OPERATING MANUAL FOR THE U.S. GEOLOGICAL SURVEY MINIMONITOR, 1988 REVISED EDITION

Analog-Voltage Model

By James H. Ficken and Carl T. Scott

U.S. GEOLOGICAL SURVEY

Open-File Report 89-403

Stennis Space Center, Mississippi

1989

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Use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

HIF APPLICATION NOTES

The following changes need to be made to U.S. Geological Survey Open-File Report 89-403, "*Operating Manual for the U.S. Geological Survey Minimonitor, 1988 Revised Edition, Analog-Voltage Model*," by James H. Ficken and Carl T. Scott.

Figure 2.--Minimonitor electronics assembly removed from can.

Replace label "MUX" with "POWER/ANALOG" as shown on the attached drawing.

Figure 3.--POWER/ANALOG board. 1 through 8--Signal conditioner input sockets.

Replace with new drawing attached.

The section heading (page 46) "OPERATION OF THE MINIMONITOR WITH THE LABARGE GOES DATA-COLLECTION PLATFORM" should read "OPERATION OF THE MINIMONITOR WITH GOES DATA-COLLECTION PLATFORM." The first paragraph should be changed to read as follows: The Minimonitor has been designed to interface to all data-collection platforms that are designed to read 0-to-5-volt dc analog inputs. For platform interface instructions, please refer to "Goes Data-Collection System Instrumentation, and Maintenance Manual," U.S. Geological Survey Open-File Report 86-479. For the Labarge data-collection platform, refer to the connection list below or the above reference.

3-22-90

CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric (International System) units by the following factors.

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
foot per second (ft/s)	0.3048	meter per second (m/s)

Additional Abbreviations and Symbols

1 mil	0.001 in.
COND	conductivity
dc	direct current
DCP	data-collection platform
DO	dissolved oxygen
GOES	Geostationary Operational Environmental Satellite
HCl	hydrochloric acid
Hg	mercury
JTU	Jackson Turbidity Units
mg/L	milligrams per liter
MUX	multiplexer board
p	pressure
P	barometric pressure
S	solubility
Temp Comp	temperature compensation
TEMP	temperature
μS/cm	microsiemens per centimeter
mm Hg	millimeters of mercury
pots, trimpots	potentiometers
ppm	parts per million

OPERATING MANUAL FOR THE U.S. GEOLOGICAL SURVEY MINIMONITOR
1988 REVISED EDITION
Analog-Voltage Model

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ABSTRACT

This manual describes the U.S. Geological Survey Minimonitor Water-Quality Data-Measuring System. It also provides instructions for calibrating, servicing, maintaining, and operating the system.

The Survey Minimonitor is a battery-powered, multiparameter water-quality-monitoring instrument designed for field use. A watertight can containing signal conditioners and control electronics is connected with cable and waterproof connectors to various water-quality sensors. Measurement outputs are in the form of analog voltages. The device requires an external battery.

The manual describes the operation and maintenance of various sensors and signal conditioners for temperature, specific conductance, dissolved oxygen, and pH. Calibration instructions are provided for each parameter, along with maintenance instructions for each sensor. Sections of the report explain how to connect the Minimonitor to measure direct-current voltages, such as signal outputs from other instruments. Instructions for connecting a satellite data-collection platform or a solid-state data recorder to the Minimonitor also are given.

The instructions include basic information for servicing the Minimonitor and troubleshooting some of its electronic components as well as a discussion of the use of test boxes to test sensors, isolate component problems, and verify calibration values.

INTRODUCTION

The U.S. Geological Survey, under its authority to conduct water-resources surveys, investigations, and research, monitors certain water-quality constituents with automatic equipment. The data derived from monitoring activities are used to determine short-term and, in some cases, real-time fluctuations in the concentrations of these water-quality constituents.

The Hydrologic Instrumentation Facility (HIF) of the U.S. Geological Survey, in 1983, developed a system to effectively monitor data at relatively remote sites, some of which lack electrical utility service. HIF Operating Manual 6-83-02, the Survey Minimonitor, was published to enable field personnel to use the newly developed system. This manual, revised in 1988, incorporates changes made to the system for operation as an analog-voltage unit to be interfaced to data-collection platforms (DCP's) and various solid-state data recorders.

Purpose and Scope

The purpose of this manual is to describe in some detail the Survey's Minimonitor Water-Quality Data Measuring System. Various components and parts of the system are described and directions are given for assembly and disassembly. Procedures are given for calibrating, servicing, and maintaining the system. Instructions are provided for proper operation of the equipment. Some troubleshooting procedures are included. No information has been provided in this manual for the operation of recorders used with this system other than a description of the control signal, which must be furnished by recorders, and the analog output signals from the Minimonitor, which must be read by recorders. Not covered is the selection of monitoring sites, for the selection and installation of shelters, sensors, and equipment. U.S. Geological Survey Open-File Report 83-681, *Guidelines for Use of Water Quality Monitors*, should be consulted for this information.

General Description

The Minimonitor is a system designed to measure as many as four values of water-quality constituents or properties. An expanded version can measure as many as eight constituents or properties. A watertight can containing signal conditioners is connected with cable and waterproof connectors to various water-quality sensors. The system is composed of a battery-powered electronics package, sensors with or without extension cables having underwater connectors, and, in some instances, a Geostationary Operational Environmental Satellite (GOES) data-collection platform or other equipment. Figure 1 shows a Minimonitor connection. An external battery is required and, when in operation, the unit is activated by an external device such as an electronic recorder. Once activated, the Minimonitor measures and provides analog voltages, which are proportional to the constituents or properties being measured. (The Minimonitor is turned OFF by the external device.) Unlike the Survey Flow-Through Monitor, the sensors can be placed directly into the river, provided they are protected. This feature eliminates the need for a pump and a sample chamber. The Minimonitor system functions also with the sensors positioned in a sample chamber that has water pumped into it. The Minimonitor is available to measure temperature, specific conductance (conductivity), dissolved oxygen (DO), and pH, along with other acceptable voltage inputs from instruments like the Ultrasonic Ranger. The Minimonitor is available on a rental basis from the HIF.

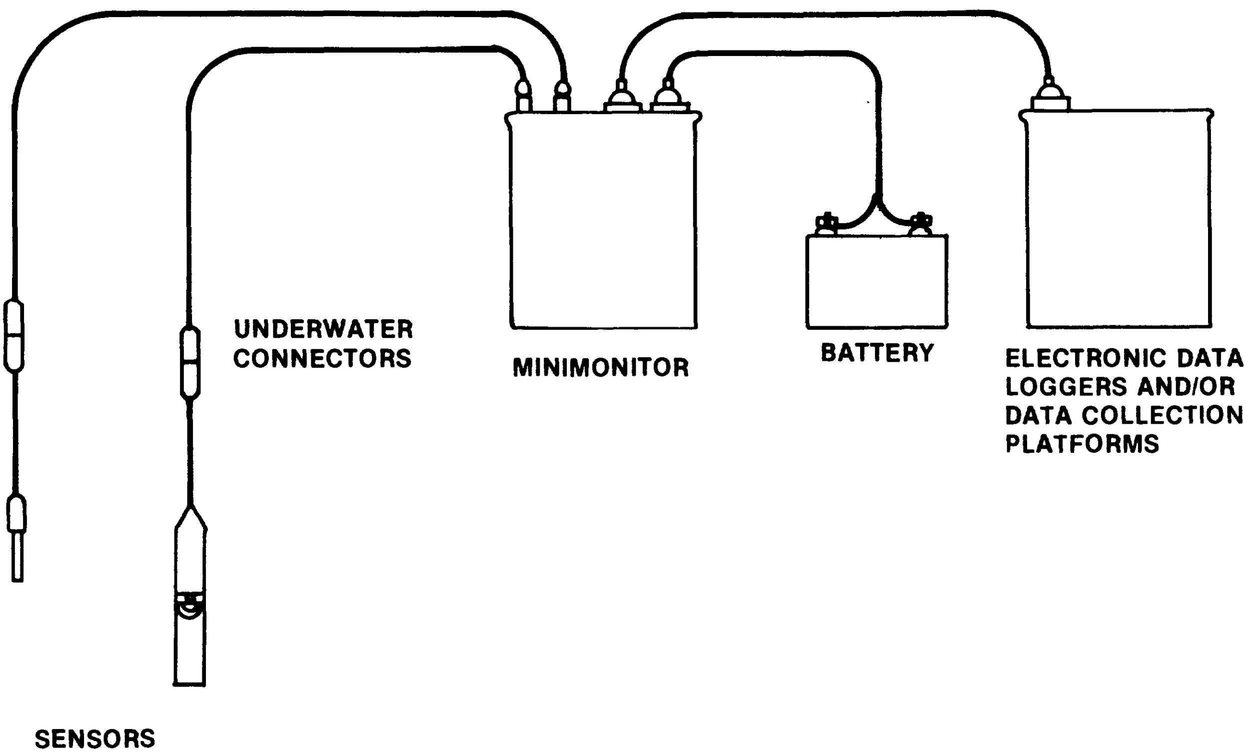


Figure 1.--Minimonitor connection.

Specifications

Minimonitor specifications include the following:

- Number of available channels: Up to 8; each channel may contain the same or different parameters.

- Operating temperature range: -40 to 55 °C.

- Operating voltage range: 10 to 15 volts. **WARNING:** Voltages higher than 15 volts can damage the unit.

- Battery type: External; 12-volt, dry-cell or lead-acid gel type. Two 6-volt batteries can be used in series. Do **not** use 15-volt batteries or 7.5-volt batteries in series because the actual voltage of these batteries can exceed 15 volts.

- Battery consumption: Less than a 1-ampere hour per month at a 1-hour recording interval with temperature and specific conductance.

- Current consumption:
  - In standby mode--120 microamperes with temperature and specific conductance and 300 microamperes with temperature, specific conductance, and DO.
  - With the signal conditioners on (temperature and specific conductance)--100 milliamperes.

- Control/turn-on input: An applied direct-current voltage from 5 to 18 volts turns on the Minimonitor. All signal conditioners turn on, and their outputs become active.

- Analog output: 0 to 5 volts from each channel, remaining active as long as signal conditioners are on.

- Size: Electronics housed in a watertight container 10 inches high (15 inches high with cables plugged in) by 10.5 inches in diameter. Container for 8-channel unit is about 14.5 inches high (16 inches high with cables plugged in) by 10.5 inches in diameter.

- Temperature measuring system: Range from 0 to 50 °C; other ranges by special request. Sensor Size: 0.75 inch in diameter by 7.5 inches long.

- Specific-conductance measuring system: Four ranges: 0 to 100, 0 to 1,000, 0 to 10,000, and 0 to 100,000 microsiemens; referred to 25 °C based on 1,000-microsiemen potassium-chloride solution; four-electrode method is used to reduce effects of fouling. Sensor Size: 10.5 inches long by 1.4 inches in diameter.

- Dissolved-oxygen measuring system: Polarographic membrane sensor with stirrer; normally 2 ranges--0 to 10 and 0 to 20 milligrams per liter (mg/L). Use of membranes other than 1-mil thickness can change range.

- pH measuring system: Uses an industrial-grade refillable combination electrode; ranges: 0 to 10 and 2 to 12 pH units. Sensor environment can significantly affect the accuracy of the acquired data.

- Voltage SIGNAL CONDITIONER:
  - Range--0 to 100 millivolts (minimum) to 0 to 10 volts (maximum);
  - Input impedance--1 to 5 megohms;
  - Common mode input-voltage range: +7 to -4 volts;
  - Differential input-voltage range: 100 millivolts to 5 volts full scale.

  The voltage SIGNAL CONDITIONER has a relay that can be used to apply power to other instrumentation.

Sensor and extension cables: Sensors come with a 10-foot cable terminated with an underwater connector. Extension cables in 100-foot sections are standard; other lengths are available.

SERVICING INTERNAL COMPONENTS OF THE MINIMONITOR

Occasionally, the inside of the Minimonitor must be opened to change settings on switches, to change fuses on older models, to add or remove circuit boards, and to change the desiccant. The can must be closed carefully to prevent damage to components and to ensure proper operation of the monitor.

Opening the Minimonitor

To prevent moisture from affecting the electronic circuitry, the Minimonitor should be opened only indoors under dry and warm conditions.

The following procedure is used:

1. Disconnect any cables from the top of the Minimonitor. Mark the sensor connectors and cables so they can be reinstalled correctly.

2. Remove the bolt or bolts that secure the locking ring to the top rim of the can.

3. Remove the locking ring from the top rim of the can.

4. Lift the cover and the electronics assembly from the can.

Figure 2, Minimonitor electronics assembly removed from can, shows the normal positioning of the circuit boards in the electronics assembly. The POWER/ANALOG board is in the top slot and SIGNAL CONDITIONER boards are positioned in the slots below the POWER/ANALOG board (fig. 3). The boards are referred to as SIGNAL CONDITIONERS in the rest of this report.

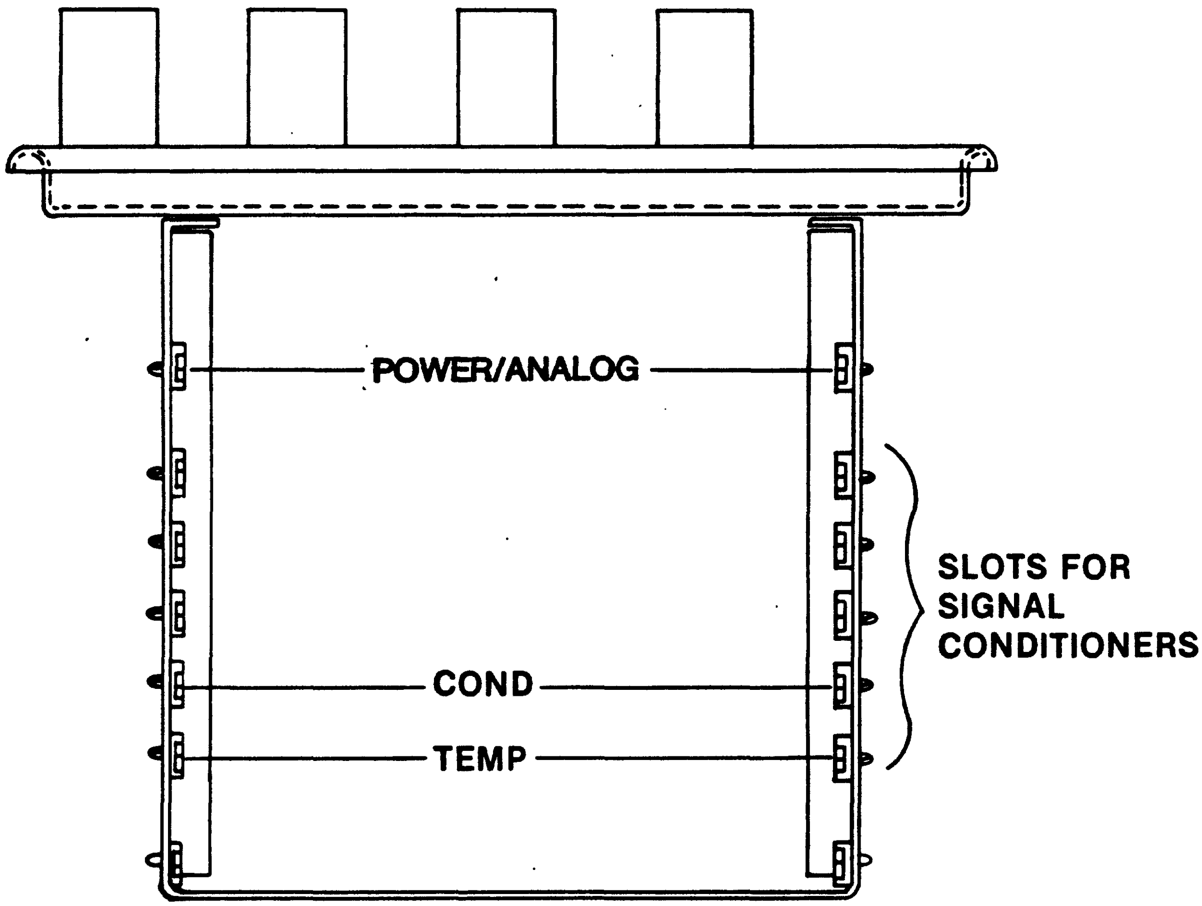


Figure 2.--Minimonitor electronics assembly removed from can.

The circuit boards are connected to each other and to ZERO and SPAN potentiometers (called pots or trimpots in the rest of this report) located under the Minimonitor cover. The connectors on the Minimonitor cover are terminated with both ribbon cables and 16-pin, dual in-line connectors that plug into sockets on the circuit boards.

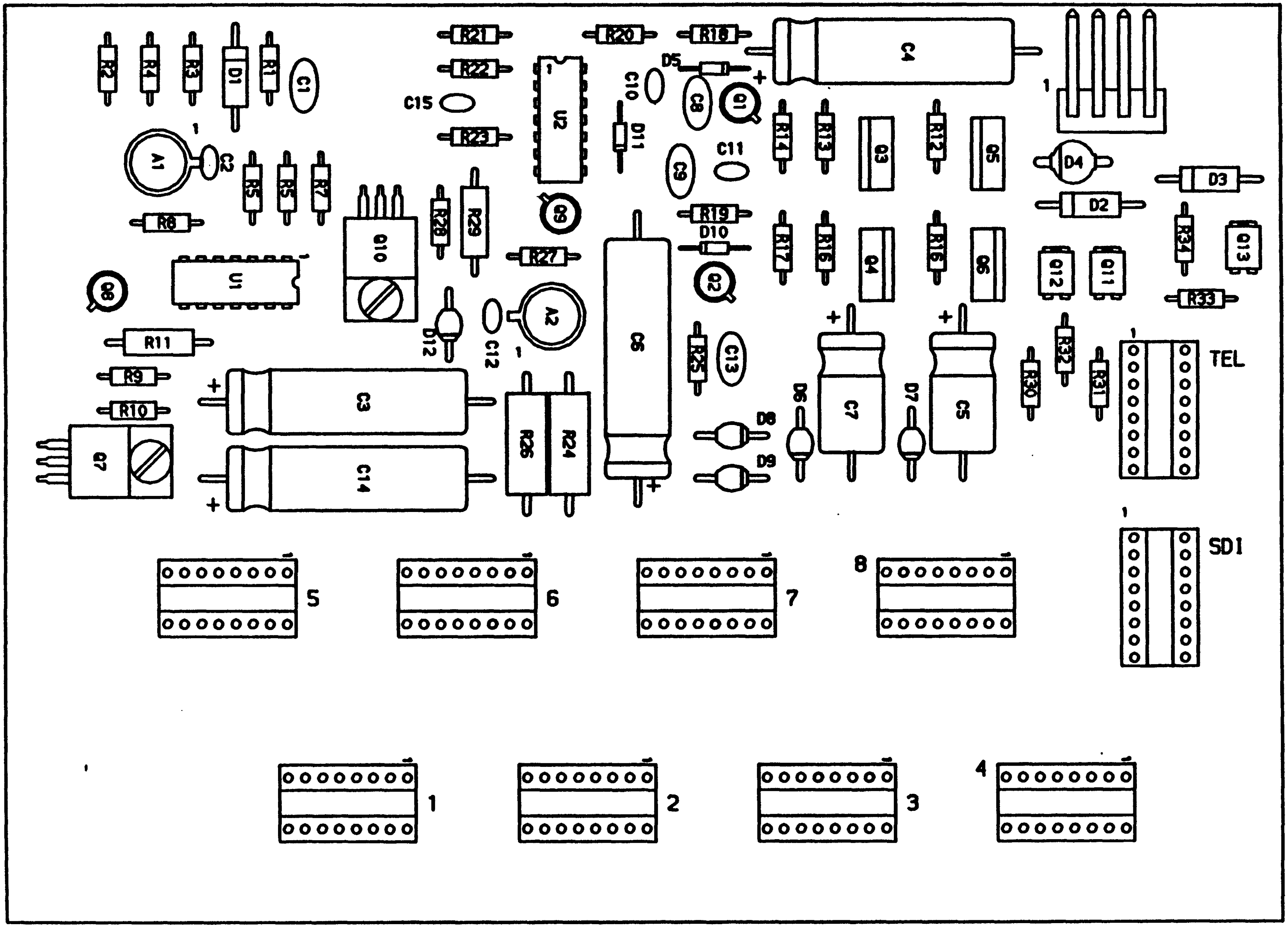


Figure 3.--POWER/ANALOG board.
1 through 8--Signal-conditioner input sockets

Internal Settings

Reasons for Internal Settings

The following items require the setting of internal switches:

- specific-conductance range;
- DO range; and
- pH range.

