings.

1816DO electronics (8) – Handles all signal manipulation and results.

LED display (9) – Provides digital readout of concentration, temperature, error codes, etc.

Keypad (10) – Consists of scroll keys; cal, enter, sample, error, cancel and select keys; ppm/ppb units LED; error indicator and electrode stable LED.

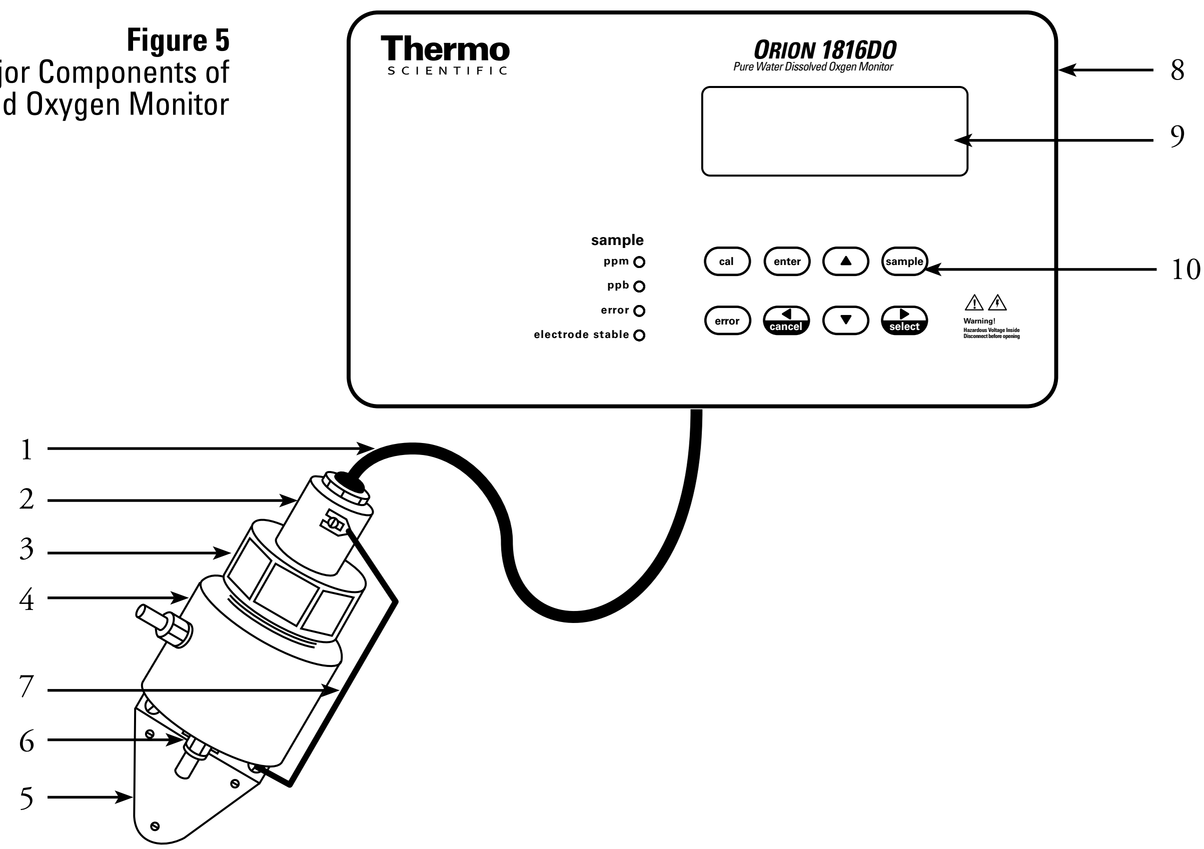


Figure 5
Major Components of Dissolved Oxygen Monitor

Chapter 2 Instrument Preparation

Unpacking the Instrument

Report any obvious damage to the shipping container to the carrier and hold the package for inspection. The carrier (not Thermo Fisher Scientific) is responsible for any damage incurred during shipment.

1. Open the outer box and user guide.

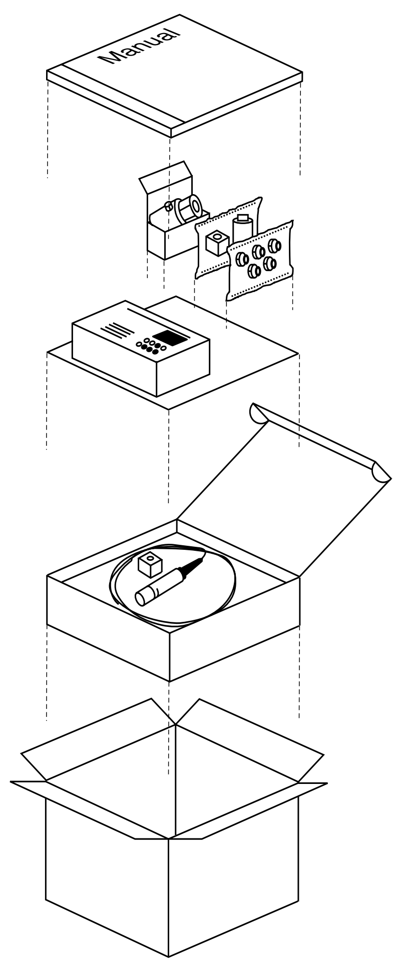
2. Remove the bag containing 5 lead clamps.

3. Lift out the 1816DO monitor and carefully place it in a convenient location.

4. Lift out the flow cell box and module and fill solution box. Place them with monitor. Retain the module box to store the membrane module should the monitor be shutdown for more than 24 hours.

5. Lift out the sensor assembly box and carefully place it with the monitor.

Figure 6
Unpacking the 1816DO Monitor



Monitor Mounting, Plumbing and Wiring

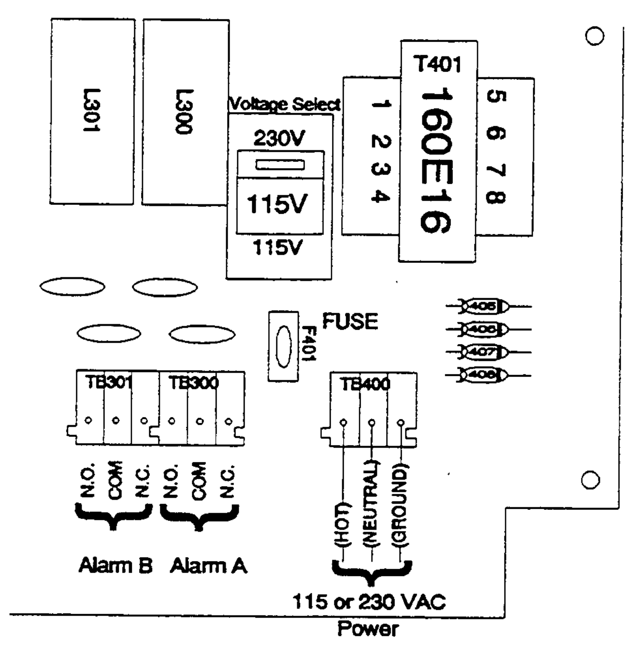
Nominal input power for the 1816DO microprocessor monitor is 115 VAC ± 10 %, single phase 50/60 Hz. Power connections are made at TB400. See Figure 7. The three-wire grounded power must be used, with the third wire connected to a good earth ground. If this ground connection is not made, published instrument specifications may no be achieved.

There are five 0.5 inch conduit entrances in the bottom of the instrument enclosure. Recommended use: line power right-hand entrance, alarm wiring right center entrance, RS232 wiring left hand entrance, sensor wiring left center entrance, 4 to 20 mA wiring middle entrance. All conduit connections should be gasketed and sealed to maintain environmental integrity within the instrument enclosure.

The basic wiring scheme for all Thermo Scientific Orion sensors is shown in Figure 8. This wiring scheme is intended for cable runs less than 3 meters (10 feet) where electrical interference is expected not to be severe. The sensor at 1 ppb dissolved oxygen produces less than 1 microamp. It is recommended that the sensor be located as near as possible to the dissolved oxygen transmitter to minimize any effects of ambient electrical noise interference. All long low-level sensor signals should be run through a dedicated conduit. Take care to route signal wiring away from AC power lines, to minimize unwanted electrical interference.

For alarm, RS232 or output wiring see the **Outputs** or **Alarms and Serial Communications** chapters.

Figure 7
Power Wiring



Flow Cell Mounting

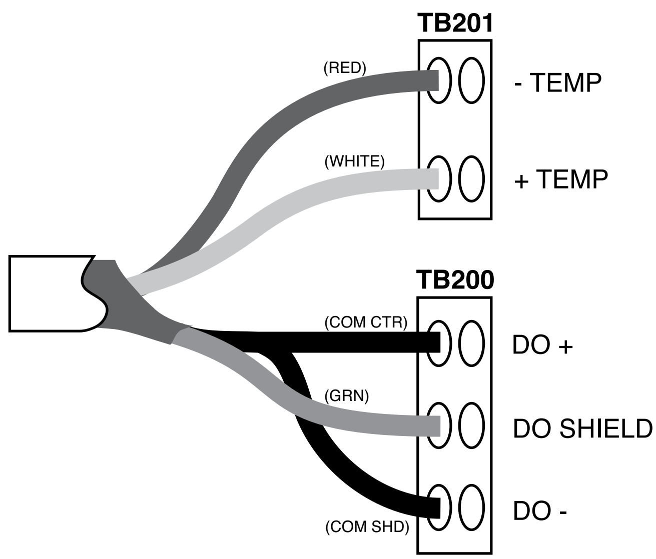
1. There are mounting screws on the bottom of the cell.

2. Arrange the cell for up-flow to the inlet at the bottom, with the cell at an angle of 15 to 45 degrees from vertical. This up-flow arrangement will encourage entrained bubbles in the sample flow to pass through the sample system with minimum dissolved oxygen upset. Allow 8 to 12 inches clearance above the flow cell nut for sensor removal. Ensure the O-ring seal fitting at the cell inlet is fully sealed and no oxygen in leakage is occurring.

Note: Overtightening this fitting may deform seal, causing air leaks and erratic readings.

3. Hook up the sensor to cell grounding wire for the best static interference resistance, which gives good stable low ppb level dissolved oxygen readings.

Figure 8
Sensor Wiring



Assembly of the DO Sensor

This procedure should be done over a sink. Wear thin plastic or rubber gloves as the electrolyte is a caustic solution. Wash hands thoroughly with lots of water if the electrolyte comes in contact with the skin. Rinse until the slippery feel of the caustic disappears.

1. Remove the protective cap exposing the coils and silver tip. Inspect the electrode to ensure the coils are clean and the silver electrodes are bright and not tarnished. If tarnished, wipe in the direction of the coils with a lint-free tissue.

Note: Make sure that the brown sealing O-ring is seated in the electrode groove.

2. Install a membrane module in the cap with the membrane facing down so that it covers the center hole in the cap.

3. Flush the coils of the electrode with electrolyte solution. Holding the electrode cap with membrane module installed in an upright position, fill with electrolyte until the center cavity is full. Tilt at about 30° and add an extra 1/8 inch of electrolyte, observing that the crack around the membrane module fills with electrolyte.

4. Hold the cap like a cup and slowly lower the electrode coils vertically down into the cap until the threads touch. Rotate the sensor body until you can see the flat area through the threads. Slowly rotate the cap on, allowing the excess electrolyte and bubbles to overflow up the flat. Continue to slowly rotate the cap until a firm stop is reached.

Warning: Do not force the cap beyond the stop. The parts are plastic and may break.

5. Dry the sensor and blot the tip. Examine the tip, the membrane should be smooth with no wrinkles or cuts and the surface contours of the silver electrode should be clear. There should be no lines from trapped bubbles between the membrane and the silver electrode. If there are no visible problems as described here, then the sensor is ready to be put into service.

Inserting the Sensor into the Flow Cell

1. Inspect the inside of the flow cell for any foreign matter and wipe out if necessary. It should appear clean, shiny and bright.

2. Insert the assembled sensor through the nut and seal ring. Rock back and forth to pass the ring.

3. Press slowly all the way down until the sensor firmly contacts the flow cell bottom.

4. By hand, tighten the nut firmly to get a good seal. This should be good for 5 to 10 psig.

Warning: Do not use a large wrench to tighten the nut. The plastic parts of the sensor could be broken or deformed.

Note: The flow cell is not intended for use at high pressure. The Teflon seal ring is not a tubing ferrule designed to hold against pressure.

Figure 9
Sensor and Sample System

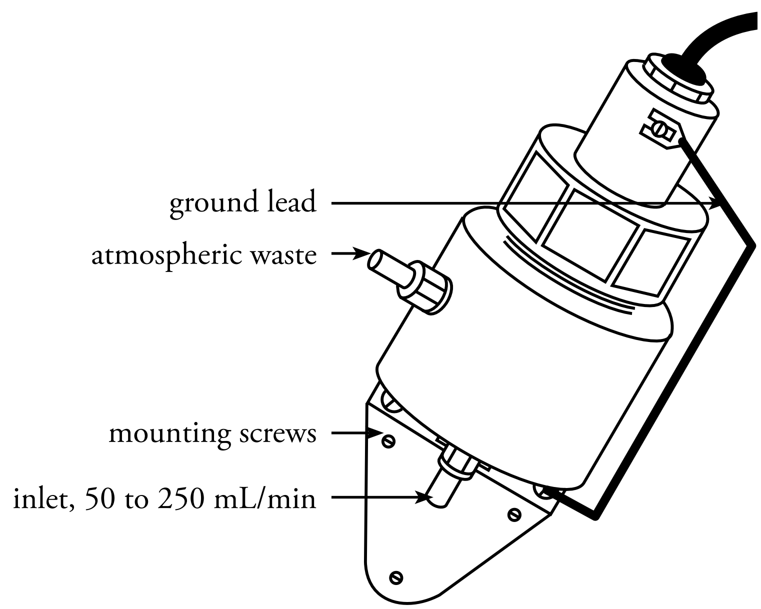
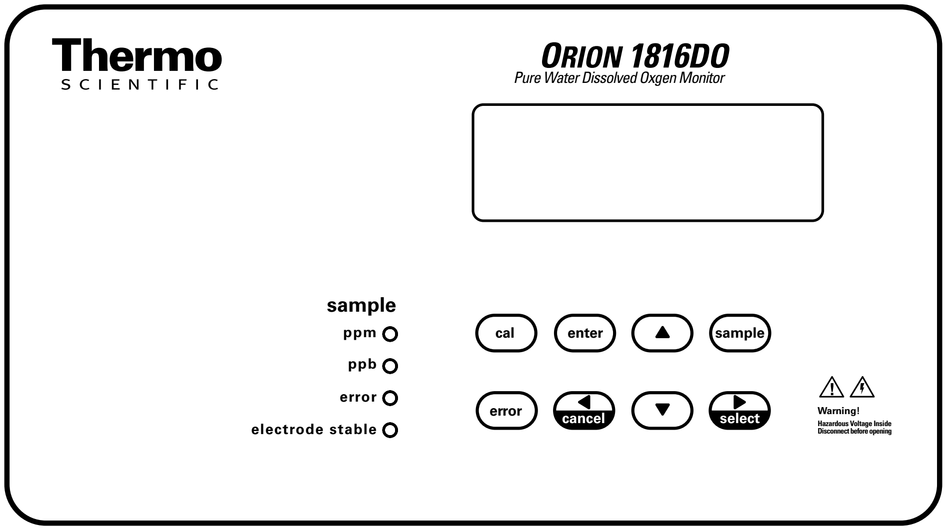


Figure 10
Front Panel Keypad



Chapter 3 Instrument Operation

Description of Basic Unit Controls

LCD display – Displays four and a half digits and plus/minus sign used to read dissolved oxygen concentration, temperature, error messages, as well as the entire menu used to control the monitor.

ppm LED – Indicates that the sample is being displayed on the LCD and that the units of the measurement are in parts per million dissolved oxygen.

ppb LED – Indicates that the sample is being displayed on the LCD and that the units of the measurement are in parts per billion dissolved oxygen.

Error LED – When the error LED is lit, it indicates that an error or alarm condition has been detected. Use the error key to list errors.

Electrode stable LED – When lit, indicates that the dissolved oxygen input is stable (has not changed by more than 2% over the last 60 seconds).

Up and down arrow keys – Moves up and down in the menu. In edit mode, adjusts blinking digit or selects an item from the list. Refer to description of edit mode.

Cancel/left arrow key – Moves left in the menu. In edit mode, moves left one digit or cancels edit. Refer to description of edit mode.

Select/right arrow key – Moves right in the menu. In edit mode, moves right one digit. Refer to description of edit mode.

Enter key – Enters the edit mode when displaying a value that can be edited. In the edit mode, it accepts the displayed setting. Refer to the description of the edit mode.

Sample key – From anywhere in the menu, press the sample key to return to the dissolved oxygen measurement display.

Cal key – From anywhere in the menu, starts the 1816DO monitor into calibration mode.

