



## **TECHNICAL MANUAL**

**FOR**

**MODEL 8410A**

**PORTASAL™**

### **NOTICE**

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## 1. INTRODUCTION

### 1.1. SCOPE

This manual describes the operation and servicing of the Model 8410A Portasal portable salinometer.

Contained in this document is background theory of the associated circuitry as well as the procedures required to electrically test its operation. Schematic drawings, assembly drawings, parts lists and additional specific system or circuit details beyond the scope of this document may be obtained from Guildline Instruments or one of its authorized sales and service representatives.

### 1.2. GENERAL DESCRIPTION

The 8410A Portable Salinometer is used to make precision conductivity comparisons between an unknown water sample and a reference water sample. The measurement results can be displayed as either conductivity ratio or Practical Salinity Units (PSU). The measurement is made on a sample kept at a constant temperature in a temperature controlled bath. The control and measurement conversion is performed by a microprocessor. The control panel incorporates a push-button keypad for operator control, and an easy to read digital display for monitoring various parameters. The measurement range is from 0.004 mS/cm to 76 mS/cm with a resolution of 0.0003 mS/cm. The measurement can be made at a bath temperature selectable from 15°C to 38°C in steps of 1°C. The accuracy of measurement is better than 0.003 equivalent Practical Salinity Units.

In addition to the front panel manual controls, the salinometer functions can be controlled from either an RS-232C interface, a 20 mA SAIL interface, or a GPIB (IEEE-488) bus interface. Remote control commands include monitoring the current conductivity or temperature as well as modifying the bath set point temperature. The bath uses constant cooling from a thermoelectric cooling module and balances this with intermittent heating to provide the exact heating/cooling required to maintain a constant bath temperature.

The conductivity is measured by a four electrode conductivity cell excited by a square wave voltage.

The tank and cabinet are of a fiberglass construction. The electronic hardware is housed in a metal chassis to protect it from electrical interference as well as from water damage.

Features of the 8410A Portable Salinometer include:

- Portability allows easy shipboard installation
- Temperature stability makes temperature compensation unnecessary
- Up to 25 measurement values can be stored in the Portasal non-volatile memory
- Semi-automatic measurement in less than one minute
- Modular construction makes for ease of maintenance

### 1.3. CONTROLS AND INDICATORS

All indicators and controls are mounted on the front panel of the 8410A Portable Salinometer. The rear panel of this unit contains the power entry module as well as the RS-232C and the GPIB I/O connectors. **Note: Do not operate 8410A unless tank is filled with water.**

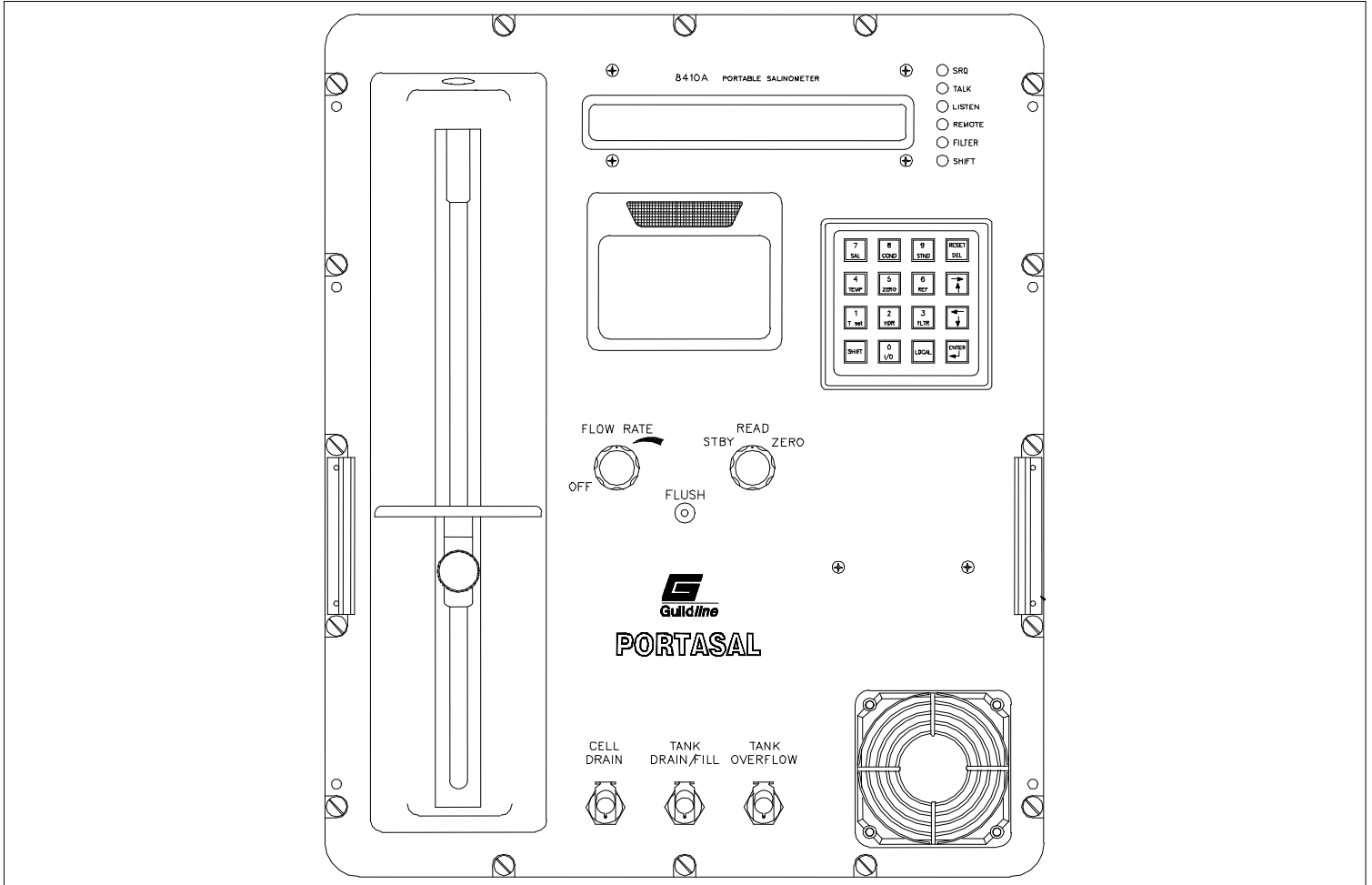
The main function of the salinometer's controls, indicators, and connectors are as follows:

#### 1.3.1. FRONT PANEL

Figure 1 details the front panel controls and indicators

##### 1.3.1.1. FLOW RATE

This valve regulates the flow of the sample water by controlling the air pressure in the sample bottle. A flow rate of 40 ml/min is available with flow rate valve at maximum (valve fully clockwise). Decreasing the flow rate allows more time for the sample temperature to equal the bath temperature before sample water enters the conductivity cell. The flow rate control switches off the air pumps when turned fully counterclockwise.



**Figure 1: Front Panel**

### **1.3.1.2. FUNCTION**

This switch has three positions. In the STDBY (standby) position, the conductivity of a reference resistor is measured. This gives an indication of the gain drift of the electronics. In the READ position, the conductivity of the sample water is measured. In the ZERO position, zero conductivity is measured. This gives an indication of the zero drift of the electronics.

### **CAUTION**

**This switch should not be left in the READ position when no sample water is in the conductivity cell.**

### **1.3.1.3. FLUSH**

This air vent controls the air pressure in the conductivity cell flushing manifold. Covering the vent with the finger causes the sample water in the conductivity cell to discharge through the CELL DRAIN spigot.

### **1.3.1.4. CELL DRAIN**

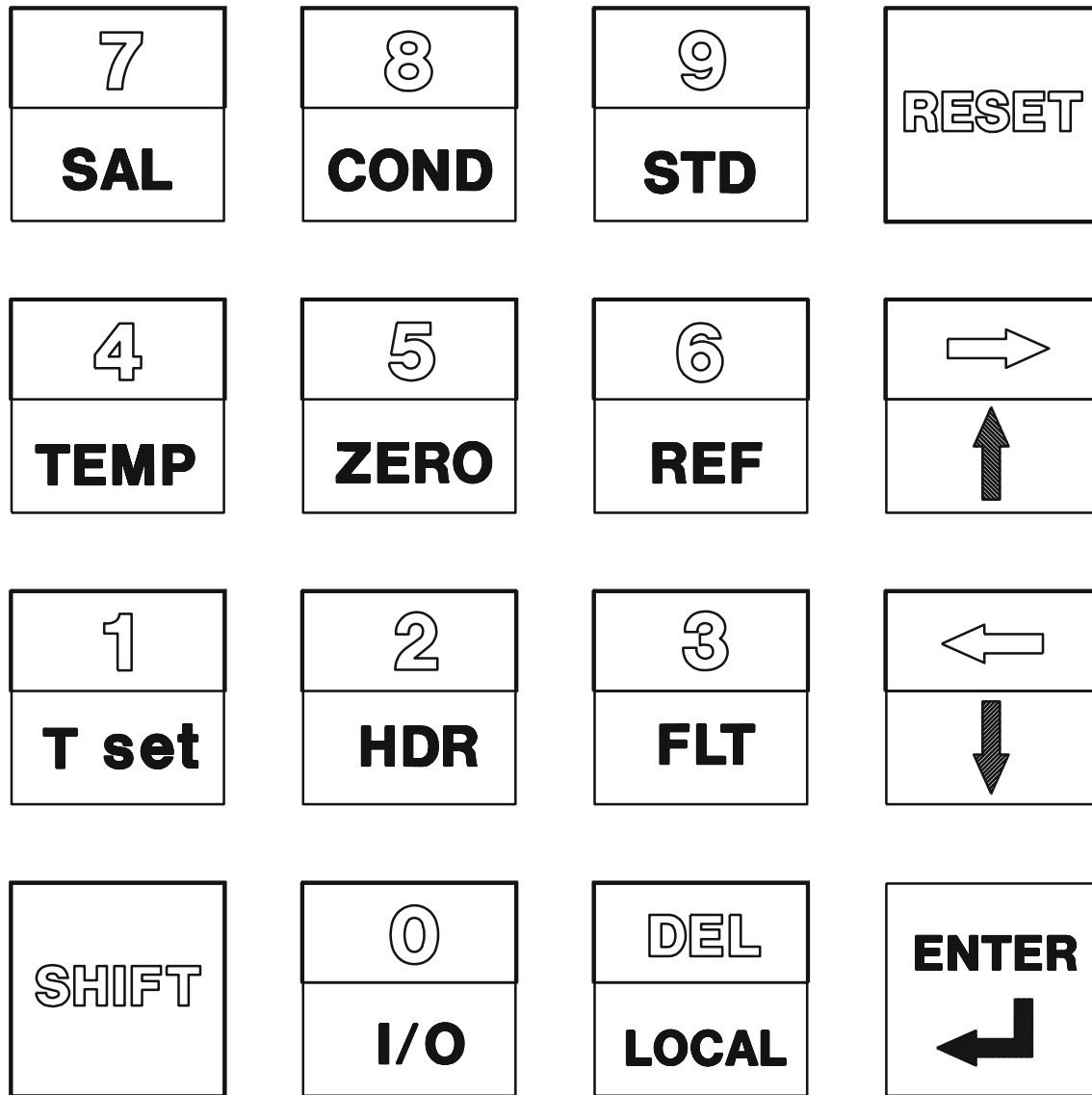
The sample water discharges through this spigot. A quick connect coupling with a short length of tubing attached is connected to this spigot to direct the discharge to a waste water container.

### **1.3.1.5. TANK DRAIN/FILL**

The temperature bath is filled or drained through this spigot. A quick connect coupling with a hose fitting is supplied to accomplish this. A valve in the spigot prevents the tank from draining when the quick connect coupling is not installed and a valve in the coupling stops the hose flow when disconnected.

### **1.3.1.6. TANK OVERFLOW**

The temperature bath is vented through this spigot. A quick connect coupling with a short length of tubing attached can be connected to this spigot to collect any overflow from the temperature bath. This spigot does not contain a valve. Caution must be exercised in sealing this spigot, as destructive pressures will build up in the tank when the tank is being filled with this spigot sealed.



**Figure 2: Keypad**

## 1.3.1.7. KEYPAD

The individual keys are detailed in Figure 2 and function as follows:

### 1.3.1.7.1. SAL

Displays the conductivity measurement in Practical Salinity Units. The display has the format:

SALINITY nn.nnn

### 1.3.1.7.2. COND

Displays the conductivity measurement as a ratio with respect to the conductivity of the standard water. The display has the format:

RATIO n.nnnnn

### 1.3.1.7.3. STD

Performs the following function:

Prepares the operator for standardization of the Portasal.

The display has the format:

**STD STANDARDIZE**

Pressing **ENTER** key will initiate the standardization procedure (see section 3.5.4 for details).

Allows the operator to enter the following coefficients:

- temperature coefficients.
- set point coefficients.
- conductivity suppression coefficients.

The display has the format:

**STD COEFFICIENTS**

Pressing the **ENTER** key will initiate the coefficient entry procedure (see section 3.10 for details).

#### 1.3.1.7.4. TEMP

Displays the bath temperature. The display has the format:

TEMP nn.nnn°C

While the temperature is being displayed each press of the ↑ key alters the display to the following:

TH1 TEMP XX.XXX°C  
TH2 TEMP XX.XXX°C  
TEMP XX.XXX°F  
TH1 TEMP XX.XXX°F  
TH2 TEMP XX.XXX°F  
TEMP XX.XXX°C

Each press of the ↓ key scrolls the temperature type in the reverse order. TH1 TEMP is the temperature as measured by thermistor #1 only and TH2 TEMP is the temperature as measured by thermistor #2 only.

#### 1.3.1.7.5. ZERO

Displays the zero correction in raw A/D converter data units. The display has the format:

ZERO -n.nnnnn

Unless the **FUNCTION** switch is in the **ZERO** position this value is displayed briefly and then the display reverts to its previous measurement. If the **FUNCTION** switch is in the **ZERO** position this value is averaged in with the current conductivity measurement and saved and displayed as the new zero correction. This averaging continues until any key is pressed.



### 1.3.1.7.6. REF

Displays the suppression scale in raw A/D converter data units. The display has the format:

REFERENCE nnnnn

Unless the **FUNCTION** switch is in the **STDBY** position this value is displayed briefly and then the display reverts to its previous measurement. If the **FUNCTION** switch is in the **STDBY** position the reference resistor is measured on suppression step 6 and displayed in the format:

-REFERENCE nnnnn

Then after 20 samples the reference resistor is measured on suppression step 7 and displayed as:

+REFERENCE nnnnn

After another 20 samples the average is used to determine the scaling factor and this new scaling factor is saved. This measurement continues to toggle between suppression step 6 and suppression step 7 until any key is pressed.

### 1.3.1.7.7. T set

Displays the current bath temperature set point. The display has the format:

SET POINT XX

If a numeric entry is made while set point is being displayed, the numeric entry becomes the pending set point. If the  $\uparrow$  or  $\downarrow$  keys are pressed while displaying set point the pending set point is incremented or decremented by one degree. The pending set point does not become the current set point until **ENTER** key is pressed.

### 1.3.1.7.8. HDR

Displays the header information in a 16 line 16 character format. Sequential lines are displayed by pressing the ↑ or ↓ keys. The first six lines are predetermined and cannot be altered. They are:

- Portasal serial number
- Date / time
- Standard water batch number
- Conductivity ratio
- Salinity
- Bath temperature (rounded to nearest °C)

For the next ten lines, if the SHIFT key is pressed the currently displayed line can be edited in a typeover mode (see section 3.8). The display reverts to the previous display after a brief delay with no key pressed.

### 1.3.1.7.9. FLT

Toggles the digital filter on or off. When FILTER is on, the RATIO and SALINITY display shows one extra significant digit.

When the FUNCTION switch is in either STDBY or ZERO and the filter is toggled ON the operator is prompted for the filter type with the message:

FLT WEIGHTED AVG

or

FLT MOVING AVG

The type can be changed with the ↑ or ↓ keys. When ENTER key is pressed the displayed type becomes the new filter type. The operator is then prompted for the sample size with the message:

SAMPLE SIZE n

If a numeric entry is made, the numeric entry becomes the new sample size. If the ↑ or ↓ keys are pressed the displayed sample size is incremented or decremented. When ENTER key is pressed the displayed number becomes the new sample size and the filter becomes active. The display then reverts to the previous display before FLT key was pressed.

## **1.3.1.7.10. RESET**

Power on reset of the Portasal. To Reset the Portasal press **SHIFT** key then **RESET** key.