Before the Minimonitor can be placed into operation, the electronics package must be set for the desired ranges on the SIGNAL CONDITIONERS of the constituents to be measured. These items were set before the monitor was shipped. To change the initial settings, open the Minimonitor as directed in the section entitled "Opening the Minimonitor."

WARNING: The internal wiring and circuits are not designed to withstand rough handling. Changes to internal settings are best made carefully indoors under dry, warm conditions and with fresh desiccant added. Internal settings usually are not changed in the field.

Setting Ranges on SIGNAL CONDITIONERS

When the Minimonitor can is open, the desired ranges may be set on SIGNAL CONDITIONERS. Ranges can be set on SIGNAL CONDITIONERS for measuring specific conductance, DO, pH, and voltage. To set the ranges, refer to the specific sections in the manual associated with range selection.

Changing Fuses

An AGC-type fuse, 0.5-ampere, is used to protect Minimonitor circuitry. When replacing a fuse, be sure that the correct replacement size is used and is put in the proper place.

The fuse is located in a waterproof fuse holder on the lid of the Minimonitor (fig. 4). The fuse holder cap must be unscrewed to replace the fuse. Screw the cap on tightly after replacing the fuse.

Do not substitute a fuse of a larger value than indicated because this may result in serious damage to the Minimonitor.

WARNING--TURN OFF POWER BEFORE REPLACING FUSE.

Removing or Adding Circuit Boards

NOTE: The HIF will not be responsible for damage caused by improper connection of circuit boards. To ensure proper installation of circuit boards, return the unit to the HIF.

The following steps outline the procedure for adding or removing circuit boards:

1. Turn off the power. Open the Minimonitor can as directed in the preceding section, "Opening the Minimonitor."

2. If a SIGNAL CONDITIONER is being replaced, disconnect the two connectors that are plugged into it. **Be very careful not to bend the pins on the 16-pin connectors.** Pry the connector loose with a small screwdriver before pulling on the connector. Wedge the screwdriver between the socket and the connector to loosen the connection.

3. Remove the board retainers and slide out the SIGNAL CONDITIONER.

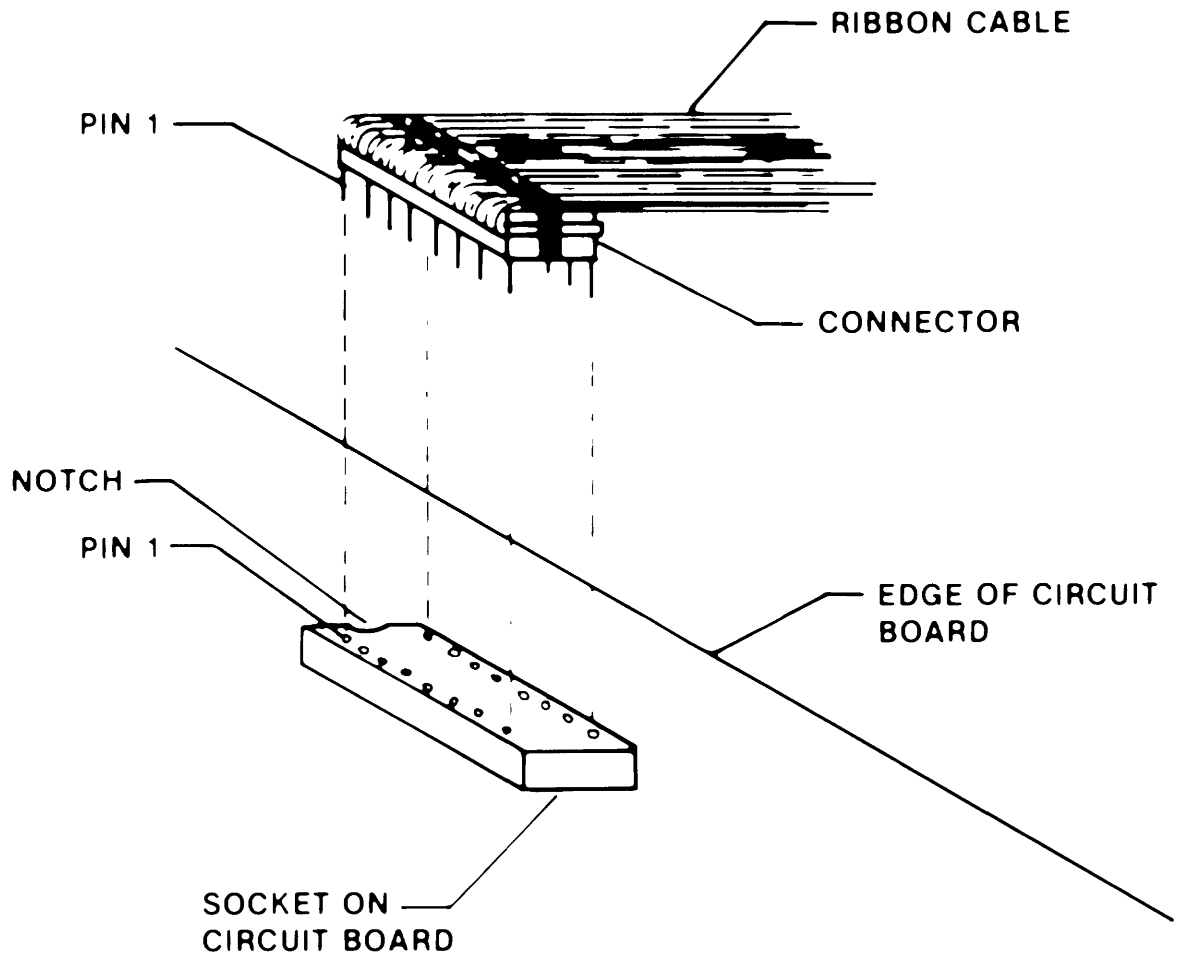
4. Slide the new SIGNAL CONDITIONER into the desired position. The board retainers may be mounted temporarily from the back side of the mounting screws. This provides a finger grip to aid in installation. First, insert the edge of the circuit board with the socket labeled "SENSOR." The opposite edge, with the socket labeled "MUX," is then on the same side as the eight channel sockets on the POWER/ANALOG board. Replace the board retainers.

5. Connect the socket on the SIGNAL CONDITIONER labeled "MUX" to the desired channel socket on the POWER/ANALOG board. The channel sockets are numbered 1 through 8. Use a ribbon cable assembly with a 16-pin connector on each end. Plug the ribbon cable connector into the socket on the circuit board as shown in figure 5.

6. Plug the ribbon cable connector from the sensor connector on the cover into the socket on the SIGNAL CONDITIONER labeled "SENSOR." Insert the connector as shown in figure 5. Be sure to connect the SIGNAL CONDITIONER to the sensor connector associated with the desired channel. Mark each sensor connector on the cover to identify the constituent being measured. Earlier assemblies do not have ribbon cables from the sensor connectors. Instead, a bundle of wires from the trimpots and each sensor connector is soldered to a 16-pin connector. Plug in these connectors so that the higher numbered pins on the connector are on the side of the socket closest to the edge of the circuit board.

Desiccant

The Minimonitor contains packets of silica gel desiccant material, which prevents moisture buildup in the electronics package. When the monitor is opened for any reason, replace the old desiccant with dry desiccant. The old desiccant can be dried by heating it in an oven at 245 to 260 ^{o}F for 12 hours. After drying, store the packets of desiccant in a sealed container to prevent the absorption of moisture from the air.



When plugging a ribbon cable connector into a socket on a circuit board, align pin 1 on the connector with pin 1 on the socket as shown in the above figure. When properly installed, the cable extends away from the circuit board. Be sure that each pin is straight and aligned with its socket hole before applying pressure to plug in the connector.

NOTE: Pin 1 on the socket is indicated by the notch at one end.

Figure 5.--Connection of ribbon cable.

Closing the Minimonitor

Set the cover assembly back into the can, being careful not to pinch any wires between the cover and the can. Check that the rubber seal in the lid rim is in the proper position. Replace the locking ring around the lid rim and fasten with the bolt or bolts. On locking rings with a single bolt, the ring is put on the can by starting on one side and carefully working the ring around the edge of the can.

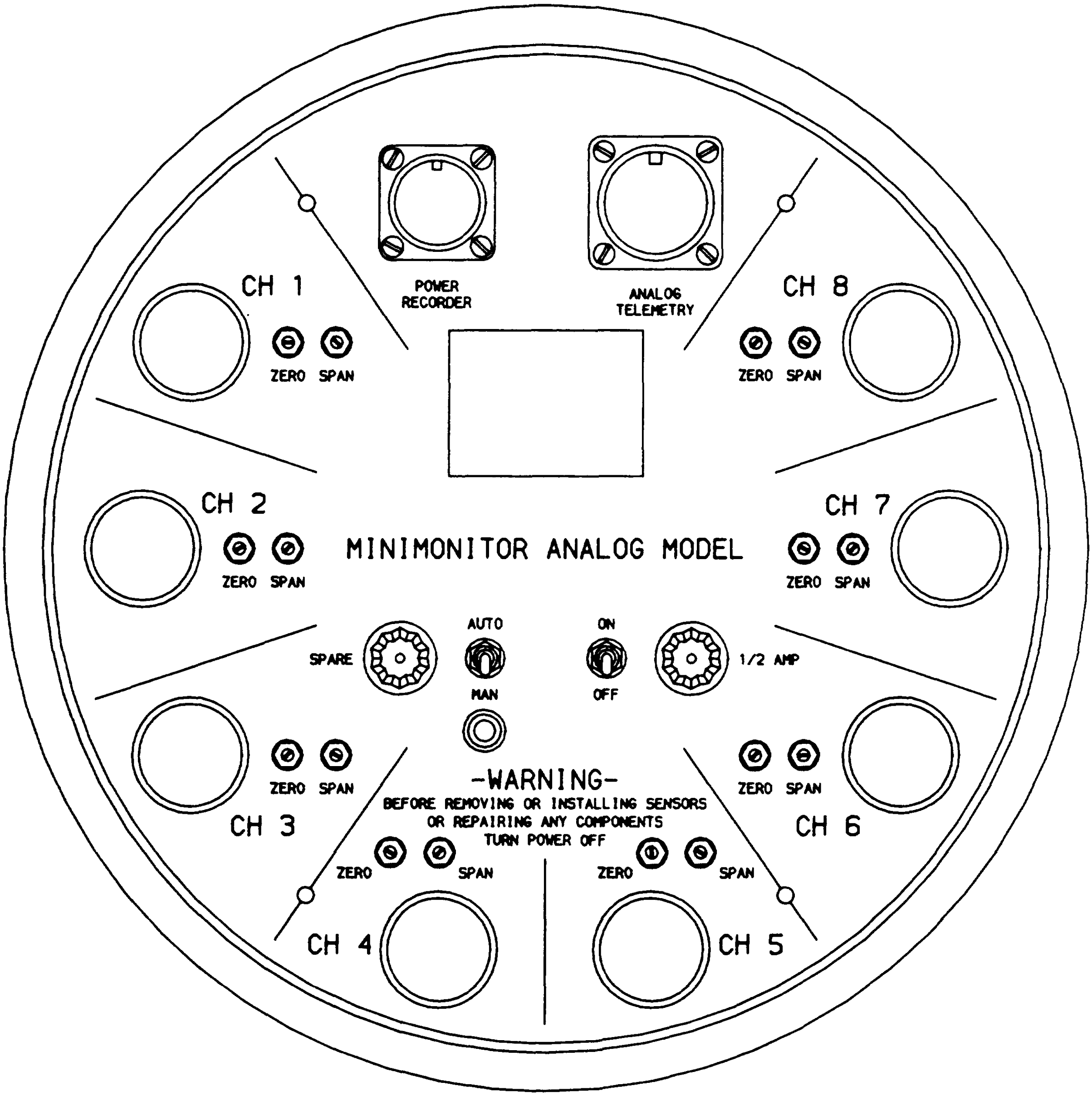


Figure 4.--Minimonitor front panel.

CONNECTING THE MINIMONITOR FOR OPERATION

Installing the Sensors

The Minimonitor is capable of handling from one to eight sensors with their associated SIGNAL CONDITIONERS. Each channel may hold the same or different measuring systems and they may be placed in any order. For example, eight temperature systems may be installed or two specific-conductance, two temperature, two pH, and two DO systems may be used. Any combination is allowed. All eight channels do not have to be used. Any channel, from one through eight, may be used.

Because each site is different, only general suggestions on sensor mounting are made. Consult U.S. Geological Survey Open-File Report 83-681, *Guidelines for Use of Water Quality Monitors*, for more detailed information. Methods of mounting the sensors must be tailored to fit each particular site. Sensors may be protected from silting-in and from damage caused by debris, freezing, vandalism, or other causes. Sensors should be accessible under all river conditions.

The sensors may be held in place by a stainless- or galvanized-steel rod or bracket and anchored to the holding device with hose clamps of the same noncorrosive material. The sensors may be slid down the pipes. Mount the sensors so they can be removed easily for cleaning and calibration (during any stream conditions). The cables may be routed to the gage house through a plastic pipe or conduit. The maximum length of cable from any sensor to the monitor is 1,000 feet. In cold weather, the rubber connectors become firm, making them difficult to pull apart.

Sensor Cables and Connectors

Sensor cables and connectors are identical for all parameters, which allows interchangeability of these parts. However, it is possible to plug the wrong sensor into a SIGNAL CONDITIONER, causing damage to the sensor or the electronics. Mark the cables to help prevent improper connections. Many of the Minimonitors have the SENSOR CONNECTORS marked with special tape as follows: TEMP, COND, DO, pH. This marking tape is available upon request from the HIF warehouse. The connectors have alignment markings on the outside body that vary in shape and location depending on the manufacturer. When mating the connectors, align these marks and push the connectors together. Figure 6 shows the sensor cable connector.

CAUTION: Forcing the connectors together without aligning the marks can damage the connectors and may electrically harm the SIGNAL CONDITIONER or sensor. After the connector is properly mated, the locking sleeves can be screwed together. **NOTE:** A thin film of silicone grease, electrically non-conductive type, spread on the connector bodies helps the connectors work easier. Avoid getting grease on the pins.

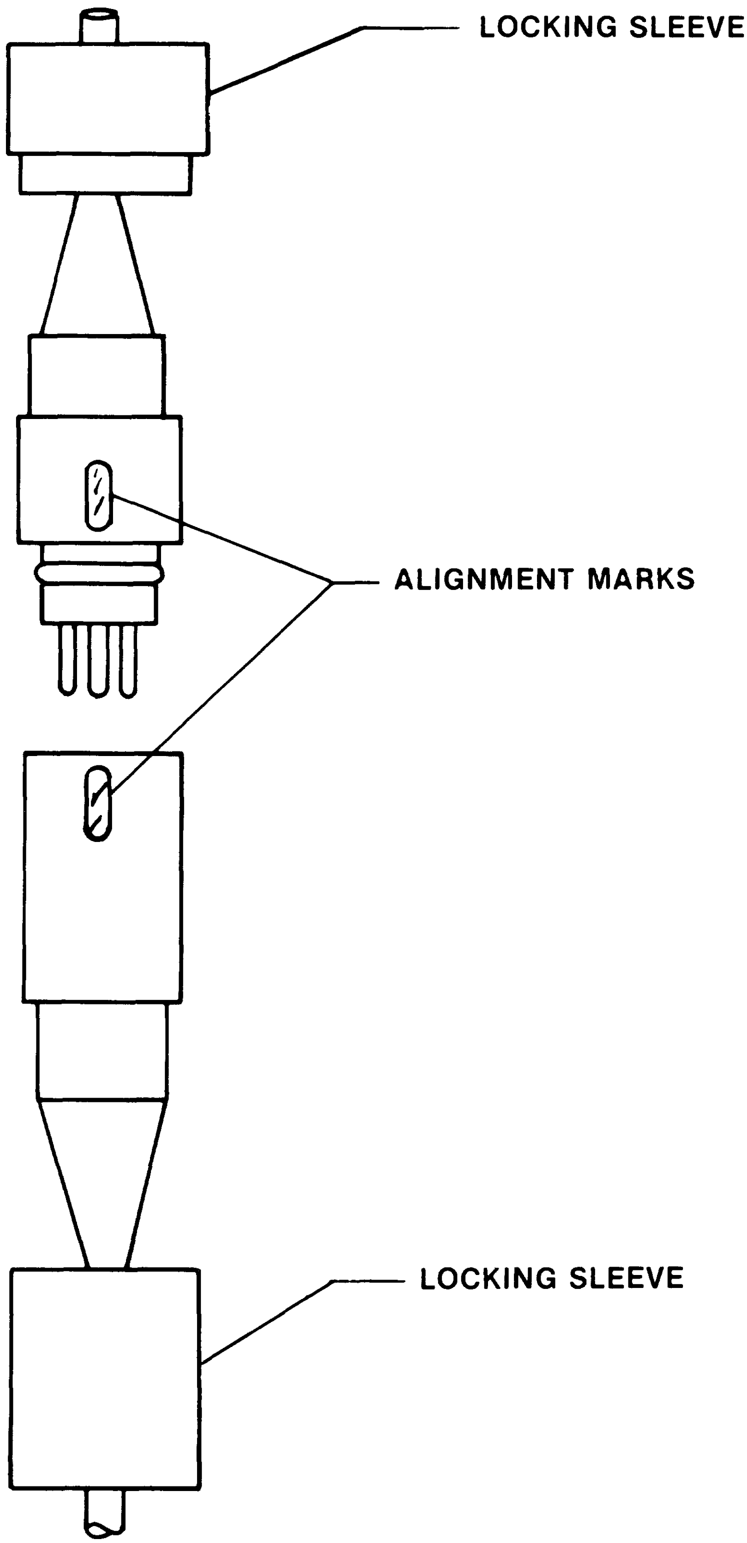


Figure 6.--Sensor cable connector.

Final Connection of Cables

Complete the final connections as follows:

1. Connect the sensor cables to the monitor as described in the section entitled "Sensor Cables and Connectors." Check that the sensors are plugged into the channels that correspond to the matching SIGNAL CONDITIONERS. Always turn off or remove power from the unit before installing or removing the sensors or other connectors.