Error key – If error LED is lit, then pressing the error key causes the LCD to display an error code. If not error condition has been encountered, the LCD will show [NONE].

Menu Display

Figure 11
Main Menu

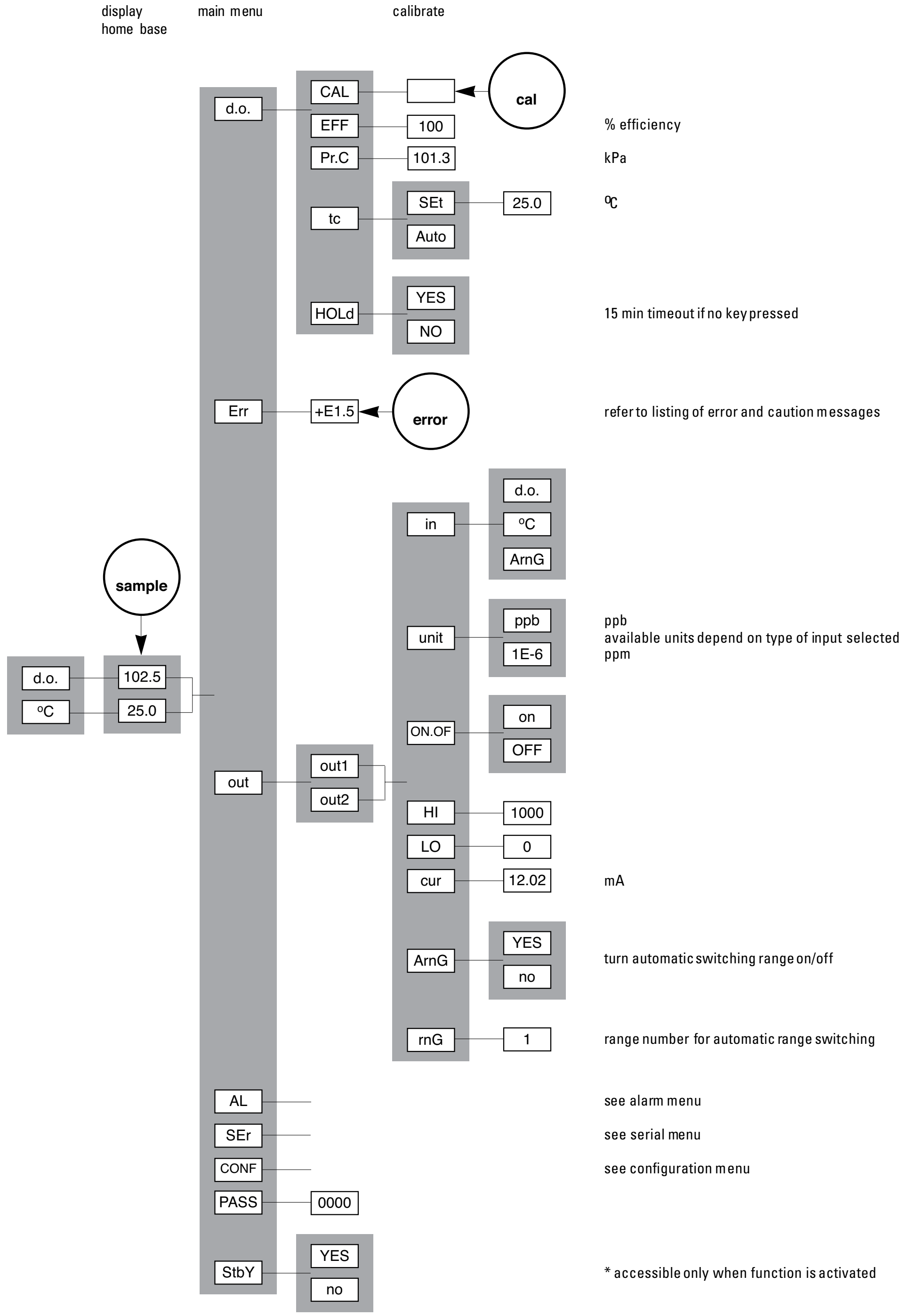


Figure 12
Alarm Menu

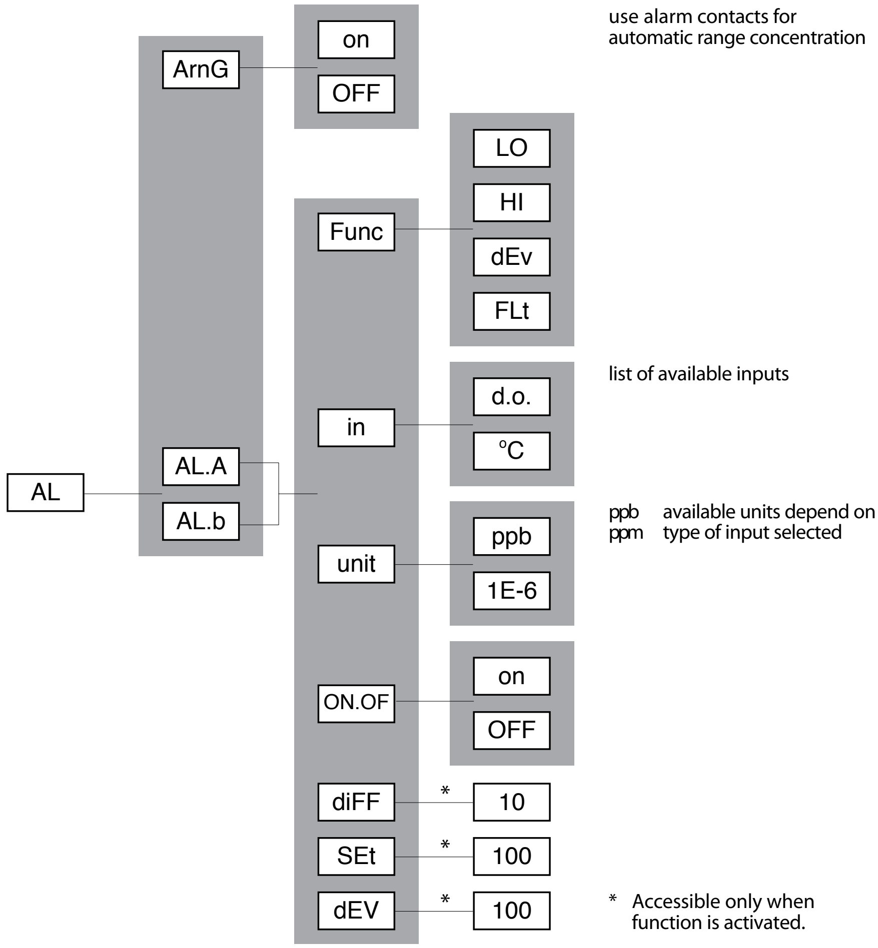


Figure 13
Serial Communications Menu

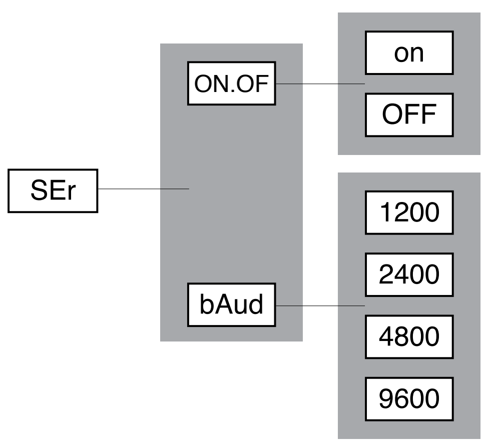
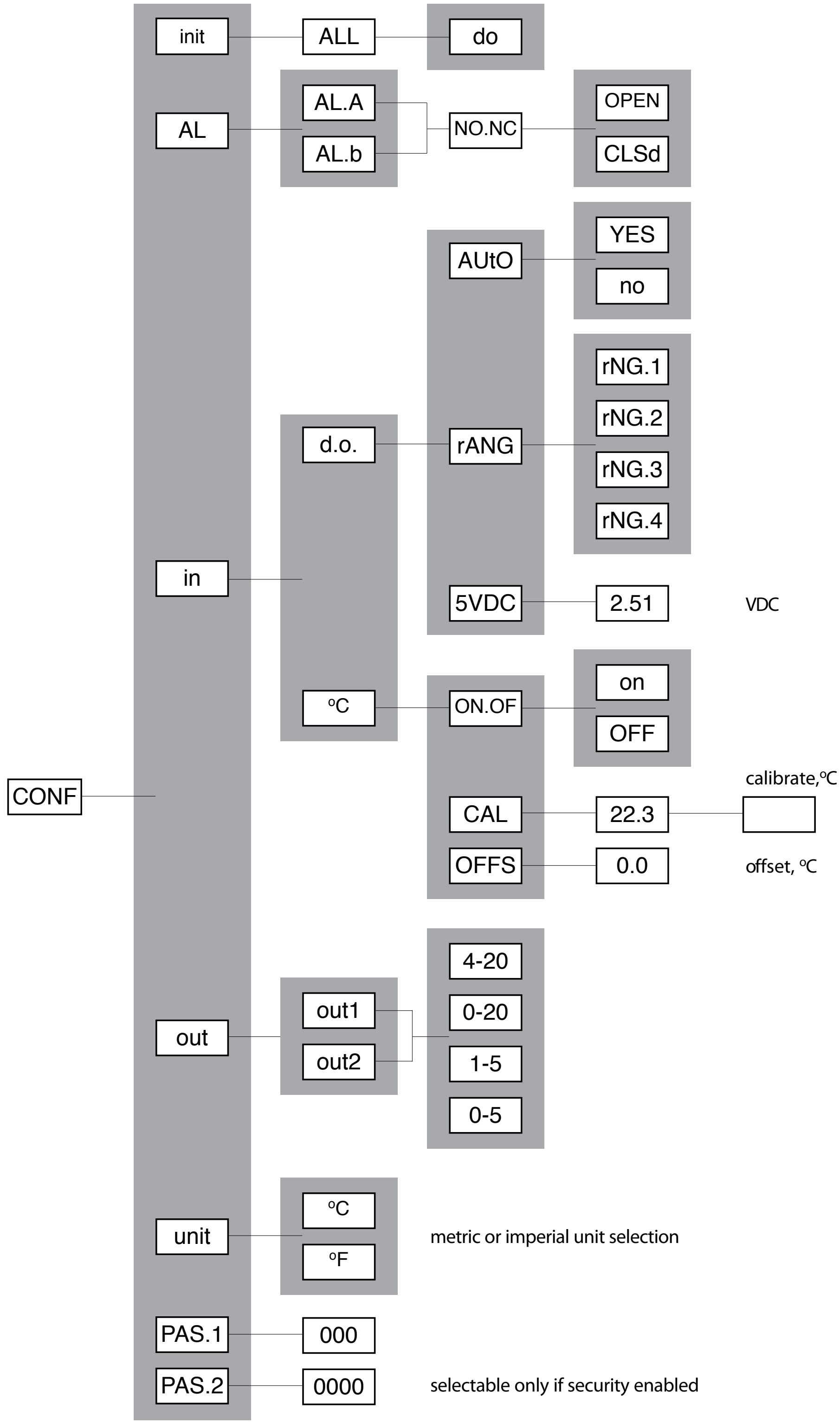


Figure 14
Configuration Menu



Start-up and Normal Instrument Operation

1. Install the 1816DO monitor according to the instructions in the **Instrument Preparation** section. Verify that the power supply has been wired for the proper voltage and the instrument is suitably grounded.

2. Turn on flow at the sample inlet.

3. Power up the 1816DO monitor.

4. The startup procedure will begin by alternately flashing [tESt] and [- -] while performing the memory tests.

5. The monitor will display in sequence the monitor number, in this case [1816] and the program version number, i.e. P1.10.

6. The display test lights each of the implemented display segments in turn. At the same time, each of the LEDs will be lighted in turn.

7. If the monitor passes all the tests, the hardware is functioning properly and the monitor will proceed to display dissolved oxygen.

8. If the monitor displays +Err, this indicates that the dissolved oxygen input is off-scale. The error LED will be lighted as long as either the dissolved oxygen or the temperature input is off-scale. An off-scale error can indicate that a sensor is not in solution, is off-scale or is not connected properly. If the error LED remains lighted, press the error key to see what errors have been detected by the monitor.

9. After completing the above steps, the monitor is now in normal operational mode. The monitor settings and parameters can be viewed or changed at any time using the keypad. Refer to the menus starting with Figure 11. The areas shaded in dark gray indicate program settings which can be changed by the user. Menu areas shaded in light gray are view-only menus.

Initial Instrument Setup

Refer to Appendix A for a listing of factory default settings used by the monitor. Before putting the monitor into operation, verify the settings to ensure that they agree with the intended setup. For a more detailed description of any setting, refer to the appropriate section of this user guide.

1. Change the defaults for the alarms. Set the alarm function (high, low, deviation, fault alarm), input (DO, temperature), differential, setpoint and on/off switch. Set the normally open/normally closed configuration of the alarm contacts in [CONF] [AL]. The program setting must reflect the actual NO/NC wiring.

2. Change defaults for the outputs. Set input (DO, temperature), high limit, low limit and on/off switch. Each output can be calibrated for 4-20 mA, 0-20 mA, 1-5 VDC or 0-5 VDC.

3. Set preferences for metric or imperial units in [CONF] [unit].

4. If desired, install password security.

Moving Around in the Menu

The layout of the program is shown in the menus found in Figure 11 and the following.

The monitor remembers where home base is. It remembers which areas of the menus you used last and it will loop around columns in the menu for you. You can explore the menu with the arrow keys to find any capability and simply press the sample key to return to home base. Then use the right arrow key to return to exactly where you were.

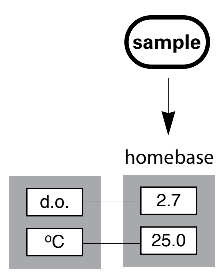
Home Base – Press the Sample Key

The function of the sample key is to provide a known starting point displaying the home sample or home input. The sample key is usable from anywhere in the menu.

The dissolved oxygen display is the default home base display for the monitor. The monitor's inputs, dissolved oxygen and temperature, are arranged underneath each other at the left-hand side of the menu. Use the up or down arrow key to display each of the readings in turn.

Use the sample key from anywhere in the menu to return to the dissolved oxygen or home sample display. The program will safely abort whatever it was doing at the time and return to display the dissolved oxygen sample.

Figure 15
Home Base



Home Base Features

1. The monitor has a built-in timer that returns the program to displaying the home base if no key has been pressed for 15 minutes. This time-out has the same effect as pressing the sample key. If security has been enabled as well, the time-out will change the access level back to 0 or 1 automatically, which gives the user read-only access. The user will have to enter an appropriate password to go to a higher access level. If output hold for dissolved oxygen is in effect, the same timer will release the output hold.

2. When displaying the home base, you can press the left arrow key to show which of the samples is displayed. Pressing the right arrow key displays the same sample again.

3. If the temperature input does not show up in the menu and cannot be selected, then it has been turned off in the configuration step. Each input can be turned off and thereby effectively disappear from the menu if it is turned off in the configuration menu.

Arrow Keys

The four arrow keys on the keypad are used to move around the menu. The same keys can have other functions as well, see the **Edit Mode** section, but when moving around frames in the menu these keys work as expected.

Example: Press the sample key to make sure that you are at home base. Press the right arrow key. One of the prompts in the column starting with [out] will be displayed. Use the up or down arrow keys to display the prompt above or below. If the prompt at the top or the bottom is displayed the program will loop around. Press the up or down arrow key until [AL] is displayed. Press the left arrow key to return to the dissolved oxygen display. Press the right arrow key again and [AL] will be displayed.

Edit Mode

The edit mode is used to change a numeric value or to select between different options. The values and settings which can be edited are identified by the darker shading in the menus. Any frame which has a white background cannot be modified by going into edit mode, but can be viewed.

Editing by Selecting a Setting

Examples of selecting a value are on/off settings and switching between different alarm types. Editing a value is like picking an option from a list. You can see only one item on the list at a time.

Example: Turn alarm A off. From the menu select [AL] [AL.A] [ON.OF]. The monitor will now display either [ON] or [OFF], which are the two choices. To change the setting, press the enter key to go into edit mode. The display will start blinking. Use the up or down arrow key to switch between the possible options, which in this case are [ON] and [OFF]. When [OFF] is displayed, press the enter key again to accept the new setting and leave edit mode.

Editing a Numeric Value

Numeric values such as an alarm setpoint are adjusted by going into edit mode and then adjusting each digit until the new value is displayed. Use the left and right arrow keys to move between digits and use the up and down arrow keys to adjust each digit.

When you press the enter key to go into edit mode two things will happen. First, the last digit will start blinking to show that this digit can be changed. Second, any blank spaces will change to zeros and a plus or minus sign will appear. Now each digit can be accessed. Change between positive and negative numbers by switching between plus and minus sign using the up or down arrow key when the plus/minus segment is blinking.