## **1.3.1.7.11. LOCAL**

Returns keyboard control to the Portasal.

## **1.3.1.7.12. SHIFT**

Enables the red keys. The **SHIFT** mode is enabled until the **ENTER** key is pressed.

## **1.3.1.7.13. I/O**

Displays the input-output format of:

- GPIB parameters
- RS-232C parameters
- SAIL parameters

Sequential lines are displayed by pressing the  $\uparrow$  or  $\downarrow$  keys. The changes do not become effective until a reset (SHIFT RESET) occurs.

## **1.3.1.7.14. ENTER**

Whenever an alpha-numeric entry is being made, this key enters the line. If an accept/reject response is expected this key accepts. If the conductance is being measured and this is the first key pressed the current measurement along with header information is stored for output in the pre-programmed format.

## **1.3.1.7.15. $\uparrow$**

Scrolls forward through multiple choice displays.

## **1.3.1.7.16. $\downarrow$**

Scrolls backward through multiple choice displays.

## **1.3.1.8. LED INDICATORS**

The Portasal has the following status indicators:

### **1.3.1.8.1. SRQ**

Indicates the Portasal is requesting service from the GPIB remote control interface (Service ReQuest).

### **1.3.1.8.2. TALK**

Indicates the Portasal is actively sending data to one of the remote control interfaces (GPIB or RS-232C).

### **1.3.1.8.3. LISTEN**

Indicates the Portasal is actively receiving data from one of the remote control interfaces (GPIB or RS-232C).

### **1.3.1.8.4. REMOTE**

Indicates the Portasal has been programmed from the GPIB remote control interface for remote control only. The remote state can be overridden by the local key provided a "local lock out" has not been sent by the GPIB controller.

### **1.3.1.8.5. FILTER**

Indicates measurements are averaged.

### **1.3.1.8.6. SHIFT**

Indicates the red function of keypad is enabled.

### **1.3.1.9. ALPHA NUMERIC DISPLAY**

A sixteen character, fourteen segment plus period and comma vacuum fluorescent display.

## **1.3.2. REAR PANEL**

Figure 3 details the rear panel controls and connections.

### **1.3.2.1. POWER ENTRY MODULE**

An integrated receptacle with the following features:

- Connects a standard power cord to an AC power source.
- Fuses the AC line. Should be 3 A slow-blow for 120 V operation and 1.5 A slow-blow for 240 V operation.
- Switches the AC power on or off.
- Filters the AC power line.

### **1.3.2.2. LINE VOLTAGE SELECTOR**

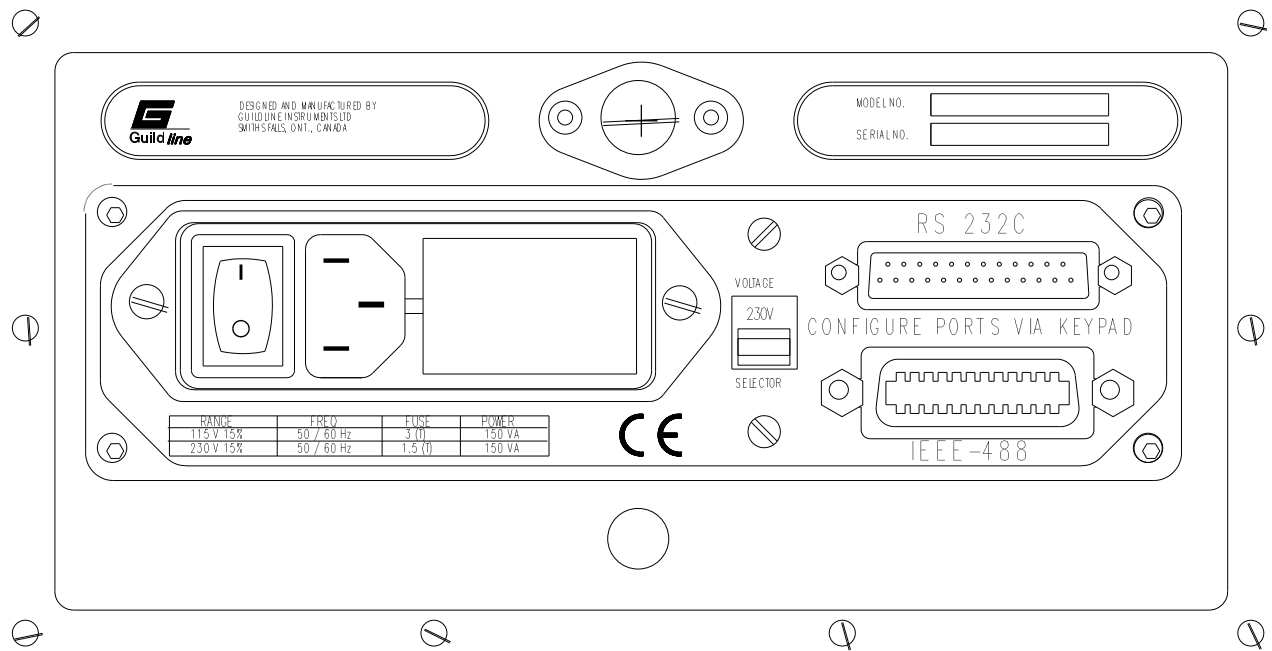
A selector switch for 115 (90 min. to 132 max.) or 230 (200 min. to 265 max.) V AC power operation.

### **1.3.2.3. RS-232C**

An RS-232C standard interface connector (DB25S type) to connect to user supplied data terminal equipment. Pins 14 and 15 do not conform to RS-232C but are used to connect to a 20 mA loop.

### **1.3.2.4. IEEE 488**

An IEEE 488.1 standard interface connector.



**Figure 3: Rear Panel**

## 2. SPECIFICATIONS

### 2.1. GENERAL

Temperature: Operating;	5 to 40	°C
Storage;	-40 to 70	°C
Max Operating Humidity:	80	% RH (non condensing)
Shock:	20	g 7-11 ms half sine
Vibration:	1.5	g 5-200 Hz
Dimensions:	530h X 450w X 420d	mm
	20.9 X 17.7 X 16.5	inches
Bath Volume:	9	liters
	2.3	US gals.
Weight (bath empty):	20	kg
	44	lbs
Power Requirements:	90 to 132,	V AC 50/60 Hz
	200 to 265	V AC 50/60 Hz
	150	V A maximum

### Interface

#### RS-232C:

Configured as data communication equipment (DCE).

Baud rate, parity, framing and flow control programmable from front panel.

#### SAIL:

20 mA current loop

#### IEEE 488.1:

Provides full talker/listener facilities and remote control of all functions.

Subset: SH1,AH1,T5,L4,SR1,RL1,PP0,DC1,DT0,C0,E2

## 2.2. PERFORMANCE

Measurement Range:	0.004 to 76 0.000 1 to 1.15 2 to 42	mS/cm conductivity ratio equivalent PSU <sup>1</sup>
Accuracy:	±0.003	equivalent PSU <sup>2</sup>
Resolution:	0.000 3 0.000 3	mS/cm equivalent PSU <sup>3</sup>
Sample Volume:	100	ml minimum
Bath Temperature Range:	15 to 38	°C
Bath Temperature Accuracy	±0050	°C of setting (1 Yr)
Stability:	±0.001 ±0.010	°C per 24 hr °C per year

**CAUTIONARY NOTE: ELECTROMAGNETIC COMPATIBILITY**

The displayed readings may exhibit uncertainties outside the stated precision of this device if the unit is exposed to a direct source of electromagnetic radiation of 3 V/m or higher. The user should therefore take care not to operate this device in proximity to known sources of powerful electromagnetic radiation.

<sup>1</sup> The Practical Salinity Scale is defined only from 2 to 42 PSU (Practical Salinity Units). Derate to 40 PSU at 38°C bath Setpoint temperature.

<sup>2</sup> Measurement made at same bath set point temperature as standardization, with: (ambient temperature -2°C) ≤ bath Setpoint temperature ≤ (ambient temperature +4°C), and within 24 hr of standardization. This is equivalent to ±0.000 077 in conductivity ratio at 35 PSU and over the bath temperature range.

<sup>3</sup> At 15°C and 35 PSU



### 3. OPERATION

#### 3.1. LINE VOLTAGE SELECTION

To gain access to the power line input socket raise the door on the rear of the cabinet. Use a coin or a large screw driver to turn the door fastener a quarter turn counter-clockwise. The fastener will pop outward. Raise the door and push the fastener in, giving it a quarter turn clockwise. This will hold the door in the raised position.

The Portasal has been shipped with line voltage selector set to 230 V. Switch the line input selector to the desired voltage. The settings available are 115 V or 230 V. Remove the warning label positioned across the power line input socket after setting the correct operating voltage.

Fit unit with correct fuse: 3 A slow-blow (MDL -3A/250 V) for 115 V nominal and 1.5 A slow-blow (MDL – 1.5A/250 V) for 230 V nominal line voltage. Only fuses with the rated current and specified type should be used for replacement.

The supplied molded line cord should be plugged into the 3 pin power receptacle on the rear panel of the instrument. Ensure that the other end of the cord is plugged into a wall socket or extension cord provided with a protective ground for safe operation of the instrument. Where 3-contact supply outlets are not available a suitable protective ground connection must be made before switching the instrument on. Any interruption of the protective ground may possibly render the instrument unsafe.

Where the molded plug on the supplied line cord does not match the outlet socket of the local service, the plug can be removed. The cable should then be stripped back and replaced with a 3-pin plug of the correct type. The plug should be wired as follows:

Brown	- Line
Blue	- Neutral
Green/Yellow	- Ground

#### **CAUTION**

**Do not operate the Portasal with the front cover on. Do not block the overflow spigot while filling the tank. Fill the tank at a rate of less than 40 ml/sec. Do not power on unless tank is full.**

### 3.2. INSTALLATION

Place the Portasal on a solid bench close to the edge so tubing from cell drain and overflow ports can lead straight downward to waste containers. Insert the supplied couplers into suitable lengths of the supplied tubing and connect the tubing to the **CELL DRAIN** and **TANK OVERFLOW** spigots.

Insert the supplied coupler into a suitable length of 3/8 inch ID hose. Connect this hose to the **TANK DRAIN/FILL** spigot. Slowly fill the tank through the hose with distilled water<sup>4</sup>. It is important not to fill the tank too fast to avoid excessive pressures in the tank. Fill until water starts to discharge from **TANK OVERFLOW**. Disconnect the hose from the **TANK DRAIN/FILL** spigot first then from the water supply.

Plug remote cables (if used) into the receptacles on the back of the cabinet and connect to the appropriate equipment. Plug the power cord into the power entry module on the back of the cabinet and connect to an appropriate supply.

### 3.3. LOCATION

The Portasal must be operated in an upright position. The cabinet feet will hold the Portasal secure provided it is on a stable platform, otherwise the Portasal must be secured by straps passing over the top of the cabinet and through the handles.

The Portasal does not require any clearance on the sides or top. Clearance on the back is required only for the power cord and Bus control cables.

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<sup>4</sup> If distilled water is not available add an algae inhibitor to the bath by pouring the algaecide into the connected hose before filling the tank with water. A suitable algae inhibitor can be prepared by dissolving 5 to 10 g of thymol crystals in 50 ml of methyl hydrate.

### 3.4. PRELIMINARIES

#### 3.4.1. POWER ON SEQUENCE

Before power up check that the **FUNCTION** switch is in the **STDBY** or **ZERO** position if there is no sample in the conductivity cell. Switch the Portasal on with the power switch on the back panel. Observe that the fan draws air in through the filter at the bottom right corner of the instrument and expels the air through the top of the viewing tunnel. Observe that the bath water is circulating in a counter-clockwise direction.

The Portasal will first show all LED indicators on, then all display segments on.

The display will next show the GPIB address.

The Portasal will then begin to measure the bath temperature and display it in degrees Celsius.

#### 3.4.2. FLOW RATE CHECK

Turn **FLOW RATE** on. Ensure air flow discharges from **FLUSH** air vent. Turn **FLOW RATE** off.

#### 3.4.3. ZERO CHECK

Set **FUNCTION** switch to **ZERO**. Press **Cond.** If the display does not read **RATIO 0.000 00** ( $\pm 0.000 01$ ) perform a zero calibration (see section 3.5.3).

#### 3.4.4. TEMPERATURE CHECK

- 1) Select bath temperature set point of 36°C (see section 3.9). Observe that both heater lamps light if the bath water temperature is below 36°C. If either heater lamp has failed the message **HEATER 1 FAILURE** or **HEATER 2 FAILURE** will be displayed within 15 seconds.
- 2) Select bath temperature set point of 15°C. Observe that both heater lamps remain off if the bath water temperature is above 15°C.

### 3.4.5. BATH TEMPERATURE CONTROL CHECK

- 1) Press TEMP key and note the bath temperature. Select bath temperature set point (see section 3.9) 2°C above the mean ambient temperature<sup>5</sup>. The real bath temperature will then be displayed. Wait until the bath has reached the set point temperature. This is indicated by a regular on and off cycling of the heater lamps. The displayed TEMP tt.ttt°C must be within 0.02°C of the set point temperature.
- 2) Press ↑. Note the displayed TH1 TEMP tt.ttt°C.
- 3) Press ↑. The displayed TH2 TEMP tt.ttt°C must be within 0.04°C of TH1 TEMP.
- 4) Press ↓ twice to display TEMP in °C (or ↑ to display TEMP in °F).

If any of the above checks fail, verify that the temperature coefficients or set point trimming coefficients have not been corrupted. These coefficients are found on the alignment coefficient report supplied with each unit. If TH1 TEMP and TH2 TEMP do not agree within 0.04°C then at least one of the thermistors is defective. If TH1 TEMP and TH2 TEMP do agree within 0.04°C but TEMP is not within 0.02°C of the set point temperature then the temperature scale requires recalibration.

### 3.4.6. CONDUCTIVITY CELL CHECK

- 1) Install pick-up tube and cell drain tube as follows:
  - (a) Insert a supplied coupler into a suitable length of 3/8 inch ID plastic tube and connect to CELL DRAIN spigot.
  - (b) Arrange tubing so as to drain into a waste container, ensuring cell drain arrangement complies with the following important specifications:
    - i. Ensure cell drain remains isolated from possible electrical ground paths.<sup>6</sup>
    - ii. Never allow CELL DRAIN tube to form traps or loops, causing water to fill an entire cross-section of tube. The resulting siphoning action may empty the conductivity cell.

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<sup>5</sup> If the bath temperature is far from ambient, the wait period may be several hours. For expedience set the temperature as close as possible to the bath water temperature.

<sup>6</sup> If the cell drain tube provides an electrical leakage path to ground, erroneous measurements will be made. Even a plastic tube with a wet outer wall can cause this error. Arrange the tube so the water discharges into a plastic container (preferably located on the floor) and the tube does not touch the container or its contents.

- iii. Never elevate CELL DRAIN tube above level of cell. Water in the tube may back up to the cell electrode arms, flooding the flushing manifold.
- (c) Attach one piece of 1 mm ID Teflon tubing to metal tube protruding from rubber stopper in sample bottle holder, cutting tubing so it can reach but not touch bottom of sample bottle.
- 2) Select a bottle of saline water (any salinity from 5 to 40) and mix well to eliminate gradients. Do not shake sample bottles. Rock gently to mix sample without getting air bubbles suspended in sample.
  - 3) Place sample bottle in holder, fitting pick-up tube into bottle. Lock bottle holder shelf in position using knob beneath sliding shelf, to form an air-tight seal at the bottle mouth.
  - 4) Ensure FUNCTION switch is set to STDBY. Turn FLOW RATE to about  $\frac{3}{4}$  position.
  - 5) Observe through tank window that all four arms of the conductivity cell fill sufficiently to cover electrodes. If the cell does not fill completely, cover FLUSH vent momentarily with fingertip then allow to refill after increasing flow rate, if necessary to maximum.
  - 6) When cell is full, set FUNCTION switch to READ. Press COND key and observe a stable conductivity ratio measurement.
  - 7) If another sample will not be measured immediately leave the sample bottle in the sample bottle holder, set FUNCTION switch to STDBY and turn off FLOW RATE. If another sample will not be measured for at least 12 hours set FUNCTION switch to STDBY, remove the sample bottle, install a bottle of distilled water, fill and flush the conductivity cell at least 3 times, then with the conductivity cell full, turn off FLOW RATE.

- 8) Remove sample bottle by the following steps:
  - (a) Set FUNCTION switch to STDBY.
  - (b) Reduce flow rate to minimum.
  - (c) Flush conductivity cell.
  - (d) Lower bottle platform and remove sample bottle.
  - (e) Wipe pick-up tube.
  - (f) Raise and insert end of pick-up tube into pick-up tube holder.