2. Connect the power-cable assembly (fig. 7) to the Minimonitor.

3. Make sure that the ON-OFF switch is toggled to OFF. Connect the power leads to a 12-volt, direct-current (dc) power source. The monitor is now ready for operation.

Power Source

Power the Minimonitor from a 12-volt, dry-cell, lead-acid battery or a dc power supply. Two 6-volt, dry-cell batteries or rechargeable 12-volt, lead-acid batteries can be used. A solar panel may be used to charge the batteries. Contact the HIF for information.

CAUTION: Never use two 7.5-volt batteries or a 15-volt battery because the actual voltage of these batteries may exceed 15 volts and damage the monitor.

FUNCTION OF FRONT-PANEL SWITCHES, ADJUSTMENT POTS, AND CONNECTORS

On-Off.--In the OFF position, all power is disconnected from the monitor. Toggle this switch to OFF when changing sensors.

Auto-Manual.--In the MANUAL position, the SIGNAL CONDITIONERS are turned on. When leaving the station, leave this switch on AUTO or the SIGNAL CONDITIONERS remain on and the batteries discharge much faster than normal. When this switch is in the AUTO position, the SIGNAL CONDITIONERS are only turned on when the control/turn-on input is held high. See analog connector.

Zero.--Screwdriver adjustment for offset calibration of individual SIGNAL CONDITIONERS.

Span.--Screwdriver adjustment for gain calibration of individual SIGNAL CONDITIONERS.

Channel (CH) Connectors.--Waterproof, neoprene connectors for sensor cables; channels (CH) are numbered counterclockwise from 1 to 8, starting to the left of the power connector.

Power/Recorder Connector.--For connecting to a 12-volt, dc power source.

Analog-Telemetry Connector.--Provides 0- to 5-volt analog output for each channel when the SIGNAL CONDITIONER power is on; also contains the control/turn-on input port. This connector is to be used to connect to data logger/recorders or DCP's.

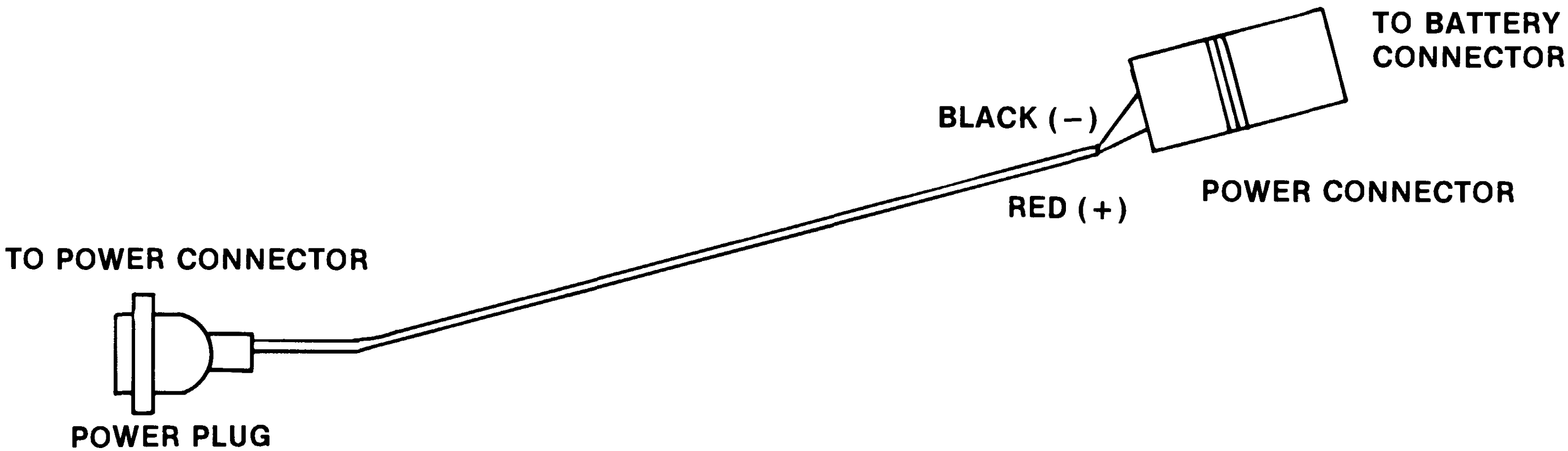


Figure 7.--Power-cable assembly.

Fuse Holder.--The 0.5-ampere fuse is located in a waterproof fuse holder. A spare-fuse holder is available also.

CALIBRATION OF THE MINIMONITOR READING ANALOG VOLTAGES

A voltmeter capable of reading from 0- to 15-volt direct current is necessary for calibrating the Minimonitor sensing systems. Calibration of the Minimonitor sensing systems is achieved by placing the various sensors in solutions of known values and adjusting, with a small screwdriver, the ZERO and SPAN pots until the ANALOG-VOLTAGE reading appearing on the analog-telemetry connector reaches the desired value. Socket locations, which correspond to the channels as shown below, are shown in figure 8.

Socket	Channel	Function
A	1	Channel 1 out (0 to 5 volts)
B	2	Channel 2 out (do)
C	3	Channel 3 out (do)
D	4	Channel 4 out (do)
E	5	Channel 5 out (do)
F	6	Channel 6 out (do)
G	7	Channel 7 out (do)
H	8	Channel 8 out (do)
I	Analog ground	Analog ground
J	Control/turn on	Control/turn on

For example: To read the ANALOG VOLTAGE indicated by a sensing system in channel 1, the voltmeter positive lead would be inserted in socket A and the ground or negative lead inserted in socket I (analog ground). All ANALOG-VOLTAGE outputs on the analog-telemetry connector should read positive with respect to analog ground. To read the ANALOG-VOLTAGE output from any signal conditioner, either the AUTO-MANUAL switch must be set to MANUAL or the control/turn-on input must be held high (5 to 18 volts).

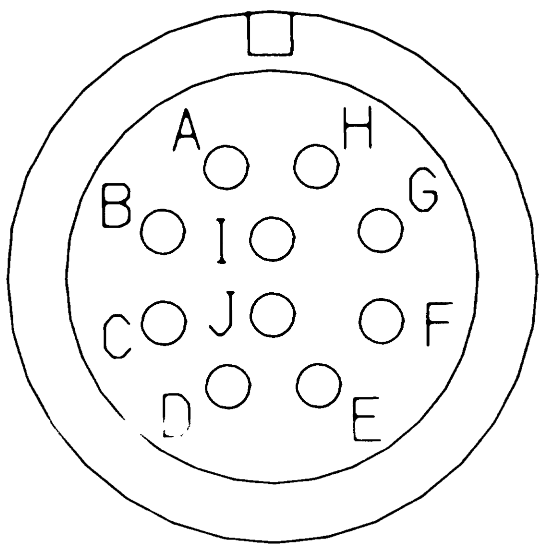


Figure 8.--Top view of analog-telemetry connector and channel assignments.

TEMPERATURE CALIBRATION AND SENSOR MAINTENANCE

Calibration Procedure

The standard temperature range is 0 to 50 ^{o}C. If another range is necessary, contact the HIF Field Service and Supply Section. Figure 9 shows the socket locations on the temperature SIGNAL CONDITIONER.

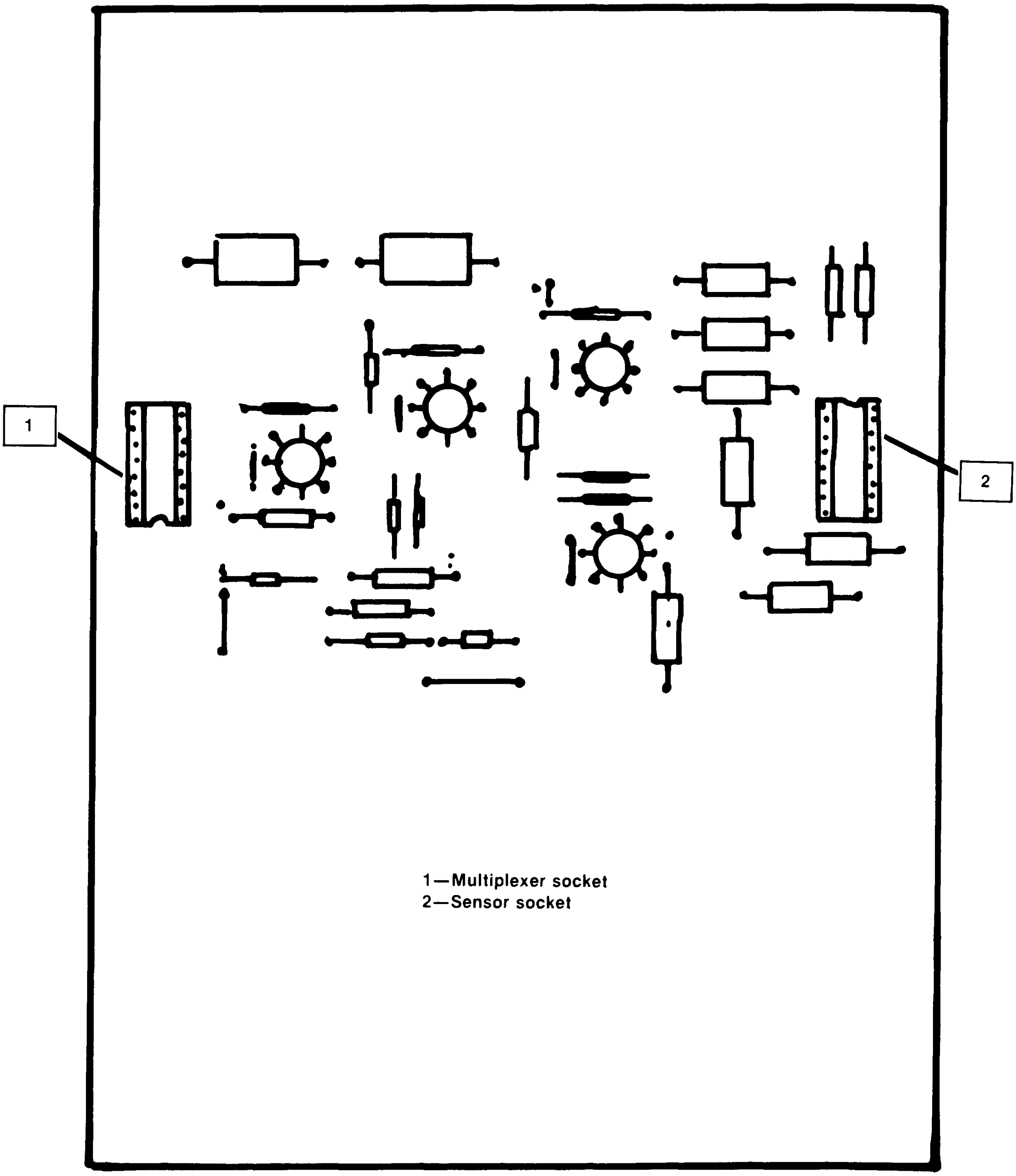


Figure 9.--Temperature signal conditioner.

Zero degrees Celsius equals zero volts on the analog-telemetry socket and 49 °C equals 4.90 volts.

Perform the following steps to calibrate the temperature signal conditioner:

1. Place the temperature sensor in a stirred cold solution as close to 0 °C as possible; an ice-and-water mixture works well. Place a thermometer, accurate to within 0.1 °C, in this solution.

2. Check that the sensor is plugged into the correct channel and connect a voltmeter to the analog-telemetry connector in the socket corresponding to the desired channel. (See Calibration of the Minimonitor Reading Analog Voltages.) Toggle the ON-OFF switch to ON and set the AUTO-MANUAL switch to MANUAL.

3. Adjust the ZERO pot located above the channel connector until the ANALOG-VOLTAGE reading is +0.00 volts. Stirring the solution is recommended. Wait long enough for temperature and voltage readings to stabilize, read the thermometer, and record this reading.

4. Place the temperature sensor and the thermometer in a solution having a high, near-maximum temperature that will be measured. Stirring the solution is recommended. After the ANALOG-VOLTAGE and thermometer readings stabilize, adjust the SPAN pot until the ANALOG VOLTAGE is 0.1 times the difference between the high- and low-temperature values.

5. With the sensors still in the high-temperature water, adjust the ZERO pot until the ANALOG VOLTAGE is 0.1 times the high-temperature value. The proper value is 0.1 times the actual temperature for a 0- to 50-°C range.

   NOTE: 0 °C = 0.00 volts, 10 °C = 1.00 volts, 20 °C = 2.00 volts, 30 °C = 3.00 volts, 40 °C = 4.00 volts, and so forth.

6. Check the calibration by placing the sensor and the thermometer in a solution of about half the temperature of the previous high-temperature solution. If the thermometer and voltage readings check, the calibration is accurate. An example follows:

With Sensor In	Adjust	Until ANALOG VOLTAGE Reads
00.3 °C	ZERO	+0.00 Volts
36.0 °C	SPAN	(High temperature - low temperature) X 0.1 = 3.57 Volts
36.0 °C	ZERO	(Actual temperature) 36.0 X 0.1 = 3.60 volts for 0- to 50-°C range
21.0 °C	None	2.10 volts (check the reading for 0- to 50-°C range)

Table 1 shows the relation between temperature values and Minimonitor ANALOG-VOLTAGE readings.

Table 1.--*Relation between temperature values and Minimonitor analog-voltage readings*

Temperature value at sensor (°C)	Minimonitor analog-voltage readings, in volts (0- to 50-°C Range)
0.0	+0.00
10.0	1.00
15.0	1.50
20.0	2.00
25.0	2.50
27.6	2.76
30.0	3.00
35.0	3.50
40.0	4.00
45.0	4.50
50.0	5.00
55.0	over range

Temperature Sensor Maintenance

Clean the temperature sensor by scrubbing with a soft-bristled brush and detergent solution. The rubber area at the top of the sensing portion of the sensor is easily damaged; do not use sharp or hard objects to clean the sensor. Films on the stainless-steel portion of the sensor that resist removal usually can be removed by soaking in a detergent-and-water solution.

If problems are encountered, contact HIF Field Service and Supply Section for assistance.

SPECIFIC-CONDUCTANCE RANGE SELECTION, CALIBRATION, AND SENSOR MAINTENANCE

Selecting the Specific-Conductance Range

Four specific-conductance ranges are available: 0 to 100, 0 to 1,000, 0 to 10,000, and 0 to 100,000 microsiemens per centimeter (μS/cm). The desired range is selected by a set of switches on the specific-conductance SIGNAL CONDITIONER (fig. 10). To set the switches, follow the steps listed.

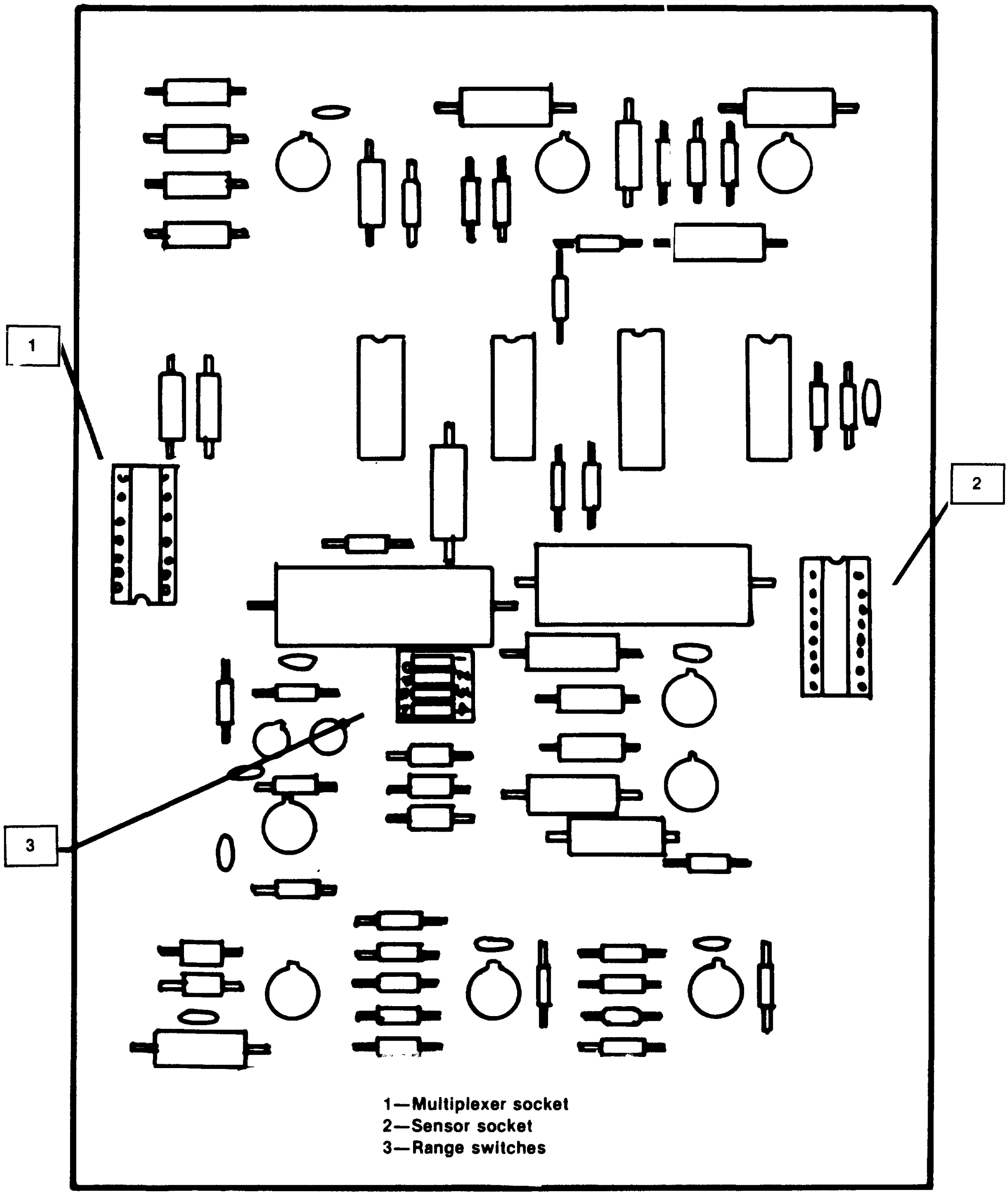


Figure 10.--Specific-conductance signal conditioner.

1. Open the can according to instructions in the section of this manual entitled "Servicing Internal Components of the Minimonitor."

2. Locate the specific-conductance SIGNAL CONDITIONER. This board has a cable running from it to the sensor connector to which the specific-conductance sensor attaches.

3. Locate the switch assembly in the center of the card.

4. Use a ballpoint pen or a small screwdriver to select the switch closures (fig. 11) for the range desired.

Switch	0 to 100 microsiemens	0 to 1,000 microsiemens	0 to 10,000 microsiemens	0 to 100,000 microsiemens
1	OPEN	OPEN	CLOSED	CLOSED
2	CLOSED	OPEN	OPEN	OPEN
3	OPEN	CLOSED	CLOSED	OPEN
4	OPEN	OPEN	OPEN	CLOSED

Figure 11.--Switch settings for specific-conductance ranges.

If a very large specific-conductance range will be encountered, the use of two specific-conductance systems set to different ranges may be advantageous.

Calibration Procedure

Once the desired range has been set, connect the sensor cables to the proper channels on the Minimonitor. The following items are needed to calibrate the specific-conductance signal conditioner: cloth or paper towels, two clip leads, distilled water, and two known solutions--one near the maximum value of the selected range and one about one-half the specific conductance of the first.