Press the enter key again to leave edit mode. Now before the new value is changed, the monitor will check the new value to make sure that it is within range. If the new value is lower than the lowest value allowed for that frame, then the monitor will use the lowest allowable value instead of the new value you have entered. Likewise if the new value you entered is higher than allowable, then the highest allowable value is used instead. The monitor will display whatever value it has stored in memory.

Example: Change the alarm A setpoint from 10 to 20. From the menu select [AL] [AL.A] [Set]. The current setpoint (e.g., [10]) will be displayed. Press the enter key to enter edit mode. The display will change to [+0010] and the last digit will start blinking. Press the cancel key to move left one digit. The second digit from the end will now be blinking. Press the up arrow key to change the ‘1’ to ‘2’. Press the enter key again and the display will change from [+0020] to [20] indicating that the new value has been stored in memory. The alarm A setpoint has now been changed from 10 to 20. Press the left arrow key to display [Set], [AL.A] etc.

Summary of Key Functions in Edit Mode

Key	Function
enter	Enters the edit mode. The entire display or a single digit will blink to indicate that the monitor is in edit mode. Press the enter key again to leave edit mode and accept the new value.
▲	Adjusts blinking digit upward or selects the previous item from the list. If a '9' is displayed then the digit will loop around to show '0'.
▼	Adjusts blinking digit downward or selects the next item from the list. If a '0' is displayed then the digit will loop around to show '9'.
▶ select	For numeric values only, it moves to the right one digit. If blinking is already at last digit, the display will loop to the ± sign on the left.
◀ cancel	For numeric values only, it moves to the left one digit. If blinking is at the ± sign, then it goes to the last character. For settings, leaves the edit mode without doing anything.

Input On/Off Switch

The temperature input has been provided with an on/off switch. The most common use of this feature is to 'turn off' the temperature input if no temperature compensator or temperature sensor has been installed. Turning off an input will make the temperature [°C] display at the left side of the menu disappear, as if it did not exist.

Refer to Figure 14 for the configuration menu.

Metric Units or Imperial Units

By default the monitor will use metric units. This means that temperature will be displayed using degrees Celsius and that the prompt for the temperature input will be [°C]. Using metric units, the pressure is displayed as kPa. The monitor can also be made to use imperial units. Using imperial units, temperature will be displayed using degrees Fahrenheit and the prompt for the first temperature input will be °F instead of °C. Pressure will be displayed as psi throughout the program.

For practical reasons, the temperature input is always identified as °C throughout this user guide and in the menus.

To select imperial units for the monitor, select [unit] from the configuration menu, then go into edit mode and change the [°C] prompt to [°F]. Since this is a global setting, both the units used for temperature and for pressure will change.

Error Messages

To display errors detected by the monitor, select [Err] from the main menu. If there are no error messages, [NONE] will be displayed; otherwise scroll through the error list using the up and down arrow keys. Error messages are numbered. Errors are identified as [En.e] where n is the input number and e is the error number. For example, E1.1 is error 1 for the dissolved oxygen input. Off-scale errors are not numbered and are identified as [+Err] and [-Err], depending on whether the input is at the top or the bottom of the scale. The off-scale error is displayed instead of the sample reading and does not show up in the error menu with the numbered error messages, if any.

Errors can be acknowledged but cannot be removed from this list directly; each error/caution will be removed automatically when appropriate, e.g. errors associated with improper calibration will be cleared after a successful calibration. The error LED will be on as long as there is an unacknowledged error message or as long as any input is off-scale. Each source of error must be removed or acknowledged before the error LED will go off. If no electrode or sensor is attached to an input, it may be most convenient to 'turn off' the input. For example, if there is no temperature input, the temperature display would consistently be off-scale without a resistor across the input terminals, causing the error LED to always remain lighted.

Acknowledging an Error Message

To turn off the error LED and shut down the external fault alarm contact, the error must be acknowledged. To acknowledge the error, select [Err] from the main menu or press the error key. Us the up or down arrow key until the error message to be acknowledged is displayed.

Errors are displayed with either a '+' or a '-' sign in front. The '+' sign is used to indicate an active or unacknowledged error, the '-' sign indicates an inactive or acknowledged error. Acknowledging the error will change the sign from '+' to '-'. Press the enter key to go into edit mode. The '+' to '-' sign will be flashing. Use the up or down arrow key to change the sign, then press the enter key again.

Table 1
Error Codes

Error Code	Message
E1.1	Electrode has not stabilized after 5 minutes of calibration
E1.2	Sensor efficiency would be more than 500%. Previous setting retained.
E1.3	Sensor efficiency would be less than 30%. Previous setting retained.
E1.5	Temperature compensator for dissolved oxygen not working.
+Err	Reading off scale (high).
- Err	Reading off scale (low).
E4.1	Alarm 'A' high alarm
E4.2	Alarm 'A' low alarm
E4.3	Alarm 'A' deviation alarm
E4.4	Alarm 'A' fault alarm
E5.1	Alarm 'B' high alarm
E5.2	Alarm 'B' low alarm
E5.3	Alarm 'B' deviation alarm
E5.4	Alarm 'B' fault alarm

Shutdown and Start-up Procedure

Note: If the 1816DO monitor will be shut down for more than 24 hours, it is essential to remove the membrane module in order to maximize lifetime.

1. Remove the white electrode cap and membrane module.
2. Rinse the electrode with pure water and wipe it to remove any trace of internal fill solution.
3. Rinse the membrane module, carefully blot it dry and store it in the original plastic case in which it was shipped.
4. Replace the white electrode cap. The following procedures should be followed if a loss of sample flow is expected for more than three days. This will prevent possible build-up of oxidation products in the sensor.

Shutdown

1. Shut off the sample flow prior to the flow cell inlet.
2. Shut off the drain flow cell to stop oxygen entering.
3. Leave the power on.
4. Keep the flow cell full of ppb dissolved oxygen water.
5. Since the sensor consumes small quantities of dissolved oxygen, it will store for months in a sealed flow cell if the power is on or if the cell leads are shorted.
6. If it is necessary to turn the power off, first remove and disassemble the sensor. Rinse the internal components with pure water and blot them dry. Turn off the power. A disassembled sensor stored in a clean dry container has years of shelf life.

Flow Off

If the monitor is expected not to have flow for time periods less than seventy-two (72) hours, leave the instrument on and either neglect its output or put the monitor in standby mode. If the time is expected to be greater than seventy-two (72) hours, follow shutdown procedures.

Start-up, if Stored in a Sealed Flow Cell

1. Open the drain valve.
2. Open the sample inlet valve.
3. Read the ppb dissolved oxygen.

Start-up, if Stored Disassembled and Dry

1. See the **Instrument Preparation** section in this user guide.

Standby Mode

Standby mode can be selected from the main menu. In standby mode the alarms will not function and the 4-20 mA outputs will go to 4.00 mA. When the sample key is pressed, both the outputs will show [StbY] instead of the normal input measurement.

The monitor will not resume normal operations until it is taken out of standby mode. While in standby mode the entire menu and all settings are accessible to the operator, as before. None of the settings will take effect until the monitor is returned to normal operation.

The standby feature is protected by security level 2.

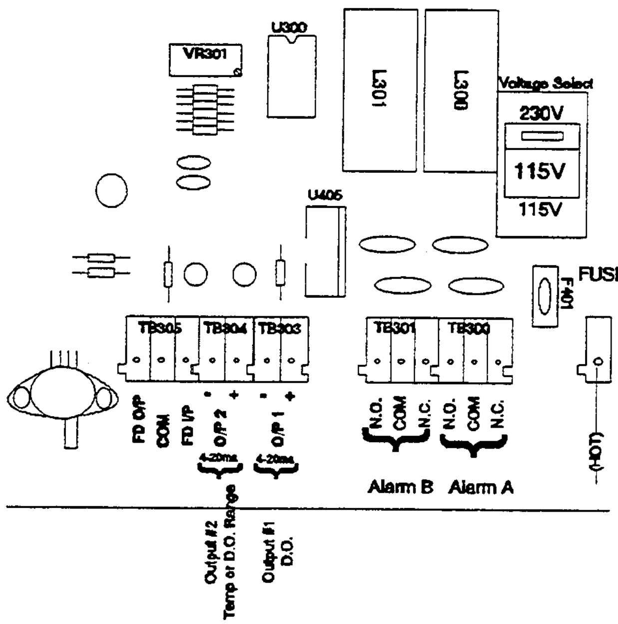
Chapter 4 Outputs

Dual Output Signals

Two assignable 4 to 20 mA output channels are provided. The operator may configure the monitor to determine which input signal will be transmitted by each 4 to 20 mA output channel. Each output channel can be configured to transmit a dissolved oxygen or a temperature signal. Out2 can also be used to transmit the range number for out1.

The output channels function independently of each other. Each output channel has a separate on/off switch and adjustable low and high span adjustments. It is normal to transmit two dissolved oxygen signals using both out1 and out2, with each output using a different set of low and high span adjustments. Output settings are selected from the [out] menu.

Figure 16
Output Wiring



Wiring and Calibration

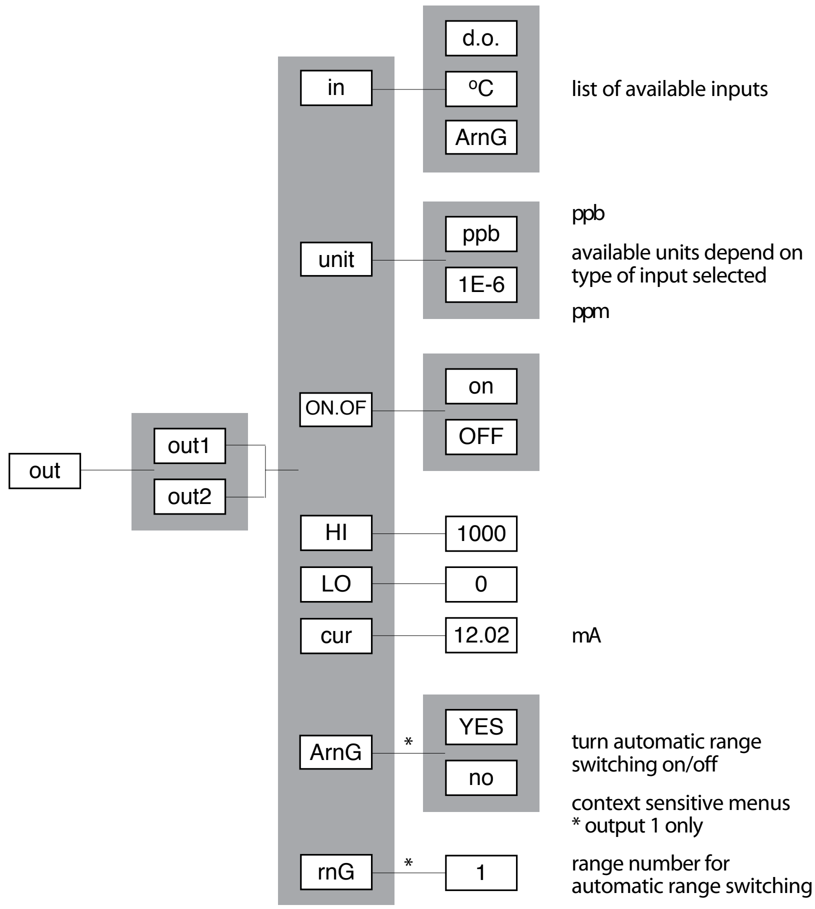
Refer to Figure 16 for wiring instructions for the output channels. The factory default is to calibrate the outputs for 4-20 mA output. The outputs can also be calibrated for 0-20 mA output. For calibration, refer to the **Calibration of 4 to 20 mA Outputs** section.

0-5 VDC or 1-5 VDC output can be achieved by placing a 250 ohm, 1% resistor across the 4 to 20 mA output. To make the program display of the current output, i.e. [out] [out1/2] [cur], agree with the calibrated output, the program configuration needs to agree with the hardware calibration. The setting in [CONF] [out] [out1/2] can be changed to 0-5, 1-5, 0-20 and 4-20 to agree with the hardware calibration of the particular output.

Output Span Adjustment

To adjust the output span or output 'window', set [LO] to correspond to the low end of the scale or 4 mA output and set [HI] to correspond to the high end of the scale or 20 mA output. The monitor will automatically scale the output according to the new settings. Practically any combination of output settings can be set.

Figure 17
Output Menu



Reversing the 4 to 20 mA Output

The low scale setting will normally be lower than the high scale setting. It is possible to reverse the output or 'flip the window' by reversing the settings of the low and high scale.

Example: Define an output window from 0 to 100 pbb dissolved oxygen with 100 ppb corresponding to 4 mA output and 0 ppb corresponding to 20 mA output. Set [LO] to 100 and set [HI] to 0.

Figure 18
Output without Range Switching

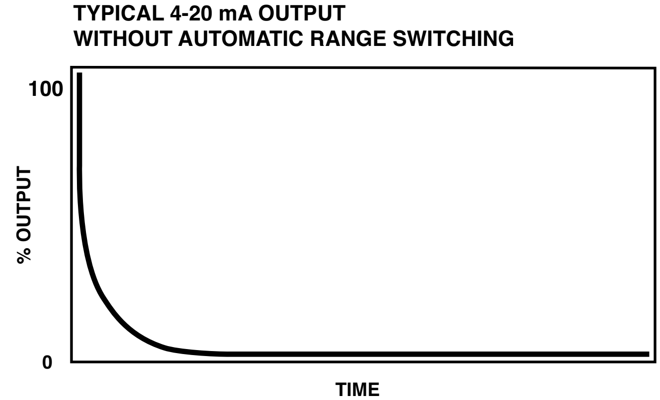
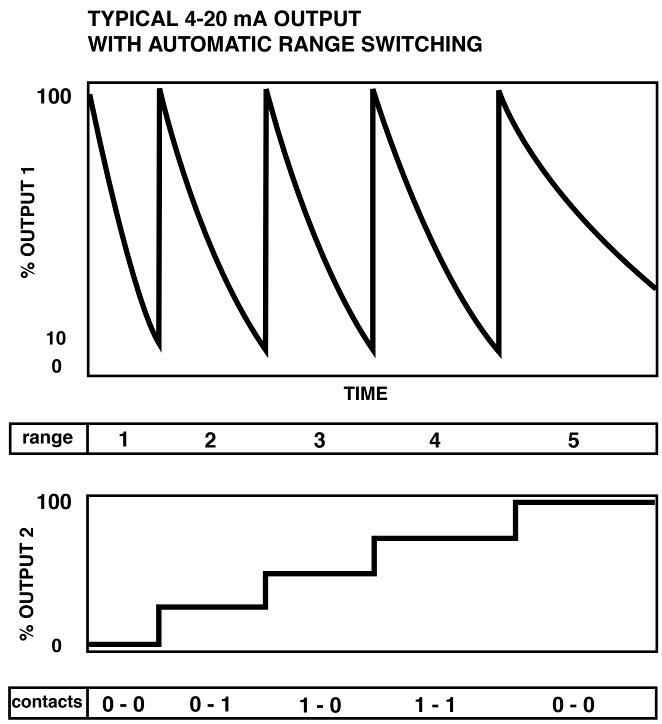


Figure 19
Output with Range Switching



Output 1 Automatic Range Switching

Automatic range switching greatly enhances the resolution capability of the 4-20 mA output. A typical application would track the dissolved oxygen input from 0 to 20000 ppb. As soon as the level drops below about 1000 ppb, a typical recorder would be able to show very little resolution. Figure 18 shows typical recorder output. The alternative of having an operator change the scale adjustment is impractical in most cases.

Automatic range switching will automatically expand the span adjustment by a factor of 10 each time the output level is within the bottom 10 per cent of the scale. With automatic range switching in effect for out1 the output will adjust automatically over 5 ranges, moving from range 1 which is 100% of full scale through range 4 which is 10% of full scale of range 5, which is 0.01% of full scale. For dissolved oxygen, this means that with full scale setting of 20 ppm, the output will automatically switch down through the different ranges to range 5 which represents 0 to 2.0 ppb.

While automatic range switching is most practical for the dissolved oxygen input, the concept will work for the temperature input as well.

A hysteresis is built into the output logic to avoid having the output switch between ranges too frequently, thereby painting the chart recorder. The output will stay on the current range if the output level is between 9.5 and 100% of the current scale. The output will not switch downscale or to the next highest range number until the output reaches 9.5% of the current scale. The output will switch upscale again when the output reaches 100% of the current scale.

Enabling Automatic Range Switching

Only out1 has automatic range switching available. From the menu select [out] [out] [ArnG], then edit the setting to show [YES]. A common setting for [LO] is 0, which is the lowest possible value for the DO input. Set the [HI] value to the full scale value for range 1. The [unit] selection for DO should be [1E-6] which represents ppm.

With automatic range switching for output 1 enabled, you can tell at the monitor which range output 1 is on by selecting [out] [out1] [rnG] from the menu. This frame gives a live update of the range number. The [rnG] frame can only be selected from the menu if [ArnG] is set to [YES].