### 3.5. OPERATING PROCEDURE

The Portasal measures the conductance of a sample of unknown water and displays the measurement as a conductivity ratio with respect to an equivalent sample of reference water. This measurement can be displayed as conductivity ratio or can be converted to Practical Salinity Units (PSU) using the practical salinity scale algorithm described in section 6.6.3.3. In order to achieve the specified accuracy of  $\pm 0.003$  PSU, it is necessary to follow the procedures outlined below. The specified accuracy applies to measurements made within 24 hours of performing a standardization (section 3.5.4) in an environment where the ambient temperature remains between  $-4^{\circ}\text{C}$  and  $+2^{\circ}\text{C}$  of the Portasal bath temperature. Through experience, it may be determined that the standardization interval can be extended to meet the desired accuracy under particular environmental conditions. It will be necessary, however, to perform a standardization every time the Portasal has been powered up or the bath temperature has been changed. To achieve the specified accuracy, always allow at least 3 hours after the bath temperature has begun regulating before standardizing. In addition, always precede the standardization with a reference calibration (section 3.5.2) and a zero calibration (section 3.5.3), in that order.

#### 3.5.1. SAMPLE MEASUREMENT

Samples up to  $15^{\circ}\text{C}$  below the bath temperature or  $5^{\circ}\text{C}$  above the bath temperature can be measured if the flow rate is reduced sufficiently to allow the sample to reach the bath temperature while in the heat exchanger, however this practice may not give the most accurate results obtainable. To measure the conductivity of a given sample do the following:

- 1) Install sample bottle by the following steps:
  - (a) Store pertinent information about bottle sample (see Header Entry section 3.7 for details).
  - (b) Rock sample gently to eliminate gradients.

- (c) Open bottle and place in holder, inserting pick-up tube into bottle neck and hold bottle mouth over rubber stopper<sup>7</sup>. Ensure that pick-up tube reaches almost to bottom of bottle such that flow will not be restricted.
  - (d) Raise bottle platform to press bottle mouth against rubber stopper making an airtight seal. Secure platform by tightening thumb screw.
- 2) Turn on **FLOW RATE** to a medium flow rate and allow conductivity cell to fill with sample water. If the cell does not fill completely, cover **FLUSH** vent momentarily with fingertip then allow to refill after increasing flow rate, if necessary to maximum.
- A marked change in the duty cycle of the heater lamps indicates that the flow rate is too fast. Slowly reduce the flow rate until the heater lamps cycle at a slow regular rate.
- 3) Flush sample water out of cell by placing fingertip over **FLUSH** air vent.
  - 4) Fill and flush again.
  - 5) Allow conductivity cell to refill and sample water to flow out of the **CELL DRAIN**. Be sure there are no air bubbles in the conductivity cell. Then set **FUNCTION** switch to **READ**.
  - 6) Press **COND** key. Allow the ratio measurement to stabilize. Note the ratio measurement.
  - 7) Set the **FUNCTION** switch to **STDBY**. Flush and fill the conductivity cell. Set the **FUNCTION** switch to **READ**. Allow the ratio measurement to stabilize. Repeat this process until measurement agrees with previous flushing.
  - 8) To display the sample salinity in Practical Salinity Units press **SAL** key.
  - 9) To filter the measurement press **FLT** key (see section 1.3.1.7.9 for details on setting the filter parameters).
  - 10) Record the measurement. To output the sample data on the remote bus press **ENTER** key (note: both conductivity ratio and salinity are updated whenever either is displayed).

---

<sup>7</sup> Care must be exercised not to contaminate the sample. Do not handle the pick-up tube, rubber stopper or neck of the bottle except with clean lint-free tissue for wiping or surgical gloves for handling. Insert the end of the pick-up tube into the pick-up tube holder to allow sample water in the pick-up tube to siphon away from the end of the tube.

- 11) If another sample will not be measured immediately leave the sample bottle in the sample bottle holder, set FUNCTION switch to STDBY and turn off the flow rate. If another sample will not be measured for at least 12 hours set FUNCTION switch to STDBY, remove the sample bottle, install a bottle of distilled water, fill and flush the conductivity cell at least 3 times then, with the conductivity cell full, turn off the flow rate.
  
- 12) Remove sample bottle by the following steps:
  - (a) Set FUNCTION switch to STDBY.
  - (b) Reduce flow rate to minimum.
  - (c) Flush conductivity cell.
  - (d) Lower bottle platform and remove sample bottle.
  - (e) Wipe pick-up tube.
  - (f) Raise and insert end of pick-up tube into pick-up tube holder.

### 3.5.2. REFERENCE CALIBRATION

The instrument must have been powered up for a minimum of 3 hours after the bath temperature begins regulating before any calibration is performed.

Set the FUNCTION switch to **STDBY** and press **REF** key. After a delay of approximately 8 seconds the display will read **-REFERENCE xxxxx** and will update for 16 seconds. Next, the display will read **+REFERENCE xxxxx** and will update for 7 seconds, after which the display will read **REFERENCE xxxxx** for 8 seconds. This procedure will repeat itself until any key is pressed. The **-REFERENCE** and **+REFERENCE** numbers must stabilize to between 19750 and 19999. The **-REFERENCE** and **+REFERENCE** numbers must agree with each other to within  $\pm 2$  counts after 10 cycles and must remain stable to within  $\pm 2$  counts over 10 minutes.

### 3.5.3. ZERO CALIBRATION

Before any calibration is performed the instrument must have been powered for a minimum of 3 hours with the bath temperature regulating.

Set the FUNCTION switch to **ZERO** and press **COND** key. When satisfied that the zero conductivity ratio measurement is stable press **ZERO**. The display will then read **ZERO x.xxxxx**. The ZERO value should not exceed  $\pm 0.00075$ . When satisfied that this number is not drifting press **COND** key. The display should then read **RATIO 0.000 00**.



### 3.5.4. STANDARDIZATION

Perform the Reference Calibration and the Zero Calibration described above. Using a vial of Standard Sea Water<sup>8</sup>, obtain a good conductivity measurement as described in the Sample Measurement procedure steps 1 through 7 (see section 3.5.1). Reduce the flow rate to minimum and do the following:

#### NOTE

**Once the following procedure has commenced do not flush the cell and do not move the FUNCTION switch from READ.**

- 1) Leave FUNCTION switch in READ and press STD.
- 2) The following prompt will be displayed:

STD STANDARDIZE

Press ENTER key.

- 3) You will then be prompted with, for example:

COND NO 0.999 84

Enter the conductivity ratio of the Standard Sea Water (see section 3.8 for entering data).

- 4) You will then be prompted with, for example:

BATCH NO P113

Enter the Standard Sea Water batch number. (see section 3.8 for entering data).

- 5) You will then be prompted with:

ENTER WHEN READY

Turn FLOW RATE to a suitable flow rate and, when satisfied that the conductivity cell is full and sample is flowing, press ENTER key.

- 6) Measuring... will briefly appear on the display followed by, for example:

STANDARD 4.22000

---

<sup>8</sup> To open a vial, score glass across end piece and snap off. Fit standard vial adapter over the open end.

When satisfied that the displayed STANDARD number is stable, press COND key. This will terminate STD operation and display the conductivity ratio using the new calibration values.

### Note

Because a digital filter is applied to the measurement data during standardization, any significant change in STANDARD number will cause the new standardization to approach its final value over a period of several minutes. This apparent drift in standardization will be minimized by strictly adhering to the above procedure. Depending on the circumstances between standardizations, the change in STANDARD number may be up to  $\pm 0.0005$  typical.

- 7) If another sample will not be measured immediately leave the vial in the sample bottle holder, set **FUNCTION** switch to **STDBY** and turn off the flow rate. If another sample will not be measured for at least 12 hours set **FUNCTION** switch to **STDBY**, remove the vial, install a bottle of distilled water, fill and flush the conductivity cell at least 3 times, then with the conductivity cell full, turn off the flow rate.
- 8) Remove vial by the following steps:
  - (a) Set **FUNCTION** switch to **STDBY**.
  - (b) Reduce flow rate to minimum.
  - (c) Flush conductivity cell.
  - (d) Lower bottle platform and remove vial.
  - (e) Wipe pick-up tube.
  - (f) Raise and insert end of pick-up tube into pick-up tube holder.
- 9) With the function switch set to **STDBY** record the conductivity ratio. If this number changes significantly the instrument must be restandardized.

### 3.6. I/O CONFIGURATION

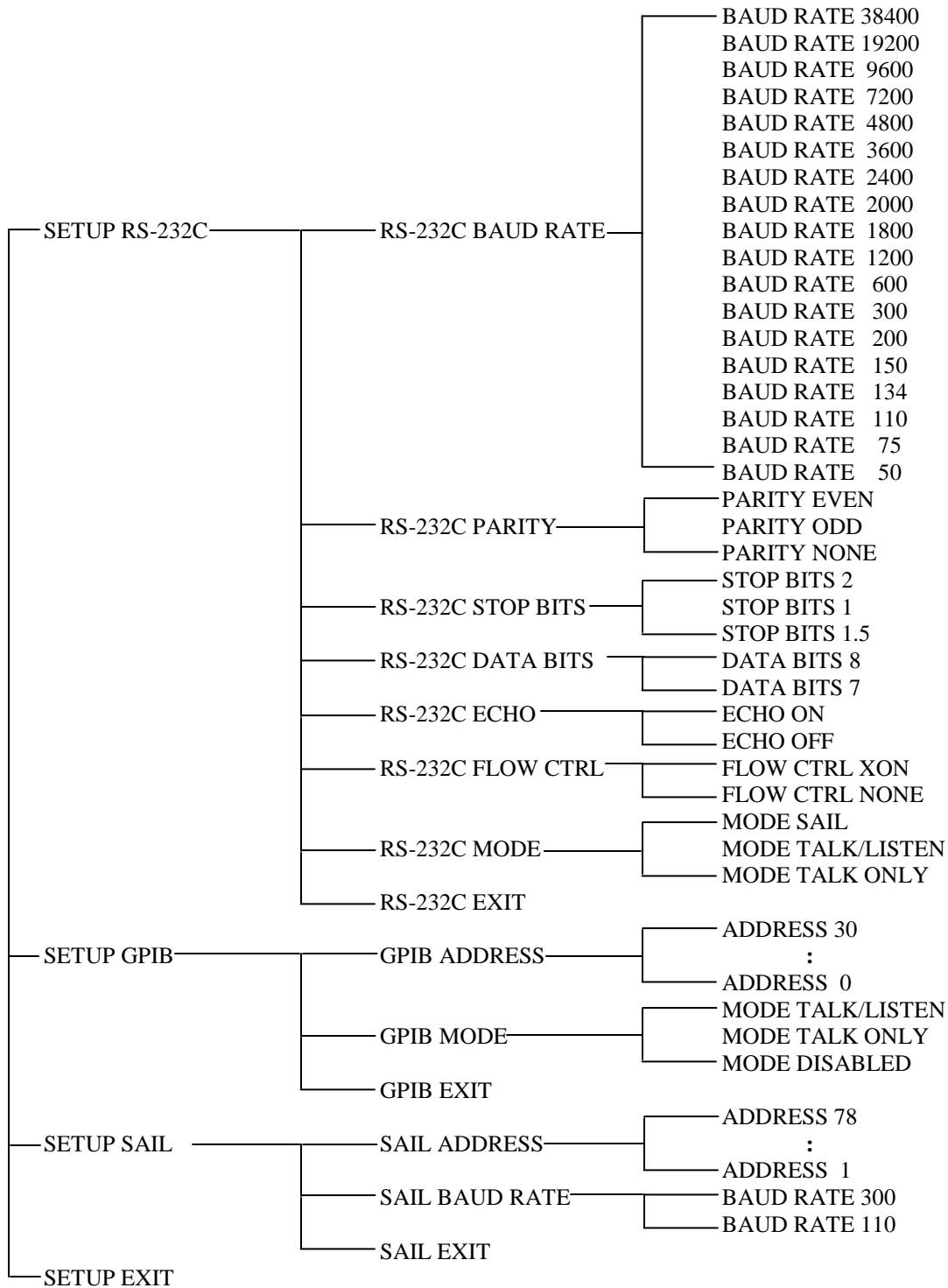
I/O configuration is menu driven as illustrated in Figure 4. To enter the I/O configuration menu press **I/O** key. To advance to the next menu or parameter in a given column press  $\downarrow$  key. To advance to the next column on a given line press **ENTER** key. To back up a line in a given column press  $\uparrow$  key. To back up a column advance to the **EXIT** prompt and press **ENTER** key. Scrolling from one line to the next wraps around at the end of that group. To modify a parameter press  $\uparrow$  or  $\downarrow$  key, or press **SHIFT** key then the digits then **ENTER** key. To accept the displayed parameter press **ENTER** key. To make the parameters selected valid push the **SHIFT** key then the **RESET** key.

### 3.6.1. RS-232C CONFIGURATION

To illustrate the procedure for configuring the RS-232C port take the example of setting the RS-232C for dumping the header directly to a printer. The printer expects 7 data bits plus even parity at 300 baud. The printer controls the data flow with the DTR signal. Do the following:

KEY PRESS	DISPLAY
I/O	SETUP RS-232C <sup>9</sup>
ENTER	RS-232C <b>BAUD RATE</b>
ENTER	BAUD RATE <b>9600</b>
SHIFT	BAUD RATE <u>9600</u>
3	BAUD RATE <u>3600</u>
0	BAUD RATE <u>3000</u>
0	BAUD RATE <u>3000</u>
DEL	BAUD RATE 300_
ENTER	BAUD RATE <b>300</b>
ENTER	RS-232C <b>BAUD RATE</b>
↓	RS-232C <b>PARITY</b>
ENTER	PARITY <b>NONE</b>
↑	PARITY <b>ODD</b>
↑	PARITY <b>EVEN</b>
ENTER	RS-232C <b>PARITY</b>
↓	RS-232C <b>STOP BITS</b>
ENTER	STOP BITS <b>1.5</b>
↑	STOP BITS <b>1</b>
↑	STOP BITS <b>2</b>
ENTER	RS-232C <b>STOP BITS</b>
↓	RS-232C <b>DATA BITS</b>
ENTER	DATA BITS <b>7</b>
ENTER	RS-232C <b>DATA BITS</b>
↓	RS-232C <b>ECHO</b>
↓	RS-232C <b>FLOW CTRL</b>
↓	RS-232C <b>MODE</b>
ENTER	MODE <b>TALK ONLY</b>
ENTER	RS-232C <b>MODE</b>
↓	RS-232C <b>EXIT</b>
ENTER	SETUP <b>RS-232C</b>
↑	SETUP <b>EXIT</b>
ENTER	

<sup>9</sup> Characters in bold print are flashing. Underscored characters alternate between the character and the underscore.



**Figure 4: I/O Configuration Structure**

### 3.6.2. GPIB CONFIGURATION

To illustrate the procedure for configuring the GPIB port take the example of a controller expecting the Portasal at address 24. Do the following:

<b>KEY PRESS</b>	<b>DISPLAY</b>
I/O	SETUP <b>RS-232C</b> <sup>10</sup>
↓	SETUP <b>GPIB</b>
ENTER	GPIB <b>ADDRESS</b>
ENTER	ADDRESS <b>0</b>
SHIFT	ADDRESS <u><b>0</b></u>
2	ADDRESS 2_
4	ADDRESS 24_
ENTER	ADDRESS <b>24</b>
ENTER	GPIB <b>ADDRESS</b>
↓	GPIB <b>MODE</b>
ENTER	MODE <b>DISABLED</b>
↑	MODE <b>TALK ONLY</b>
↑	MODE <b>TALK/LISTEN</b>
ENTER	GPIB <b>MODE</b>
↓	GPIB <b>EXIT</b>
ENTER	SETUP <b>GPIB</b>
↓	SETUP <b>SAIL</b>
↓	SETUP <b>EXIT</b>
ENTER	

---

<sup>10</sup> Characters in bold print are flashing. Underscored characters alternate between the character and the underscore.