Perform the following steps to calibrate the specific-conductance signal conditioner:

1. Remove the shield on the specific-conductance sensor. This requires that one or two screws be removed and the shield slid off the end of the sensor. Care must be taken as any binding may bend the electrode pins.

2. Dry the sensor completely with a cloth or a paper towel.

3. Attach one clip lead from the center electrode to an adjacent electrode. Attach the second clip lead from the outside electrode to the adjacent electrode. See figure 12, specific-conductance sensor.

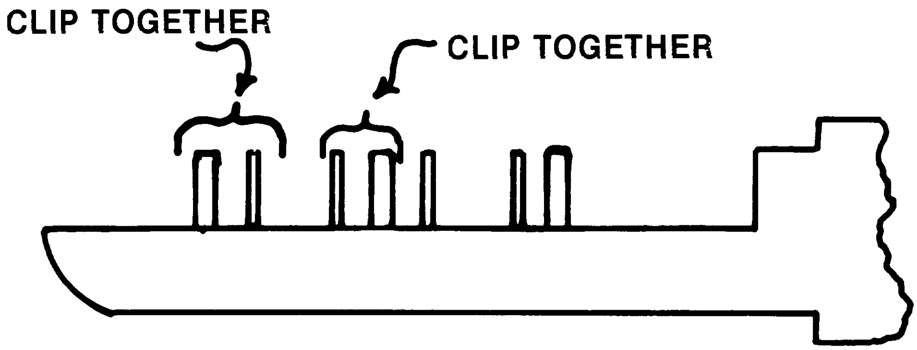


Figure 12.--Specific-conductance sensor with shield removed.

4. Connect a voltmeter to the analog-telemetry connector in the socket corresponding to the desired channel. (See Calibration of the Minimonitor Reading Analog Voltages.)

5. Turn the ON-OFF switch to ON and set the AUTO-MANUAL switch to MANUAL. The correct ANALOG-VOLTAGE reading on the voltmeter is 0.00 or 0.01 volt. If this reading does not appear, use a small screwdriver to adjust the ZERO pot located above the channel connector until the proper voltage is seen.

6. Remove the clip leads and replace the shield on the sensor.

7. Place the sensor into a known standard solution that is near the maximum specific-conductance value expected.

8. With the monitor on and in the MANUAL mode, note the ANALOG VOLTAGE. After the reading has stabilized, adjust the SPAN pot located above the sensor connector until the voltage indicates the value of the test solution as shown in table 2. Table 2 shows the relation between specific-conductance values and Minimonitor ANALOG-VOLTAGE readings.

Table 2.--*Relation between specific-conductance values and Minimonitor analog-voltage readings*

Specific-conductance value at sensor (μs/cm)	Minimonitor analog-voltage readings (volts) (0-100 μS)	(0-1,000 μS)	(0-10,000 μS)	(0-100,000 μS)
0	+0.00	+0.00	+0.00	+0.00
10	0.50	0.05	0.00	0.00
25	1.25	.125	0.01	0.00
50	2.50	.25	0.02	0.00
75	3.75	.38	0.04	0.00
100	5.00(over range)	.50	0.05	0.00
250	5.00 do	1.25	0.12	0.01
500	5.00 do	2.50	0.25	0.02
750	5.00 do	3.75	0.38	0.04
1,000	5.00 do	5.00(over range)	0.50	0.05
2,500	5.00 do	5.00 do	1.25	0.12
5,000	5.00 do	5.00 do	2.50	0.25
7,500	5.00 do	5.00 do	3.75	0.38
10,000	5.00 do	5.00 do	5.00(over range)	0.50
25,000	5.00 do	5.00 do	5.00 do	1.25
50,000	5.00 do	5.00 do	5.00 do	2.50
75,000	5.00 do	5.00 do	5.00 do	3.75
100,000	5.00 do	5.00 do	5.00 do	5.00
150,000	5.00 do	5.00 do	5.00 do	(over range)

9. Calibration is complete. If the user wishes to verify that the system is calibrated correctly, rinse the sensor with distilled water and then rinse with a small portion of the second known solution.

   Place the sensor in a second known solution having about one-half the specific conductance of the first. If the ANALOG VOLTAGE indicates the specific conductance of this solution correctly, the calibration is accurate. An example follows:

   A range of 0 to 10,000 μS/cm is desired and the range switch has been set accordingly. A standard solution having a value of 8,700 μS/cm at 25 °C is available. In this range, 0 to 5.00 volts would equal 0 to 10,000 μS/cm. Therefore, the value of the standard solution, 8,700 μS/cm, would be indicated as 4.35 volts if the specific-conductance signal conditioner were properly calibrated.

   On other ranges, an ANALOG-VOLTAGE reading of 4.35 volts would indicate values of 87 μS/cm on the 0 to 100 range, 870 μS/cm on the 0 to 1,000 range, and 87,000 μS/cm on the 0 to 100,000 range.

Specific-Conductance Sensor Maintenance

Regular cleaning is necessary because dirt or deposit buildup in the electrode area of the sensor can affect sensor response.

A brush and laboratory-type detergent is needed. The following steps should be followed when cleaning the sensor:

1. Remove the shield from the conductance sensor. One or two screws can be found, depending on the sensor design. Slide the shield off carefully as any forcing may bend the electrode pins.

2. Clean the inside of the shield with a laboratory-type detergent and brush.

3. Rinse the shield thoroughly after cleaning.

4. Clean the body of the sensor in the same manner.

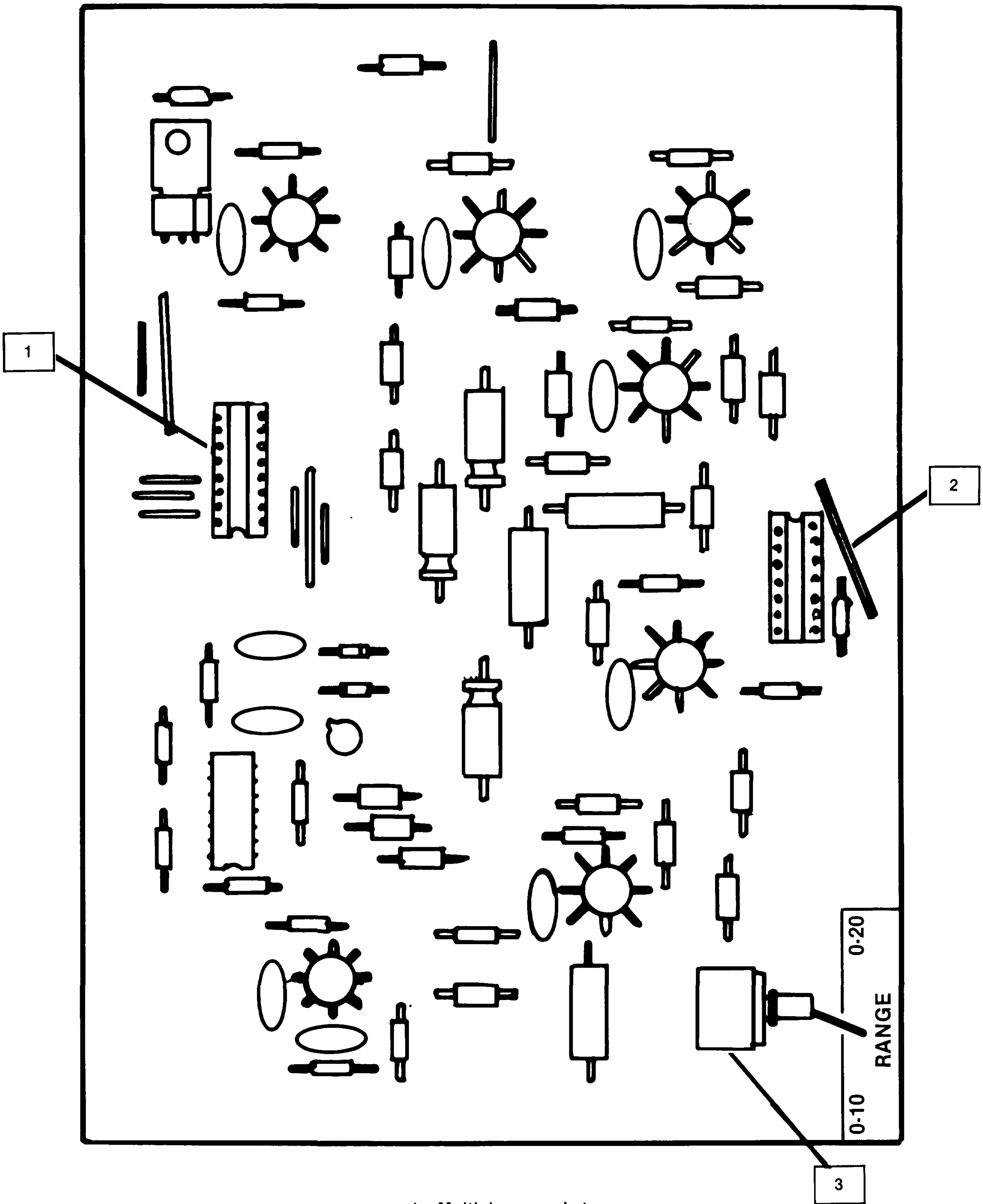
5. Reinstall the shield.

Care must be taken not to damage the insulating material surrounding the electronics of the sensor and the electrodes because premature failure of the sensor may result. If any dirt or deposits resist cleaning, allow the sensor to soak in a detergent-and-water solution and rescrub with the brush and detergent. Do not use objects such as screwdrivers, knives, or wire brushes to remove dirt or deposits from the sensor.

If any problems are encountered, contact HIF Field Service and Supply Section for assistance.

DISSOLVED-OXYGEN RANGE SELECTION, CALIBRATION, SENSOR MAINTENANCE, AND PERFORMANCE CHECKS

The DO measuring system uses a stirrer and DO sensor manufactured by the Yellow Springs Instrument Company (YSI) (1975, 1978, 1979). The operation and maintenance of these components are described in detail in the manufacturer's instructions, which are repeated with permission in appendix I. The DO SIGNAL CONDITIONER shown in figure 13 has been designed by the Survey.



1—Multiplexer socket
2—Probe socket
3—Range switch

Figure 13.--Dissolved-oxygen signal conditioner.

Selecting Dissolved-Oxygen Range

The system has a two-range capability when the 1-mil-thickness plastic membranes provided with the sensor units are used. These ranges can be extended by using membranes of other thicknesses available from YSI. Open the Minimonitor can to find a toggle switch located on the DO SIGNAL CONDITIONER board. The switch positions marked 0-20 and 0-10 provide the following ranges:

Thickness of plastic membrane (in)	(mils)	Switch position range (mg/L) 0-10	0-20
0.0005	0.5	0 to 5	0 to 10
.001	1	0 to 10	0 to 20
.002	2	0 to 20	0 to 40

The membrane kit furnished with this system has 1-mil (0.001 in) membranes.

The DO measuring system operates in the following manner: When the Minimonitor ON-OFF switch is toggled to the ON position, a 0.8-volt polarizing electrical potential is applied to the DO sensor at all times. When the monitor is turned on by a control/turn-on signal or when the AUTO-MANUAL switch is toggled to MANUAL, the DO stirrer and the SIGNAL CONDITIONERS are turned on. The length of time that the stirrer needs to operate before a stable voltage reading is obtained depends upon the membrane thickness. Table 3 shows the preferred delay times before reading the output voltage on a DO system. The times are based on experimental results obtained in still water.

Table 3.--*Delay times when operating a dissolved-oxygen system*

Membrane thickness (mils)	Time delays to get a stable analog voltage (seconds)
[a]1	40
2	112

[a] Standard with Survey system.

Install the DO SIGNAL-CONDITIONER board following instructions provided in the section on "Removing or Adding Circuit Boards."

Calibration

The following steps detail the calibration procedure:

1. With the sensor and stirrer properly prepared and plugged into the correct channel, connect a voltmeter to the analog-telemetry connector in the socket corresponding to the desired channel. (See "Calibration of Minimonitor Reading Analog Voltages.") Toggle the ON-OFF switch to ON and the AUTO-MANUAL switch to MANUAL. This powers the Minimonitor and turns on the DO stirrer.

2. Submerge the sensor and stirrer in a container of water having zero DO. This water is prepared by stirring a small amount of sodium-sulphite crystals into the water. About 4 grams for each liter is more than sufficient. A pinch of cobalt-chloride crystals may be added to hasten the reaction. Read the ANALOG VOLTAGE on the analog-telemetry connector after a minute or two to determine that the output value is changing. Adjust the ZERO pot until ANALOG VOLTAGE is 0.00 volts. The ANALOG VOLTAGE decreases for a few minutes and then stabilizes. Keep observing the ANALOG VOLTAGE and keep adjusting the ZERO pot to hold the value at 0.00 volts. After the reading stabilizes, adjust the ZERO pot until the ANALOG VOLTAGE is 0.00 volts.

3. Carefully wash the sensor and stirrer with water to remove all traces of the sodium-sulphite solution; then place the unit in a container of water having a known DO concentration or directly into the river or stream if the DO content is known. Adjust the SPAN pot until the ANALOG VOLTAGE reads the proper value according to the range selected. Wait until the reading stabilizes to make the final adjustment. Table 4 shows the relation between the selected DO range and Minimonitor ANALOG-VOLTAGE readings.

Table 4.--*Relation between dissolved-oxygen concentrations and Minimonitor analog-voltage readings*

Dissolved-oxygen value at sensor (mg/L)	Minimonitor analog-voltage reading, (volts): range 0 to 10 (mg/L)	Minimonitor analog-voltage reading, (volts): range 0 to 20 (mg/L)
0.0	0.00	0.00
2.0	1.00	0.50
4.1	2.05	1.02
6.0	3.00	1.50
8.0	4.00	2.00
9.9	4.90	2.22
10.0	5.00	2.50
12.0	5.00 (over range)	3.00
14.0	5.00 (do)	3.50
18.0	5.00 (do)	4.50
19.9	5.00 (do)	4.98

4. Table 5 shows the solubility of oxygen in water exposed to water-saturated air as a function of temperature and chloride concentration. The suggested method of determining DO is the Winkler method. Regardless of what method is used, do not remove the stirrer from the sensor. If air-saturated water is used, table 5 may be used to estimate the concentration of oxygen.

Table 5.--*Solubility of oxygen in water exposed to water-saturated air as a function of temperature and chloride concentration*[1]

Temperature (°C)	Chloride concentration in water (mg/L) 0	5,000	10,000	15,000	20,000
0	14.60	13.72	12.90	12.13	11.41
1	14.19	13.35	12.56	11.81	11.11
2	13.81	12.99	12.23	11.51	10.83
3	13.44	12.56	11.91	11.22	10.56
4	13.09	12.33	11.61	10.94	10.30
5	12.75	12.02	11.32	10.67	10.05
6	12.43	11.72	11.05	10.41	9.82
7	12.12	11.43	10.78	10.17	9.59
8	11.83	11.16	10.53	9.93	9.37
9	11.55	10.90	10.29	9.71	9.16
10	11.27	10.65	10.05	9.49	8.96
11	11.01	10.40	9.83	9.28	8.77
12	10.76	10.17	9.61	9.08	8.58
13	10.52	9.95	9.41	8.89	8.41
14	10.29	9.73	9.21	8.71	8.24
15	10.07	9.53	9.01	8.53	8.07
16	9.85	9.33	8.83	8.36	7.91
17	9.65	9.14	8.56	8.19	7.78
18	9.45	8.95	8.48	8.03	7.61
19	9.26	8.77	8.32	7.88	7.47
20	9.07	8.60	8.16	7.73	7.33
21	8.90	8.44	8.00	7.59	7.20
22	8.72	8.28	7.85	7.45	7.07
23	8.56	8.12	7.71	7.32	6.95
24	8.40	7.97	7.57	7.19	6.83
25	8.24	7.83	7.44	7.06	6.71
26	8.09	7.69	7.31	6.94	6.60
27	7.95	7.55	7.18	6.83	6.49
28	7.81	7.42	7.06	6.71	6.38
29	7.67	7.30	6.94	6.60	6.28
30	7.54	7.17	6.83	6.49	6.18
31	7.41	7.05	6.71	6.39	6.08
32	7.28	6.94	6.61	6.29	5.99
33	7.16	6.82	6.50	6.19	5.90
34	7.05	6.71	6.40	6.10	5.81

Table 5.--*Solubility of oxygen in water exposed to water-saturated air as a function of temperature and chloride concentration*[1] (continued)

Temperature (°C)	Chloride concentration in water (mg/L)				
	0	5,000	10,000	15,000	20,000
35	6.93	6.61	6.30	6.01	5.72
36	6.82	6.51	6.20	5.92	5.64
37	6.71	6.40	6.11	5.83	5.56
38	6.61	6.31	6.02	5.74	5.48
39	6.51	6.21	5.93	5.66	5.40
40	6.41	6.12	5.84	5.58	5.33
41	6.31	6.03	5.76	5.50	5.25
42	6.22	5.94	5.68	5.42	5.18
43	6.13	5.85	5.60	5.35	5.11
44	6.04	5.77	5.52	5.27	5.04
45	5.95	5.69	5.44	5.20	4.98
46	5.86	5.61	5.37	5.13	4.91
47	5.78	5.53	5.29	5.06	4.85
48	5.70	5.45	5.22	5.00	4.78
49	5.62	5.38	5.15	4.93	4.72
50	5.54	5.31	5.08	4.87	4.66

[1] At a total pressure of 760-mm Hg. Under any other barometric pressure, P, obtain the solubility S'(mg/L) from the corresponding value in the table by the equation:

$$S' = S\left(\frac{P - p}{760 - p}\right)$$

in which S is the solubility at 760-mm Hg and p is the pressure, in millimeters of mercury, of saturated water vapor at the water temperature. For elevations less than 1,000 meters and temperatures below 25 °C, p can be ignored. The equation then becomes:

$$S' = S\left(\frac{P}{760}\right) = S\left(\frac{P'}{29.92}\right)$$

where P' is the barometric pressure in inches of mercury. Dry air is assumed to contain 20.90 percent oxygen. Calculations were made by Whipple and Whipple in 1911 and published in the Journal of the American Chemical Society, 33:362 (Franson, 392).

Sensor Maintenance

If the system fails to perform acceptably, check the following:

Problem	Resolution
Damaged or wrinkled membrane	Change membrane.
Fouled or coated cathode (gold)	Resurface as per instructions supplied with YSI 5675 Sensor Service Kit (Not provided, available from local scientific supply houses).
Fouled anode (silver), blackening of anode or buildup of grayish precipitate in sensor	Soak 24 hours in 3-percent ammonia solution, rinse thoroughly with distilled water and retest.
Damaged cable or connectors	Replace and retest.
Broken stirrer diaphragm	Replace diaphragm.

Any questions regarding installation or operation can be referred to HIF Field Service and Supply Section.

Manufacturer's instructions for the stirrer and DO sensor are supplied in appendix I of this report.

Sensor Performance Checks

The following checks can be made to determine sensor performance without using specialized equipment:

Checking sensor performance

1. Speed of response

   a. Prepare and calibrate the sensor.

   b. With sensor in air, read the ANALOG VOLTAGE.

   c. Immerse the sensor in a 25-^{0}C oxygen-depleted sample. Samples may be prepared by adding approximately 1 gram of sodium sulphite to 0.5 liter of water.

   d. A good sensor responds down-scale to 10-percent air saturation in 1 minute.