Example of Range Switching for DO Input

Figure 19 shows the effect of adding range switching to the first 4-20 mA output. The first graph shows the DO level coming down after a calibration, but has virtually no resolution at the operating level. The second graph shows the 4-20 staying with 10 to 100% of scale by automatically switching between ranges. Only on the last range, range 5, is the output of the 4-20 allowed to go below 10% of scale.

To achieve results similar to those in the graph, use the following settings. For output 1 [in] = [d.o.], [ON.OF] = [on], [unit] = [1E-6] (for ppm), [HI] = 2-, [LO] = 0, [ArnG] = [YES]. For output 2 [in] = [ArnG], [ON. OF] = [on], [LO] = 1, [HI] = 5. To use the alarm contacts for range indication, set [AL] [ArnG] to [on].

Table 1 summarizes the results for these settings.

Remote Indication of Range

Once output 1 is set to switch between ranges automatically, you need to be able to indicate to a recorder or a digital control system which range number output 1 is on. This task can be accomplished either by using the alarm contacts or by using the second 4-20 mA output. The monitor will also allow both methods to be used simultaneously.

Table 2
Example of Range Switching for DO Input

Range Number	Output 1, % Full Scale	Output 1, Scale ppb DO	Output 2, mA	Relay Contacts
1	100.00	20000	4.00	A=0, B=0
2	10.00	2000	8.00	A=0, B=1
3	1.00	200	12.00	A=1, B=0
4	0.10	20	16.00	A=1, B=1
5	0.01	2	20.00	A=0, B=0

Using the Relay Contacts

The alarm contact method uses the two alarm contacts to distinguish between ranges. With two contacts there are four possible combinations. Ranges 1 and 5 use the same combination. This duplication of codes should not present a problem. First of all, the input may never get down this far and secondly, the operator should be able to distinguish between ranges 1 and 5 after output 1 has gone through ranges 2, 3 and 4. The on/off combinations for the A and B contacts are shown in Table 1.

Set the alarm contacts for range indication by selecting [AL] [ArnG] from the menu, then editing the setting to show [on]. While the alarm contacts are being used for remote range indication of output 1, the alarms will continue to function as normal, i.e. LED indication and alarm type display in SAMPLE frame will continue. It is not possible to use an alarm contact for alarm indication and range indication at the same time. Also note that while the alarm contacts are being used for range indication, the normally open/ normally closed configuration will be observed. See Figure 14.

Using the Second 4-20 mA Output

A more versatile method for indicating the range number for output 1 remotely is to use output 2. The following settings for output 2 will transmit the range number: [in] = [ArnG], [ON.OF] = [on]. Also set the [HI] and [LO] parameters to indicate which values represent 4.00 and 20.00 mA.

Table 3
Using Second 4-20 mA for Range Indication

Range Number	LO=0, HI=5	LO=1, HI=5	LO=5, HI=1	LO=5, HI=0
OUT2 = OFF	4.00	4.00	4.00	4.00
1	7.20	4.00	20.00	20.00
2	10.40	8.00	16.00	16.80
3	13.60	12.00	12.00	13.60
4	16.80	16.00	8.00	10.40
5	20.00	20.00	4.00	7.20

Unit Selection

The output module will be using different units for its high and low settings, depending on the input selected. Select [unit] from the output menu to display the units in use for this output.

The temperature input will use different units depending on whether metric or imperial units are selected – Celsius units for metric and Fahrenheit units for imperial units. The choice between metric or imperial units is made in the configuration menu. See Figure 14.

The DO input allows the user to select between ppm and ppb units. Edit the unit setting to choose the desired units for the HI and LO settings.

Testing with Simulated 4 to 20 mA Output

Select [cur] from the output menu to display the signal currently transmitted by the output channel. The signal is displayed in mA. The display will be updated as the output signal changes based on the input signal and the output settings.

To simulate a different 4 to 20 mA output signal press the enter key to enter edit mode. Use the up or down arrow key to display the desired signal needed for testing the output signal. Press the enter key to have the displayed value take effect. The output signal will change to transmit the displayed value. This process can be repeated as often as necessary.

The output signal is held at the displayed level until the program leaves this part of the menu.

Troubleshooting and Servicing

See the **Electronic Hardware Troubleshooting** section for troubleshooting and servicing procedures.

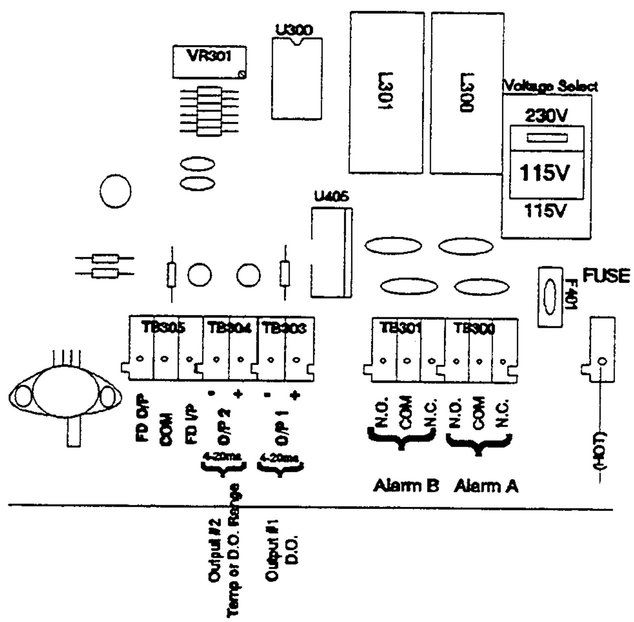
Chapter 5 Alarms and Serial Communications

Alarms Overview

Two alarms, alarm A and alarm B, are a standard feature for the 1816DO monitor. Each alarm has an alarm contact associated with it which can be used for remote alarm indication or for control functions. The two alarms function independently of each other. Either alarm can monitor the dissolved oxygen or the temperature input.

Each alarm features an adjustable setpoint, user-selectable alarm type, adjustable differential (also called hysteresis) and an on/off switch. The alarm types which are available are high, low, deviation and fault alarm. Alarms can be set anywhere between 0 and 9999 ppb or ppm for the dissolved oxygen input or -5 °C and 105 °C for the temperature input. The differential setting is adjustable from 0 up to 100 ppb or ppm for dissolved oxygen.

Figure 20
Alarm Wiring



Wiring and NO/NC Contacts

Refer to Figure 20 for the alarm wiring diagram.

The alarm contacts for alarms A and B may be wired as normally open or normally closed. By default the 1816DO monitor assumes the alarm contacts are wired normally open. A normally open alarm contact will be inactive if there is no alarm condition and will be active when there is an alarm condition. If the program configuration and the wiring for each alarm do not match then the incorrectly configured alarm contact will generate an alarm when there is no alarm condition and vice versa.

Refer to Figure 14 for the configuration menu. Select [CONF] [AL] from the menu.

The normally open/normally closed configuration selected will remain in effect even when the alarm contacts are used to indicate the range number for the first 4-20 mA output.

Use of Alarm Contacts

By default the alarm contacts will be used to indicate alarm conditions. If there is an alarm condition for either alarm, then the alarm will be indicated using both the alarm LED and the alarm contact. This usage of the alarm contacts is selected by setting [AL] [AL.A] to [OFF].

The alarm contacts can also be used for remote indication of the range number for the first 4-20 mA output. In this case the alarms will continue to function. An alarm is indicated using the alarm LED, but not the alarm contact. This usage of the alarm contacts is selected by setting [AL] [AL.A] to [on]. Remote range indication is described in the section describing the 4-20 mA outputs.

Unit Selection

The alarm module will be using different units for its settings, depending on the input selected. Select [unit] from the alarm menu to display the units in use for this alarm.

The DO input allows the user to select between ppm and ppb units. Edit the unit setting to choose the desired units for alarm settings.

The temperature input allows the user to select between °C and °F units. Edit the unit setting to choose the desired units for alarm settings.

High or Low Alarm

A high alarm is set when the dissolved oxygen rises above the setpoint and is cleared when the dissolved oxygen drops to below the setpoint minus the differential. A low alarm is set when the dissolved oxygen drops below the setpoint and is cleared when the dissolved oxygen rises to above the setpoint plus the differential (see Figures 21 through 23). The differential has the effect of setting the sensitivity of the alarm. The differential provides a digital equivalent of a hysteresis.

Figure 21
High Alarm

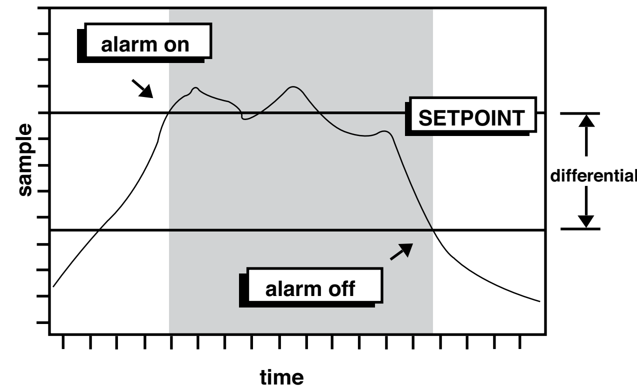


Figure 22
Low Alarm

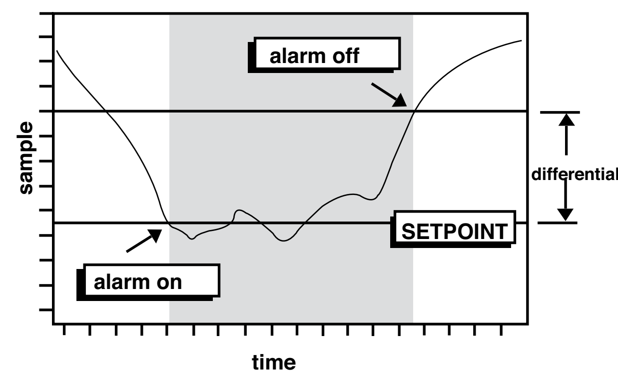
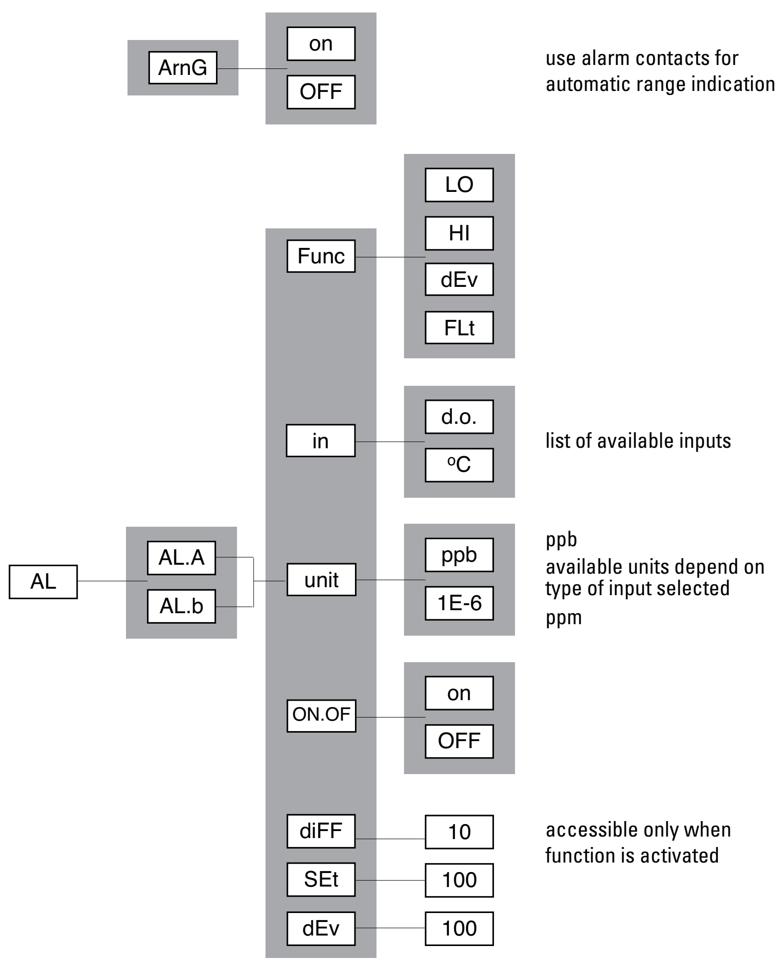


Figure 23
Alarm Menu



Deviation Alarm

A deviation alarm is practical when the process is expected to stay within a certain range. An alarm will be set if the input deviates too far from a setpoint. Please note that the [dEv] frame only shows up in the menu after the alarm function has been changed to deviation alarm, since it would have no effect for a high, low or fault alarm.

Example: If the dissolved oxygen is expected to stay between 100 and 200 ppb, then we would set [in] to [d.o.], [Func] to [dEv], [Set] to 150 and [dEv] to 50. Effectively we simultaneously have a high alarm at 200 ppb and a low alarm at 100 ppb.

The differential setting will continue to function for high and low alarms.

Fault Alarm

A fault alarm for an input will be set when anything goes wrong with that input. Something is wrong with an input if the input is off-scale or an unacknowledged error or caution message exists for that input.

To use an alarm as a fault alarm, select [FUNC] from the alarm menu, then select [Flt]. To enable the alarm, make sure the on/off switch is set to [ON].

The setpoint and differential for the alarm have no effect when the alarm is used as a fault alarm.

Alarm Indication

If there is an alarm condition on either alarm A or B, the error menu will indicate the alarm type using an error number. In case of an alarm the error LED on the front panel will be lighted. Table 3 lists the error codes used to indicate alarm conditions. In addition, an alarm condition for an input will cause the sample display for that input to alternate with the alarm function display, either [LO], [HI], [dEv], or [Flt]. Press the sample key, then use the up or down arrow key to display each of the two samples, if necessary. Each sample frame will first display the sample reading, then after two seconds the alarm type for that input, if any.

Table 4
Error Codes for Alarm Conditions

Error Code	Meaning
E4.1	Alarm ‘A’ high alarm
E4.2	Alarm ‘A’ low alarm
E4.3	Alarm ‘A’ deviation alarm
E4.4	Alarm ‘A’ fault alarm
E5.1	Alarm ‘A’ high alarm
E5.2	Alarm ‘A’ low alarm
E5.3	Alarm ‘A’ deviation alarm
E5.4	Alarm ‘A’ fault alarm

Using Alarms for On/Off Control

The alarms can also be used for process control. The alarms contracts will then function as on/off signals for switches controlling a valve, pump, motor, etc. The setpoint determines the control point of the system and the setting of the differential controls the amount of corrective action before a controlled shut-off occurs.

Figure 24
Low Control

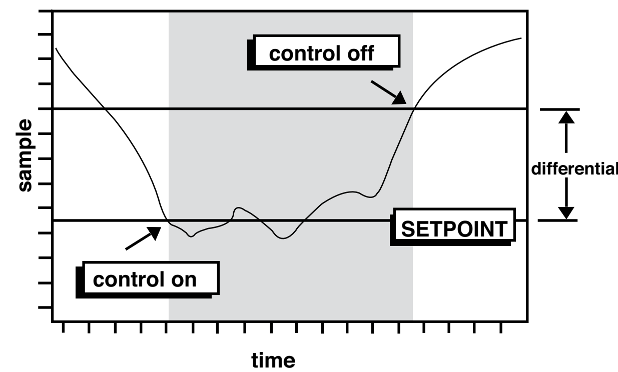
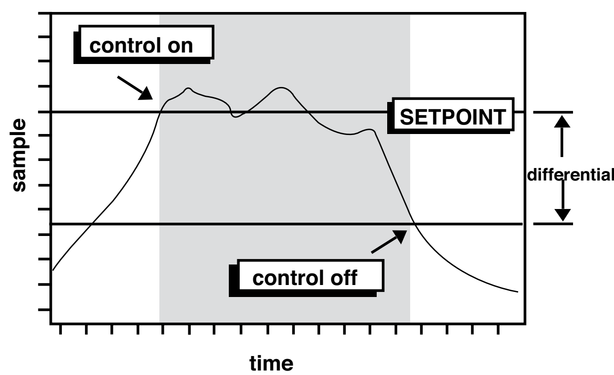


Figure 25
High Control



Serial Communications Overview

Serial communications give the monitor the ability to communicate with a communication program running on an IBM compatible personal computer or with any computer that is able to capture and process serial data.

No knowledge of data formats is required if a Thermo Scientific Orion communications program is used. The description of the data format supplied in this section is needed only if data sent out by the 1816DO monitor needs to be captured by a customer's computing device.