### 3.6.3. SAIL CONFIGURATION

To illustrate the procedure for configuring the SAIL port take the example of a controller expecting the Portasal at address 42 and defaulting to a baud rate of 300. Do the following:

<b>KEY PRESS</b>	<b>DISPLAY</b>
I/O	SETUP <b>RS-232C</b>
ENTER	<b>RS-232C BAUD RATE</b>
↓	<b>RS-232C PARITY</b>
ENTER	<b>PARITY NONE</b>
↑	<b>PARITY ODD</b>
↑	<b>PARITY EVEN</b>
ENTER	<b>RS-232C PARITY</b>
↓	<b>RS-232C STOP BITS</b>
↓	<b>RS-232C DATA BITS</b>
↓	<b>RS-232C ECHO</b>
↓	<b>RS-232C FLOW CTRL</b>
↓	<b>RS-232C MODE</b>
ENTER	<b>MODE TALK ONLY</b>
↑	<b>MODE TALK/LISTEN</b>
↑	<b>MODE SAIL</b>
ENTER	<b>RS-232C MODE</b>
↓	<b>RS-232C EXIT</b>
ENTER	<b>SETUP RS-232C</b>
↓	<b>SETUP GPIB</b>
↓	<b>SETUP SAIL</b>
ENTER	<b>SAIL ADDRESS</b>
ENTER	<b>ADDRESS 1</b>
SHIFT	<b>ADDRESS <u>1</u></b>
4	<b>ADDRESS 4_</b>
2	<b>ADDRESS 42_</b>
ENTER	<b>ADDRESS 42</b>
ENTER	<b>SAIL ADDRESS</b>
↓	<b>SAIL BAUD RATE</b>
ENTER	<b>BAUD RATE 110</b>
↑	<b>BAUD RATE 300</b>
ENTER	<b>SAIL BAUD RATE</b>
↓	<b>SAIL EXIT</b>
ENTER	<b>SETUP SAIL</b>
↓	<b>SETUP EXIT</b>
ENT	

### 3.7. HEADER ENTRY

The header consists of 16 lines of 16 characters. The first 6 lines are predefined and can be reviewed but can not be altered. The next 10 lines are user lines and can be edited in a typeover mode.

To view the header lines press **HDR** key. The first user line will be displayed. To scroll through the header lines press **↑** or **↓** keys. To edit the displayed header line press **SHIFT** key. To accept the header line as displayed press **ENTER** key. To exit the header function scroll to the EXIT prompt and press **ENTER** key.

**NOTE: The Portasal will automatically exit the header function after approximately 12 seconds without a key being pressed.**

An "end-of-header" marker, the "\*", is available and must be placed in the FIRST character position of a user line to function as such. The "end-of-header" marker terminates writing of header information at the end of the preceding header line.

It is recommended that initially the "end-of-header" marker be inserted in the following manner:

- i) Press **HDR** key to display first user line.
- ii) The first 2 characters should be an "\*1" and the rest of the line should be blank.
- iii) If correct, press **ENTER** key to display the next user line.
- iv) If not, press and hold **SHIFT** key. While holding **SHIFT** key press **6/REF** key. Release **SHIFT** key and press the required number key(s). Press **DEL** key until the remainder of the user line is blank. Press **ENTER** key. Press **ENTER** key to display next user line.
- v) Repeat Step iii) or iv) (depending on the original status of the user line) until the EXIT field is reached.
- vi) Press **ENTER** key to exit header routine.

Header information can be written to memory or to a remote device (RS-232C or GPIB) only when the Portasal is measuring conductance. To write header information, press the **ENTER** key.

If header information is being written to memory (i.e. neither RS-232C MODE or GPIB MODE is TALK ONLY), the message STORING DATA will appear briefly on the Portasal display, followed by the message ENTER TO CONFIRM. Pressing the ENTER key a second time will store the data. If the ENTER key is not pressed a second time within approximately 12 seconds, the ENTER TO CONFIRM message will disappear and data will NOT be stored.

It is possible that the buffer for storing header data may become corrupted. This buffer can be cleared in the following way:

- i) Connect the Portasal to an RS232 terminal.
- ii) Set the Portasal RS232 parameters to match the RS232 terminal settings (see section 3.6), including set RS232 mode to TALK/LISTEN and set RS232 ECHO to ON.
- iii) Enter E? on the RS232 terminal. The Portasal will respond with some message.
- iv) Repeat the E? command until the response "NO DATA Available" appears.

If header information is being written to a remote device through RS-232C (i.e. RS-232C MODE is TALK ONLY) or through GPIB (i.e. GPIB MODE is TALK ONLY), the message OUTPUT TO RS-232C (or OUTPUT TO GPIB) will appear briefly on the Portasal display and data will be written to the remote device. When writing to remote devices through RS-232C and GPIB simultaneously, the number of header lines being written must be limited to nine (6 predefined lines + 3 user lines). In this case, an "end-of-header" marker must be the FIRST character of user line 4.

Header information can be written in two different ways depending on whether the Portasal is in "terse" mode (see section 4.3.44) or in "verbose" mode (see section 4.3.51). If header information is being written with the Portasal in "terse" mode, the header lines will be written side-by-side, separated by commas. If header information is being written with the Portasal in "verbose" mode, the header lines will be written on separate lines.

### 3.8. SHIFT OPERATION

The **SHIFT** key enables the entry of alpha numeric characters. If no key entry was expected the message RESET OR ENTER is displayed. Pressing **RESET** key causes the Portasal to reset; pressing **ENTER** key causes the Portasal to continue whatever it was doing before **SHIFT** key was pressed. If a key entry is expected a flashing cursor ( ) will be displayed. There may be a prompt message before the cursor and there may be data after the cursor. The data can be altered in a typeover method. The cursor can be moved left or right with the ← or → key respectively.

The numbers 0 through 9 are entered by pressing the appropriately labeled key. The number is stored in a buffer and the cursor moves to the next position waiting for the next character.

The letters A through Z are entered by holding the **SHIFT** key down and pressing the ↑ or ↓ key. The ↑ key scrolls the letters from A to Z then wraps around to A again. The ↓ key scrolls the letters Z to A then wraps around to Z again. The cursor position remains fixed until the **SHIFT** key is released. When the **SHIFT** key is released the displayed letter is stored in a buffer and the cursor moves to the next position waiting for the next character.

The following additional characters are entered by holding the **SHIFT** key down and pressing:

- 0 to enter [space]
- 2 to enter .
- 5 to enter -



6 to enter \*  
8 to enter ,  
9 to enter ?

The character at the cursor position is deleted by pressing **DEL** key.

The edited data is accepted as displayed by pressing **ENTER** key.

### 3.9. SETTING BATH TEMPERATURE

To select a new bath temperature press **T set** key. The display will read SET POINT TT where the temperature TT in °C will be flashing. The set point can be incremented or decremented by pressing the ↑ or ↓ key. A new set point can be entered by pressing the **SHIFT** key and entering the new temperature in °C. By either method, the new temperature is not accepted until the **ENTER** key is pressed.

As an example if the set point temperature is 23°C and is to be changed to 28°C, do the following:

<b>KEY PRESS</b>	<b>DISPLAY</b>
T set	SET POINT 23
↑	SET POINT 24
↑	SET POINT 25
↑	SET POINT 26
↑	SET POINT 27
↑	SET POINT 28
ENTER	

Or do the following:

<b>KEY PRESS</b>	<b>DISPLAY</b>
T set	SET POINT 23
SHIFT	SET POINT <u>23</u>
2	SET POINT <u>23</u>
8	SET POINT 28_
ENTER	SET POINT 28
ENTER	

### 3.10. STD OPERATION

STD operation is menu driven as illustrated in Figure 5. To enter the STD operation, press the **STD** key. Use the  $\uparrow$  or  $\downarrow$  key to select one of:

STD STANDARDIZE - for standardization.  
STD COEFFICIENTS - coefficient entry.  
STD EXIT - to exit STD operation.

### 3.10.1. STANDARDIZATION

Select STD STANDARDIZE to standardize the unit (see section 3.5.4 for details).

### 3.10.2. COEFFICIENT ENTRY

- 1) Select STD COEFFICIENTS and press **ENTER** key.
- 2) The Portasal will prompt for entry of a password.

PASSWORD?

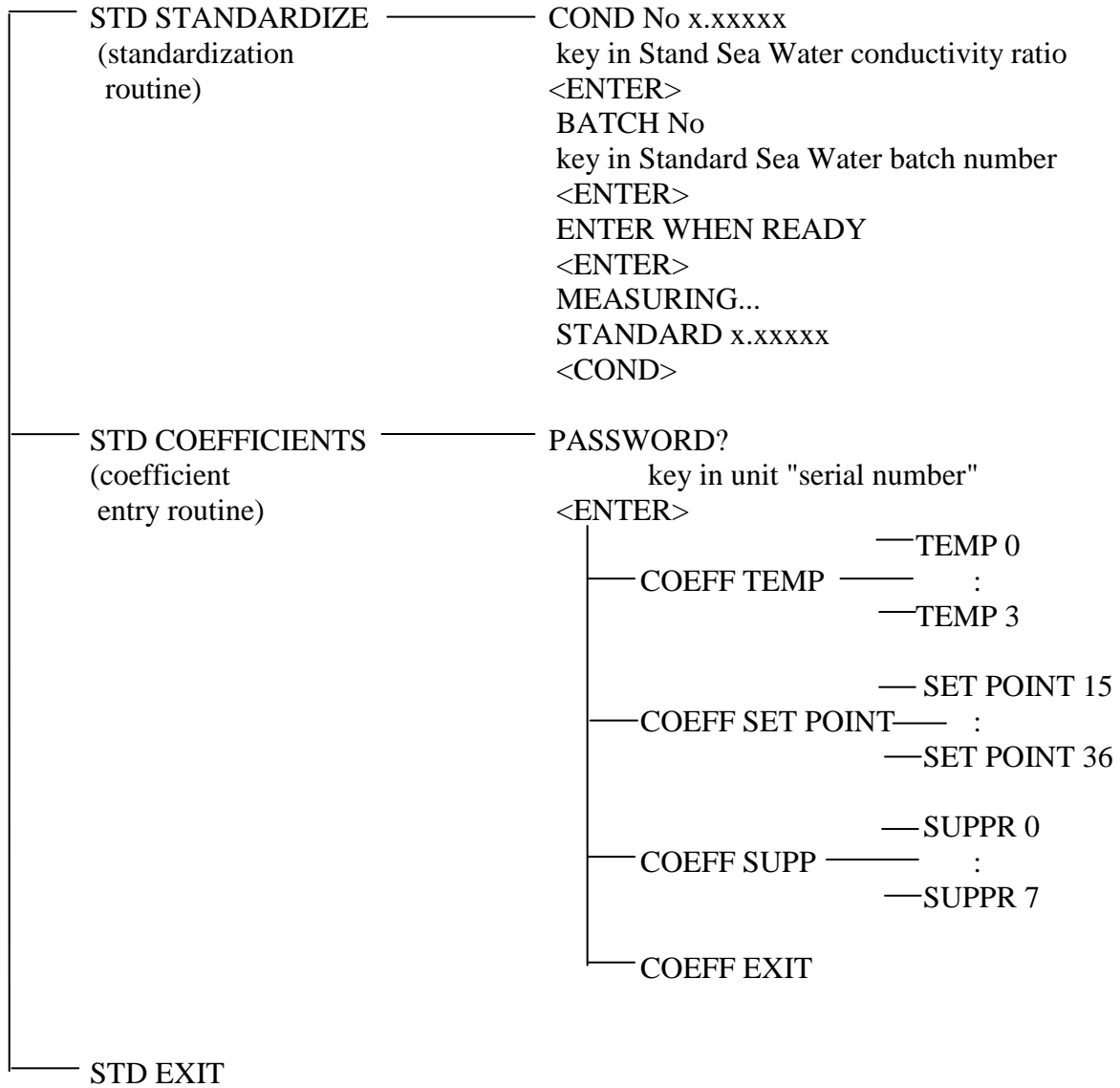
The password is the unit's "serial number" (see section 4.3.39 for details). Key in the serial number and press **ENTER** key.

- 3) The following will be displayed:

COEFF TEMP

The  $\uparrow$  or  $\downarrow$  key can be used to select the desired coefficient group. Press the **ENTER** key to start the entry routine for the selected coefficient group.

- 4) The coefficients can be left as is or altered as follows:
  - i) by using the SHIFT OPERATION (see section 3.8 for details).
  - ii) by using the  $\uparrow$  or  $\downarrow$  key to increment or decrement the right-most digit of the displayed value.
- 5) Once the displayed coefficient is as desired, press **ENTER** key to store the displayed coefficient value and display the next coefficient. The coefficient group is automatically exited upon entry of the last coefficient of the group.
- 6) Select COEFF EXIT and press the **ENTER** key to exit the coefficient entry routine.
- 7) Select STD EXIT and press the **ENTER** key to exit the STD operation.



**Figure 5: STD Operation**

## 4. REMOTE CONTROL

The 8410A has two remote control interfaces, RS-232C and GPIB. This chapter describes the interfaces and the commands which the 8410A will respond to.

### 4.1. RS-232C INTERFACE

The 8410A has an RS-232C interface. The interface is configured the same as a modem, hence most computers should be able to communicate with the 8410A through a modem port. The connector for the RS-232C interface is a standard DB25 connector with standard pinouts as shown in Table 1. Pins 14 and 15 do not conform to RS-232C standard. Pins not shown in Table 1 are unused and ignored.

Pin		Direction	Name
1	CHG		Chassis Ground
2	TxD	Input	Transmit Data
3	RxD	Output	Receive Data
4	RTS	Input	Request to Send
5	CTS	Output	Clear to Send
6	DSR	Output	Data Set Ready
7	GND		Signal Ground
8	DCD	Output	Data Carrier Detect
14	T1	Loop Current	SAIL Loop
15	T2	Loop Current	SAIL Loop
20	DTR	Input	Data Terminal Ready

**Table 1: RS-232C Pin Designation**

The 8410A uses the RS-232C signals as follows:

#### **CHG**

The chassis ground pin is tied to the frame of the equipment

#### **TxD**

Transmit Data, this is ASCII serial data transmitted to the 8410A from a computer or terminal. The format and speed of the data can be programmed from the front panel of the 8410A, refer to section 3.6.1.

#### **RxD**

Receive Data, this is ASCII serial data received by the computer or terminal from the 8410A. The format and speed of the data is the same as that of TxD.

**RTS**

Request To Send, the computer or terminal should make this signal true when it wishes to send commands to the 8410A.

**CTS**

Clear To Send, after the 8410A receives the RTS signal it will make CTS true. The 8410A always echoes RTS on CTS.

**GND**

Ground, all other RS-232C signal levels are with respect to the potential at this pin.

**DCD**

Data Carrier Detect, normally a modem would activate this signal when a valid carrier signal from another modem is detected, the 8410A will activate this signal after the power up diagnostics are completed and the 8410A is ready.

**T1**

Test Pin 1, this pin is one of the two pins of a current loop interface. An external current source must be provided.

**T2**

Test Pin 2, this pin is one of the two pins of a current loop interface. An external current source must be provided.

**DSR**

Data Set Ready, normally this signals that a modem is ready to respond to hand shaking signals, the 8410A activates this signal when the power is turned on indicating that the 8410A is ready to respond to hand shaking signals.

**DTR**

Data Terminal Ready, normally this signals to a modem that the controlling terminal is ready to generate and respond to hand shaking signals, the 8410A expects this signal to indicate to the 8410A that the controlling terminal or computer is ready to generate and respond to hand shaking signals.

## 4.2. GPIB INTERFACE

The 8410A meets the subsets of the GPIB interface specification IEEE-488.1 shown in Table 3. The pin connections on the GPIB interface connector are shown in Table 2.

PIN	NAME	DESCRIPTION
1	DIO1	Data Input Output Line 1
2	DIO2	Data Input Output Line 2
3	DIO3	Data Input Output Line 3
4	DIO4	Data Input Output Line 4
5	E0I	End or Identify
6	DAV	Data Valid
7	NRFD	Not Read For Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Screening On Cable (connected to safety ground)
13	DIO5	Data Input Output Line 5
14	DIO6	Data Input Output Line 6
15	DIO7	Data Input Output Line 7
16	DIO8	Data Input Output Line 8
17	REN	Remote Enable
18	GND6	Ground Wire of Twisted Pair With DAV
19	GND7	Ground Wire of Twisted Pair With NRFD
20	GND8	Ground Wire of Twisted Pair With NDAC
21	GND9	Ground Wire of Twisted Pair With IFC
22	GND10	Ground Wire of Twisted Pair With SRQ
23	GND11	Ground Wire of Twisted Pair With ATN
24	GND	Logic Ground

**Table 2: IEEE-488 Pin Designation**

NAME	DESCRIPTOR	DESCRIPTION
Source Handshake	SH1	The 8410A has complete source handshake capabilities.
Acceptor Handshake	AH1	The 8410A has complete acceptor handshake capabilities.
Talker	T5	The 8410A has talker capabilities with a single primary address in the range 0 to 30. Extended addressing is not supported. Talk only mode is supported.
Listener	L4	The 8410A supports basic listener. The talk and listen addresses will always be the same. Extended Listen addressing is not supported. Listen only mode is not supported.
Service Request	SR1	The 8410A has complete service request generation capabilities.
Remote Local	RL1	The front panel keypad of the 8410A can be locked out by the GPIB controller. The front panel lockout is indicated by the REMOTE LED.
Parallel Poll	PP0	The 8410A has no parallel poll capabilities.
Device Clear	DC1	The 8410A has full device clear capabilities.
Device Trigger	DT0	The 8410A has no device trigger capabilities.
Controller	C0	The 8410A will never become the bus controller.
Electrical Interface	E2	The 8410A has all required electrical interface capabilities.