2. Background current

   After performing the speed-of-response steps, leave the sensor in the depleted sample for approximately 10 minutes. The ANALOG-VOLTAGE reading, in most cases, falls below 1-percent air saturation.

3. Calibration stability

   a. Carefully calibrate the sensor in moist air.

   b. Place the sensor in air-saturated water and allow the instrument to operate for 24 hours or longer.

   c. A good sensor holds calibration plus 2 percent in 24 hours and plus 3 percent in 7 days.

4. Service

   If the sensor does not perform properly, see section entitled "Sensor Maintenance."

If these steps do not restore performance, the sensor may require replacement.

DISCUSSION OF DISSOLVED OXYGEN

Following is a discussion of measurement errors that the Yellow Springs Instrument Company provides with its Model 56 DO Monitor. Not all of the errors apply to the Minimonitor, especially those associated with instrument-component errors. However, the discussions of all errors are included to better explain the propagation of errors.

Instrument-Component Errors

- Recorder linearity
  Error = +0.5 percent of full scale of measurement range.

- Range-to-range error
  Switching from 0 to 100 percent to the 10 parts-per-million (ppm) range.
  Error = 0
  Switching from 10-ppm range to the 0- to 5- or 0- to 20-ppm range.
  Error = +1 percent of reading

- Temperature coefficient (zero setting)
  Error = ±0.05-percent °C of full scale of the measurement range (from 25 °C).

Nonideal Sensor Behavior

- Background signal varies with sensor temperature. See sensor background error below.

- Temperature-compensation uncertainty
  Error = 0 if readings are taken at the calibration temperature.

  Error = ±1 percent of reading if readings are taken within 5 °C of the calibration temperature.

Error = ±3 percent of reading for all other conditions.

Sensor Background Error

(ppm)	Error (0 to 10 percent)	Temperature (°C)
0.28	1.9	0
.14	1.2	10
.07	.8	20
.04	.6	30
.02	.4	40

NOTE: Use of the YSI STANDARD membranes reduces these errors by 50 percent.

Sensor-Calibration Uncertainty

- Barometric pressure effect.--If normal barometric pressure is assumed (+0.5-inch or 12-mm Hg)
  Error = 1.7 percent of reading
- Altitude effect.--If altitude is estimated +500 feet,
  Error = +1.8 percent of reading
  NOTE: Last two errors are eliminated if true barometric-pressure data are available.
- Calibration drift with time.--Calibration may drift +3 percent of reading over a 7-day period in 0- to 30-°C samples. In 30- to 45-°C samples, calibration may drift +5 percent. Actual drift during a run can be checked by a postmeasurement calibration check.

NOTE: In the discussion of measurement errors, YSI uses concentrations of DO expressed in ppm. For all practical purposes, concentrations expressed in ppm are equivalent to mg/L.

Example of a Typical Error Calculation

The following example represents a typical error calculation for a 1-week period of data collection.

Data: Instrument calibrated with a 20-°C sensor on the 0- to 100-percent air-saturation range; elevation estimated at 2000 ±500 feet; normal barometric pressure presumed. Readings taken on the 0- to 10-ppm scale. Highest sample temperature is 25 °C. Lowest sample temperature is 15 °C. Ambient instrument air temperature is 10 to 30 °C. Error calculated for a reading of 6 ppm at 21 °C.

Description	Calculation		Error ppm
Linearity	+0.005 by 10 ppm	=	0.05
Range-to-range	0	=	- -
Temperature coefficient (zero)	(25 to 10 ^{0}C) by 0.0005 by 10 ppm	=	0.08
Background	at 20 ^{0}C	=	.07
Temperature compensation	0.01 by 6 ppm	=	.06
Barometer	0.017 by 6 ppm	=	.10
Altitude	0.018 by 6 ppm	=	.11
Drift	0.03 by 6 ppm	=	.18
	Maximum possible error		0.55 ppm

Summation of errors to produce the maximum possible error is unlikely. More often, some errors oppose others to produce a statistical error approximating a root-mean-square error of about one-half the maximum possible error or about 0.3 ppm.

pH-RANGE SELECTION, CALIBRATION, AND SENSOR MAINTENANCE

The pH measuring system consists of a sensor assembly and a SIGNAL CONDITIONER designed by the U.S. Geological Survey. The sensor assembly contains a preamp and a combination pH-reference electrode. The standard pH sensor has a combination electrode with a refillable reference mounted directly on the sensor assembly.

The Minimonitor pH system can also accept most combination pH electrodes that are submersible and have standard dimensions of 0.5 inch by 6 inches.

To use pH electrodes other than those discussed here, contact HIF Field Service and Supply Section.

Selecting pH Range

The system provides for two measuring ranges, 0 to 10 pH or 2 to 12 pH, selected by a toggle switch located on the pH SIGNAL CONDITIONER board (fig. 14, pH SIGNAL CONDITIONER).

Install the pH SIGNAL CONDITIONER board following instructions provided in section entitled "Servicing Internal Components of the Minimonitor."

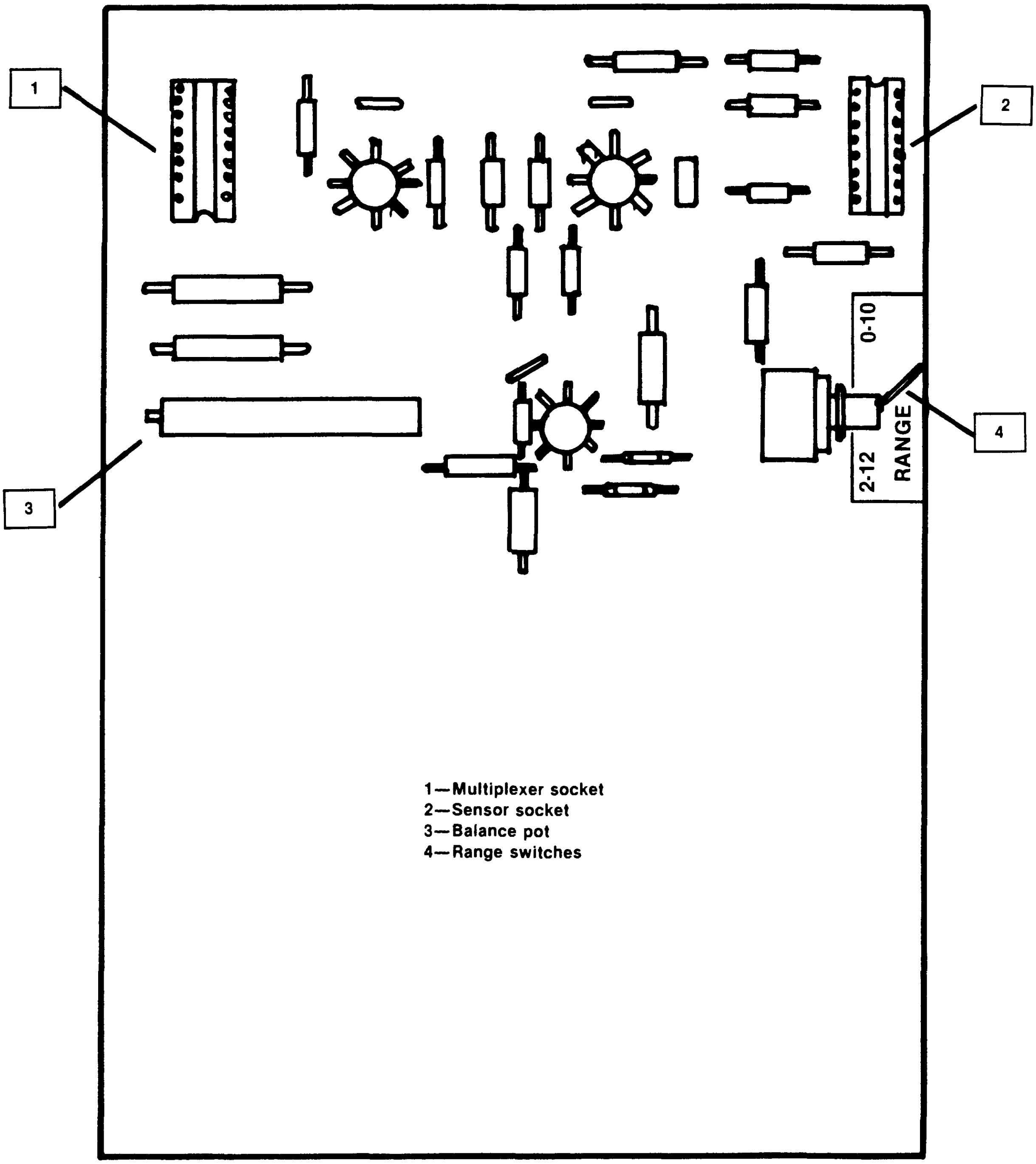


Figure 14.--pH signal conditioner.

Before resealing the can, the SIGNAL CONDITIONER electronics must be "balanced." Do not plug in the pH sensor at this time.

1. Set the toggle switch to the desired pH range. The 0- to 10-pH range is recommended.

2. Connect power to the Minimonitor and a voltmeter to the analog-telemetry connector in the socket corresponding to the desired channel. (See "Calibration of the Minimonitor Reading Analog Voltages.")

3. Toggle the ON-OFF switch to ON.

4. Set the AUTO-MANUAL switch to MANUAL.

5. Use a small screwdriver to adjust the balance pot (fig. 14) until the ANALOG-VOLTAGE output is 3.5 volts if the range selected is 0- to 10-pH or 2.50 volts if the range selected is 2- to 12-pH.

6. Turn off power (ON-OFF switch to OFF) and reseal the can.

Calibration

After the desired range has been set, prepare the pH sensor by following instructions provided in the section "Sensor Maintenance." After the sensor has been prepared, connect the pH sensor to the Minimonitor. Place the sensor in the 7.0 pH buffer. **NOTE: The wire that is down the side of the pH electrode is for grounding purposes and must be kept in the solution being monitored. If the wire does not remain in the solution, erroneous results occur.** Allow the sensor to stabilize and adjust the ZERO pot so the ANALOG VOLTAGE reads 3.50 volts (0 to 10 range) or 2.50 volts (2 to 12 range). Place the sensor in a 4.0-pH buffer, or a 10.0-pH buffer if high pH values are expected. Adjust the SPAN pot until the ANALOG VOLTAGE reads 2.00 volts (0 to 10) or 1.00 volts (2 to 12) if using a 4.0 buffer. When using a 10.0 buffer, the ANALOG VOLTAGE should read 5.00 volts (0 to 10) or 4.00 volts (2 to 12). Check again in the 7.0 buffer for a voltage of 3.50 volts. The value changes very little if the system is operating properly. Repeat the above process if the voltage reading in the 7.0 buffer is not correct. The use of a pH buffer that has a pH value other than 7.0 significantly increases the number of repetitions of the calibration process necessary to achieve calibration. Table 6 shows the relation between pH values and ANALOG-VOLTAGE readings.

Table 6.--*Relation between pH values and Minimonitor analog-voltage readings*

pH value at sensor	Minimonitor analog-voltage readings: Range 0 to 10 pH	Minimonitor analog-voltage readings: Range 2 to 12 pH
0.0	0.00	--
1.0	0.50	--
2.0	1.00	0.00
3.0	1.50	0.50
4.0	2.00	1.00
5.0	2.50	1.50
6.0	3.00	2.00
7.0	3.50	2.50
8.0	4.00	3.00
9.0	4.50	3.50
9.5	4.75	3.75
10.0	5.00	4.00
11.0	5.00 (over range)	4.50
12.0	5.00 (do)	5.00
13.0	5.00 (do)	5.00 (over range)
14.0	5.00 (do)	5.00 (do)

Sensor Maintenance

pH sensors require minimum maintenance. Simple guidelines follow:

- During storage, keep sensors near room temperature.
- Do not remove the cap on the tip of the sensor.

These caps are filled with a weak 7.0-pH buffer to keep the reference junction wet. Semiannually, check the sensors in storage to assure that the cap retains moisture. The 7.0-pH buffer can be replaced with ordinary tap water if the buffer has evaporated. Keep the connector located at the end of the sensor cable clean and dry.

Cleaning the pH sensor is easy. The reference junction usually requires no maintenance. Any coatings covering the exposed part of the reference junction usually can be removed with detergent and a brush. Care must be taken not to break the glass bulb when cleaning the reference junction.

Glass pH electrodes can be cleaned in a number of ways. Scaling, persistent oils, and other stubborn coatings usually can be removed by soaking the reference in a 3- to 10-percent HCl solution for a few minutes and then rinsing it under tap water. Unusually heavy coatings may require more than one soaking. Simple cleaning of minor coatings often can be accomplished by directing a stream of clean water directly onto the glass. Wiping the glass with a clean, soft cloth is permissible with new sensors. Care must be taken with this approach as the glass may break when mishandled.

pH Sensor Preparation

Prepare the sensor as follows:

1. Examine the sensor for damage, paying particular attention to the electrode. Handle the sensor with care because the glass bulb is extremely fragile. If damaged, contact the HIF. Do not attempt to disassemble or repair the sensor assembly as further damage may result.

2. Check the glass bulb for air bubbles in the electrolyte. Hold the sensor vertically with the electrode-end down. If air is present, gently tap the lower end of the sensor (**not the electrode!**) against the heel of your hand until the bubbles no longer are present in the bulb. The sensor must not be inverted or bubbles may re-enter the bulb and cause erroneous measurements.

3. Soak the sensor for a minimum of 24 hours before calibration is attempted or drift may occur. Distilled water may be used, but a pH buffer of 4.0- or 7.0-pH units is preferred.

4. The prepared sensor is ready to be connected to the Minimonitor. Align the waterproof plugs and sockets as shown in figure 6 and connect them to the proper channel. To make connector identification easier, use adhesive labels marked "pH" on both the sensor cable and the sensor connector on the Minimonitor.

Refilling pH Reference

To refill the reference on the pH electrode, remove the screw plug in the side of the electrode. Using distilled water and a squirt bottle, rinse the old reference solution out of the electrode. The reference solution used in the pH electrode is a liquid gel and is somewhat difficult to remove. Make sure all the old reference solution is washed out of the electrode or problems may occur when the sensor is placed back into service. Using the solution supplied with the sensor, refill the reference, making sure no air bubbles are trapped inside. (To remove air, hold the sensor assembly with the electrode pointing down and gently tap the side with the heel of the hand.) Replace the plug, using thread-sealing tape on the threads.

pH Sensor Shipping Procedure

When packing the pH sensor for shipment, please follow this procedure:

- Place the shipping cap over the end of the electrode. To prevent air from being forced into the reference electrode, fill the cap completely with water or buffer solution. Electrodes shipped without this cap dry out and sometimes cannot be salvaged.

- Wrap the electrode end of the sensor with some cushioning material to prevent damage to the electrode. This is the most fragile part of the assembly and may be damaged during shipment.

VOLTAGE-INPUT SPECIFICATIONS, APPLICATIONS, AND CALIBRATION

A voltage SIGNAL CONDITIONER (fig. 15) has been designed by the HIF to allow the Minimonitor to accept voltage and, in some cases, current signals from other instruments. The voltage SIGNAL CONDITIONER has a selectable gain, which is applied to the input signals. Settings of the gain and the SPAN and ZERO pots on the Minimonitor cover determine the voltage levels passed to the data recorder or DCP. In addition, the voltage SIGNAL CONDITIONER has relays available to provide electrical power from the Minimonitor, or other sources, to other instruments. The relays normally are activated when the Minimonitor control/turn-on line is turned on or when the AUTO-MANUAL switch is switched to MANUAL.

Examples of some instruments that may be interfaced are

- Pressure transducers
- Turbidimeters
- Meteorological sensors
- Specific-conductance meters
- pH meters
- DO meters
- Ultrasonic Ranger
- Potentiometers
- Bridges
- Metritape (Stage-measurement device)

Almost any voltage-producing device can be interfaced, provided that its voltage output falls within the specifications of the voltage SIGNAL CONDITIONER.

Voltage Signal Conditioner Technical Specifications

Direct-current voltage inputs, full scale:

Maximum: 0 to 10 volts or more[1]
Minimum: 0 to 100 millivolts

Input impedance: 1 to 5 megohms

Common-mode, input-voltage range: +7 to -4 volts
(Maximum input voltage that can be applied to either input)

Differential input-voltage range: 100 millivolts to 5 volts full scale.

Applications

Address questions concerning interfacing of the voltage SIGNAL CONDITIONER to any particular device or instrument to the HIF Field Service and Supply Section. Specifications of the device or instrument need to be provided to determine if the device will interface.

The Field Service and Supply Section will prepare the voltage SIGNAL CONDITIONER, making any necessary component adjustments to satisfy the needs of the user.

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[1] Consult HIF for higher voltage inputs.

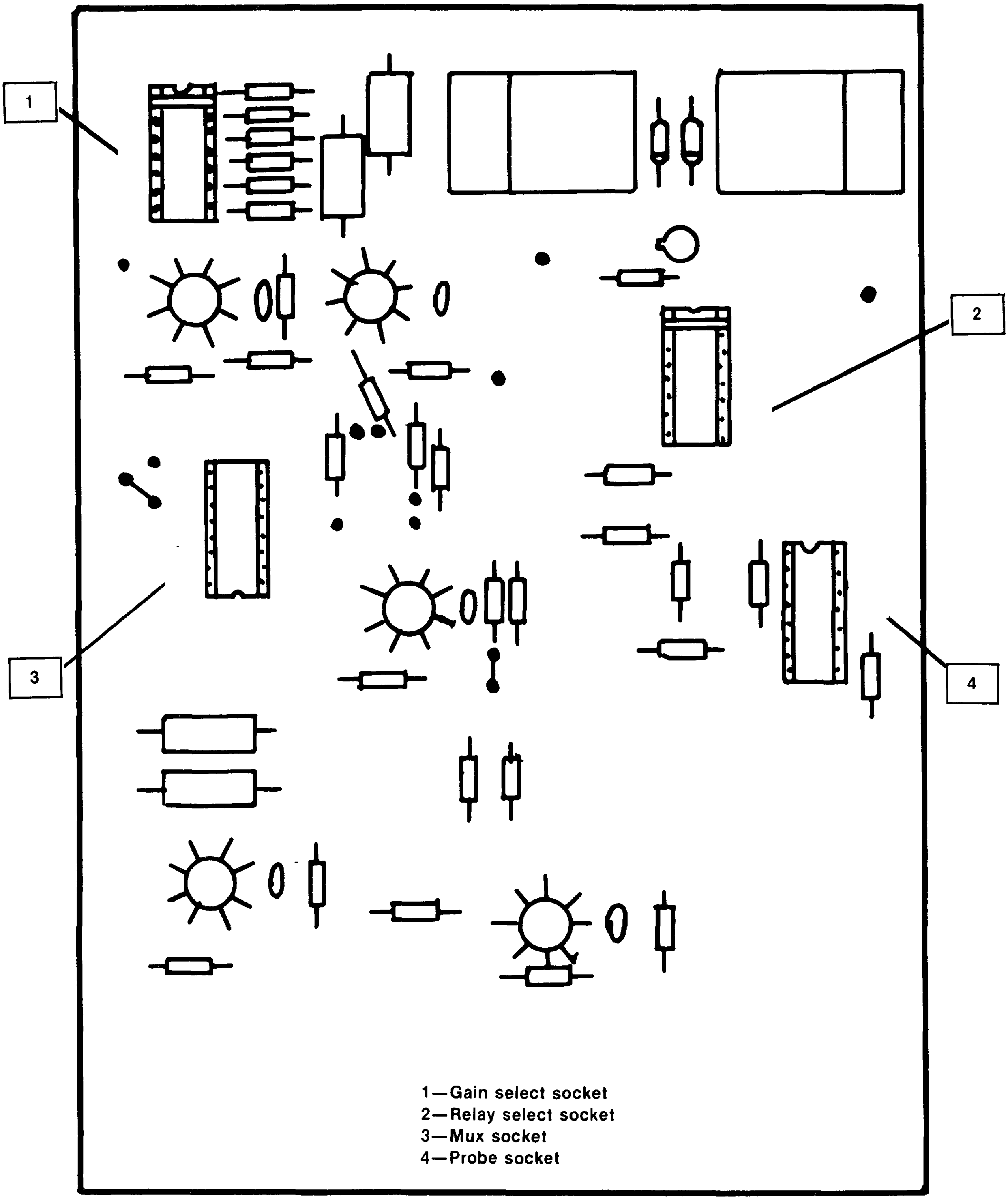

Figure 15.--Voltage signal conditioner.