Figure 26
Serial

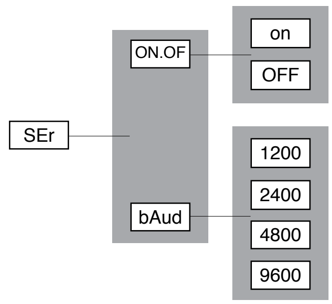
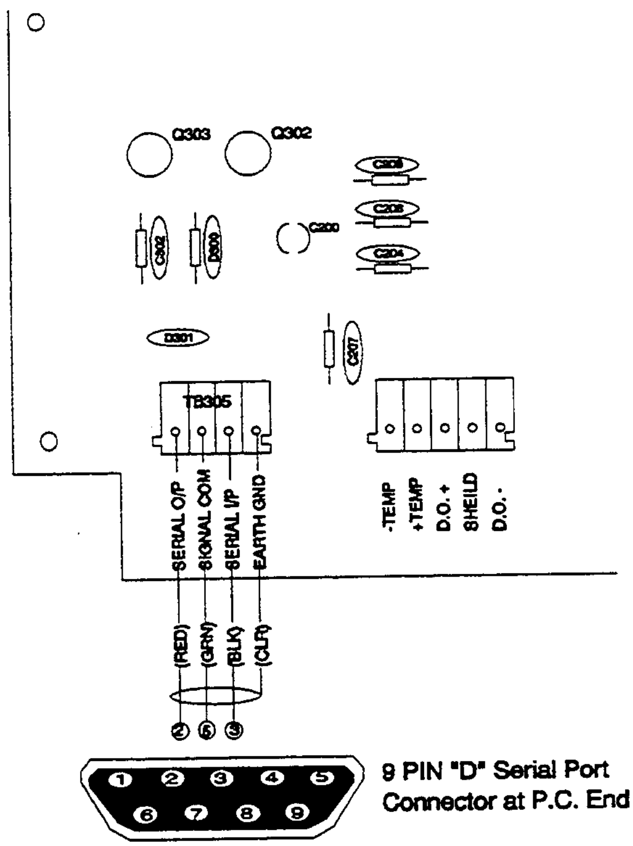


Figure 27
Serial Communications Wiring



Serial Port Wiring and Enabling

To connect the 1816DO monitor to a serial port, consult Figure 27 for the wiring diagram and component locations. The 1816DO monitor uses 8 data bits, no parity and 1 stop bit. To enable serial transmission by the monitor, set the serial ON/OFF switch to ON and set the desired baud rate. See Figure 26.

Format of Data Frames

All data transmitted by the monitor is transferred in the form of frames. A frame is an encapsulation of data which allows the detection of the end of the message and the addition of error checking. The end of a frame is detected by counting the number of data bytes specified in the byte count field. Application code can optionally test the integrity of the data by calculating the check byte and comparing the calculated value with that received in the check byte field. The frame format consists of the following fields. All fields except for the data field are 8-bit unsigned bytes.

':' STATUS CMD# # BYTES DATA CHECK BYTE

1. Recognizable start character, which is the colon.

2. Status byte, normally this is set to 0. Application code can choose to either ignore the status byte or discard all frames with a non-zero status.

3. Command number, determines the meaning of the data in this frame.

4. Byte count, this field specifies the number of bytes in the data field.

5. Data field, the structure of this field is determined by the type of command being sent. Lengths from 0 to 255 bytes are possible.

6. Check byte, the value of the check byte is calculated by a bitwise XOR of all bytes of the transmitted frame from the leading colon to the last data byte.

Command Structures

The structures of individual commands are explained below, presented in the form of 'C' source code. Length in bytes of character is 1, integer is 2, floating point is 4 (IEEE standard) and long is 4. Additional commands may be sent out by the monitor which are not documented here.

```
/*command 0: Dissolved Oxygen input */
struct cmd_0 {
  unsigned int a_to_d; /*internal A/D conv. value */
  float ppb_do;      /*calculated D.O., in ppb*/
  unsigned int range_number;
     /*internal range number of DO input circuit*/
}
/*command 1:analyzer LCD display*/
struct cmd_1 {
  char display[8];
    /*analyzer display,null-terminated string*/
  char blink;
    /*FALSE = display steady,
      TRUE = display blinking*/
  unsigned long pattern;
    /*segment-by-segment bit pattern indicating*/
    /*which LCD segments are blinking*/
}
/*command 2: calculated values of the input signals
   to the analyzer*/
struct cmd_2{
  float ppb_do;/*value of DO input in ppb*/
  float degrees_celsius;
     /*value of temperature input in degrees C*/
}
/*command 3:values transmitted by the analyzer
  4-20 mA outputs*/
struct cmd_3{
  float ma_output1;
     /*value transmitted by first 4-20 mA output*/
  float ma_output2;
     /*value transmitted by second 4-20 mA output*/
}
```

Chapter 6 Calibration

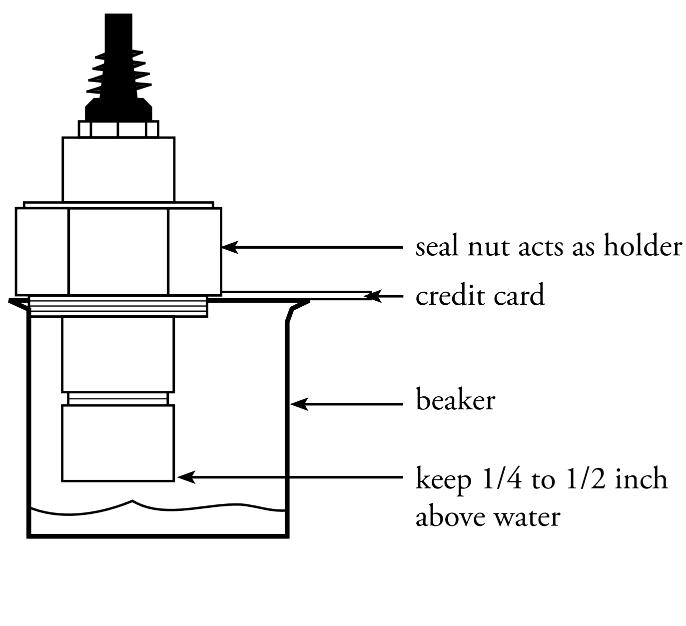
Removal of the Dissolved Oxygen Sensor

1. Stop the sample flow to the dissolved oxygen sensor.
2. Release the large nut on the top of the flow cell a few times. It should only be hand tight.
3. Gently rock the dissolved oxygen sensor back and forth to ease the Teflon seal back up the compression throat. This lets air enter the flow cell and breaks any vacuum that would form.

Caution: Removal of the dissolved oxygen sensor from a sealed flow cell will vacuum stretch the thin dissolved oxygen sensing membrane. Stretching the membrane will cause slow response and higher readings at low ppb levels. Splitting the membrane will cause dissolved oxygen sensor failure.

4. Back the large nut off the rest of the threads. This gently lifts the sensor.
5. When the nut is free, slowly remove the sensor, allowing air to enter the flow cell.
6. Turn the nut and seal ring back onto the threads to keep them from getting lost.

Figure 28
DO Sensor Setup for Calibration



Calibration Procedure

When executing the calibration procedure the monitor will adjust the efficiency constant for the DO cell.

1. Obtain the atmospheric pressure measurement and enter it into the program.

2. Remove the sensor from the flow cell.

3. Take the sensor and suspend it above water. See Figure 28.

4. Press the cal key. The monitor will show the dissolved oxygen reading. The display will be blinking to indicate that the monitor is calibrating and testing for stability.

Note: The calibration is automatic from here on. As soon as the sensor reading has stabilized sufficiently the display will stop flashing and the new sensor efficiency constant will be calculated.

5. When the reading stops blinking, the calibration has been completed. The reading will be displayed using the new calibration value.

6. Press the sample key to return to normal operation. If this key is not pressed, the monitor will return to the sample display after the 15 minute time-out.

7. Output hold will be in effect until it is turned off or until no key has been pressed for 15 minutes.

8. After a successful calibration, select [d.o.] [EFF] from the menu to inspect the new calibration value. This value is used internally to determine the monitor gain.

It is possible to override the automatic operation of the monitor. The enter key may be pressed before the electrode has stabilized, forcing the monitor to calibrate using the current dissolved oxygen reading. Also, the calibration may be redone or started over at anytime. Press the cancel key to display the [CAL] frame, then press the select key to restart the calibration.

The calibration setting will be based on the temperature used for temperature compensation and the pressure used for pressure compensation. The proper ppm dissolved oxygen reading is obtained from an internal table. See Appendix B for a table of values used by the 1816DO monitor.

Error Checking

If the monitor detects a problem during calibration, an error message will appear. If an error has been detected then the calibration was not successful and the previous calibration has been retained. Press any key to acknowledge the error message. Take corrective action and redo the calibration. Consult the **Troubleshooting** section for details. Press any key to resume normal operation after an error message has appeared.

Inserting the Sensor into the Flow Cell

1. Inspect the inside of the flow cell for any foreign matter and wipe out if necessary. It should appear clean, shiny and bright.
2. Insert the assembled and calibrated sensor through the nut and seal ring. Rock back and forth to pass the ring.
3. Press slowly all the way down until the sensor firmly contacts the flow cell bottom.
4. By hand, tighten the nut firmly to get a good seal. This should be good for 5 to 10 psig.

Warning: Do not use a large wrench to tighten the nut. The plastic parts of the sensor could be broken or deformed.

Note: The flow cell is not intended for use at high pressure. The Teflon seal ring is not a tubing ferrule designed to hold against pressure.

Output Hold

The 1816DO monitor allows the user to hold the output for dissolved oxygen. Output hold affects both outputs and alarms if and when these monitor the dissolved oxygen input.

Enable output hold by changing the [d.o.] [HOLd] setting to [YES]. Output hold has the following effect:

1. 4-20 mA output signals transmitting dissolved oxygen are frozen at their current levels.
2. Alarms monitoring DO will maintain existing on/off condition.

The output hold remains in effect until the operator changes the [d.o.] [HOLd] setting to [no], or until no key has been pressed for 15 minutes. The 15 minute time-out ensures that output hold for dissolved oxygen will not remain in effect for longer than 15 minutes if the monitor is left unattended.

Low Level Dissolved Oxygen Test Method

The best way to check low level dissolved oxygen readings at the point of use in the plant is to use a sodium sulfite scrubber with a cobalt chloride catalyst (low ppb level oxygen standard).

Preparation of the Low Level Dissolved Oxygen Standard

To 1 liter of distilled water add 20 grams of sodium sulfite (Na_2SO_3) and 10 milligrams of cobalt chloride (Co_2Cl_2) and mix thoroughly. Alternatively, a 2 % sodium sulfite solution can be used if cobalt chloride is not available. Ensure that the low level standard is used within 8 hours because the oxygen scavenger will be used up quickly with exposure to air.

Submerge the dissolved oxygen sensor in a deep beaker so that it is 2 to 3 inches below the surface of the low level standard. Provide gentle mixing to ensure that any oxygen present is consumed. The sensor reading should rapidly fall to low ppb levels. A dissolved oxygen reading of 50 ppb or less indicates good sensor response in the low level range.

Note: Another method for checking very low ppb response is to plumb the monitor to a known low ppb sample. In power plants, the economizer inlet sample usually has the lowest ppb dissolved oxygen, typically less than 3 ppb. It is always important to plumb low ppb dissolved oxygen samples to the monitor with stainless steel tubing, as plastic tubing will diffuse a few ppb dissolved oxygen and cause high results.

Temperature Compensation

Almost all industrial applications encounter fluctuating temperature and need rapidly responding automatic compensation. The Thermo Scientific Orion dissolved oxygen sensors have a TC built into the dissolved oxygen sensor. The TC is wired to the monitor, allowing the 1816DO monitor to provide digital temperature compensation.

Selecting Manual Temperature Compensation

To see the current temperature compensation method used by the 1816DO monitor during calibration, select [d.o.] [tc] from the menu. See Figure 29.

At this point either [Auto] (for automatic temperature compensation), or [Set] (for manual temperature compensation setpoint) will be displayed, depending on the current setting. To change the setting from [Auto] to [Set] press the enter key to edit the current setting. The display will start blinking, indicating that a selection needs to be made. Use the up or down arrow key to display [Set]. Press the enter key to select manual temperature compensation.

With [Set] still displayed, press the select key (to display and/or adjust the temperature setting to be used with manual temperature compensation. If the current value needs to be changed, press the enter key to edit the current setting. The display will start blinking. Use the up or down arrow key to display the desired temperature for manual temperature compensation. Press the enter key to accept the displayed value.

Barometric Pressure Compensation

The 1816DO monitor uses a manual pressure compensation method. When the monitor is calibrated, the specified pressure is used to determine the concentration of dissolved oxygen. The 100% saturation reading is affected both by temperature and by pressure. While the barometric pressure only affects the 100% saturation reading at calibration, its use eliminates calibration errors due to atmospheric pressure fluctuations that may cause all readings to be off by as much as 2%.

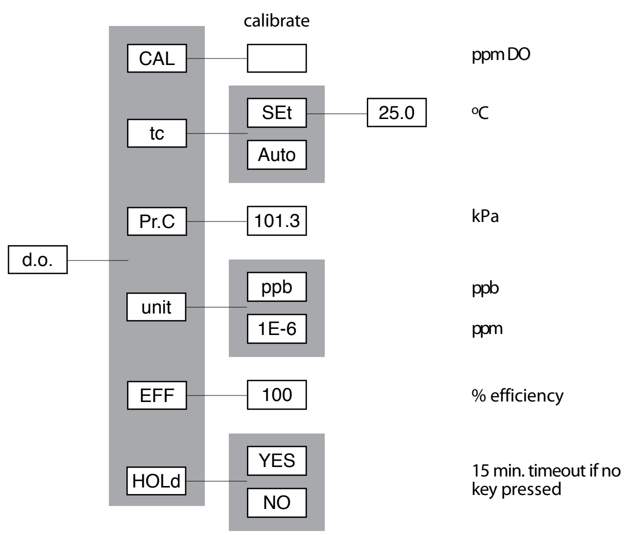
Atmospheric pressure is affected by altitude and weather conditions.

Setting Manual Pressure Compensation

Select [d.o.] [Pr.C] from the menu. See Figure 29. The pressure setting to be used for manual pressure compensation will be displayed. If the current value needs to be changed, press the enter key to edit the current setting. The display will start blinking. Use the up or down arrow key to display the desired pressure for manual pressure compensation. Press the enter key to accept the displayed value.

When metric units are selected (the default), pressure is displayed in kPa. When imperial units are selected, psi is used.

Figure 29
Dissolved Oxygen Menu



Range – Automatic or Manual

Refer to Figure 30.

The 1816DO dissolved oxygen monitor is an auto-ranging monitor. The monitor has four ranges and will automatically switch between these ranges to avoid going off-scale. Under normal operating conditions the monitor will always be configured to switch between ranges automatically. The ranges described here are part of the DO measuring circuitry. The range numbers associated with the 4-20 mA output are part of the output module and are independent of the ranges described here.

You can determine the range which the DO measuring circuit is currently using by selecting [CONF] [in] [d.o.] [rANG]. If the monitor is using manual ranging for the DO measurement then you can go into edit mode and switch ranges. If the monitor is using automatic ranging then this setting can be viewed only.

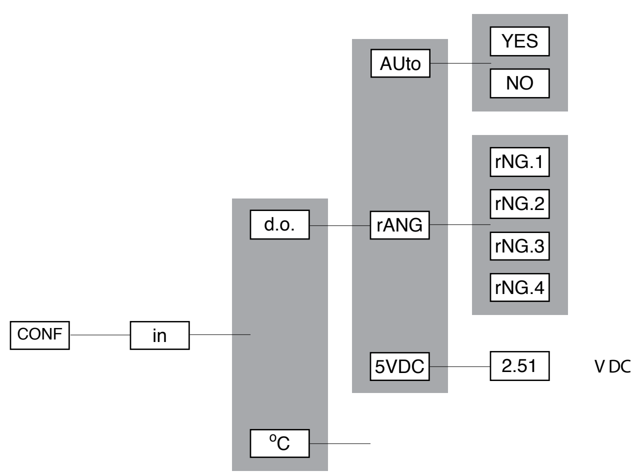
Manual Ranging

By default the monitor is configured to automatically switch between ranges. The automatic switching capability can be disabled in the configuration menu by changing the setting of [CONF] [in] [d.o.] [AUtO] from [YES] to [no]. Once automatic ranging has been disabled you can manually adjust the range by changing the setting in [CONF] [in] [d.o.] [rANG].

Displayed Range

The measuring range of the instrument, e.g. 0 to 10000 ppb dissolved oxygen, is determined by the gain used by the monitor itself and the cell current of the dissolved oxygen sensor. The displayed measuring range is determined by multiplying the cell current by the monitor range gains.

Figure 30
Configuration Menu for DO Input



Chapter 7 Security

Password Security

As part of the installation procedure you need to decide whether password security is to be implemented or not. The factory default is no security.

No password security should be necessary if you are the only user and no protection of settings is needed. Password security should be implemented for critical applications where program settings may only be changed by authorized personnel.