**Table 3: GPIB Device Capabilities**

### 4.2.1. GPIB INPUT BUFFERING

The GPIB input buffer is 256 bytes long, the input full bit is set when the buffer is above 75% full (64 bytes remaining), hence if the programmer limits messages sent to the 8410A to 32 bytes and checks the IFL bit in the status register before sending each message then under normal operating conditions the buffer should never overflow. If the buffer is full and the programmer sends more data the 8410A will perform the necessary handshaking as per usual but the data WILL be lost, this is done for two reasons:

- (a) if the buffer is full, the system programmer is probably in error since the 8410A should never become full (the 8410A interprets most commands in under 150 milliseconds)
- (b) the 8410A will never lock up the GPIB bus.

### 4.2.2. GPIB OUTPUT BUFFERING

Output from query commands are placed in a 256 byte output buffer. When the controller reads data from the 8410A the responses will come from the output buffer in, "first in first out order". If for some reason the controller does not read the responses from its query commands the output buffer will overflow, in this case the first data into the buffer will still be valid and the later data will be lost. When output data is lost the query error bit in the status register will be set. When the output buffer is not empty then the message available (MAV) bit will be set in the status register.

### 4.2.3. GPIB DEADLOCK

If the controller demands a byte of data from the 8410A and the buffer is empty and this condition persists for a period of 8 seconds, the 8410A will place the current measurement into the output buffer and use this data to satisfy the controllers demand for data. The format of the data is set by the current state of the Terse/Verbose flag (see Terse and Verbose commands).

## 4.3. REMOTE COMMANDS

The following list of commands is decoded by the 8410A. The upper case characters are required. The lower case characters are included for clarity but are not required by the parser.

### 4.3.1. \*ESE - SET EVENT STATUS ENABLE REGISTER

This command sets the standard event status enable register bits. When the bits in the Event Status Enable (ESE) register are ANDed with the bits in the Event Status Register (ESR) if the result is non-zero then the Event Status Bit (ESB) in the Status Byte Register (STB) is set. The values accepted for the \*ESE command are between 0 and 255, all other values are considered to be an error.

### 4.3.2. \*ESE? - EVENT STATUS ENABLE QUERY

This command reports the current value of the Event Status Enable Register. The value returned will be between 0 and 255.

### 4.3.3. \*ESR? - EVENT STATUS REGISTER QUERY

This query allows the programmer to determine the current contents of the event status register. Reading the Event Status Register clears it.

### 4.3.4. \*IDN? - IDENTIFICATION QUERY

This command causes the 8410A to reply with an identification string. The identification string is built up of four (4) fields delimited by commas (.). The first field is the manufacturer (i.e. Guildline), the second field is the model (i.e. 8410A), the third field is the serial number (i.e. 55065) and the final field is the firmware revision (i.e. A).



A typical response might read:

Guildline Instruments, 8410A, 55065, A

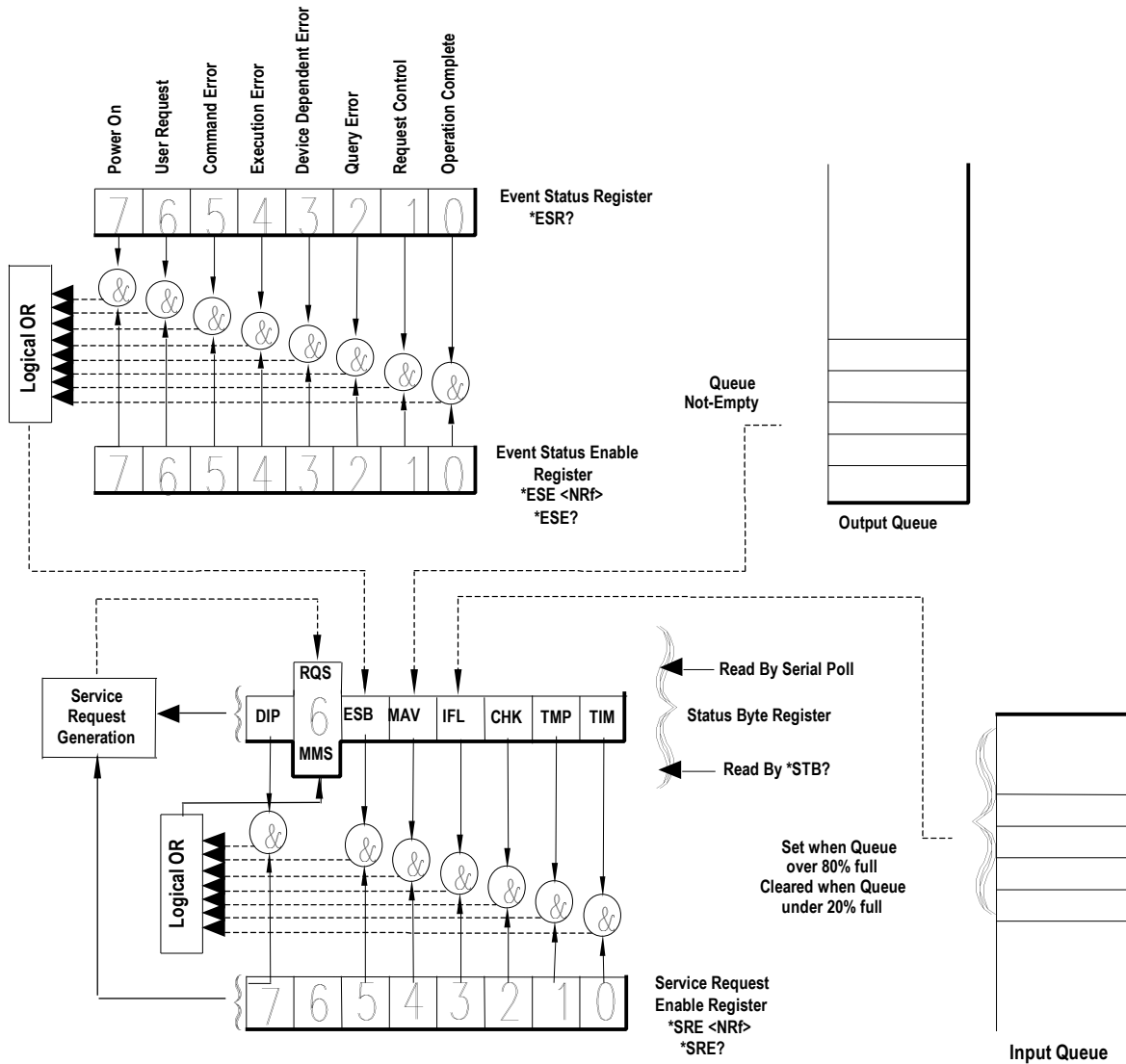
The reply string will be shorter than 73 characters.

### **4.3.5. \*OPC - OPERATION COMPLETE**

This command will cause the 8410A to set the Operation Complete bit (bit 0) in the Event Status. Since the 8410A processes all commands sequentially the operation complete bit will be set as soon as the command is parsed.

### **4.3.6. \*OPC? - OPERATION COMPLETE QUERY**

This query will place a numeric 1 in the output buffer indicating that all pending operations are complete.



**Figure 6: Event Status Bit Operation**

BIT LOCATION		NAME	DESCRIPTION
0	LSB	OPC	OPeration Complete – This event bit is set in response to the *OPC command. It indicates that the 8410A has completed any pending operations and that the parser is ready to accept more program messages.
1		RQC	ReQuest Control – This event bit indicates to the GPIB controller that the 8410A is requesting permission to become the controller in charge. The 8410A will NEVER set this bit.
2		QYE	QuerY Error – This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending, or that data in output queue has been lost (queue overflow). See also GPIB Deadlock.
3		DDE	Device Dependent Error – Not used.
4		EXE	EXecutive Error – Set when 1) a program data element is evaluated to be outside the legal input range or is inconsistent with the 8410A's capabilities, 2) a valid program message could not be properly processed.
5		CME	CoMmand Error – Set when 1) a syntax error has been detected by the parser, 2) a semantic error has occurred indicating that an unrecognized header has been received, 3) a Group Execute Trigger was entered into the input buffer inside of a program message.
6		URG	User Request – Set when any key is depressed on the 8410A keyboard.
7	MSB	PON	Power ON – This bit is set after the 8410A is powered up.

**Table 4: Event Status Register**

### 4.3.7. \*RST - DEVICE RESET

This command is intended to return the 8410A to a known state, specifically a return to Terse mode. This command will not affect the following:

- The Output Queue
- The state of the IEEE-488 interface
- The selected address of the 8410A
- The \*SRE setting
- The \*ESE setting
- Calibration data that affects device specifications

### 4.3.8. \*SRE - SET SERVICE REQUEST ENABLE REGISTER

The service request enable command allows the 8410A to generate a service request on the GPIB interface under a limited set of conditions. The limitations on the conditions are defined by the numeric parameter following the \*SRE command. The numeric parameter is a decimal integer in the range 0 - 255. The numeric parameter when expressed in base 2 (binary) represents the bit values of the Service Request Enable Register. For all bits (except bit 6) a bit value of one (1) indicates an enabled condition and a bit value of zero (0) represents a disabled condition. \*SRE? is the companion query command.

### 4.3.9. \*SRE? - SERVICE REQUEST ENABLE QUERY

This command allows a programmer to determine the current contents of the Service Request Enable Register. A decimal number between 0 and 63 or between 128 and 191 will be returned.

### 4.3.10. \*STB? - STATUS BYTE QUERY

This command allows the programmer to read the status byte and master summary bits (shown in Table 5). The response from this command is a decimal integer in the range 0 - 255. This decimal integer when expressed in base 2 (binary) represents the bit values in the Status Byte Register. Note that the Master Summary Status bit and Not RSQ is reported in bit 6. The Status Byte Register can also be read with the Read Serial Poll hardware command on the GPIB interface.

BIT LOCATION		NAME	DESCRIPTION
0	LSB	TIME	System Time has Changed – This bit is set once each second as the real time clock ticks, and is cleared by the execution of the Time? command.
1		CONV	Conversion Complete – This bit is set after each measurement is received from the analogue to digital converter (once every 400 milliseconds) and is cleared by the execution of Count?, Ratio?, Salinity? or Temperature?
2		CHK	Checksum Computation Complete – This bit is set once after instrument power on after the completion of the computation of the ROM checksum and is cleared by the RomChecksum? command.
3		IFL	Input full – This bit is set when the input queue is over 75% full and cleared when the queue drops below 25% full.
4		MAV	Message AAvailable – This bit is set when the output queue is not empty.
5		ESB	Event Status Bit – This bit is set when the result of a bitwise AND of the Event Status Register and the Event Status Enable Register is not zero.
6		RQS	ReQuest for Service – This bit is set when the result of a bitwise AND of the Status Byte Register and the Service Request Enable Register is not zero.
7	MSB	unused	Always 0.

**Table 5: Status Byte Register**

### **4.3.11. CondScale? - CONDUCTIVITY SCALE FACTOR QUERY**

This query responds with the scaling coefficient for the A/D converter when measuring conductivity ratio. The verbose reply will be:

Conductivity Scale 2.53271E-05

### **4.3.12. CondScale - SET CONDUCTIVITY SCALE FACTOR**

This command will allow the programmer to set the conductivity scale. The format of the command is:

CSC NR3

where NR3 is a floating point number for the conductivity scale factor. All values are considered valid.

### **4.3.13. CondSTandard? - STANDARDIZATION VALUE QUERY**

The ConductivitySTandard? query command responds with the raw data value of the conductivity ratio measurement of standard sea water. The verbose reply will be:

Conductivity Standardization 4.219435

### **4.3.14. CondSTandard - SET STANDARDIZATION VALUE**

This command will allow the programmer to set the value of the standard sea water conductivity. The format of the command is:

CST NR3

where NR3 is a floating point number for the standard sea water conductivity. All values are considered valid. A RESET must be performed after the new value has been entered so that the unit can update to the new value.

### **4.3.15. CondSuppStep? - CONDUCTIVITY SUPPRESSION COEFFICIENTS QUERY**

This query responds with the conductivity suppression coefficients. The verbose reply will be for example:

Conductivity Suppression Steps  
0. 1.000012 2.000033 3.000029 4.000065 5.000093 6.000112 7.000115

### **4.3.16. CondSuppStep - SET CONDUCTIVITY SUPPRESSION STEPS**

This command will allow the programmer to set the values of the conductivity suppression steps. The format of the command is:

CSS NR3<sub>0</sub>,NR3<sub>1</sub>,NR3<sub>2</sub>,NR3<sub>3</sub>,NR3<sub>4</sub>,NR3<sub>5</sub>,NR3<sub>6</sub>,NR3<sub>7</sub>

where NR3<sub>0</sub> through NR3<sub>7</sub> are floating point numbers for the conductivity suppression steps. The values considered to be valid are NR3<sub>x</sub> ±0.02% where the midpoint values of NR3<sub>x</sub> are the integers 0 through 7.

### **4.3.17. CondZero? - CONDUCTIVITY ZERO CORRECTION QUERY**

This query responds with the conductivity zero correction. The verbose reply will be:

Conductivity Zero 0.00032

### **4.3.18. CondZero - SET CONDUCTIVITY ZERO CORRECTION**

This command will allow the programmer to set the value of the conductivity zero correction. The format of the command is:

CZ NR3

where NR3 is a floating point number for the conductivity zero correction. The values considered to be valid are numbers less than 1.

### **4.3.19. Cooling? - COOLING MODULE POWER QUERY**

This query responds with the thermo-electric cooling module power being added to or removed from the temperature bath. A negative value is power removed from the bath. The Verbose reply will be:

Cooling -20.00 Watts

### **4.3.20. Count? - A/D CONVERTER QUERY**

This query responds with the current output of the Analogue to Digital (A/D) converter. The output will be a decimal integer in the range -19 999 to +19 999. The verbose reply will be:

Count 12808

### 4.3.21. Date? - DATE QUERY

This query will report the date maintained in the system real time clock. The verbose reply will be:

Date YYYY/MM/DD

Where YYYY, MM and DD are the year, month and day respectively.

### 4.3.22. Date - SET SYSTEM DATE

This command allows the programmer to set the real time clock date registers (see also the Time command). The format of a valid Date command is:

D YYYY/MM/DD

where YYYY, MM and DD are numbers representing the year, month and day of the month respectively.

### 4.3.23. Extract? - HEADER QUERY

This query responds with one header record. The header records are stored in a first-in first-out buffer. This command extracts the first-in record and removes it from the buffer. The verbose reply for a header record stored while the Portasal was in "terse" mode and with an "end-of-header" marker (see section 3.7) at the beginning of user line 1 will be for example:

Stored Data  
19654, 1990/05/23 14:37, P114, 1.020807, 35.8198, 23

The verbose reply for a header record stored while the Portasal was in "verbose" mode and with an "end-of-header" marker at the beginning of user line 1 will be for example:

Stored Data  
SERIAL No           19654  
1990/05/23           14:37  
BATCH                P114  
RATIO                1.020807  
SALINITY             35.8198  
TEMPERATURE         23



Entering this query after the last header record has been extracted from memory will produce the reply:

Stored Data  
No Data Available

The terse replies will be as above without the "Stored Data" message.

#### **4.3.24. Filter? - FILTER PARAMETERS QUERY**

This query responds with the status and parameters of the filter. The verbose reply will be:

1=ON, 0=MOVING AVG, CONSTANT=10

the terse reply will be: 1, 0, 10

#### **4.3.25. Filter - SET FILTER PARAMETERS**

The Filter command will allow the programmer to set the filter parameters. The format of the command is:

F a,b,c

where a is either 0 (filter off) or 1 (filter on), b is either 0 (moving average) or 1 (weighted average) and c is an integer from 3 to 20.