Voltage Calibration

After the voltage SIGNAL CONDITIONER has been set up properly for the application, install it in the Minimonitor. (See section entitled "Servicing Internal Components of the Minimonitor.")

Exercise care in making the correct connections to the external devices or damage may result to the voltage SIGNAL CONDITIONER, the Minimonitor, and the external devices.

The power that is applied to the device through the relays on the voltage SIGNAL CONDITIONER, under normal circumstances, activates when the Minimonitor control/turn-on line comes on or when the AUTO-MANUAL switch is placed on MANUAL.

After the voltage SIGNAL CONDITIONER has been installed and the correct connections made, calibrate the Minimonitor as follows:

1. Turn the ON-OFF switch to ON, and the AUTO-MANUAL switch to MANUAL. This powers up the Minimonitor and turns on the DO STIR signal. This also powers up the external device if it is connected to the voltage SIGNAL CONDITIONER relay.

2. Connect a voltmeter to the analog-telemetry connector in the socket corresponding to the desired channel. (See "Calibration of the Minimonitor Reading Analog Voltages.")

3. Provide a voltage signal from the external instrument or device representing a low or zero input and a voltage signal that represents an input value close to full scale.

   If the device is a pressure transducer that provides 0 to 1 volt for a 0- to 10-foot water depth, the pressure transducer would be raised to just below the water surface to provide a voltage signal and then lowered to some known distance less than 10 feet below the surface to provide a voltage signal close to full scale. Adjust the ZERO pot for the low-voltage signal and the SPAN pot for the full-scale voltage signal.

4. Example:

   Pressure Transducer
   0 to 10 feet of water = 0 to 1 volt from transducer = 0.00- to 5.00-volt Minimonitor ANALOG VOLTAGE.

Pressure transducer	Depth (foot)	Sensor voltage (volt)	Adjust	Until ANALOG VOLTAGE reads (volt)
Low signal	0.10	0.010	ZERO	0.00
High signal	9.50	0.950	SPAN	4.70
High signal	9.50	0.950	ZERO	4.75

If the low signal is not low enough, the ZERO pot will have insufficient range to make the ANALOG VOLTAGE read 0.00 volt. In this case, either reduce the low signal or adjust the ZERO pot to make the ANALOG VOLTAGE read the equivalent to the low signal and the SPAN pot to make the ANALOG VOLTAGE read the equivalent to the high signal. Many trial adjustments have to be made using this method.

5. Example:

A Minimonitor is interfaced to a turbidimeter.

Turbidimeter
0 to 1,000 JTU = 0- to 5-volt direct current from turbidimeter = 0.00- to 5.00-volt Minimonitor ANALOG VOLTAGE.

Turbidimeter	Turbidity (JTU)	Sensor voltage (volt)	Adjust	Until ANALOG VOLTAGE reads (volt)
Low signal	0	0.00	ZERO	0.00
High signal	950	4.75	SPAN	4.75

6. The Minimonitor is now calibrated.

ULTRASONIC RANGER SPECIFICATIONS, INSTALLATION, CALIBRATION, AND WATER-STAGE CALCULATIONS

The Ultrasonic Ranger is a distance-measuring device that uses ultrasonic pulses to measure distances up to 35 feet from its sensor. The unit has been developed primarily to measure water stage. This section deals with the Ultrasonic Ranger when used with a Minimonitor.

The following components are necessary when the Ultrasonic Ranger is used with a Minimonitor:

- Ultrasonic Ranger with temperature sensor (fig. 16).
- Voltage SIGNAL CONDITIONER (fig. 15) and ribbon cable connector if used on Minimonitor.
- Sensor cable (normally 100 feet).
- Minimonitor and data logger/recorder.
- Site, mounting brackets, shelter, power, and so forth.

All except the last line of items will be furnished by the HIF.

Figure 16.--Temperature-compensated Ultrasonic Ranger.

Ultrasonic Ranger Technical Specifications

Operating Temperature:	-20 to +50 °C.
Range:	35.5-foot maximum. 1-foot minimum.
Accuracy:	Approximately ±0.1 foot throughout the operating range depending on variations in air temperature in the column of air below the sensor.
Resolution:	About 0.05 foot.
Output voltage:	0 to 4.88 volts, 15-milliampere current maximum. 0 volts = A surface 35.5 feet from sensor. 4.88 volts = A surface 0.9 foot from sensor. Rising water stage causes increasing output voltage. The output is linear within the operating range (7.1 feet per volt).
Power required:	11- to 15-volt direct current; may be powered separately or with the same source used for companion equipment.
Power consumption:	2.5 amperes for 1 millisecond during each ultrasonic pulse; 55 milliamperes time-averaged.
Cable length:	Up to 1,000 feet.
Divergence angle:	20 degrees; needs an unobstructed view of the water surface in a circle of about 13-foot diameter when the water surface is 35 feet directly below the sensor.

Distance below sensor (ft)	Diameter of field of view (ft)
35	13
20	7.3
10	3.6
5	1.8

Updating:	An initial value is given about 4 seconds after turn-on; then the measurement is updated about every 20 seconds.
Survey Minimonitor:	A voltage SIGNAL CONDITIONER is needed in the Minimonitor to operate the Ultrasonic Ranger.
Range on Minimonitor:	Water stage 0 foot = ANALOG VOLTAGE of 0.00 volt Water stage 34.6 feet = ANALOG VOLTAGE of 3.46 volts

Installation

The Ultrasonic Ranger needs to be suspended or mounted with the long axis perpendicular to the water surface above the unobstructed stream surface at a distance no greater than 35 feet. The Ranger neither indicates nor measures distances greater than 35.5 feet. The unit may be suspended from a cable, but arrangements must be made to keep sway to a minimum. Position the Ranger's temperature sensor out of the sunlight to provide the best air-temperature measurement. The Ranger may be installed in a steel pipe to protect against vandalism, but the view[1] from the bottom must be unobstructed. Refer to the "Divergence angle" in the preceding "Ultrasonic Ranger Technical Specifications" of this section for the unobstructed surface area needed by the Ranger at different distances from the water surface.

CAUTION: Protect the ultrasonic transducer on the bottom of the Ranger from damage by puncture or other shocks during shipping and transport. Avoid getting water into the transducer. **The transducer is not waterproof.**

Locate the Minimonitor in a shelter near the Ultrasonic Ranger to minimize the length and cost of the sensor cable. Use the standard Minimonitor sensor cable and connectors.

A voltage SIGNAL CONDITIONER that has been prepared especially by the HIF for the Ultrasonic Ranger is required. Do not install a voltage SIGNAL CONDITIONER for the Ultrasonic Ranger that has no label indicating such preparation.

Install the voltage SIGNAL CONDITIONER as instructed in the section "Servicing Internal Components of the Minimonitor." The SIGNAL CONDITIONER may be installed in any desired channel.

The Ultrasonic Ranger requires at least 4 seconds to provide a reading. If the Ultrasonic Ranger is used in channel 1 of the Minimonitor, a delay of at least 8 seconds should occur before reading the ANALOG VOLTAGE on channel 1 after turning on the SIGNAL CONDITIONERS.

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[1] This corresponds to a 0- to 50-foot range on the Minimonitor analog voltage.

Calibration

The Minimonitor-Ultrasonic Ranger system can be calibrated through the use of a piece of HIF-provided plastic foam and a piece of cardboard or some other smooth-surface material. Access to the Ultrasonic Ranger is necessary.

1. On the Minimonitor, switch the ON-OFF switch to ON and the AUTO-MANUAL switch to MANUAL. This action powers-up the Minimonitor and turns on the Ultrasonic Ranger.

2. Connect a voltmeter to the analog-telemetry connector in the socket corresponding to the desired channel. (See "Calibration of the Minimonitor Reading Analog Voltages.")

3. Hold or tape a piece of plastic-foam sponge over the ultrasonic transducer at the lower end of the Ranger. Adjust the ZERO pot associated with that channel on the Minimonitor lid until the ANALOG VOLTAGE reads 0.00 volts. Full scale can also be achieved by pointing the Ranger at the sky. Wait at least 20 seconds for the value to stabilize.

4. Hold or tape a piece of cardboard or other sound-reflective material over the ultrasonic transducer at the lower end of the Ranger. The target must be closer than 0.9 foot from the end of the Ranger. After the value has stabilized, adjust the SPAN pot associated with that channel on the lid of the Minimonitor until the ANALOG VOLTAGE reads 3.46 volts. This is based on a distance of 0 to 50 feet corresponding to a 0.00- to 5.00-volt ANALOG VOLTAGE.

5. Repeat steps 3 and 4 until the desired readings are achieved and the system is calibrated.

Distance in feet from the Ultrasonic Ranger is calculated as follows:

Minimonitor

Distance in feet from the Ranger to a surface	=	35.5 - (ANALOG VOLTAGE X 10)
Distance in feet upwards to a surface from a plane 35.5 feet below the Ranger	=	(ANALOG VOLTAGE X 10)

Water-Stage Calculations

Correlation of the Minimonitor ANALOG-VOLTAGE readings with water stage (gage height) is achieved in the following manner:

Calibrate the Ultrasonic Ranger and install it within 35.5 feet of the water surface at the lowest expected gage height. Subtract the ANALOG-VOLTAGE reading times 10 from the closest outside gage-height reading. This is a constant value that is added to the ANALOG-VOLTAGE reading after the ANALOG-VOLTAGE reading is converted to feet.

Minimonitor-Ultrasonic Ranger
gage height, in feet = (ANALOG VOLTAGE X 10) + constant

where the constant = gage datum Ultrasonic Ranger - gage datum outside gage.

On visits to the gaging station, the calibration is checked by reading the outside gage, reading the Minimonitor ANALOG VOLTAGE, multiplying the ANALOG-VOLTAGE value by 10, and adding the constant. The calculated gage height from the Ultrasonic Ranger compares closely with the outside gage reading unless malfunctions occur.

If the stream gage height falls below the gage datum of the Ultrasonic Ranger, the ANALOG VOLTAGE will continue to read 0.00 volt.

OPERATION OF THE MINIMONITOR WITH THE LABARGE GOES DATA-COLLECTION PLATFORM

The Minimonitor has been designed to interface to the LaBarge data-collection platform. For operation with the platform, refer to the connection list that follows.

To connect the Minimonitor to other satellite data-collection platforms, please contact the Electronics group of the Field Service and Supply Section at the HIF for information.

The 10-pin, analog-telemetry connector on the Minimonitor connects to the platform as follows:

Minimonitor Pin	Function	Platform Pin
A	Channel 1 out (0 to 5 volts)	j
B	Channel 2 out (do)	z
C	Channel 3 out (do)	m
D	Channel 4 out (do)	N
E	Channel 5 out (do)	AA
F	Channel 6 out (do)	T
G	Channel 7 out (do)	U
H	Channel 8 out (do)	n
I	Analog ground	P
J	Control/turn-on	A

After hooking up the telemetry, perform the following test to verify that the system is working properly:

1. Set the platform on a 6-minute data-acquisition cycle.

2. Turn the Minimonitor ON-OFF switch to ON and the AUTO-MANUAL switch to AUTO.

3. When the 12 volts on the platform are activated, the Minimonitor powers-up. When the 12-volt activation shuts off, the Minimonitor powers-down.

4. The sequence in step 3 repeats every 6 minutes. One can verify the analog data by reading the data stored in the platform through the platform-test set.

5. When the test is complete, return the platform to its 1-hour data-acquisition time.

To put the system into operation, proceed according to these steps:

1. Set the platform to the correct time and set the platform data-acquisition time.

2. The Minimonitor will be powered up by the next data-acquisition cycle of the platform.

Table 7 shows the delay times for the LaBarge GOES platform when the Minimonitor has a DO system.

Table 7.--*Delay times for the LaBarge GOES platform with a dissolved-oxygen system on the Minimonitor*

DO Sensor Membrane thickness (mils)	Time delay to set on the platform (seconds)
1	40
2	112

OPERATION OF THE MINIMONITOR WITH THE CR21 MICROLOGGER

The Minimonitor is turned on by a signal from any one of four CR21 output control ports, and the data are recorded 1 minute later by the CR21.

A special CR21-to-Minimonitor interface (fig. 17) is used because the Minimonitor output voltage of 5 volts needs to be reduced to 2 volts. When used with the Minimonitor, no connection is made to the L (low) side of the CR21 sensor inputs because they are 1 volt above the CR21 ground and will be forced to ground through the sensor. The interface is designed to allow the CR21, Minimonitor, and the A21 REL (relay) driver to use the same battery for power. A schematic is shown in figure 18.

The interface accommodates up to four inputs from the Minimonitor through the analog-telemetry connector. The interface-to-CR21 connections are made with almost any type of wire that is 14 AWG, or smaller, by using screw-type connectors.

NOTE: Turn off the Minimonitor while any connections are being made.

CAUTION: MAKE NO CONNECTIONS TO THE L (LOW) SIDE OF THE CR21 SENSOR CONNECTORS. **NEVER** ALLOW THE 5-VOLT OUTPUT VOLTAGE FROM THE CR21 TO GO TO GROUND. WHEN THIS HAPPENS, ALL DATA AND PROGRAMS ARE ERASED.

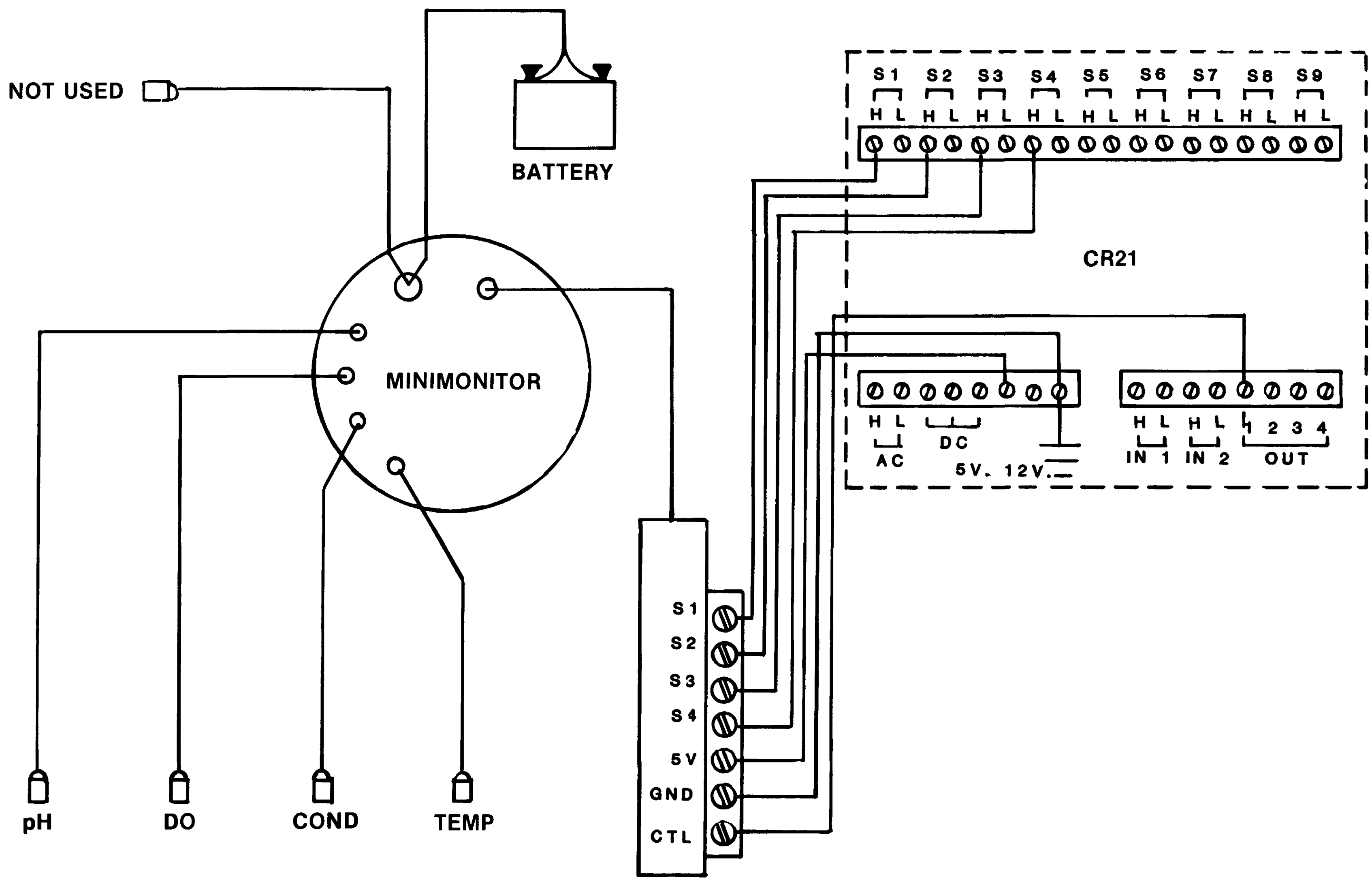

Figure 17.--CR21-to-Minimonitor (four-channel) interface.