For minimal security, we advise that the user set a level 2 password. Leaving the level 1 password at '000' gives the operator complete access to all areas of the program but does not allow him to change program settings in the configuration menu. With minimal security in place you prevent unauthorized users from enabling password security.

Access Levels

Access Level	Description
0	View-only access to all settings.
1	Access to all settings except for configuration menu. Usage: operator access. No changes can be made to configuration and passwords cannot be changed.
2	Access to all settings. This gives you the same access to the program when password security is not enabled. Passwords can be changed. Usage: installation, management.

Having security disabled gives you the same access to the program as being at access-level 2 at all times.

With security enabled any operator can view settings anywhere in the program. When you do not have proper access rights, the program will display [PASS] for 2 seconds, indicating that you must first enter a proper password before you are allowed to proceed.

Enabling Security

When security is disabled both password 1 and password 2 are set to '0000'. Security is enabled by setting password 2 to a non-zero value.

Select [CONF] [PAS.2] from the menu. The monitor will display [0000]. Use the arrow keys to change the display to the desired password for level 2. You can press the sample key at any time to safely cancel password entry. Press the enter key to enter the password into memory and to enable password security. The monitor program automatically returns to the configuration menu.

With only password 2 set to a non-zero value, level 2 access is required to made changes in the configuration menu but all other settings are unprotected. Effectively the user will always have at least level 1 access.

At this point password 1 is still '000'. You may optionally enable operator access control or level 1 security by changing the level 1 password from '000' to a non-zero value. Change the password by selecting [CONF] [PAS.1] from the menu, then entering an appropriate 3 digit password.

You may want to write down the passwords you set and store them in a secure place. Once a password has been set there is no way to re-display it. Since passwords are set in the configuration menu, level 2 access is required to change either password. If you have forgotten the level 2 password, there is no simple way to regain access to the monitor. Contact Thermo Fisher Scientific if you find yourself locked out of the monitor.

Disabling Password Security

Password security can be disabled by setting the level 2 password to '0000'. To change the password, you must first have level 2 access to the program.

Select [CONF] [PAS.2] from the menu, then press the enter key when the program displays [0000]. Both passwords 1 and 2 are set to '0000' and security is now disabled. The main menu will be changed to exclude the [PASS] frame and the configuration menu will no longer have the [PAS.1] frame.

Password Example – A Quick Tour

With security disabled, select [CONF] [PAS.2] from the menu. Set the level 2 password to ‘0002’. Select [CONF] [PAS.1] from the menu. Set the level 1 password to ‘001’. Security is now enabled. Select [PASS] from the main menu. Press Enter with [0000] displayed. The monitor will display [ACC.0] to indicate we are now at access level 0.

Try changing the input 1 low setting. Select [out] [out1] [LO] from the menu. The current value will display. Press the enter key to go into edit mode. The monitor will display [PASS] for 2 seconds because we need to enter a password first. Level 1 security is needed to change this setting.

Select [PASS] from the main menu again. Change the displayed value to [0001], which is the level 1 password. Press the enter key. The monitor will display [good], followed by [ACC.1], indicating that the password is valid and that we now have level 1 access.

Try changing the output 1 low setting again. You will find that this time we can go into edit mode unhindered.

Select [PASS] from the main menu again. Enter the level 2 password, which is ‘0002’. We are going to set the level 2 password to ‘0000’ again to disable password security. Password 2 is found in the configuration menu and therefore requires level 2 access before it can be accessed. Select [CONF] [PAS.2] from the menu. Press the enter key with [0000] displayed. Both passwords are set to ‘0000’ again and password security is disabled.

Entering a Password

With security enabled, the operator will need to enter a password to gain full access to all monitor functions. To enter a password, select [PASS] from the main menu. The monitor will display [0000]. Use the arrow keys to display your level 1 or level 2 password, then press the enter key. The program will display [good], followed by your access level before returning to the main menu. If an incorrect password was entered the program displays [bAd] instead. Refer to Figure 31 to determine how the program validates a password.

You will now have level 1 or level 2 access for as long as you are working with the monitor. The access level will automatically be restored to level 0 after no key has been pressed for 15 minutes. This 15 minute time-out will also re-display the main sample.

It is good practice to return the monitor to level 0 access (or level 1 access is password 1 is set to ‘000’) when you have finished using the monitor. This is accomplished by selecting [PASS] from the main menu, then pressing the enter key with [0000] displayed.

Passwords – A Quick Tour

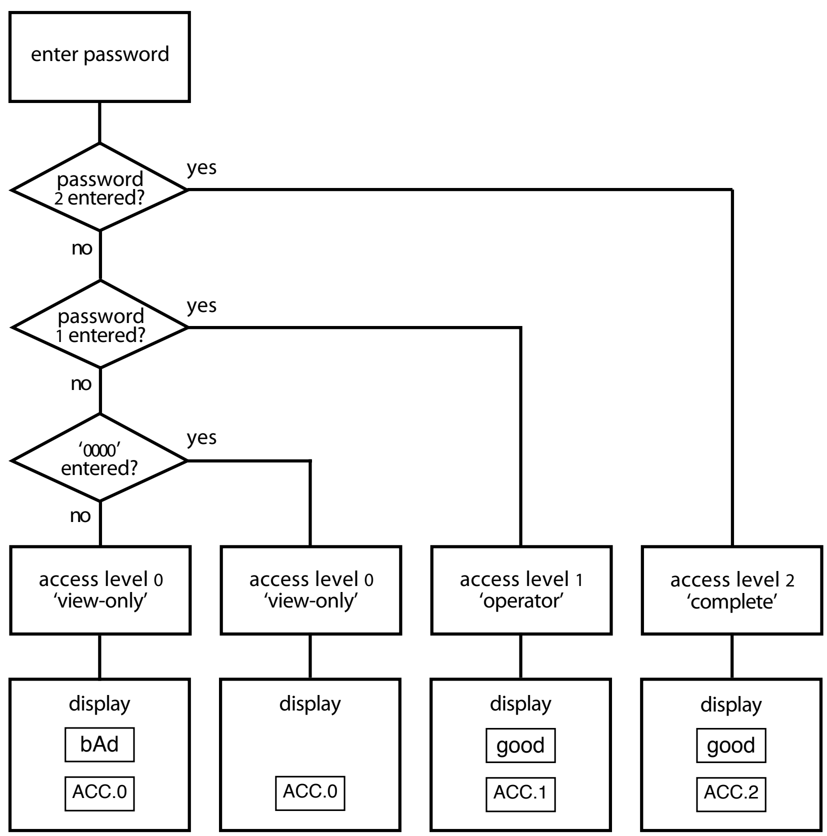
Assuming that password 1 is defined and we are at access level 0, try changing the output 1 low setting. Select [out] [out1] [LO] from the menu. The current value will display. Press the enter key to go into edit mode. The monitor will display [PASS] for 2 seconds because we need to enter a password first. Level 1 security is needed to change this setting.

Select [PASS] from the main. Change the displayed value to the level 1 password, then press the enter key. The monitor will display [good], followed by [ACC.1], indicating that the password is valid and that we now have level 1 access.

Try changing the output 1 low setting again. You will find that this time we can go into edit mode unhindered.

Before walking away from the monitor, we should disable level 1 access to prevent unauthorized users from using the monitor. Select [PASS] from the menu again, then press the enter key with [0000] displayed. The monitor will display [ACC.0] indicating that we have returned to the lowest access level.

Figure 31
Password Validation



Chapter 8 Instrument Maintenance and Troubleshooting

Instrument Maintenance

The Thermo Scientific Orion dissolved oxygen sensors are designed for simple maintenance. The sensors are robust and will withstand difficult applications when properly applied and maintained. Follow instructions in this section to promote proper operation.

Table 5
Recommended Maintenance Schedule

Frequency	Operation
Weekly	Check flow rate, perform visual inspection
Monthly	Inspection of sensor calibration
Yearly	Replace membrane module, replace electrolyte

Weekly Maintenance

1. Check that sample flow rate is between 50 and 200 mL/min.
2. Inspect the unit for leakage.
3. Check that there are no error indications and the displayed concentration is reasonable.

Monthly Maintenance

Certain applications may require occasional sensor cleaning.

1. Do a visual examination of the sensor cell area. If needed, a soft wipe can be used to blot, plus detergent and water to remove any deposits.
2. After cleaning, rinse the sensor cell area with demineralized water.
3. Perform a calibration and return the monitor to service. Refer to the **Calibration** section for step-by-step instructions.
4. Black or red discoloration inside the sensor cap may not cause problems. However, if after calibration the electrode response is slow, replace the electrolyte and wipe the coils and surface lightly using a soft wipe. Recharge with fresh electrolyte.
5. Place the electrode back into sample and run one hour prior to calibration. If the response time is still slow, the membrane module may need replacement. Follow the Yearly Maintenance procedure. Use of an inlet filter upstream of sensor will prolong membrane life.
6. Calibrate and return the sensor to service.

Yearly Maintenance

Replace the membrane module and electrolyte.

1. Unscrew the electrode cap and discard the contents.

2. Flush the cell internal components with demineralized water and rinse with electrolyte.

3. Remove the old membrane module from the cell and replace with a new one. Place electrode back into sample and run at least one hour prior to calibration.

4. Calibrate and place in service.

Assembly of the DO Sensor

This procedure should be done over a sink.

Warning: The electrolyte solution is caustic. Wear thin plastic or rubber gloves. Wash hands thoroughly with lots of water if the electrolyte comes in contact with the skin. Rinse until the slippery feel of the caustic disappears.

1. Remove the protective cap exposing the coils and silver tip. Inspect the electrode to ensure the coils are clean and the silver electrodes are bright and not tarnished. If tarnished, wipe with a lint-free tissue.

2. Install a membrane module in the cap with the membrane facing down so that it covers the center hole in the cap.

3. Flush the coils of the electrode with electrolyte solution. Holding the electrode cap with membrane module installed, in a upright position, fill with electrolyte until the center cavity is full. Tilt it at about a 30 degree angle and add an extra 1/8 inch of electrolyte, observing that the crack around the membrane module fills with electrolyte.

4. Hold the cap like a cup and slowly lower the electrode coils vertically down into the cap until the threads touch. Rotate the sensor body until you can see the flat area through the threads. Slowly rotate the cap on, allowing the excess electrolyte and bubbles to overflow up the flat area. Continue to slowly rotate the cap until a firm stop is reached.

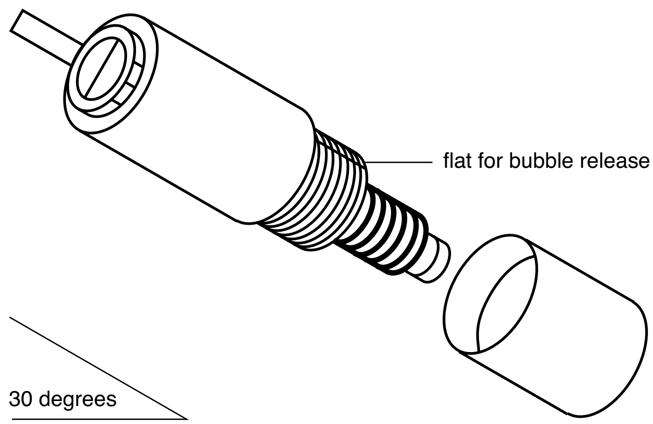
Warning: Do not force the cap beyond the stop. The parts are plastic and may break.

5. Dry the sensor and blot the tip. Examine the tip – the membrane should be smooth with no wrinkles or cuts and the surface contours of the silver electrode should be clear. There should be no lines from trapped bubbles between the membrane and the silver electrode. If there are no visible problems as described here, then the sensor is ready to be put into service.

Re-Inserting the Sensor into the Flow Cell

Refer to the step-by-step instructions in the **Calibration** section. The recommended supplies for this procedure are packaged in the maintenance kit, Cat. No. 181622, which includes a membrane module, O-ring and electrode internal fill solution.

Figure 32
DO Cell Assembly



Troubleshooting

The following section covers troubleshooting that can be performed, mostly without special tools or skills.

Error and Description	Causes	Remedy
+ Err Reading off scale	Dissolved oxygen is beyond measuring capability range	Switch to automatic range switching or select higher range in [CONF] [in] [do] [rANG] New sensor needed or monitor needs electronic range adjustment
000 No dissolved oxygen measurement	Sensor reading is below measuring capability of monitor or there is an open circuit	Manual range switching in effect and monitor needs to be on lower range Sensor not connected or bad connection
E11 Sensor has not stabilized after 5 minutes of calibration	Poor sensor performance, sample is not stable or interference present	Check sensor and setup until stable reading is achieved, then redo the calibration
E12 Sensor efficiency would be greater than 500% and the previous setting was retained	Improper sensor setup or sensor failure	Setup sensor and redo calibration Refer to the **Troubleshooting** section
E13 Sensor efficiency would be less than 33% and the previous setting was retained	No DO signal, signal from sensor is very weak or manual range switching in effect and analyzer is on low range	Check the sensor connection and redo the calibration Change to automatic range switching or change range to range 4
E15 Temperature compensator is off scale	Process outside of TC operating range of -5 °C to 105 °C or the TC is not connected	Use manual temperature compensation Check TC connections or install TC
- Err Temperature reading off scale, temperature is less than -5 °C	Electronic calibration necessary or temperature is less than -5 °C	Verify process and sensor location Follow the procedure in the **Electronic Hardware Troubleshooting** section
+ Err Temperature reading off scale, temperature is greater than 105 °C	Temperature compensator not attached, electronic calibration necessary or temperature is greater than 105 °C	Attach temperature compensator, verify process and sensor location Turn off temperature input, follow Input On/Off Switch procedure in the **Instrument Operation** section Connect a resistor to TC terminals to stimulate a constant temperature, refer to the **Electronic Hardware Troubleshooting** section

Slow response
Typically this problem is due to excessive sample line length and low flow, thus producing long sample transport lags. Resolve the issue by adding a fast-flow loop with the sensor in a short side stream, or by shortening the line. Slow response can also be caused by a buildup of dirt in the sample line. In this case the problem may be alleviated by changing the take-off point or by installing a knock-out pot or sintered stainless steel filter. Consult Technical Support for specific solutions.

Readings consistently low or spike low
This problem is characteristic of wiring problems between the monitor and the sensor, an open circuit in the field wiring will result in zero cell current and a reading less than 1 ppb. Review the installation instructions in the **Instrument Preparation** section.

Readings gradually falling
This problem is usually due to the monitor no longer being calibrated properly. This issue is typical of sludge/slime deposits on the sensor face. The sensor will need to be cleaned. Refer to the yearly maintenance procedure in the **Instrument Maintenance** section.

Readings trend where expected but spike high
This problem is typical of air bubbles in the sample line. If a bubble hangs up in the DO flow cell, you may see a high surge that slowly falls over some hours. Correct by finding air in-leakage point and stopping leak.

Note: You can clear an air bubble stuck in the flow cell by loosening the cell retaining nut and letting the cell rise up a bit, then pressing it back in until it bottoms.

Assistance

After troubleshooting all components of your measurement system, contact Technical Support. Within the United States call 1.800.225.1480 and outside the United States call 978.232.6000 or fax 978.232.6031. In Europe, the Middle East and Africa, contact your local authorized dealer. For the most current contact information, visit www.thermo.com/contactwater.

For the latest application and technical resources for Thermo Scientific Orion products, visit www.thermo.com/waterapps.

Warranty

For the most current warranty information, visit www.thermo.com/water.

Electronic Hardware Troubleshooting

Alignment of the Dissolved Oxygen Detection Circuit

1. Set up a precision multimeter, Fluke 8051A or equivalent, to read VDC.

2. Use the 'D.O. +' sensor connection, TB200-1 and 'D.O.-' sensor, TB200-3, as common. See the wiring diagram.

3. Place the monitor on manual range selection by selecting [CONF] [in] [d.o.] [Auto] from the menu and editing the setting to read [no].

4. Set the DO input range to range 4 by selecting [CONF] [in] [d.o.] [rANG] from the menu and editing the setting to read [rNG.4].

5. Set the DO efficiency constant to 100% by selecting [d.o.] [EFF] from the menu and editing the value to read 100.0%.

6. Adjust the electronic standardize with blue trimpot VR200, located mid-board above the DO terminal block. Adjust the trimpot to a reading of 2.50V at TP201 while imputing 0.120 VDC through a 10K 1% resistor. 0.120 VDC simulates 8240 ppb DO at approximately 100% efficiency under above conditions.

7. Return the monitor to automatic range selection by selecting [CONF] [in] [d.o.] [Auto] from the menu and editing the setting to read [YES].

Alignment of the Temperature Input Circuit

The temperature input can be adjusted both by making electronic adjustments and/or by having the program compensate for differences in offset. Both procedures are described in the following sections.

Adjusting Electronic Calibration

1. Remove any offset calculated by a previous software calibration of the temperature input. Select [CONF] [in] [°C] [OFFS] from the menu and edit the offset to read 0.0.