#### **4.3.26. HeaterPower? - HEATER POWER LEVEL QUERY**

This query responds with the HeaterPower. In Verbose mode the reply will be:

Heating 27.31 Watts

#### **4.3.27. Key? - LAST KEY PRESSED QUERY**

This query will report the value of the key most recently pressed on the keyboard. In terse mode the response will be one of:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, D, E, L, S, U, X, ?

where ? indicates that no keys have been pressed since the 8410A was last Reset. The verbose mode reply will be preceded with Key. The meanings of the various key characters are shown in Table 6.

### 4.3.28. Key - ENTER KEYSTROKE

This command causes the 8410A to perform actions similar to the actions performed when a front panel key is pressed. Allowable values for k are:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, D, E, L, S, U, X

where each of these is a single ASCII character. Multiple characters may be placed on the key command line and they will be processed in the order given, for example the command:

K 1S20EE

will change the SetPoint to 20°C.

Character	Key Name
0	0 or I/O
1	1 or T set
2	2 or HDR
3	3 or FLT
4	4 or TEMP
5	5 or ZERO
6	6 or REF
7	7 or SAL
8	8 or COND
9	9 or STD
D	← or ↓
E	ENTER
L	DEL or LOCAL
S	SHIFT
U	→ or ↑
X	RESET

**Table 6: Keyboard Character Designation**

### 4.3.29. LinearCoefficient? - LINEAR COEFFICIENT QUERY

This query responds with the linear coefficient at the chosen salinity value.

LC? Integer

The possible Integers are: any integer from 2 to 24. The verbose reply will be:

Linear Coefficient salinity,coefficient

### 4.3.30. LinearCoefficient - SET LINEAR COEFFICIENT

This command will allow the programmer to select the linearity coefficient. The format of the measure command is:

Linear Coefficient salinity,coefficient

The possible salinity values are any integer from 2 to 24. The coefficient can be any number:

Linear Coefficient salinity,coefficient

### 4.3.31. Measure? - MEASUREMENT MODE QUERY

This query responds with the measurement type currently being made and with the FUNCTION switch position. The verbose reply will be:

MEASUREMENT 1=Conductivity Ratio, SELECTOR 1=Read

The possible measurement modes are:

0 = Temperature	measuring bath temperature, Function switch can not be in read
1 = Conductivity Ratio	measuring conductivity and displaying conductivity ratio.
2 = Salinity	measuring conductivity and displaying salinity. The salinity must be between 2 and 42 otherwise the measurement mode switches to COND.
3,8,9 = Reference	measuring conductivity of reference resistor and updating scale factor. FUNCTION switch must be in STDBY.

4 = Zero	measuring conductivity of open circuit and updating zero correction. FUNCTION switch must be in ZERO.
5,10,11,12 = Calibrate	measuring the conductivity of cardinal resistors on successive suppression steps to calibrate the suppression steps.
6,13,14,15,16 = Diagnostic	measuring analogue supply voltages. FUNCTION switch can not be in READ.
7 = Standardize	measuring the conductivity of standard water and updating the conductivity standardization value.

The possible selector positions are:

- 0 = Zero
- 1 = Read
- 2 = Standby

### 4.3.32. Measure - SET MEASUREMENT MODE

This command will allow the programmer to select the measurement mode. The format of the measure command is:

M String, Step

where String is one of TEMP, COND, SAL, REF, ZERO, CAL, DIAG or STD.  
and Step is the suppression step selection (used only with the "CAL" string)  
Step = any integer from 1 to 7

### 4.3.33. Ratio ? - CONDUCTIVITY RATIO QUERY

This query command responds with the last measured conductivity ratio. The verbose reply will be:

Ratio 1.020808

### 4.3.34. RomChecksum?- ROM CHECKSUM QUERY

This query will give the checksum of the ROM. Since the checksum algorithm is quite involved, the processor computes the checksum in its spare time, depending upon the bus activity this takes about 35 seconds after power up (or a reset). In order to determine if the computation of the checksum is complete the programmer may either poll the checksum until the value stops changing or wait for the CHK bit in the Status Byte Register to be set to one (1). It should be noted that the CHK bit will only be set once

after the 8410A is powered on, hence simply waiting for the CHK bit to become set may not always work if the RomChecksum has been previously read. Normally this command is only used for diagnostic purposes. The verbose reply will be:

ROM Checksum 1234

where the value 1234 will change as the checksum is computed.

#### **4.3.35. Salinity? - SALINITY QUERY**

This query responds with the last measured salinity. The verbose reply will be:

Salinity 35.8198

#### **4.3.36. SetPoint? - TEMPERATURE SET POINT QUERY**

This query command responds with the set point temperature of the bath in the current Units (see Unit command). The verbose reply will be:

Set Point 23.000 C

where the Units (°C/°F) is dependant upon the current units setting (see Units Command).

#### **4.3.37. SetPoint - SET TEMPERATURE SET POINT**

This command will allow the programmer to select a set point temperature of the bath. The format of the set point command is:

SP NR3

where NR3 is the desired temperature in the current Units (see Unit command). Temperatures are rounded to the nearest integer. Temperatures outside the range of the 8410A will be ignored.

#### **4.3.38. SetPointCoeffs? -SET POINT COEFFICIENTS QUERY**

This query responds with a list of set point temperatures versus set point coefficients. The verbose reply will be:

Set Point Coefficients  
15,108  
16,178  
17,248  
18,88  
19,158  
20,229

21,73  
22,143  
23,213  
24,61  
25,130  
26,199  
27,49  
28,117  
29,185  
30,37  
31,104  
32,170  
33,24  
34,88  
35,152  
36,7  
37,71  
38,135

### **4.3.39. SetPointCoefficient? TT**

This query (TT is one of the above listed temperatures) responds with a set point temperature versus set point coefficient. The verbose reply will be:

Set Point Coefficient 15,108

the terse reply will be: 108

### **4.3.40. SetPointCoefficient - SET SET POINT COEFFICIENT**

This command will allow the programmer to set the value of one bath temperature set point coefficient. The format of the command is:

SPC TT,NNN

where TT is one of the above set point temperatures and NNN is the corresponding set point coefficient. Note that temperatures are in °C. The coefficients must be from 0 to 255 to be acceptable.

### **4.3.41. SerialNumber - SET THE 8410A SERIAL NUMBER**

This command accepts an integer in the range 0 to +200 000, this number will be reported in the serial number field of the \*IDN? command, will be used in the first line of the header and is the password to enter the standardization procedure.

### **4.3.42. SInce? - TIME OF LAST RESET QUERY**

This query will display the date and time that the 8410A was last powered up (or reset). The reply will be:

1988/06/02 10:55:22

where the date displayed will depend upon the start-up date. Under normal conditions the 8410A should be able to operate for months or years without a reset, therefore this command reflects when the last power failure occurred (and the temperature regulation was lost).

### 4.3.43. Temperature? - TEMPERATURE QUERY

This query responds with the current bath temperature in the current Units (see Unit command). The verbose reply will be:

Temperature 22.997 C

where the Units (°C/°F) is dependant upon the current unit's setting (see Units Command). It should be noted that the terse reply will be in the current units even though no indication of units is given.

### 4.3.44. TemperatureCoeff? - TEMPERATURE COEFFICIENTS QUERY

This query responds with the coefficients for converting the A/D converter output to temperature in °C. The verbose reply will be:

Temperature Coefficients 21.804 -16.687 -0.404 -0.618

### 4.3.45. TemperatureCoeff - SET TEMPERATURE COEFFICIENTS

This command will allow the programmer to set the temperature coefficients. The format of the command is:

TC NR3<sub>0</sub>,NR3<sub>1</sub>,NR3<sub>2</sub>,NR3<sub>3</sub>

where NR3<sub>0</sub> through NR3<sub>3</sub> are floating point numbers for the temperature coefficients. The coefficients must be as follows:

Coefficients	Minimum Acceptable Value	Maximum Acceptable Value
NR3 <sub>0</sub>	0	43.8
NR3 <sub>1</sub>	-33.4	0
NR3 <sub>2</sub>	-0.78	0
NR3 <sub>3</sub>	-1.22	0

### 4.3.46. TErse - SET TERSE MODE

This is the default mode for the 8410A after reset. Unless otherwise noted in this section, terse replies are the numeric part only of the verbose reply. When terse mode is set, header information will be written in a side-by-side format, with header lines separated by commas (see section 4.3.23).



### **4.3.47. Time? - SYSTEM TIME QUERY**

This query responds with the time maintained in the system real time clock. The verbose reply will be:

Time HH:MM:SS TimeZone

where HH, MM and SS are the hours, minutes and seconds in 24 hour format, and TimeZone is the current time zone (see TimeZone command). It should be noted that the 8410A maintains two real time clocks, one is battery backed up and is read only at power up, the other clock is derived from the microprocessor clock.

### **4.3.48. Time - SET SYSTEM TIME**

This command will set both internal clocks in the 8410A. The format of the time command is:

TI HH:MM:SS

where HH, MM and SS are the hours, minutes and seconds respectively. The hours should be expressed in 24 hour format.

### **4.3.49. TimeZone - SET TIME ZONE**

Internally the 8410A maintains all times as a 32 bit integer representing the number of seconds since January 1st 1970 Greenwich Mean Time (GMT). When a time is input or displayed it is converted either to or from local time. In order for the 8410A to be able to perform this conversion the instrument must know the current time zone. The TimeZone command has the form:

TZ aaabbbccc

where aaa is the 3 letter abbreviation for the local standard time zone (e.g. CST) and bbb is an integer from -9 to +9 indicating the value that is subtracted from GMT in order to obtain local standard time. Both aaa and bbb are required but ccc is the abbreviation for the local daylight savings time zone (e.g. CDT) and it should be present only if daylight savings time is currently in effect.

Time zones that have more than 9 hours difference from GMT are not attainable through the TZ command. For these time zones the TI (time) and D (date) commands must be used.

### **4.3.50. Units - SET TEMPERATURE UNITS**

This command allows the programmer to set the temperature units for the instrument to either °C or °F. The format of the Units command is:

U c

where c is either the letter C or the letter F.

### **4.3.51. Units? - TEMPERATURE UNITS QUERY**

This query allows the programmer to determine in which temperature units the 8410A is currently operating in. The Verbose reply will be either:

Units C

or

Units F

the Terse reply will be either:

C

or

F

### **4.3.52. Uptime? - RUNNING TIME QUERY**

This query will reply with the number of seconds since the last power failure (or reset). The Verbose will be:

Uptime 23461 Seconds

where the number 23461 will change to reflect the actual up time. Note: The number of seconds can get quite large, as large as 2147483647 however the number of seconds in a year is only 30758400. hence it will take nearly 70 years to overflow this number.

### **4.3.53. Verbose - SET VERBOSE MODE**

This command causes the output of all subsequent commands to contain additional information, this mode should be used for determining problems with programs and when the instrument is being used interactively (such as with a terminal on the RS-232C interface). When verbose mode is set, header information will be written with each header line on a separate line (see section 4.3.23).

### 5. CALIBRATION PROCEDURE

The following subsections contain a step by step procedure for testing the electronic performance of the 8410A and calibrating the instrument. This procedure can be used to check operation, repair circuitry or recalibrate.

The circuit references are to the pertinent schematic and assembly drawings (see Section 8). The test equipment required for circuit checking is standard electronic instrumentation

- voltmeter (4 digit accuracy, 0.01 V resolution)
- Ohmmeter (5 digit accuracy, 0.1 ohm resolution)
- frequency counter

The additional equipment required for calibration is:

- digital thermometer (Guildline 9540 or equivalent)
- RS-232C terminal
- decade resistance box (0.01% precision, 10 k ohm range)
- Standard Seawater (IAPSO or equivalent).

The calibration is performed with the chassis withdrawn from the cabinet (see section 7.5).

#### **CAUTION**

**This procedure should only be attempted by qualified electronic personnel.**

#### **WARNING** **SHOCK HAZARD**

Line voltage is present on back panel when Portasal is connected to line, even when NOT turned on.

Calibration data are stored within each Portasal in the instruments non-volatile memory. This data is listed on sheet 2 of the instruments "Certificate of Conformance" included with the manual and can be examined or changed by access through the front panel controls or the communication port.

**NOTE: Not all calibrated data listed on the "Certificate of Conformance" can be viewed from the front panel (Rom Version, Rom Checksum are available only from the communication port)**

## 5.1. POWER SUPPLY CALIBRATION

This procedure should be performed whenever any portion of the calibration is done.

- 1) Check that the line voltage select switch is in the proper position. Check that the line fuse is installed and is the correct value then plug the power cord into the power outlet.
- 2) Turn the power on and check that the cooling fan and the tank stirrer operate.
- 3) Turn the pumps on and check that they both operate. Turn off pumps and power.
- 4) Open the front panel and remove the electronics enclosure cover.
- 5) Turn power switch ON.
- 6) Measure the voltage on the left lead of inductor L1 on the display PCB with respect to TP1. The voltage must be between 4.75 V and 5.25 V.
- 7) Measure the voltage on the output connectors of the switching power supply with respect to chassis ground. The voltages should be within the following limits:

Terminal	Wire Color	Minimum	Maximum
T10	violet	13.5 V	16.5 V
T12	yellow	-16.5 V	-13.5 V
T13	orange	21.6 V	26.4 V
T15	red	+4.75 V	+5.25 V
T18	brown	-96 V	-64 V

- 8) Measure the frequency at TP8 of the Cond./Temp. PCB 18714.01.02. The frequency should be 150 Hz.
- 9) Replace covers and close front panel.

## 5.2. THERMISTOR CALIBRATION

The procedure for calibrating individual thermistor elements is not recommended practice for field units. Should a thermistor element become faulty the Portasal should be returned to the factory for repair or a replacement thermistor kit be purchased for installation by the user. The replacement thermistor kit is Guildline model number 84104 and includes two thermistor assemblies (TH1 and TH2) attached to a thermistor scaling printed circuit board.

Removal and replacement of the thermistor assembly and scaling p.c.b. is described in Section 7 of the manual.

Once the new thermistor assembly is in place and plug P15 is inserted into the mating connector on the scaling p.c.b. the calibration can be checked by turning the Portasal ON, selecting to view the bath temperature and then setting the bath setpoint to match the bath temperature. When the bath temperature has stabilized select TH1 then TH2 temperatures for viewing on the front panel display. Ensure that the two temperatures displayed are within 0.040°C of each other.

Once the thermistor calibration check is complete the Temperature Calibration should be verified.

### 5.3. TEMPERATURE CALIBRATION

This procedure should be done annually or if a difference of more than 0.020°C is observed between the set point temperature and the displayed bath temperature.

- 1) Cool the water in the tank to 15°C. Cool the ambient to 13°C ±2°C. Remove the cap from the overflow tee fitting. Insert the thermometer probe through the overflow tee fitting into the Portasal bath. Put Portasal into its cabinet. Plug RS-232C terminal into RS-232C connector at rear of Portasal. Plug in Portasal. Turn Portasal ON. Set RS-232C ECHO parameter to ON. Set RS-232C MODE parameter to TALK/LISTEN. Set the other RS-232C parameters to correspond with the RS-232C terminal. Measure TEMP on the Portasal.
- 2) Wait for the bath temperature to stabilize. If the actual bath temperature is more than 0.007°C from the set point temperature change the set point coefficient. A change of 1 of the set point coefficient changes the bath temperature by approximately 0.014°C. To change the set point coefficient send "SPC? tt" on the RS-232C terminal where tt is the current bath set point and the Portasal will respond with the coefficient. Change the coefficient by the desired amount and send "SPC tt,nnn" on the RS-232C terminal where nnn is the new coefficient. Wait for the bath temperature to stabilize again to confirm the actual bath temperature is within the desired tolerance. Record the actual bath temperature and the average A/D reading of the Portasal. To display A/D reading send "CT?" on the RS-232C terminal and the Portasal will respond with the latest A/D reading.
- 3) Once the set point has been calibrated select the next higher set point and keep the ambient temperature to less than the bath temperature but not lower than 4°C below the bath temperature. Repeat step 2 at this new set point temperature.
- 4) Repeat step 3 for all set points up to 38°C.

- 5) Compute a least squares fit to a third order polynomial of the actual bath temperature verses the normalized A/D reading (divide the A/D reading by 20000). Enter these polynomial coefficients into the Portasal by sending "TC a,b,c,d" on the RS-232C terminal where a b c and d are the polynomial coefficients from lowest order to highest.

The above procedure of steps 1 through 5 can be automated and is available from Guildline Instruments as part number 18673.10.20. This procedure runs on a PC compatible computer with a National Instruments GPIB interface and a Guildline 9540 thermometer.