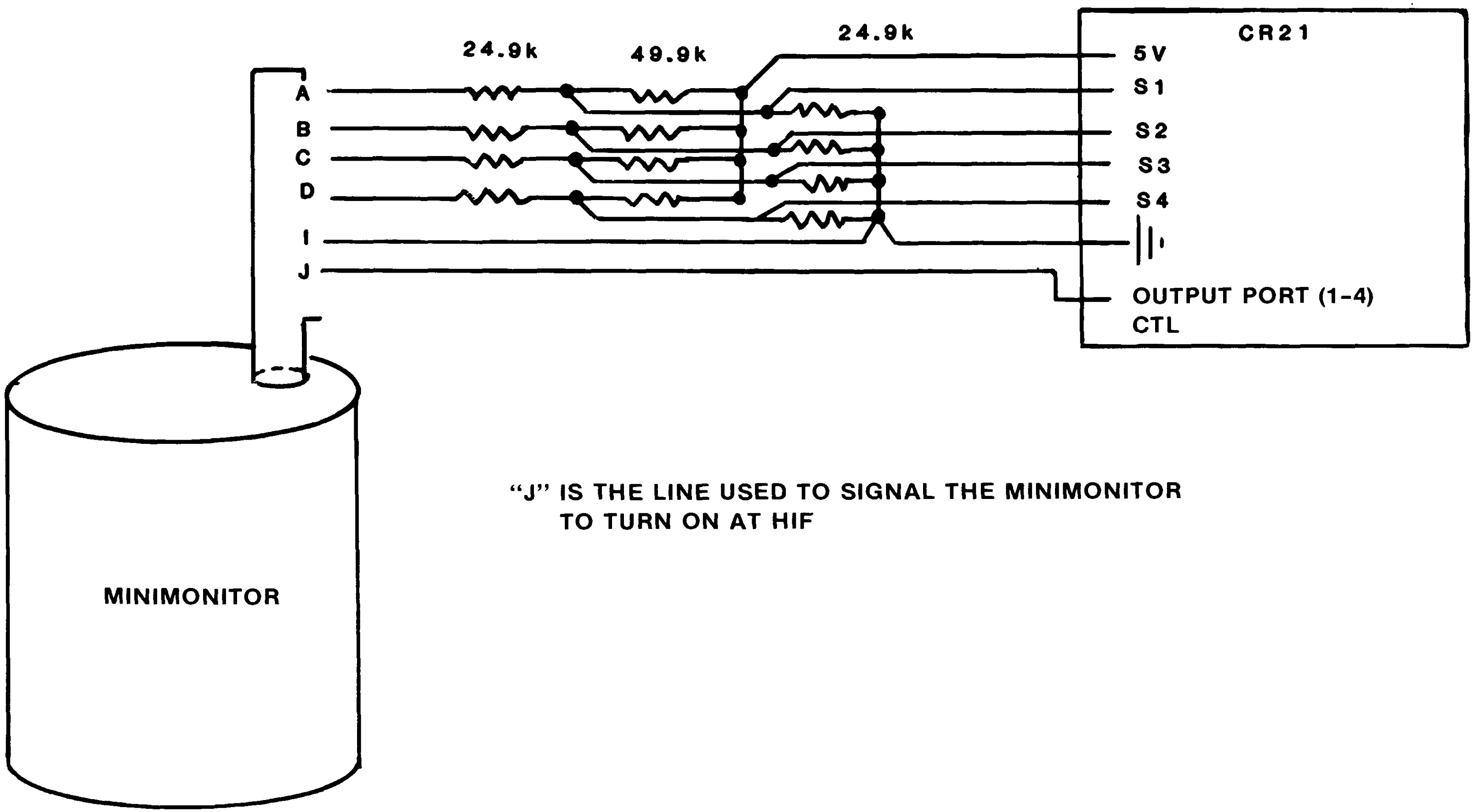

Figure 18.--CR21-to-Minimonitor (four channel) interface schematic.

COMMON PROBLEMS AND TROUBLESHOOTING

Common Problems

Some problems that may occur with the Minimonitor system follow:

Weak or Dead Battery

If the battery voltage drops below 10 volts, the Minimonitor system may malfunction and record erroneous values. Always check the battery voltage first to ensure that the battery is not the source of a problem.

Blown Fuses

A fuse is located in a fuse holder in the front panel of the Minimonitor. When the fuse is blown, the Minimonitor system is completely inoperable.

Malfunctioning SIGNAL CONDITIONER boards may cause blown fuses. Remove all SIGNAL CONDITIONER boards and, if the Minimonitor operates satisfactorily, replace SIGNAL CONDITIONER boards one at a time until the problem board is found.

Sensor and Cable Connectors Misaligned

Carefully check to determine that sensor and cable connectors have not been improperly aligned and then forced together. This can happen when a new system is installed. If the cables are not plugged in properly, the sensors and SIGNAL CONDITIONERS will not be properly mated, and malfunctions will occur.

Cables are occasionally cut or abraded, and the underwater connectors sometimes leak. These problems usually appear as sensor problems.

Sensor Failure

Failure of the sensors can usually be determined by replacing the sensor with a new sensor or by using test boxes.

Electronic-Board Failures

These problems are not easy to isolate unless spare boards are available. In some cases, failure of a SIGNAL CONDITIONER can be isolated by the use of test boxes. As a general rule, failure of a POWER/ANALOG board affects all channels; whereas, in many cases, the failure of a SIGNAL CONDITIONER affects only that channel.

Damage in Shipment

In many cases of Minimonitor malfunction, the unit has been damaged in shipment by rough handling. If a Minimonitor fails to operate when received, open and carefully inspect it for damage or loose connections. A wire may have come loose and replacement of the wire may cause the Minimonitor to operate properly.

Troubleshooting

Repair and maintenance of the electronic circuitry in the Minimonitor are normally handled by the HIF. However, it is beneficial for the field personnel to be able to identify Minimonitor or sensor failures and, by following instructions in other sections of the manual, be able to:

- Change a blown fuse,
- Add, remove, or change SIGNAL CONDITIONERS or other boards,
- Set switches on SIGNAL CONDITIONERS for ranges,
- Change sensors or Minimonitor.

After the problem has been identified and the faulty item isolated, replace the faulty item with an operational item and send the faulty item to the HIF for repair.

Ideally, field personnel need to have a spare Minimonitor and spare sensors. When a malfunction occurs, the questionable units can be exchanged with the spare units until proper operation is achieved. The inoperative or faulty unit is sent to the HIF for repair. If numerous Minimonitors are being operated and serviced, the HIF recommends that a spare Minimonitor and spare sensors be available to minimize downtime and the subsequent record loss.

Changing Minimonitors and sensors can be accomplished at the field location. If it becomes necessary to open the Minimonitor, move the Minimonitor to a warm, dry environment, preferably the office. Exercise extreme care to keep moisture out of the Minimonitor. Instructions are given in other sections of this manual.

If it is not possible to stock Minimonitors and sensors as spares, the process of troubleshooting becomes more difficult, and the station will be out of service during the time the faulty equipment is at the HIF for repair.

Test boxes that help isolate sensor problems from Minimonitor problems are available from the HIF. Test boxes do not alleviate the need for spare sensors as these are necessary to replace the faulty sensors. If spare sensors are not on hand, additional record will be lost while waiting for new sensors to be shipped.

Test boxes are used in the following manner:

1. Calibrate the Minimonitor SIGNAL CONDITIONERS in the normal manner.

2. Shut off the Minimonitor and plug in test boxes in place of the sensors or sensor cables. A test box is needed for each type of sensor. A specific-conductance test box cannot be used to test, for example, temperature. This holds true for all types of sensors. Damage to the Minimonitor may result if improper test boxes are used on the wrong channel.

3. Turn on the Minimonitor and, using a voltmeter, measure and record the ANALOG VOLTAGES for each channel and for various switch positions on the test boxes. See instructions for operation of test boxes.

4. If a drift in calibration is noted on the next station visit after the sensors have been cleaned, the test boxes are again used to generate ANALOG-VOLTAGE readings.

5. If these ANALOG-VOLTAGE readings agree with those noted on the previous station visit, the problem is with the sensors. If the ANALOG-VOLTAGE readings do not agree with those noted on the previous station visit, the problem is with the Minimonitor.

6. The signals generated by the test boxes are approximately equal to certain constituent or property values. These values can be established by noting the ANALOG-VOLTAGE values generated by the test boxes when connected to the calibrated SIGNAL CONDITIONERS. The "calibrated" test boxes can then be used to calibrate a SIGNAL CONDITIONER to the approximate ANALOG-VOLTAGE values that would be expected from a sensor when it is placed in a calibrating solution equal to the value of the "calibrated" test boxes.

Instructions for Operating Test Boxes

The test boxes (figs. 19-23) are used to replace the sensors and to generate fixed values. These fixed values help determine if problems exist in the Minimonitor electronics or in the sensors.

Operation of the test boxes

Calibrate the Minimonitor for each channel before operating the test box. THIS IS IMPORTANT.

1. Turn off the Minimonitor and plug in the test boxes in their respective channels. **WARNING: Make sure the test boxes are plugged into the proper channels; otherwise, damage may result to the electronic circuitry.**

2. Turn on the Minimonitor. Read and record the ANALOG-VOLTAGE test values generated by the test boxes.

3. These values hold steady from station visit to station visit unless the calibration pots (ZERO and SPAN) have been adjusted or the electronics have drifted or malfunctioned. Test values stay within about 0.02 volt of the original readings. Differences greater than this indicate problems in the electronics.

Special instructions for each test box

- Temperature.--Figure 20 shows the temperature test box. Three test values are generated, one for 0 °C, one for 25 °C, and one for 50 °C. The values are approximate. Each test value is generated by successively toggling the switches from OFF to each test value. Use only one switch at a time.

Figure 19.--Minimonitor test box (typical).

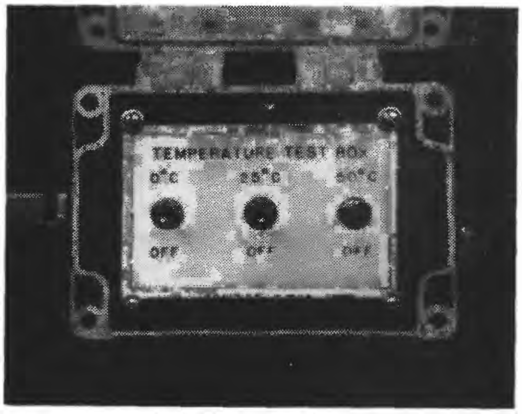

Figure 20.--Temperature test box.

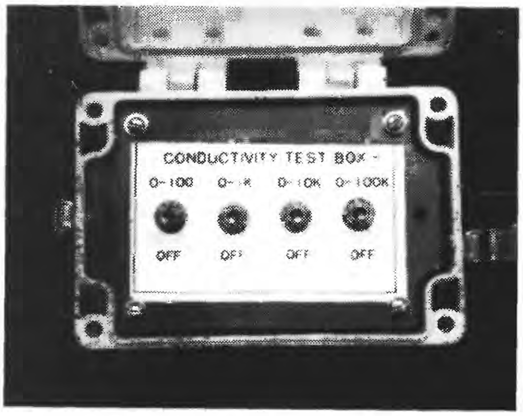

Figure 21.--Specific-conductance test box.

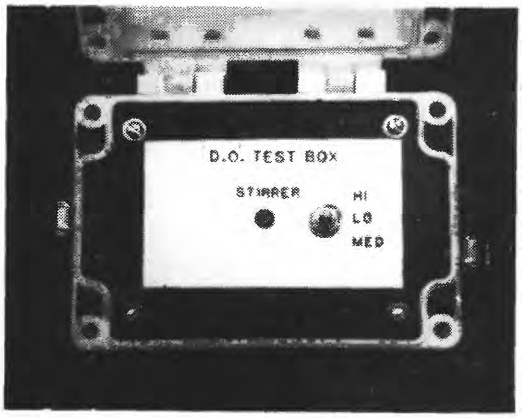

Figure 22.--Dissolved-oxygen test box.

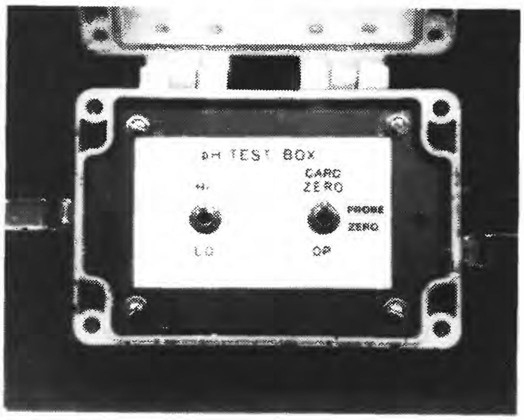

Figure 23.--pH test box.

- Specific conductance.--Figure 21 shows the specific-conductance test box. The OFF position represents zero specific conductance for all switches. Values of specific conductance can be set for any one of four ranges on the Minimonitor by use of a corresponding test switch on the test box. The 0 to 100 switch is used when the Minimonitor specific conductance has been set for the 0- to 100-μS/cm range and so on. Only one switch is used at a time.

- Dissolved oxygen.--Figure 22 shows the DO test box. The test switch has three positions: LO representing zero DO, MED representing about 10-mg/L DO, and HI representing about 20-mg/L DO. If using the 0- to 10-mg/L DO range, only the LO and MED switch positions can be used. An indicator light provided (STIRRER) will light when the Minimonitor activates the sensor stirrer motor. When the AUTO-MANUAL switch on the Minimonitor front panel (fig. 4) is in the MANUAL position, the light is on. When the switch is in the AUTO position, the light is off.

- pH.--Figure 23 shows the pH test box. Two switches are provided. With the HI-LO switch in HI and the OP-ZERO switch in OP, a pH of about 10.0 units is generated. A LO switch position generates a pH of about 4.0 units. A pH of about 7.0 units is generated with the OP-ZERO switch in the CARD-ZERO position. When the OP-ZERO switch is in the sensor ZERO position, a reading of sensor offset can be made.

Special notes

- If a suspicion exists that a cable has been damaged, the test boxes can be used to replace the sensors at the end of the cables after checks have been made at the Minimonitor. Test values are the same at the end of the cable as at the Minimonitor unless the cable has been damaged.

- The test boxes may be used to roughly calibrate the Minimonitor by generating test values instead of placing the sensors in solutions of known values. Follow instructions for the final calibrations.

SHIPPING THE MINIMONITOR

If the Minimonitor needs to be returned to the HIF for repair or shipped to another location, take precautions to prevent damage in shipment.

Pack the Minimonitor in a large carton with a minimum of 3 inches of packing such as Styrofoam or other shock-preventive material.

Considerable damage can occur to a Minimonitor shipped in a carton having little or no protective foam packing.

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Yellow Springs Instrument Co., Inc., 1975, Instructions for YSI 5700 series dissolved oxygen probes: Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio, 2 p.

----1978, Instructions for YSI model 5695 submersible stirrer: Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio, 3 p.

----1979, Instructions for YSI 5675 D.O. monitor service kit used with YSI 5739 dissolved oxygen probe: Yellow Springs Instrument Co., Inc., Yellow Springs, Ohio, 2 p.

APPENDIX I--INSTRUCTIONS FOR USE OF THE STIRRER AND DISSOLVED-OXYGEN SENSOR USED IN THE MINIMONITOR'S DISSOLVED-OXYGEN MEASURING SYSTEM AND DISCUSSION OF MEASUREMENT ERRORS.

Yellow Springs Instrument Company, Inc., Yellow Springs, Ohio, is the manufacturer of the stirrer and dissolved-oxygen sensor referenced on page 24 in this report and has granted permission to the U.S. Geological Survey to reproduce instructions for these devices in this report.

INSTRUCTIONS FOR YSI MODEL 5695 SUBMERSIBLE STIRRER

GENERAL DESCRIPTION

The YSI Model 5695 Submersible Stirrer is designed to be used with the YSI Model 56 Dissolved Oxygen Monitor and Model 5739 Dissolved Oxygen Probe. (See Figure 1.)

Figure 1
YSI Model 5739 Dissolved Oxygen Probe Mounted in YSI Model 5695 Submersible Stirrer

It should be used whenever the existing sample velocity is less than one foot per second. The stirrer creates a turbulent sample flow over the probe's sensor membrane. The turbulent flow removes the oxygen-depleted sample and continuously provides a fresh sample to the probe.

The 50' cable supplied with the stirrer also provides electrical connections between the Model 56 Dissolved Oxygen Monitor and the Model 5739 Dissolved Oxygen Probe. Therefore, if the Model 5740 Probe Cable is currently installed with the probe, it must be removed when the stirrer is in use.

SPECIFICATIONS

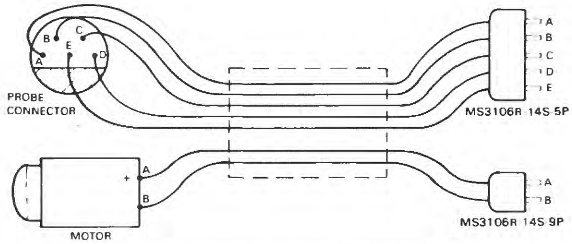
Power: 12.5 ±2 VDC, 4 mA

Cable Length: 50' (15 m) standard; lengths to 250' are available.

Motor Life: 10,000 hours typical

INSTALLATION AND OPERATION

1. If the probe is attached to a Model 5740 Probe Cable, remove the cable.
2. Remove the sensor guard from the probe.
3. Screw the probe into the stirrer until it bottoms out — about three turns.
4. Connect the cable to the probe and the monitor.



5. Place the probe with stirrer into the sample to be measured and turn the monitor to STIR. Check to be sure the stirrer is operating.
6. If there is any question about the adequacy of the stirring action, move the operating probe/stirrer up and down in the water at about one foot per second. Observe the dissolved oxygen reading — if it increases while the probe is being moved, stirring speed is probably too slow. Check the impeller, diaphragm, and power supply voltage for possible problems. (See battery pack instructions in the Model 56 Instruction Manual for checking voltage.)

MAINTENANCE

The dimension between the end of the probe and the stirrer impeller is critical for proper stirring. (See Figure 3.) If

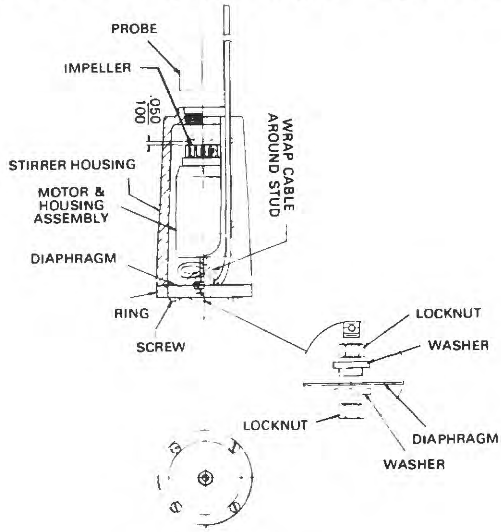


Figure 3
Component Diagram

necessary to achieve proper spacing, the diaphragm on the bottom of the stirrer can be removed and the impeller and motor assembly raised or lowered by adjusting the locknuts on the motor assembly mounting screw The motor and housing assembly is sealed at the factory, do not tamper with it.

If the impeller is grossly damaged with one or more broken blades, continued use is not recommended and the motor and housing assembly should be replaced

GUARANTEE

All YSI products carry a one-year unconditional guarantee on workmanship and parts, exclusive of batteries Damage through accident, misuse, or tampering will be repaired at a nominal charge.

If you are experiencing difficulty with any YSI product, it may be returned to an authorized YSI dealer for repair, even if the guarantee has expired. If you need factory assistance for any reason, contact.

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INSTRUCTIONS FOR YSI 5700 SERIES DISSOLVED OXYGEN PROBES

The probes described in this instruction sheet are designed for direct use with YSI Models 51B, 54ABP, 54ARC and 57 Dissolved Oxygen Meters. The probes can also be used with discontinued YSI Models 51A, 54BP and 54RC Dissolved Oxygen Meters when the YSI 5735 Cable Adaptor is employed (See Accessories).

I. PRINCIPLE OF OPERATION

Each YSI 5700 Series Probe is a complete polarographic system in itself A thin permeable membrane stretched over the sensor isolates the sensor elements from the environment, but allows gases to enter When a polarizing voltage is applied across the sensor, oxygen that has passed through the membrane reacts at the cathode, causing a current to flow

The membrane passes oxygen at a rate proportional to the pressure difference across it Since oxygen is rapidly consumed at the cathode, it can be assumed that the oxygen pressure under the membrane is zero Hence, the force causing the oxygen to diffuse through the membrane is proportional to the adsolute pressure of oxygen outside the membrane If the oxygen pressure increases, more oxygen diffuses through the membrane and more current flows through the sensor A lower pressure results in less current.