2. Set up a precision multimeter, Fluke 8051A or equivalent to read VDC.

3. Use the 'TEMP' sensor connection, TB201-2, as common. See wiring diagram. Place a 100 ohm 1% resistor across T+ and T-. Adjust blue trimpot VR201, located mid-board, for a reading of 0.200 V at TP202. Refer to the wiring diagram for component locations.

4. Place a 138.5 ohm 1% resistor across T+ and T-. Adjust blue trimpot VR202, located mid-board, for a reading of 4.85 V at TP202. Refer to the wiring diagram for component diagrams.

5. Close the case and press the sample key followed by the down arrow key to display the temperature reading.

6. Re-insert the 100 ohm 1% resistor and adjust as in step 3 until the display reads 0.0 ±0.1 °C.

7. Re-insert the 138.5 ohm 1% resistor and adjust as in step 4 until the display reads 100.0 ±0.1 °C.

Software Calibration

To do a software calibration of the temperature input, the correct temperature needs to be known.

1. Select [CONF] [in] [°C] [CAL] from the menu. The actual temperature as measured by the temperature sensor will be shown. Edit the displayed value to the known, correct temperature. Press the enter key to leave the edit mode, then press the select key to start the calibration.

2. The current temperature will be shown using a flashing display. When it looks like the input is stable, press the enter key to set the new temperature. The software offset for the temperature input will be adjusted automatically.

3. The calculated offset in degrees Celsius can be viewed by selecting [CONF] [in] [°C] [OFFS] from the menu. Whenever the hardware alignment is 'correct', the offset will be 0.0. The displayed offset can be edited.

Calibration of 4 to 20 mA Outputs

Use one of the following two approaches to get the monitor to output the desired current level and then make electronic adjustments to calibrate the output.

Approach 1 – Simulated 4-20 mA Output (Self Calibration)

1. Select [cur] from the output 1 menu to display the present output current in mA. The display will be updated as the output current changes based on the input signal and the program settings.

2. To simulate a different 4-20 mA output signal, press the enter key to enter edit mode. Use the up and down arrow keys to display the desired output needed for testing the output signal. Press the enter key to select the displayed value. The output signal will be adjusted to put out the desired current. This process can be repeated as often as necessary to output different signal levels.

3. The output signal is held at the displayed level until the program leaves this menu selection. Make calibration adjustments while the monitor shows the output at 20.00 mA.

4. Repeat the above steps for output 2.

Approach 2 – Use Voltage Source to Adjust Input

This faster calibration approach requires a voltage source for the input.

1. To calibrate output 1, set [in] = [°C]. Input a low enough signal to cause monitor to indicated [-Err]; the monitor will output 4.00 mA. Reverse the polarity or input a high enough signal to cause the monitor to indicate [+Err]; monitor will output 20.00 mA.

2. Repeat step 1 for output 2.

Note: Both outputs can be simultaneously calibrated if you set [in] = [°C] for both inputs.

Adjusting Electronic Calibration

1. Outputs are isolated from main circuit, therefore measurements are made with common at the output 2 terminal, TB304.

2. Measure output 1 ‘zero’ at TP301 (pin 8 of U304), while output 1 is outputting 4.00 mA. Reading should be between -0.870 and 0.890V. Adjust #2 voltage with VR300.

3. Change monitor output to 20.00 mA, switch meter to mA and measure + Terminal (+ terminal of O/P 1) and adjust VR301 so that the current reads 20.00 mA. Return monitor output to 4.00 mA and trim actual output to 4.00 mA using VR300. Check again at 20.00 mA and repeat adjustments until satisfied.

4. Measure output 2 zero at TP300 (pin 7 of U304), while output 2 is outputting 4.00 mA. The test point should read between -0.870 and 0.890V. Adjust #2 ‘zero’ voltage with VR302.

5. Change output at output 2 to 20.00 mA, switch meter to mA at TB304, + terminal of output 2and adjust VR303 (span pot) until the current reads 20.00 mA.

Note: Zero and span are very wide range adjustments which show small interactions. Recheck zero and span to confirm good calibration.

6. If so desired, all software settings can be returned to factory default condition by following the procedure in Appendix D.

Testing Relay Outputs

1. Relay output operation can be verified by testing for contact closure or continuity at each relay. To activate a relay, select [CONF] [NO.NC] [AL.A] from the menu. Press the enter key to go into edit mode, then press the up or down arrow key to change the normally open/normally closed configuration from open to closed. Press the enter key again to accept the new value. A closed contact should open, an open contact should close.

2. Repeat step 1 for the Alarm B contact.

3. If so desired, all software settings can be returned to factory default condition by following the procedure in Appendix D.

Notice Of Compliance

This meter may generate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type-tested and found to comply with the limits for Class A computing device in accordance with specifications in Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in an industrial installation. However, there is no guarantee that interference will not occur in a particular installation. If the meter does cause interference to radio or television reception, which can be determined by turning the unit off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the meter with respect to the receiver
- Move the meter away from the receiver
- Plug the meter into a different outlet so that the meter and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: "How to Identify and Resolve Radio-TV Interference Problems"

This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402. Stock No. 004-000-00345-4.

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

'Le present appareil numerique n'emet pas de bruits radioelectriques depassant les limites applicables aux appareils numeriques (de la class A) prescrites dans le Reglement sur le brouillage radioelectrique edicte par le ministere des Communications du Canada'.

Ordering Information

Dissolved Oxygen Monitor, Cat. No. 1816DO, 100 ppt to 10,000 ppb

Cat. No.	Description
1816DO	Low-level dissolved oxygen monitor, includes electronic housing with two 4-20 mA outputs and two relay outputs, oxygen electrode complete with membrane module, stainless steel housing and attached 10 ft. shielded cable, stainless steel flow cell, maintenance kit that includes spare membrane module, O-ring and fill solution (181622) and user guide, wired for 115/220V, 50/60 Hz, 50 watts
181621*	Dissolved oxygen electrode with stainless steel housing with attached 10 ft. cable and maintenance kit that includes membrane module, O-ring and internal fill solution
181622	Maintenance kit, includes membrane module, O-ring and internal fill solution
222609-001	O-ring seal for inlet fitting
1816FP	Fluidics panel with needle valve and bypass with carrying handle, used to prolong membrane life and provide portability of monitor

* Contact Thermo Fisher Scientific for availability of custom cable lengths up to 30 feet.

Specifications

Measuring Range	0.1 to 10,000 ppb dissolved oxygen
Display	Four and one half LCD digits for concentration, temperature, efficiency, error codes, prompts and diagnostic information
Signal Outputs	Two continuous assignable, programmable 4-20 mA or 0-20 mA, isolated max, load 600 ohms, convertible to 1 to 5 or 0 to 5 VDC Two relays, SPBT, Form C, rated 10 amp 115 V, 5 amp 230 V, 5 position BCD contact closure RS232 bidirectional serial data port
Accuracy	Standard deviation ± 2% of reading or 0.1 ppb, whichever is greater
Precision	Standard deviation ± 2% of reading or 0.1 ppb, whichever is greater
Sample Conditions	Temperature: 2 to 45 °C (35 to 113 °F) Sample Flow: 50 mL/min minimum; 200 mL/min maximum Pressure: < 60 psig (4 bar) pH > 4
Response Time	90% within two minutes, function of flow
Sample Inlet	1/4” NPT tube “0” seal fitting
Sample Outlet	1/4” NPT tube fitting
Calibration	In water vapor saturated air / monthly
Environment	Temperature: 5 to 45 °C Humidity: 95% relative max, non-condensing; splashproof IP65
Monitor Dimensions	26 x 16 x 9 cm (W x H x D) 10.24 x 6.3 x 3.54” (W x H x D)
Weight	4.9 kg 10.8 lbs
Shipping Weight	6.1 kg 13.4 lbs
Electrical Requirements	115/230 V 10%, 50/60 Hz, 50 watts, 0.5 amp single phase

Note: Specifications are subject to change without notice.

Appendix A Default Settings

The following program settings are the default settings for the monitor. New monitors will have these settings unless the setup has already been customized for your application.

	Output 1	**Output 2**
Transmitted Input	DO	Temperature
Low Setting	0 ppb	0.0 °C
High Setting	100 ppb	100 °C
Units	ppb	°C
ON/OFF Switch	ON	ON
Automatic Range Indication	OFF	—

	Alarm A	**Alarm B**
Input For Alarm	DO	DO
Alarm Function	High	High
ON/OFF Switch	OFF	OFF
Setpoint	10 ppb	100 ppb
Differential	1.0 ppb	1.0 ppb

Global Units – Metric units, temperature in degrees Celsius, pressure in kPa.

Alarm Contacts – Configured normally open.

Security – Not enabled.

Temperature Compensation – Automatic TC using temperature input.

Input ON/OFF Configuration – The temperature input is on and will show up in the sample menu.

Serial Communications – ON/OFF switch = OFF, baud rate 1200.

Appendix B Saturated DO Values

The table below lists show the concentration of dissolved oxygen in water over a range of temperature and pressure. Dissolved oxygen values are reported as parts per million. During calibration the 1816DO monitor uses the table below to determine the efficiency of the cell.

°C/TORR	700	705	710	715	720	725	730	735	740	745	750	755	760	765	770	775	780	785	790	795
0	13.41	13.51	13.60	13.70	13.80	13.89	13.99	14.08	14.18	14.28	14.37	14.47	14.57	14.66	14.76	14.86	14.95	15.05	15.15	15.24
1	13.05	13.14	13.23	13.33	13.42	13.51	13.61	13.70	13.80	13.89	13.98	14.08	14.17	14.27	14.36	14.45	14.55	14.64	14.73	14.83
2	12.70	12.79	12.88	12.97	13.06	13.15	13.24	13.34	13.43	13.52	13.61	13.70	13.79	13.88	13.97	14.07	14.16	14.25	14.34	14.43
3	12.36	12.45	12.54	12.63	12.72	12.80	12.89	12.98	13.07	13.16	13.25	13.34	13.43	13.52	13.61	13.69	13.78	13.87	13.96	14.05
4	12.04	12.12	12.21	12.30	12.38	12.47	12.56	12.64	12.73	12.82	12.90	12.99	13.08	13.16	13.25	13.34	13.42	13.51	13.60	13.68
5	11.73	11.81	11.90	11.98	12.07	12.15	12.23	12.32	12.40	12.49	12.57	12.66	12.74	12.83	12.91	13.00	13.08	13.16	13.25	13.33
6	11.43	11.51	11.60	11.68	11.76	11.84	11.93	12.01	12.09	12.17	12.25	12.34	12.42	12.50	12.58	12.67	12.75	12.83	12.91	13.00
7	11.15	11.23	11.31	11.39	11.47	11.55	11.63	11.71	11.79	11.87	11.95	12.03	12.11	12.19	12.27	12.35	12.43	12.51	12.59	12.67
8	10.87	10.95	11.03	11.11	11.19	11.26	11.34	11.42	11.50	11.58	11.66	11.74	11.81	11.79	11.97	12.05	12.13	12.21	12.29	12.36
9	10.61	10.69	10.76	10.84	10.92	10.99	11.07	11.15	11.22	11.30	11.38	11.45	11.53	11.61	11.68	11.76	11.84	11.91	11.99	12.07
10	10.36	10.43	10.51	10.58	10.66	10.73	10.81	10.88	10.96	11.03	11.11	11.18	11.26	11.33	11.41	11.48	11.56	11.63	11.71	11.78
11	10.11	10.19	10.26	10.33	10.41	10.48	10.55	10.63	10.70	10.77	10.85	10.92	10.99	11.07	11.14	11.21	11.29	11.36	11.43	11.51
12	9.88	9.95	10.03	10.10	10.17	10.24	10.31	10.38	10.46	10.53	10.60	10.67	10.74	10.81	10.89	10.96	11.03	11.10	11.17	11.24
13	9.66	9.73	5.80	9.87	9.94	10.01	10.08	10.15	10.22	10.29	10.36	10.43	10.50	10.57	10.64	10.71	10.78	10.85	10.92	10.99
14	9.45	9.51	9.58	9.65	9.72	9.79	9.86	9.93	9.99	10.06	10.13	10.20	10.27	10.34	10.41	10.48	10.54	10.61	10.68	10.75
15	9.24	9.31	9.37	9.44	9.51	9.58	9.64	9.71	9.78	9.84	9.91	9.98	10.05	10.11	10.18	10.25	10.32	10.38	10.45	10.52
16	9.04	9.11	9.17	9.24	9.31	9.37	9.44	9.50	9.57	9.64	9.70	9.77	9.83	9.90	9.96	10.03	10.10	10.16	10.23	10.29
17	8.85	8.92	8.98	9.05	9.11	9.18	9.24	9.30	9.37	9.43	9.50	9.56	9.63	9.69	9.76	9.82	9.89	9.95	10.01	10.08
18	8.67	8.73	8.80	8.86	8.92	8.99	9.05	9.11	9.18	9.24	9.30	9.37	9.43	9.49	9.56	9.62	9.68	9.75	9.81	9.87
19	8.49	8.56	8.62	8.68	8.74	8.80	8.87	8.93	8.99	9.05	9.12	9.18	9.24	9.30	9.36	9.43	9.49	9.55	9.61	9.67
20	8.33	8.39	8.45	8.51	8.57	8.63	8.69	8.75	8.81	8.87	8.93	9.00	9.06	9.12	9.18	9.24	9.30	9.36	9.42	9.48
21	8.16	8.22	8.28	8.34	8.40	8.46	8.52	8.58	8.64	8.70	9.76	8.82	8.88	8.94	9.00	9.06	9.12	9.18	9.24	9.30
22	8.01	8.06	8.12	8.18	8.24	8.30	8.36	8.42	8.48	8.53	8.59	8.65	8.71	8.77	8.83	8.89	8.95	9.01	9.06	9.12
23	7.85	7.91	7.97	8.03	8.09	8.14	8.20	8.26	8.32	8.37	8.43	8.49	8.55	8.61	8.66	8.72	8.78	8.84	8.90	8.95
24	7.71	7.76	7.82	7.88	7.94	7.99	8.05	8.11	8.16	8.22	8.28	8.33	8.39	8.45	8.50	8.56	8.62	8.67	8.73	8.79
25	7.57	7.62	7.68	7.73	7.79	7.85	7.90	7.96	8.01	8.07	8.13	8.18	8.24	8.28	8.35	8.41	8.46	8.52	8.57	8.63
26	7.43	7.49	7.54	7.60	7.65	7.71	7.76	7.82	7.87	7.93	7.98	8.04	8.09	8.15	8.20	8.26	8.31	8.37	8.42	8.48
27	7.30	7.35	7.41	7.46	7.52	7.57	7.62	7.68	7.73	7.79	7.84	7.89	7.95	8.00	8.06	8.11	8.17	8.22	8.27	8.33
28	7.17	7.22	7.28	7.33	7.38	7.44	7.49	7.54	7.60	7.65	7.70	7.76	7.81	7.86	7.92	7.97	8.02	8.08	8.13	8.18
29	7.05	7.10	7.15	7.20	7.26	7.31	7.36	7.41	7.47	7.52	7.57	7.63	7.68	7.73	7.78	7.84	7.89	7.94	7.99	8.05
30	6.93	6.98	7.03	7.08	7.13	7.19	7.24	7.29	7.34	7.39	7.44	7.50	7.55	7.60	7.65	7.70	7.76	7.81	7.86	7.91
31	6.81	6.86	6.91	6.96	7.01	7.06	7.12	7.17	7.22	7.27	7.32	7.37	7.42	7.47	7.52	7.58	7.63	7.68	7.73	7.78
32	6.70	6.75	6.80	6.85	6.90	6.95	7.00	7.05	7.10	7.15	7.20	7.25	7.30	7.35	7.40	7.45	7.50	7.55	7.60	7.65
33	6.58	6.63	6.68	6.73	6.78	6.83	6.88	6.93	6.98	7.03	7.08	7.13	7.18	7.23	7.28	7.33	7.38	7.43	7.48	7.53
34	6.48	6.53	6.57	6.62	6.67	6.72	6.77	6.82	6.87	6.92	6.97	7.02	7.07	7.11	7.16	7.21	7.26	7.31	7.36	7.41
35	6.37	6.42	6.47	6.52	6.56	6.61	6.66	6.71	6.76	6.81	6.86	6.90	6.95	7.00	7.05	7.10	7.15	7.19	7.24	7.29
36	6.27	6.32	6.36	6.41	6.46	6.51	6.55	6.60	6.65	6.70	6.75	6.79	6.84	6.89	6.94	6.98	7.03	7.08	7.13	7.18
37	6.17	6.21	6.26	6.31	6.36	6.40	6.45	6.50	6.54	6.59	6.64	6.69	6.73	6.78	6.83	6.88	6.92	6.97	7.02	7.06
38	6.07	6.11	6.16	6.21	6.25	6.30	6.35	6.39	6.44	6.49	6.53	6.58	6.63	6.67	6.72	6.77	6.81	6.86	6.91	6.95
39	5.97	6.02	6.06	6.11	6.15	6.20	6.25	6.29	6.34	6.39	6.43	6.48	6.52	6.57	6.62	6.66	6.71	6.75	6.80	6.85
40	5.88	5.92	5.97	6.01	6.06	6.10	6.15	6.19	6.24	6.29	6.33	6.38	6.42	6.47	6.51	6.56	6.60	6.65	6.70	6.74
41	5.78	5.83	5.87	5.92	5.96	6.01	6.05	6.10	6.14	6.19	6.23	6.28	6.32	6.37	6.41	6.46	6.50	6.55	6.59	6.64
42	5.69	5.73	5.78	5.82	5.87	5.91	5.96	6.00	6.04	6.09	6.13	6.18	6.22	6.27	6.31	6.36	6.40	6.45	6.49	6.53
43	5.60	5.64	5.68	5.73	5.77	5.82	5.86	5.91	5.95	5.99	6.04	6.08	6.13	6.17	6.21	6.26	6.30	6.35	6.39	6.43
44	5.51	5.55	5.59	5.64	5.68	5.72	5.77	5.81	5.86	5.90	5.94	5.99	6.03	6.07	6.12	6.16	6.20	6.25	6.29	6.33
45	5.42	5.46	5.50	5.55	5.59	5.63	5.68	5.72	5.76	5.81	5.85	5.89	5.94	5.98	6.02	6.06	6.11	6.15	6.19	6.24
46	5.33	5.37	5.42	5.46	5.50	5.54	5.59	5.63	5.67	5.71	5.76	5.80	5.84	5.88	5.93	5.97	6.01	6.05	6.10	6.14
47	5.24	5.28	5.33	5.37	5.41	5.45	5.50	5.54	5.58	5.62	5.67	5.71	5.57	5.79	5.83	5.88	5.92	5.96	6.00	6.05
58	5.16	5.20	5.24	5.28	5.32	5.37	5.41	5.45	5.49	5.53	5.57	5.62	5.66	5.70	5.74	5.78	5.83	5.87	5.91	5.95
49	5.07	5.11	5.15	5.20	5.24	5.28	5.32	5.36	5.40	5.44	5.49	5.53	5.57	5.61	5.65	5.69	5.73	5.78	5.82	5.86
50	4.99	5.03	5.07	5.11	5.15	5.19	5.23	5.27	5.31	5.36	5.40	5.44	5.48	5.52	5.56	5.60	5.64	5.68	5.72	5.77