- 6) Once temperature calibration is complete, turn Portasal OFF and remove thermometer probe from the overflow tee fitting and replace the cap. Set the temperature set point to 2°C above room temperature and operate the Portasal at this set point.

### 5.4. CONDUCTIVITY CELL CALIBRATION

The procedure for calibrating an individual conductivity cell to its matching cell resistor is not recommended practice for field units.

Should a conductivity cell become faulty the Portasal should be returned to the factory for repair or a replacement conductivity cell kit purchased from Guildline as model number 84101 for installation by the user.

The conductivity cell replacement kit consists of a conductivity cell assembly and two resistors labeled R33 on the conductivity/temperature PCB and R1 on the function switch assembly respectively.

Removal and replacement of the conductivity cell kit is described in section 7 of this manual. The old R33 cell matching resistor on the cond/temp PCB should be first removed and discarded with the faulty cell. The new matching resistor R33 should then be installed on the cond/temp PCB (No. 18714.01.02). The resistor R1 soldered to pins 9 and 10 of deck B of function switch S2, should be removed and the new resistor (R1) provided with the 84101 kit, installed in its place.

Conductivity linearity calibration should be verified.

### 5.5. CONDUCTIVITY LINEARITY CALIBRATION

This procedure should be done annually or if a non linearity is suspected in the conductivity ratio measurement.

- 1) Substitute a decade resistance box set to 2550  $\Omega$  for the conductivity cell. Plug RS-232C terminal into RS-232C connector at rear of Portasal. Turn Portasal ON. Set RS-232C ECHO parameter to ON. Set RS-232C MODE parameter to TALK/LISTEN. Set the other RS-232C parameters to correspond with the RS-232C terminal. Allow a minimum of three hours from power on for the Portasal to stabilize.
- 2) Do a reference calibration (press REF key and wait for -REFERENCE and +REFERENCE numbers to stabilize to the same value). Do a zero calibration (set function switch to ZERO position, press ZERO key and wait for number to stabilize). Do a suppression calibration (set function switch to READ position, enter "M CAL" on RS-232C terminal and adjust resistance on decade resistance box as directed by the messages on the terminal).

**NOTE: The first resistance R dialed up on the decade box will be approximately 2650  $\Omega$ , the next resistance will be approximately R/3, the next approximately R/5, the next approximately R/7, etc. up to the last resistance which will be approximately R/13. Each of the suppression step readings will remain on the display for approximately 15 seconds). Once all 7 suppression steps have been calibrated, RATIO will be displayed.**

- 3) During the first calibration run adjust the decade box slightly as necessary to get approximately 19870 on the display for each suppression step. Restart MCAL and use the new R base value calculated by multiplying the decade box setting by 13. It should not be necessary to adjust the decade box between steps except when required by the program prompt. At each prompt divide the base value by 3 through 13 as mentioned in step 2. NOTE; if you do change the decade box value after the prompt has been satisfied you will affect the calculation for the suppression step and you will have to redo the calibration.
- 4) Turn the unit back to standby and type CSS? on the terminal. The suppression steps will be read back. Record for future use.
- 5) Turn the unit off, disconnect the decade box and reconnect the conductivity cell.

## 6. PRINCIPLES OF OPERATION

The 8410A consists of the following functional blocks:

- a) Power Supply - generates 5 V,  $\pm 15$  V, 24 V and 80 V.
- b) CPU PCB - consisting of a microprocessor with its input/output latches, random access memory, read only memory, GPIB interface and keyboard/display interface.
- c) Display PCB - with keyboard and display.
- d) Analogue PCB - consisting of a four wire conductance measurement circuit, a temperature control and measurement circuit and a multiplexing Analogue to Digital converter.
- e) Control PCB - consisting of a constant speed motor controller, a heater control and a thermo-electric cooling control.
- f) Software - the operating software in read only memory.

### 6.1. POWER SUPPLY

A current mode, switching power supply provides five isolated outputs of 15 V, 15 V, 24 V, 5 V and 80 V. The two 15 V outputs are interconnected to make a  $\pm 15$  V output. The utilization of the power is as follows:

Output	Max. Load	Use
$\pm 15$ V	4 A	Thermo-electric cooling, analogue circuitry
24 V	1.5 A	Motor and fan
5 V	1 A	Logic
80 V	0.5 A	Heaters

### 6.2. CPU PCB

The CPU PCB contains a microprocessor, memory and input/output devices. The I/O devices interface to the keyboard and display, the GPIB (IEEE-488), and a serial interface (RS-232C). These sections of the CPU PCB are represented on 4 pages of schematic drawings (dwg. no. 18713.10.04).



### 6.2.1. CENTRAL PROCESSING UNIT

The CPU is an Intel 80C188 processor and the design is similar to most 80188 CPU designs. The following sections describe the major functional blocks, however a detailed timing analysis is far beyond the scope of this manual. If a problem is suspected in this section then checking the subsystems in the order in which they are presented is recommended.

#### 6.2.1.1. CLOCK GENERATION

Crystal X1 provides a 14.7456 MHz signal to the processor U5, which generates the system clock (CLK) pin 56. Flip-flop U10 is used to generate CLK/4.

#### 6.2.1.2. CONTROL SIGNAL GENERATION

The 80C188 CPU (U5) contains the required logic to generate, read, and write strobes for the memory and input/output devices. During normal system operation the RD signal (Pin 62) should show the most activity, since the processor should be continually fetching instructions from the program ROM. The WR signal (Pin 63) should toggle at a rate less than the RD signal and show a reasonable amount of activity as the processor writes to RAM.

#### 6.2.1.3. ADDRESS AND DATA BUFFERS

Addresses from the CPU cluster are latched by the 2 octal latches U1, and U12. This latching operation demultiplexes the address/data bus of the CPU cluster into separate address and data busses for the peripheral components. I.C. U16 is an octal bi-directional buffer which transfers data from the peripheral circuitry to the CPU cluster and visa versa.

#### 6.2.1.4. MEMORY AND IO ADDRESS DECODING

The CPU (U5) performs all memory and address decoding internally. The memory chip selects are UCS (for the ROM), LCS (for the RAM), and MCS0 - MCS3 for other memory devices. The IO chip selects are PCS0 - PCS6 for the various IO devices.

#### 6.2.1.5. INTERRUPT CONTROLLER

The system Interrupt Controller is within the CPU IC (U5) and interrupt priorities are set by software.

### 6.2.2. MEMORY

The Memory section of the CPU PCB consists of three 28 pin sockets which will allow up to 128 Kbytes of ROM, 32 Kbytes of RAM and 8 Kbytes of non-volatile RAM.

U17 contains a Smart Watch (which has a real time clock and battery backup for the RAM). I.C. U9A and U9B are configured to be ROM since the processor performs its boot from location 0xFFFF0, and U13 is configured as RAM.

### 6.2.3. SERIAL INTERFACE

The CPU PCB has one serial channel, which is a full RS-232C interface with hardware hand shaking signals.

#### 6.2.3.1. SERIAL COMMUNICATIONS CONTROLLER

The serial channel is controlled by U18, which is a serial channel controller. Baud rates are internally derived from the system clock which is divided by 4 by U10.

#### 6.2.3.2. RS-232C BUFFERS

I.C. U15 is a standard RS-232C buffer which converts RS-232C signal levels to TTL signal levels and back.

#### 6.2.3.3. 20 mA BUFFER

A 20 mA current loop on pin 2 and 4 of J7 is converted to RS-232C signal levels by U8, U11, Q1, Q2, CR3 and CR4. The 20 mA current source is external to the interface and the 20 mA loop is optically isolated from the CPU. Either polarity of loop current is accommodated by CR4. CR3 provides base current for Q1 when the transistor of U8 is not conducting. The loop current passes through the diode of U8 causing U11 pin 5 to be low. Some of the loop current is shunted by R3 to optimize the switching speed of U11. When the loop current is interrupted U11 pin 5 is pulled high by R6. The turn off time of U11 is decreased by R2. When Q2 goes low U8 conducts the base current away from Q1, effectively interrupting the loop current. R1 provides the current for optimum switching of U8 and R4 reduces its turn off time. Q3 and R5 improve the switching characteristics of the circuit. SW2 selects the serial communication source as either RS-232C or 20 mA.

### 6.2.4. KEYBOARD INTERFACE

The Keyboard interface section contains an interface to the keyboard/display card. A general purpose data buffer U19 provides the Keyboard/Display interface. The address lines and read/write signals are decoded and buffered by I.C. U14.

## 6.2.5. GPIB INTERFACE

The GPIB interface is built up from a Motorola 68488 controller IC (U6) and two buffers (U3 and U4). U2 produces control signals for devices which are not Intel compatible.

## 6.3. DISPLAY PCB

The display PCB contains a multiplexed vacuum fluorescent display, a latched LED display and an addressable key matrix sense. With the exception of DRQ the signals on J10 are active only during a board access and are otherwise high. These sections of the display PCB are represented on schematic drawing (dwg. no. 18719.01.04).

### 6.3.1. VACUUM FLUORESCENT DISPLAY

The characters of the vacuum fluorescent display are multiplexed by DMA. The DMA request for the first eight segments comes from a timer internal to the CPU. The write of these segments (address 0) generates a second DMA request (U2 pin 18) for the other eight segments. The write of these segments (address 1) decrements the character counter (U10 and U5). The character counter wraps around from 1 to 16 or can be set to 1 by a dummy write to address 2. Inter digit blanking is initiated by a write to address 0 and is extended by a monostable multivibrator U3. The other half of U3 is used to disable the display if there is no periodic refresh of the display.

The logic equations for U2 are:

$$\begin{aligned} \text{RST} &= \text{Q18} + \text{WR2} \\ \text{EN} &= \text{ON} * /\text{DRQ} * / \text{WR1} * / \text{BLANK} \\ \text{DRQ} &= (/ \text{WR1} * \text{DRQ}) + \text{WR0} \\ \text{CLK} &= / \text{WR1} * \text{Q9} \end{aligned}$$

### 6.3.2. LED DISPLAY

The status of all LED's is stored in U12 by a write to address 3. The LED's are written high true on. The data bit that corresponds to each LED is as follows:

SRQ	DB0
TALK	DB1
LISTEN	DB2
REMOTE	DB3
FILTER	DB4
SHIFT	DB5

### 6.3.3. KEY MATRIX

The key pad is a four row by four column matrix. Each row is a different read address. The keys are low true closed. The key that corresponds to each data bit is as follows:

ADDRESS	DB0	DB1	DB2	DB3
0	SAL	COND	STD	RESET
1	TEMP	ZERO	REF	↑
2	Tset	HDR	FLT	↓
3	SHIFT	I/O	LOCAL	ENTER

## 6.4. ANALOGUE PCB

The analogue PCB contains a regulator, reference, four phase clock, conductivity measurement, temperature control and measurement, and multiplexed Analogue to Digital converter. These sections of the analogue PCB are represented on four pages of schematic drawings (dwg. no. 18714.01.04).

### 6.4.1. REGULATOR

The analogue supplies are derived from a filtered  $\pm 15$  V supply. The four supplies  $+5$  V<sub>a</sub>,  $+10$  V,  $-5$  V<sub>a</sub> and  $-10$  V are generated by three terminal regulators U1, U2, U3 and U4 respectively. Analogue ground is tied to logic ground at the Digital to Analogue converter Z16.

### 6.4.2. REFERENCE

All analogue measurements are made ratiometrically with respect to a 2.5 V reference generated by Z21.

### 6.4.3. CLOCK

A four phase clock is generated by Z6 and Z12. The frequency is determined by a CPU timer and is divided by 32 by Z6. The clock signals are converted from logic level to  $\pm 5$  V level by Z13 and CLK1 is converted to a precision  $\pm 2.5$  V signal by Z22 and Z10–D. The reference voltage is converted to a square wave by switching Z10–D from a non-inverting to an inverting buffer.

### 6.4.4. TEMPERATURE CONTROL

The temperature control system uses two thermistors in parallel, each thermistor having its own set of matching resistors. The matching resistors linearize and scale the voltage drop across the thermistor as a function of temperature. The following algorithm is used:

$$R_1 = K * R * R_t / (R + R_t)$$

$$R_2 = K * R * R_t / ((K - 1) * R_t - R)$$

where  $R_t$  is the thermistor resistance at temperature  $t$

$$t = 25.5^\circ\text{C}$$

$$K = V_{\text{ref}} / V_t$$

$$V_t = 0.57274 \text{ Volts}$$

$R$  is the parallel combination of  $R_1$  and  $R_2$  and is defined as:

$$R = (R_{15} * R_{25.5} + R_{25.5} * R_{36} - 2 * R_{15} * R_{36}) / (R_{15} + R_{36} - 2 * R_{25.5})$$

This algorithm equalizes the voltage difference between  $15^\circ\text{C}$  and  $25.5^\circ\text{C}$  and between  $25.5^\circ\text{C}$  and  $36^\circ\text{C}$  and scales the voltage to  $V_t$  at temperature  $t$ . By linearizing the end points and the mid point of the desired scale the linearity error reduces to  $\pm 0.03^\circ\text{C}$ . Correcting the resultant non linearity with a third order polynomial reduces the error to  $\pm 0.002^\circ\text{C}$ . The variation in voltage at  $15^\circ\text{C}$  is less than  $\pm 0.7\%$ . The self heating under these conditions will be less than  $0.002^\circ\text{C}$ .

The thermistors may be selected by Z11 to be measured individually or both in parallel. There are two reasons for using two thermistors. Each thermistor measures a different sample of water and returns a better average bath temperature. The thermistors have a relatively high failure rate so by selecting each thermistor individually it can be determined if one has failed.

The thermistor voltage is compared by Z14 to the voltage drop across a precision resistor chain in a bridge arrangement. The resistor chain voltage can be trimmed by Digital to Analogue converter Z16 and Z1-B. The trimming range is approximately one step on the resistor chain. The desired voltage tap is selected by Z8. The comparator output is conditioned by a Schmidt trigger Z12 then used to control incandescent heaters to maintain the bridge in balance.

The thermistor voltage  $V_t$  is scaled by Z10-C for output to the A/D converter.

The other half of the D/A converter is used to control the cooling power of the thermoelectric cooling module.

### 6.4.5. CONDUCTIVITY MEASUREMENT

The precision  $\pm 2.5$  V signal is used to drive a resistor chain which produces a suppression signal. The precision  $\pm 2.5$  V signal is also used to drive Z1-D. The electrode P2 is the closest electrode to the grounded heat exchanger therefore P2 is maintained at ground potential by Z1-A so that no current flows from C2 to the heat exchanger. The excitation voltage across P1 to P2 is maintained by Z1-D to

$$\pm V_{ref} * R_{25}/R_{32}$$

This produces a current through the cell of

$$\pm V_{ref} * R_{25}/R_{32} * 1/R_x$$

This current is sensed across a precision resistor R33 which produces a voltage signal of

$$\pm V_{ref} * R_{25}/R_{32} * R_{33}/R_x$$

The two half cycles are added across C47 and C48 by the flying capacitor circuit Z18. The voltage sum across C47 and C48 represents the total offset errors in the amplifiers and in polarization of the conductivity cell. This error is fed back through an integrating amplifier Z9 to maintain an equal current in both directions through the conductivity cell.

Alternate half cycles are stored on C36 or C37. The difference between the suppression signal selected by Z7 and the unknown signal is amplified by Z10-B to

$$\pm V_{ref} * (R_{52}/R_{55} + 1) * (R_{25}/R_{32} * R_{33}/R_x - N/22)$$

where N is the suppression step.

This amplified difference signal is synchronously demodulated by Z22 to give a voltage level across C40 and C41 of

$$2 * V_{ref} * (R_{52}/R_{55} + 1) * (R_{25}/R_{32} * R_{33}/R_x - N/22)$$

This is further amplified by  $(R_{46}/R_{45} + 1)$  by Z10-A before being output to the A/D converter.

### 6.4.6. ANALOGUE TO DIGITAL CONVERTER

The Analogue to Digital converter Z4 is a dual slope integrating converter with a resolution of  $\pm 19\,999$  counts. The output is multiplexed BCD, most significant digit first. The converter clock is provided by Z15 which is a programmable oscillator divider hardware programmed to 100 kHz. This frequency is chosen for both 50 Hz and 60 Hz rejection. The converter reference is derived from  $V_{ref}$  through resistor divider R42 and R43. The input to the converter is selected by Z5 from one of eight sources.

## 6.4.7. DIGITAL INTERFACE

The interfacing between the CPU PCB and the Analogue PCB is performed by three peripheral devices. These devices do the following:

ADDRESS	FUNCTION	DIRECTION	COMMENTS
PCS1 +0	A/D conv.	Read	latched data generates INT1 D0 – D3: BCD0 – BCD3 D4: over-range D5: polarity D7: least significant digit
+1	Suppression	Write	D0 – D2
+1	Mux. channel	Write	D5 – D7
+2	Heater status	Read	D0: heater control D1: heater #1 state D2: heater #2 state
+2	Function	Read	D6, D7: switch position
PCS5 +0	Set point trim	Write	0=minimum temperature)
+1	Cooling power	Write	0=maximum cooling)
PCS6 +0	Set point	Write	D0 – D2
+0	Thermistor	Write	D3: Thermistor #1 D4: Thermistor #2

## 6.5. CONTROL PCB

The control PCB contains a constant speed motor control, heater control and thermo-electric cooling control. These sections of the control PCB are represented on two pages of schematic drawings(dwg. no. 18802.01.04).

### 6.5.1. MOTOR CONTROL

The motor control is driving a 1/60 HP, 24 Vdc brushless motor. The commutation of the motor windings is performed by U6. The Hall sensors on the motor are spaced 120° apart. U6 is available for either 120° or 60° separation. If the 60° version is used U7–B must be configured as an inverter (ie. LK1 links U7 pin 5 to VDD). Otherwise U7–B must be configured as a non-inverter (ie. LK1 links U7 pin 5 to PGND). The Hall sense signals are exclusive or'd by U7 to produce a clock of six times the rotational frequency of the motor. This frequency is compared against the VCO output of U8 to gate the motor current. The motor current is also limited to 3 A by R18.

### 6.5.2. HEATER CONTROL

The heaters are controlled by an optically isolated FET switch U4. The current through U4 is limited to 500 mA by VR1 and R12. The current in each heater is monitored through optically isolated detectors U2 and U3.

### 6.5.3. COOLING CONTROL

The thermo-electric cooling module is driven by a power amplifier U1. An input to this amplifier of from 0 V to -2.5 V will drive the output from -15 V to +15 V. Due to internal saturation voltages within U1 the output is limited to approximately  $\pm 12$  V.

## 6.6. SOFTWARE

The 8410A control program is approximately 65 K bytes long. It is written in the "C" programming language and is stored in a 27C512 read only memory (U9).

The input/output devices are mostly handled by interrupt routines which pass data to or from buffers. The exceptions are, the display which is multiplexed by direct memory access (DMA) and the following outputs which are set directly by the control program: LED's, temperature set point, thermistor selection, conductivity suppression and analogue to digital multiplexer selection.

The control program polls the input buffers sequentially and takes appropriate action. With the exception of the keypad buffer, action is not taken until a complete message is in the buffer. Because of operator prompting the keypad buffer is serviced for each key press.



### 6.6.1. NON-VOLATILE MEMORY VARIABLES

The control program uses several variables which are stored in non-volatile random access memory. These variables are preserved when power is off and may be altered by the operator. The non-volatile variables are:

VARIABLE	TYPE	NO. OF ELEMENTS
temperature set point	double	1
set point coefficients	integer	24
temperature coefficients	double	4
conductivity suppression	double	8
conductivity zero	double	1
conductivity scale	double	1
standard conductivity	double	1
standard temperature	double	1
standard batch number	character	10
standard conductivity number	double	1
serial number	long integer	1
time zone	character	20
filter state	Boolean	1
filter type	Boolean	1
filter constant	integer	1
line frequency	integer	1
RS-232C baud rate	long integer	1
RS-232C parity	integer	1
RS-232C stop bits	integer	1
RS-232C data bits	integer	1
RS-232C flow control	integer	1
RS-232C echo	Boolean	1
RS-232C mode	integer	1
SAIL address	integer	1
SAIL baud rate	long integer	1
GPIB address	integer	1
GPIB mode	integer	1

### 6.6.2. TEMPERATURE CALCULATION

If the measurement mode has been set to temperature measurement the control program sets the temperature set point, the thermistor selection and selects the temperature channel. When the A/D converter input buffer contains new conversion data, the control program calculates the temperature using the equation :

$$t = A_0 + A_1r + A_2r^2 + A_3r^3$$

where t is the temperature in °C,

r is the normalized raw A/D converter value

A<sub>0</sub> through A<sub>3</sub> are the temperature coefficients

### 6.6.3. CONDUCTIVITY CALCULATION

If the measurement mode has been set to conductivity ratio, salinity or standardize, the control program selects the conductivity channel and selects a conductivity suppression step which does not cause an overrange of the A/D converter. When the A/D converter input buffer contains new conversion data, the control program calculates the conductivity using the equation:

$$G = S * r + G_{\text{step}} - G_0$$

where G is the conductivity in arbitrary units

S is the conductivity scale

r is the raw A/D converter value

G<sub>step</sub> is the conductivity suppression for the selected suppression step

G<sub>0</sub> is the conductivity zero

### 6.6.3.1. STANDARD

If the measurement mode has been set to standardize, the conductivity is divided by the standard conductivity number. This value is then corrected for bath temperature to give the equivalent conductivity of standard sea water at 15 °C. The correction factor is:

$$r_t = c_0 + c_1t + c_2t^2 + c_3t^3 + c_4t^4$$

where  $t$  is the bath temperature set point in °C

$$c_0 = 0.6766097$$

$$c_1 = 2.00564e-2$$

$$c_2 = 1.104259e-4$$

$$c_3 = -6.9698e-7$$

$$c_4 = 1.0031e-9$$

The standard conductivity is calculated as :

$$G_{std} = \frac{G}{R_{std} * r_t}$$

where  $R_{std}$  is the conductivity ratio of the Standard Sea Water as entered (see section 3.5.4).

### 6.6.3.2. CONDUCTIVITY RATIO

If the measurement mode has been set to conductivity or salinity, the conductivity ratio is calculated as:

$$R_t = \frac{G}{G_{std} * r_t}$$

### 6.6.3.3. SALINITY

If the measurement mode has been set to conductivity or salinity, the salinity is calculated using the equation:

$$S = S_a + S_b$$

where  $S$  is salinity in Practical Salinity Units

$$S_a = a_0 + a_1R + a_2R^2 + a_3R^3 + a_4R^4 + a_5R^5$$

$$S_b = \frac{(-15)^t}{1 + k(-15)^t} (b_0 + b_1R + b_2R^2 + b_3R^3 + b_4R^4 + b_5R^5)$$

where  $t$  is the bath temperature setpoint in °C

$$R = \sqrt{R_t}$$

$$a_0 = 0.008\ 0$$

$$a_1 = -0.169\ 2$$

$$a_2 = 25.385\ 1$$

$$a_3 = 14.094\ 1$$

$$a_4 = -7.026\ 1$$

$$a_5 = 2.708\ 1$$

$$b_0 = 0.000\ 5$$

$$b_1 = -0.005\ 6$$

$$b_2 = -0.006\ 6$$

$$b_3 = -0.037\ 5$$

$$b_4 = 0.063\ 6$$

$$b_5 = -0.014\ 4$$

$$k = 0.016\ 2$$

### 6.6.4. FILTER

The 8410A uses two types of filters: a weighted average and a moving average.

#### 6.6.4.1. WEIGHTED AVERAGE

The weighted average is an exponential filter. The average is calculated as :

$$A = [A' * (n - 1) + X] / n$$

where

- A is the new average
- A' is the old average
- X is the new sample
- n is the filter constant

#### 6.6.4.2. MOVING AVERAGE

The moving average is the arithmetic mean of the latest n samples (n is the filter constant).

## 7. MAINTENANCE

### 7.1. INTRODUCTION

The maintenance procedures described in this section can be done with the instrument installed in the laboratory.

**WARNING**

**Disconnect power cord before attempting any maintenance inside cabinet except as required for operational tests.**

### 7.2. MAINTENANCE SCHEDULE

Table 7 contains a recommended maintenance schedule. This schedule is provided as a guide only, and individual users will find that the need for various checks will change depending on use and location of the instrument.

Table 8 shows how often the various operational checks should be made.

ITEM	MAINTENANCE PERIOD	
	LABORATORY USE	SHIPBOARD USE
1. General Interior Inspection	1 month	1 week
2. Bath Temperature Verification	1 month	2 weeks
3. Pumping Service	300 hr use	100 hr use

**Table 7: Maintenance Schedule**

ITEM	CHECK PERIOD
1. Function Check	during use
2. Bath Temperature Control Check	daily
3. Zero Reference Check	during use
4. Standardization	24 hrs for .002 ppt

**Table 8: Operating Checks Schedule**

### 7.3. GENERAL INSPECTION

Periodically examine instrument interior for loose tubing clamps, loose wiring connectors or connections, and spills. Include bath temperature control check to ensure the two thermistors are in calibration. When instrument is used on a ship, this check should be made daily.

### 7.4. GENERAL CLEANING

Wipe instrument case with soft lint-free wiper, using mild detergent to remove grease. Due to the corrosiveness of sample water, wipe spillage and neutralize corrosive surfaces as soon as spillage is detected.

### 7.5. OPENING THE CABINET

The opening is a two-stage operation; one to withdraw the chassis and one to swing open the front panel. This allows access to the interior for inspection testing and certain parts replacement.

#### CAUTION

**Be careful when opening the front panel that the Portasal does not tip forward unexpectedly. If intending to withdraw chassis, ensure there is sufficient bench space in front and that its weight is supported at all times.**

Open front panel or withdraw chassis as follows:

- (1) Remove four cap screws from rear panel.
- (2) Release sixteen front panel fasteners by turning 1/4 turn counter-clockwise.
- (3) Carefully pull front panel out of case.
- (4) Withdraw the chassis as far as necessary. If chassis is removed completely support the chassis so that the front panel does not rest on the bench.
- (5) To swing front panel open, remove four screws on right side of chassis.

### 7.6. BATH TEMPERATURE VERIFICATION TEST

#### WARNING

The following tests are done with the chassis exposed and the power turned on. There is accessible line voltage AC wiring on the rear panel. Extreme care must be exercised when working on the inside of this instrument when the instrument is connected to line voltage, especially when in a salt water environment. Lethal shock hazard may be encountered through careless procedures.

- (1) Withdraw chassis (Section 7.5).
- (2) Remove cap from Tee fitting on tank cover.
- (3) Insert platinum resistance thermometer through exposed hole and into bath to verify bath temperature accuracy and stability.

**NOTE: Use a hollow stopper to hold the thermometer secure.**

- (4) Turn on the instrument. If digital display is erratic or there is temperature drift (usually higher) check impeller drive belt for slippage. Clean pulleys and replace belt if necessary.
- (5) Remove thermometer and re-install cap.
- (6) Ensure fans are operating and air filter is clean.

### 7.7. HEATER LAMP REPLACEMENT

- (1) Turn off instrument and remove line cord. Withdraw chassis (Section 7.5).
- (2) Disconnect lamp socket wires at quick connects.
- (3) Unscrew pigtail clamp ring and carefully pull out lamp socket.
- (4) Unscrew old bulb from socket.
- (5) Smear small amount of petroleum jelly inside the lamp socket and O-ring gasket.
- (6) Slide lamp spacer ring and O-ring gasket on to base of bulb. Screw bulb into socket.
- (7) Carefully re-insert lamp in its hole, tighten the retaining screws and reconnect lamp socket wires.



### 7.8. CONDUCTIVITY CELL REMOVAL

Perform the following steps to remove the conductivity cell for cleaning, inspection or replacement. Cleaning the cell is required when an erratic digital display persists when all controls are set for normal operation, especially during standardization. The cause is usually from a contaminating film such as oil, algae etc. Proceed as follows:

- (1) Withdraw chassis from cabinet (Section 7.5).
- (2) As seen from front of instrument, disconnect drain tube on left hand side of the cell from reducer coupling. Disconnect flushing tube from left side of manifold. Disconnect electrical plug.
- (3) Remove six binder head screws securing cell assembly to tank cover.
- (4) Lift cell left hand end first so drain tube clears cover aperture.
- (5) Remove cell fill tube (1/16 in O.D.) from its coupling inside the tank. For replacement only, go to step 15.
- (6) Cut straps (2) holding cell to support pillars. Cut straps (8) holding cell to electrode assemblies. Cut straps (2) holding cell to drain tube coupling.
- (7) Hold cell assembly under hot water for one or two minutes.
- (8) Remove cell from drain tube. Do not remove coupling.
- (9) Remove plastic bushing from inside cell with small blunt nose pliers. (An alternate method is to push bushing out with an appropriate size punch. Replace bushing if damaged during removal.)
- (10) Gently but firmly ease off four plastic tubes with electrode assemblies from cell arms.
- (11) Clean cell with bottle brush using hot water and mild detergent. Rinse thoroughly with distilled water.
- (12) Connect cell to plastic tubes and support pillars. Make sure that adjacent straps are staggered to produce a good seal.
- (13) Connect fill end of cell to a water tap using suitable tube. Flush cell with running water. Pinch drain tube, creating sufficient back pressure to flush water through all four arms and air tubes.

- (14) Disconnect from water supply. Blow air through air flush tube to clear all water from cell and air tubes.
- (15) Carefully re-connect all tubing. Carefully reinstall cell assembly to its position in cover aperture.
- (16) If this is a cell replacement, see section 5.4 for instructions on replacing the matching resistors.

### **7.9. THERMISTOR ASSEMBLY REMOVAL**

Perform the following steps to remove the thermistor assembly for cleaning, inspection or replacement. The thermistor assembly consists of two thermistor elements TH1 and TH2 attached to a scaling printed circuit board. To remove the complete assembly proceed as follows:

- (1) Withdraw chassis from cabinet (section 7.5)
- (2) Locate scaling PCB on top left of the Top Plate Assembly and disconnect plug P15.
- (3) Remove the 4 screws securing the scaling PCB to the Top Plate
- (4) Using a pair of long nose pliers locate each thermistor tube TH1 and TH2 and slowly lift each assembly clear of the Top Plate

Reassembly or replacement of the thermistor assembly is achieved by following above procedure in reverse order. The thermistor tube assemblies should be installed to their correct positions TH1 (Black leads, long tube) and TH2 (White leads, short tube). Each thermistor tube should be inserted into the Top Plate with 0.25" of the tube protruding above the Top Plate. Care should be exercised when installing the thermistor tubes not to cut or damage the hook-up wire attaching the thermistor to the scaling PCB.

### **7.10. CLEANING FLUSHING MANIFOLD/TUBES**

If the small air flushing tubes on the conductivity cell become blocked with salt deposit, remove the cell as outlined in Section 7.8, including disconnecting the short large diameter tube attached to the cell support arm from the long smaller diameter tubing from the air pump. Force warm soapy water down the large tube into the small flushing tubes to clean them. Then rinse the tubing and blow dry. Reassemble the cell as in Section 7.8.

### 7.11. PUMP/STIRRER SERVICING

Work required consists of:

- (a) Lubrication of pump bearings and pistons using good quality SAE 20 engine oil.

**NOTE: Never use fuel oils, utility oils, rust preventatives or like preparations.**

- (b) Replacement of air filter.
- (c) Checking drive belt wear.

#### 7.11.1. SERVICE INSTRUCTIONS

Remove chassis completely from case (Section 7.5) and proceed as follows:

- (1) Put one drop of SAE 20 oil on each piston, on the piston leather washer and on the bronze bearing of the piston crankshaft rod.
- (2) Wipe off any excess oil. Make certain the O-ring belt is kept clean and free from oil.
- (3) Replace the air filter.

#### **CAUTION**

**Never change the air filter while the pump is running or dust may enter the valves. Never use a pump without a filter.**

- (4) Replace drive belt if worn.



### 8. PARTS LISTS (can be ordered from Guildline)

#### MODEL 8410A

PL18673.10.02	General Assembly
PL18713.10.02	CPU PCB
PL18714.01.02	Conductivity Temperature PCB
PL18719.01.02	Display PCB
PL18802.01.02	Control PCB
PL18900.01.02	Standard Spare Parts

#### MODEL 84102

PL18716.01.02	Maintenance Kit
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## 9. DRAWINGS (can be ordered from Guildline)

18673.10.02	General Assembly
18673.10.04	Interconnections Schematics
18674.01.01	Top Panel Assembly
18713.10.02	CPU PCB Assembly
18713.10.04	CPU PCB Schematic
18714.01.02	Conductivity Temperature PCB Assembly
18714.01.04	Conductivity Temperature PCB Schematic
18719.01.02	Display PCB Assembly
18719.01.04	Display PCB Schematic
18802.01.02	Control PCB Assembly
18802.01.04	Control PCB Schematic