Appendix C Display Prompts

[0-20]	Use 0-20 mA configuration for output
[0-5]	Use 0-5 VDC configuration for output
[1-5]	Use 1-5 VDC configuration for output
[1E-6]	Part per million DO unit selection in scientific notation
[4-20]	Use 4-20 mA configuration for output
[5VDC]	Diagnostic to display 0-5 VDC raw input voltage for DO input
[ACC.n]	Access level for security, displayed after password entry by user
[AL]	Alarms
[AL.A]	Alarm A
[AL.B]	Alarm B
[Auto]	Automatic ranging for DO circuit: yes/no switch
[ArnG]	Automatic range switching for 4-20 mA output
[bAud]	Baud rate for serial communications
[°C]	Temperature in degrees Celsius; use metric units
[dEv]	Deviation alarm
[CAL]	Calibrate monitor
[CLSd]	Normally closed alarm contact
[CONF]	Configuration of program to match hardware
[cur]	Signal output in mA, or current
[d.o.]	Dissolved oxygen output
[EFF]	DO cell efficiency constant, as % efficiency, adjusted by calibration
[Err]	Error or warning number, error messages 1-6 are errors, messages 7-9 are warnings
[Er.94]	Startup condition: RAM checksum failed, some settings may be lost
[oF]	Temperature in degrees Fahrenheit; use imperial units
[FLt]	Fault alarm
[HI]	High alarm; high limit (20 mA) for 4-20 mA output window
[Hold]	Output hold
[in]	Input menu or setting
[kPa]	Units for pressure
[LO]	Low alarm; low limit (4 mA) for 4-20 mA output window
[NO.NC]	Normally Open/Normally Closed alarm contact
[OFF]	Off

[OFFS]	Offset
[on]	On
[ON.OF]	On/Off setting
[OPEN]	Normally open alarm contact
[out]	Output menu
[out 1]	First 4-20 mA analog output channel
[out 2]	Second 4-20 mA analog output channel
[PAS.1]	Set password 1, operator access
[PAS.2]	Set password 2, operator access
[PASS]	Enter password to change access level
[Pr.C.]	Pressure compensation setting
[PrES]	Pressure
[PSI]	PSI units for pressure
[rANG]	Monitor DO input range selection
[rES]	Reset calibration settings
[rNG]	Range number generated by 4-20 mA output
[rNG.n]	Range number for DO measuring circuit
[SEr]	Serial communications menu
[SEt]	Setpoint; select manual temperature compensation
[StbY]	Standby mode for monitor
[t.c.]	Temperature compensation setting
[unit]	Unit display or selection

Appendix D Resetting the Instrument

Occasionally it may be desirable to re-initialize all of the program settings to bring them back to defaults. Executing the initialization procedure will cause the monitor to reset all the program variables and settings to factory-default settings as found in Appendix A.

Caution: Do not use the initialization procedure unless you are absolutely sure that you want to restore the factory-default configuration. All user setting will be lost.

After the monitor program has been initialized, you will need to re-enter the output signal settings, alarm settings, as well as the program configuration if it was different from the factory-default settings. For your convenience, the monitor will remember your most recent menu selections.

Select [CONF] [init] [ALL] from the menu. The display will flash [do]. Nothing will happen if at this point you press the cancel key or one of the escape keys (the sample, cal or error key). The 1816DO monitor will be re-initialized when the user presses the enter key.

Appendix E Unit Conversion

Dissolved Oxygen Units

1000 ppb = 1 ppm

1 ppb = 0.001 ppm

1 ppm is approximately 1 mg/L. Some variation occurs because the density of water varies slightly with temperature.

% saturation is directly related to the temperature and pressure of the system. A given ppb will give a different % saturation value depending on the variation in temperature and pressure. See Appendix B.

Temperature Units

°C = 5/9 (°F - 32)

°F = (9/5 * °C) + 32

Pressure Units

1 kilopascal = 0.145 psi

1 psi = 6.895 kilopascal

1 atmosphere = 101.3 kilopascal

1 atmosphere = 14.70 psi

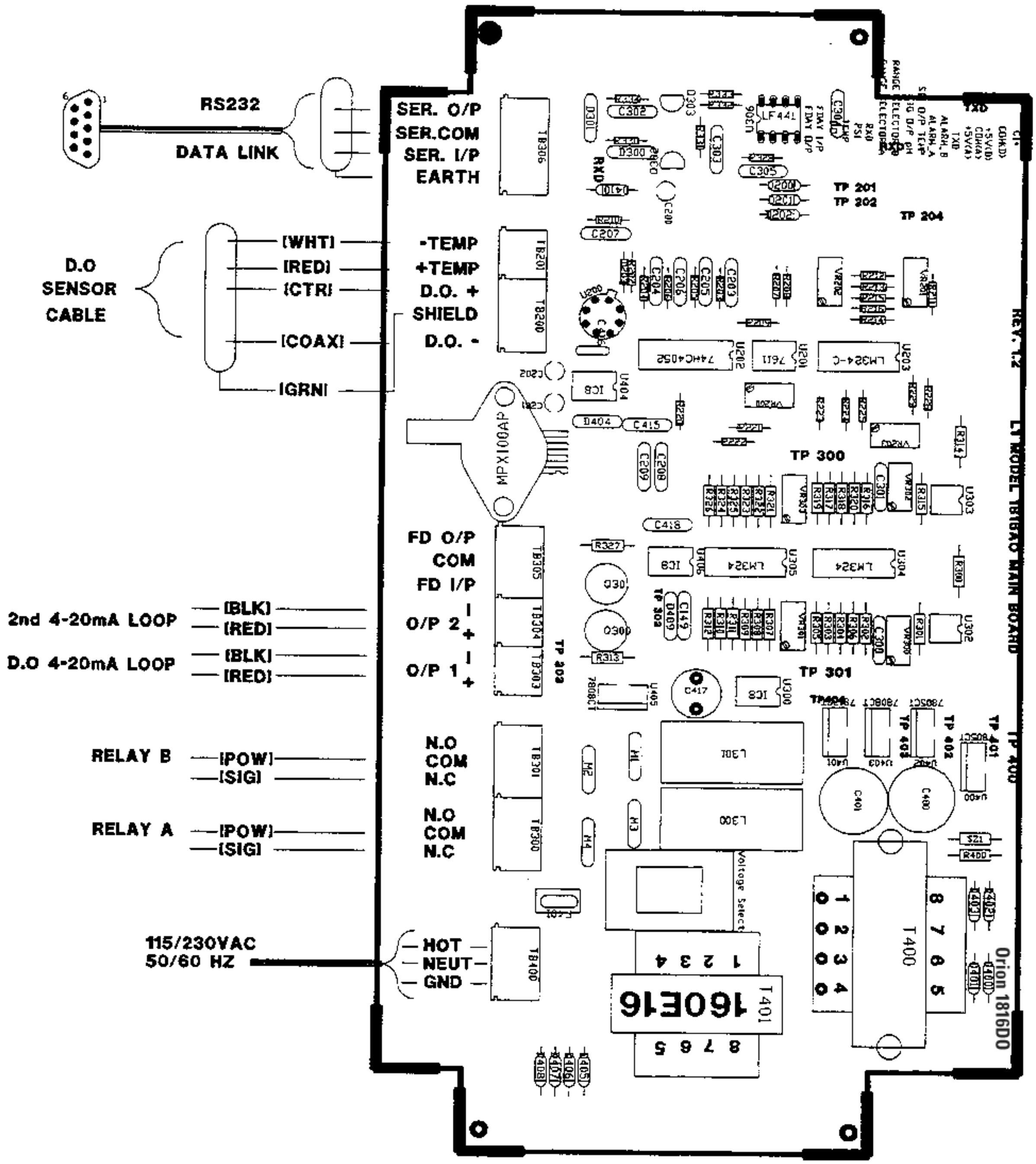
1 atmosphere = 1.01325 bar

1 atmosphere = 760 mm Hg

1 mm Hg = 1 Torr

1 bar = 100 kilopascal

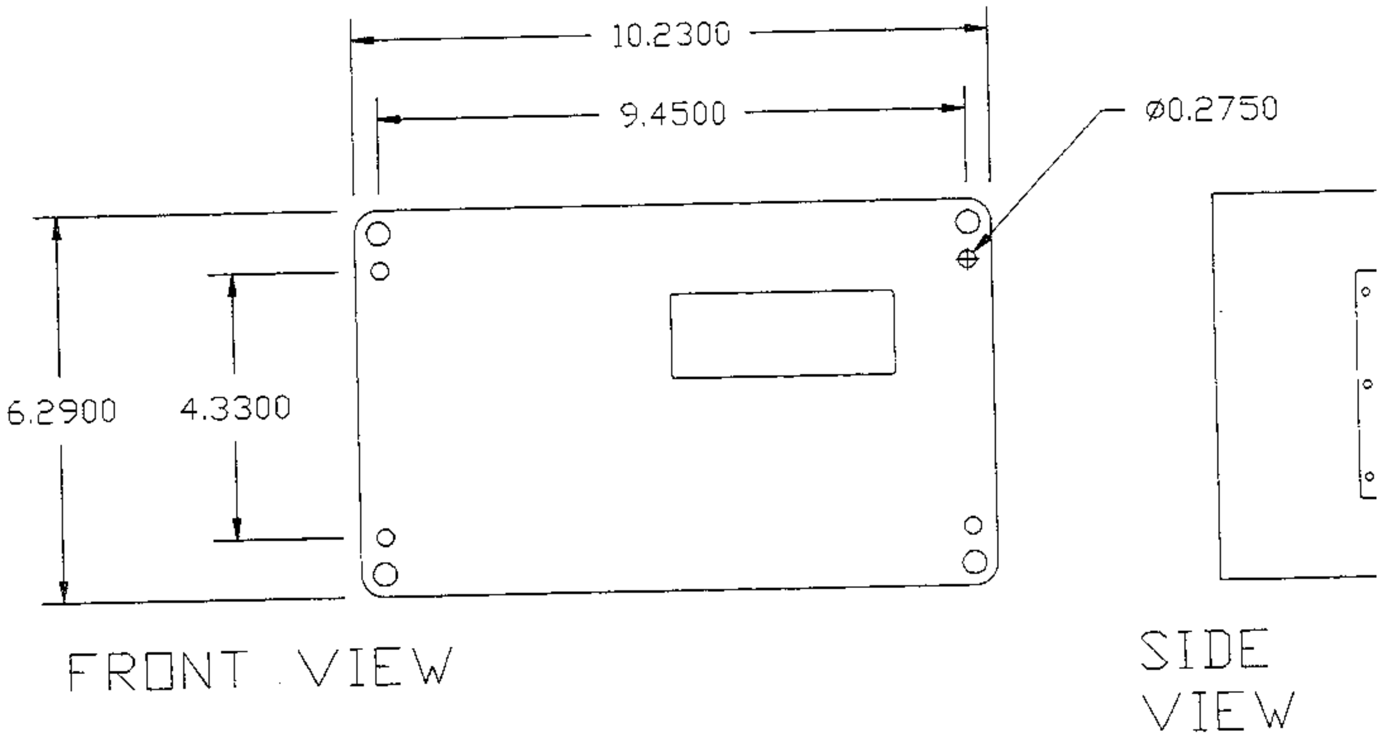
1816DO Wiring Diagram

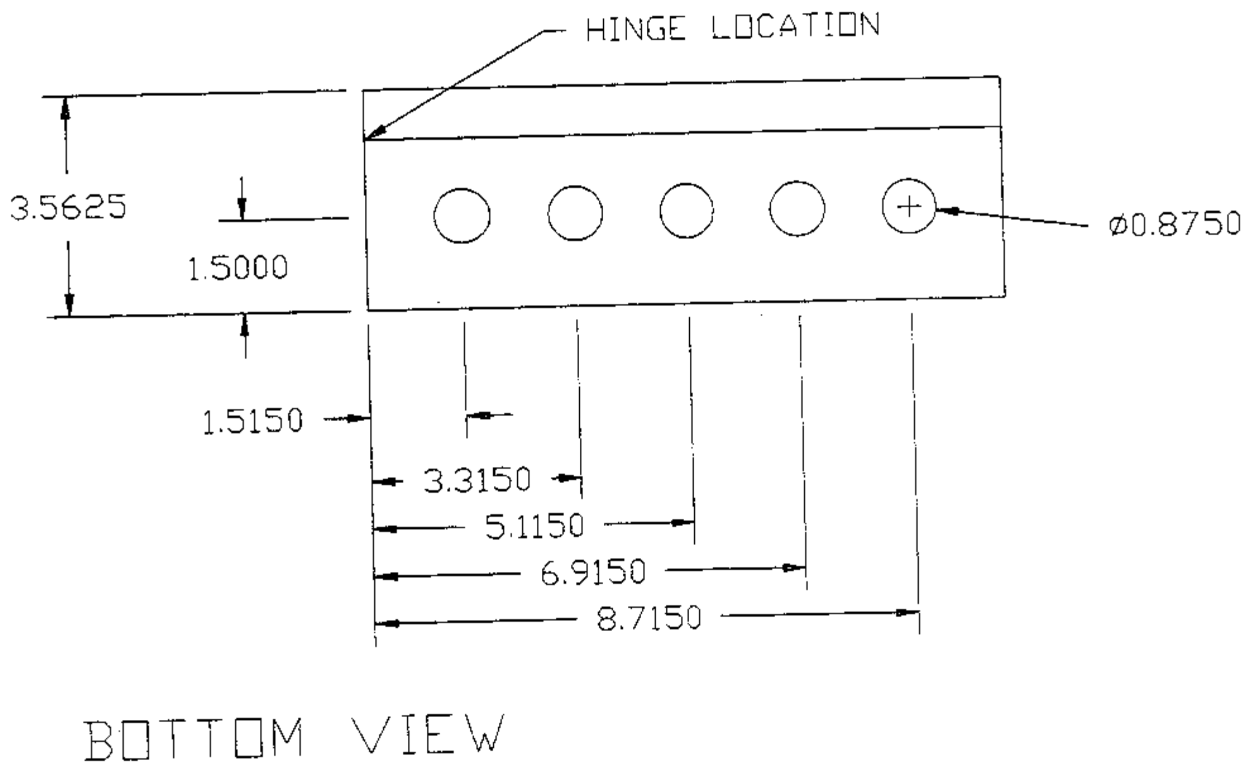


NOTE 1

LINE VOLTAGE SELECTOR SWITCH
MUST BE SET TO PROPER POSITION
BEFORE APPLYING POWER.

1816DO Mounting Dimensions





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