II. SPECIFICATIONS

Cathode — Gold
Anode — Silver
Membrane — .001" FEP Teflon (.0005" FEP Teflon available)
Electrolyte — Half saturated KCl
Temperature Compensation — (See instrument specifications)
Pressure Compensation — effective to 1/2% of reading over a 100 psi range (230 ft water)
Response Time — 90% DO value in 10 seconds
Polarizing Voltage — 0.8 volts nominal
Probe Current — Air at 30°C = 19 microamps nominal
Nitrogen at 30°C = 15 microamps or less

ACCESSORIES AND REPLACEMENT PARTS

YSI 5986 — Diaphragm Kit
YSI 5775 — Membrane and KCl Kit, Standard — includes 2 each 15-membrane packets (.001" thick standard FEP Teflon membranes) and a 30 ml bottle KCl with Kodak Photo Flo
YSI 5776 — Membrane and KCl Kit, High Sensitivity — includes 2 each 15-membrane packets (.0005" thick FEP Teflon membranes) and a 30 ml bottle KCl with Kodak Photo Flo
YSI 5945 — "O" ring pack — contains replacement "O" rings for all YSI 5700 Series Probes

Detachable cable

YSI 5740-10	10' cable
YSI 5740-25	25' cable
YSI 5740-50	50' cable
YSI 5740-100	100' cable
YSI 5740-150	150' cable
YSI 5740-200	200' cable

YSI 5735 — Cable Adaptor to mate YSI 5700 Series Probes with discontinued YSI Models 51A, 54BP and 54RC Dissolved Oxygen Meters.
YSI 5486 — Beater Boot Assembly for YSI 5720 Probe.

III. YSI 5739 DISSOLVED OXYGEN PROBE

The YSI 5739 probe, with built-in lead weight, is an improved design that replaces the discontinued YSI 5418, 5419, 5718 and 5719 probes (See Figure 1.)

The complete probe consists of the YSI 5739 probe body plus a YSI 5740 detachable cable. The detachable cable is a convenience feature that facilitates changing cable lengths and replacing damaged cables or probes The probe and cable assembly is held together with a threaded retaining nut. The connection is **not** designed for casual disconnection and should only be disconnected when necessary.

To disconnect the cable unscrew the retaining nut and slide it down the cable to expose the connector Pull gently on the cable and connector until the connector comes away from the probe body

To reassemble, inspect the connector and "O" ring for cleanliness If the "O" ring is frayed or damaged remove it by squeezing it in the groove causing it to bulge, then roll it out of the groove and off the connector A replacement "O" ring is supplied with the cable

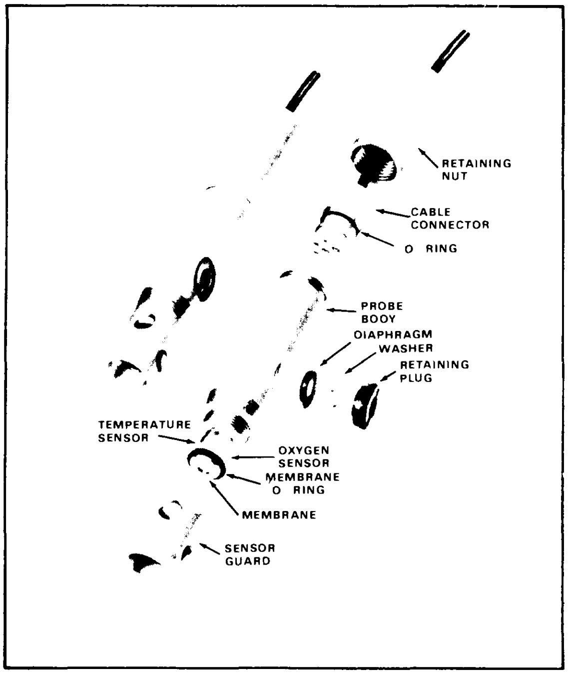

Figure 1

Push the connector into the probe body, rotating it until the two halves mate. A light coating of vaseline or silicone grease on the "O" ring will make reassembly easier. Air trapped between the connector halves which may cause them to spring apart slightly, is normal. Screw on the retaining nut, **hand tight** only. NOTE If erratic readings are experienced, disconnect the cable and inspect for water. If present, dry out and reconnect, replacing the "O" ring, if necessary.

PRESSURE COMPENSATION

The vent on the side of the probe is part of a unique pressure compensating system that helps assure accurate readings at great depths of water Pressure compensation is effective to 1/2% of reading with pressures to 100 psi (230 ft water). The quantity of air bubbles trapped under the membrane determines how serious the pressure error will be, which is why proper preparation of the probe is essential. The system is designed to accommodate a small amount of trapped air and still function properly, but the amount should be kept to a minimum.

The compensating system normally does not require servicing and should not be taken apart However, if electrolyte is leaking through the diaphragm or if there is an obvious puncture, the diaphragm must be replaced Large accumulation of salt crystals around the diaphragm plug may be due to a poorly tightened plug or dirt underneath the diaphragm Cleaning the parts in water and retightening may be tried before diaphragm replacement. A spare is supplied with the probe. Using a coin unscrew the retaining plug and remove the washer and the diaphragm, flush any salt crystals from the reservoir, install the new diaphragm (convolution side in), replace the washer, and screw in the retaining plug

PROBE SCHEMATIC

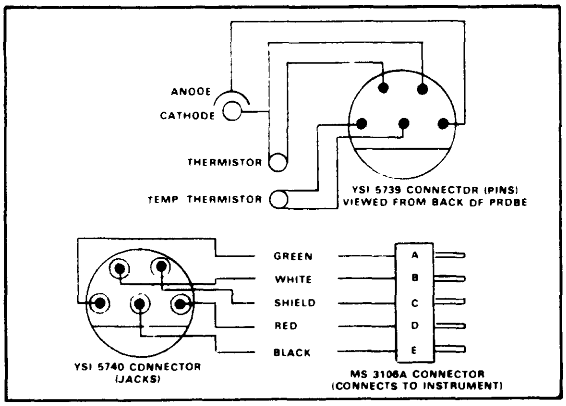

Figure 2

IV. YSI 5720 B.O.D. BOTTLE PROBE

The YSI 5720 B.O.D. Bottle Probe replaces the discontinued YSI 5420A B.O.D. Bottle Probe for measuring dissolved oxygen and temperature in standard B.O.D bottles. It is provided with an agitator for stirring the sample solution, available in models for 117VAC (95-135VAC, 50/60 Hz) or 230VAC (190-250VAC, 50/60 Hz) operation. (See Figure 3)

When using the probe, plug the agitator power supply into line power and the probe plug into the instrument. With the agitator turned off place the tapered probe end into the B.O.D. Bottle and switch agitator "ON" with switch on top of probe. The probe should be operated with a minimum of trapped air in the B.O D bottle. A slight amount of air in the unstirred region at the top of the bottle may be neglected, but no bubbles should be around the thermistor or oxygen sensor.

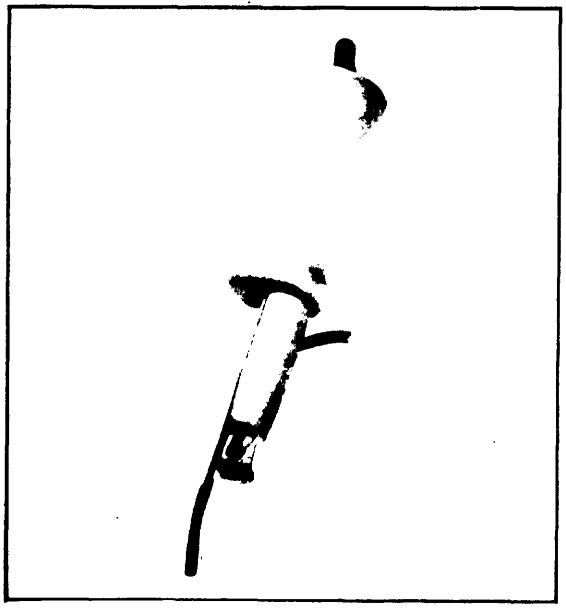

Figure 3

STIRRER BOOT

The probe uses a flexible stirring boot to transmit motion from the sealed motor housing to the sample If the boot shows signs of cracking or other damage likely to allow leaking into the motor housing, the boot must be replaced

In fresh water applications boot life is normally several years, but this may be shortened by exposure to hydrocarbons, moderate to strong acids or bases, ozone, or direct sunlight. For maximum life rinse the boot after use in contaminated samples. (See Figure 4.)

Boot replacement is as follows:

1. Pull off old assembly and clean shaft.
2. Slide on new assembly making sure the back spring is on the grooved area of the shaft. A small amount of rubber cement may be used
3. Check that there is sufficient clearance between the tip and the end of the shaft to permit turning without binding

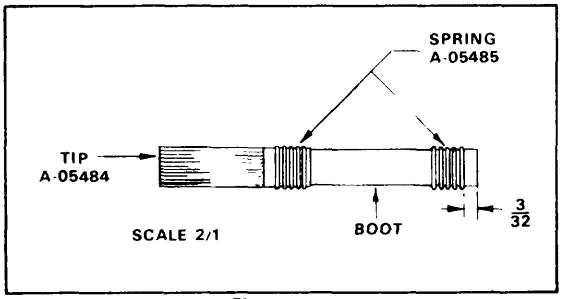

Figure 4

V. YSI 5750 B.O.D. BOTTLE PROBE

The YSI 5750 B.O.D Bottle Probe replaces the discontinued YSI 5450 B.O.D. Botte Probe. It is similar to the YSI 5720 B.O.D. Bottle Probe, except that it does not have a stirrer. Agitation of the sample must be provided by other means, such as a magnetic stirrer. (See Figure 5.)

INSTRUCTIONS FOR YSI 5675 D.O. MONITOR SERVICE KIT USED WITH YSI 5739 DISSOLVED OXYGEN PROBE

GENERAL DESCRIPTION

The YSI 5675 D O Monitor Service Kit contains supplies for preparing YSI 5700 series dissolved oxygen probes for extended time interval dissolved oxygen monitoring

The kit contains two 15-membrane packets of 0 002"-thick FEP, half-sensitivity membranes, one 30 ml bottle of KCl crystals for preparation of electrolyte, and a special probe contouring tool

The half-sensitivity membranes alter the probe's operating characteristics, making the probe more suitable for extended interval use The probe contouring tool alters the normal 5700 series D O probe electrode surface finish for optimum use with the half-sensitivity membranes The tool also functions as a probe cleaning device to remove accumulated silver deposits from the probe's cathode following extended interval probe use Cathode cleaning is normally required after 2000 hours of probe use or whenever silver is visible on the gold cathode.

PROBE SPECIFICATIONS
(when prepared with YSI 5675 Service Kit):

Cathode Gold

Anode Sintered silver

Membrane 0 002"-thick FEP Teflon

Electrolyte 0 5 Saturated KCl with Photoflo®

Pressure Compensation Effective 0.5% of reading to 100 PSI

Response Time 60 seconds to 90%

Polarizing Voltage 0 65

Probe Current 7 5 μA in air @ 760 mmHg, typical @ 25°C; less than 0 05 μA in nitrogen

Liquid Flow Rate Across Membrane For Accurate D O. Readings 1-5 *feet/second*

Probe Calibration Stability Calibration shifts less than 3% of reading per week of operation in water following warm up at 0-30 °C, ± 5% at 30-45 °C.

Thermistors (2) YSI 44004

USING THE YSI 5675 MONITOR SERVICE KIT

For optimum monitoring performance, prepare your YSI D O probe with one of the half-sensitivity membranes included in the YSI 5675 Service Kit For optimum stability, contour and clean the probe's gold sensing surface with the sanding tool included in the service kit These instructions detail both operations

1 Prepare the electrolyte provided in the service kit by dissolving the KCl crystals in the dropper bottle with distilled water Fill the bottle to the top
2 Unscrew the sensor guard from the probe and remove the "O" ring and membrane Thoroughly rinse the sensor with distilled water
3 Prepare the probe for use with the half-sensitivity membrane
   - Lightly pencil an "X" across the probe's gold sensing surface (See Figure 1)
   - Wet the specially contoured sanding tool
   - Hold the sanding tool's abrasive face uniformly against the probe's sensing surface (see Figure 2) and slowly rotate the tool in a circular fashion until all traces of the pencil mark are removed
   - Use the tool to slightly radius the outer edge of the probe face (See Figure 3)
   - *Rinse probe surface with distilled water to remove all particles.*

NOTE: If a probe has been in use for some time and the gold cathode appears tarnished or shows a slight silver ring on the inner edge, it should be restored by sanding as described in Step 3.

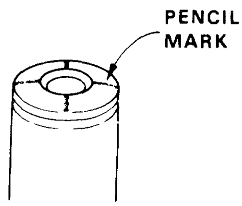

Figure 1 — Penciled X on the probe surface

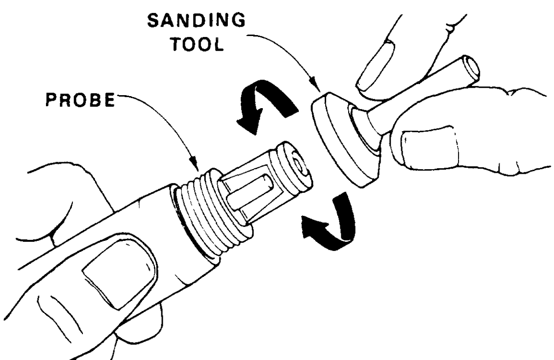

Figure 2 — Sanding the probe surface

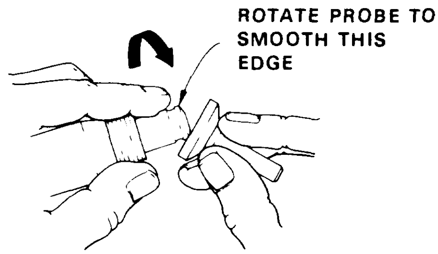

Figure 3 — Smoothing the edge

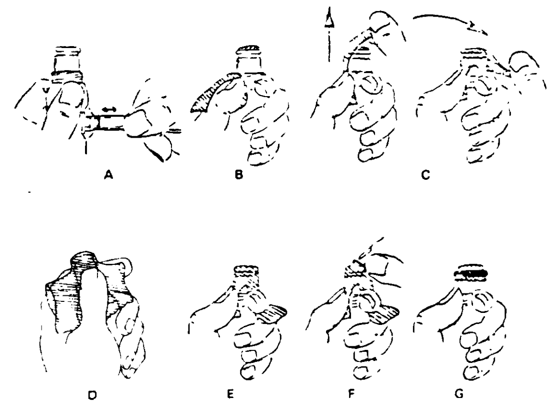

Figure 4 — Putting the membrane on the probe

4. Fill the probe with electrolyte. (See Figure 4.):
   - Grasp the probe in your left hand . . . the pressure compensating vent should be to the right.
   - Fill the sensor body with electrolyte while pumping the diaphragm with the eraser end of a pencil or similar soft, blunt tool.
   - Continue filling and pumping until no more air bubbles appear. (With practice you can hold the probe and pump with one hand while filling with the other.)
5. Secure a half-sensitivity membrane under your left thumb. Add more electrolyte to the probe until a large meniscus completely covers the gold cathode. (Figure 4B).

   NOTE: Handle membrane material with care . . . keep it clean and dust free . . . touch it only at the ends.
6. With the thumb and forefinger of your other hand, grasp the free end of the membrane.
7. Using a continuous motion, *stretch* the membrane Up, OVER and DOWN the other side of the sensor. Stretch DOWN until the membrane "cap" forms smoothly over the "O" ring groove.
8. Secure the end of the membrane under the forefinger of the hand holding the probe. (Figure 4E.)
9. Roll the "O" ring over the end of the probe. There should be no wrinkles in the membrane or trapped air bubbles Some wrinkles may be removed by lightly tugging on the edges of the membrane beyond the "O" ring. (Figure 4F.)
10. Trim off excess membrane with scissors or sharp knife. Check that the stainless steel temperature sensor is not covered by excess membrane. (Figure 4G.)
11. Shake off excess KCl and reinstall the sensor guard.
12. A bottomless plastic bottle is provided with the YSI 5739 probe for convenient calibration. Place a small piece of moist towel or sponge in the bottle and insert the probe into the open end. This keeps the electrolyte from drying out.

Membranes will last indefinitely, depending on usage Average replacement is 2-4 weeks. However, should the electrolyte be allowed to evaporate and an excessive number of bubbles form under the membrane or the membrane becomes damaged, thoroughly flush the reservoir with KCl and install a new membrane. Also replace the membrane if erratic readings are observed or calibration is not stable

User-made electrolyte can be prepared by making a saturated solution of reagent grade KCl and distilled water and then diluting the solution to half strength with distilled water. Adding two drops of Kodak Photoflo® per 100 ml of solution assures good wetting of the sensor.

GUARANTEE

All YSI products carry a one-year unconditional guarantee on workmanship and parts, exclusive of batteries. Damage through accident, misuse, and tampering will be repaired at a nominal charge.

If you are experiencing difficulty with any YSI product, it may be returned to an authorized YSI dealer for repair, even if the guarantee has expired. If you need factory assistance for any reason, contact:

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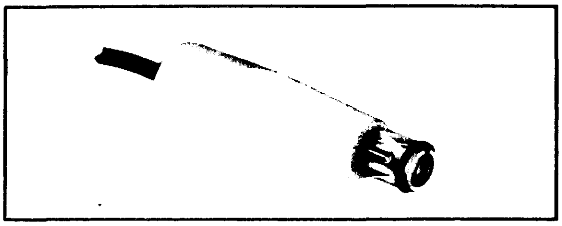

Figure 5

VI. PROBE PREPARATION AND CARE

1. Prepare the electrolyte by dissolving the KCl crystals in the dropper bottle with distilled water Fill the bottle to the top.
2. Unscrew the sensor guard from the probe (YSI 5739 only) and then remove the "O" ring and membrane. Thoroughly rinse the sensor with KCl solution.
3. Fill the probe with electrolyte as follows
   ALL PROBES ARE SHIPPED DRY — YOU MUST FOLLOW THESE INSTRUCTIONS
   A Grasp the probe in your left hand. (See Figure 6.) When preparing the YSI 5739 probe the pressure compensating vent should be to the right. Successively fill the sensor body with electrolyte while pumping the diaphragm with the eraser end of a pencil or similar soft, blunt tool Continue filling and pumping until no more air bubbles appear. (With practice you can hold the probe and pump with one hand while filling with the other.) When preparing the YSI 5720 and 5750 probes, simply fill the sensor body until no more air bubbles appear
   B Secure a membrane under your left thumb. Add more electrolyte to the probe until a large meniscus completely covers the gold cathode NOTE: Handle membrane material with care, keeping it clean and dust free, touching it only at the ends.
   C. With the thumb and forefinger of your other hand, grasp the free end of the membrane
   D Using a continuous motion **STRETCH** the membrane **UP, OVER**, and **DOWN** the other side of the sensor Stretching forms the membrane to the contour of the probe.
   E. Secure the end of the membrane under the forefinger of the hand holding the probe.
   F Roll the "O" ring over the end of the probe. There should be no wrinkles in the membrane or trapped air bubbles. Some wrinkles may be removed by lightly tugging on the edges of the membrane beyond the "O" ring.
   G. Trim off excess membrane with scissors or sharp knife. Check that the stainless steel temperature sensor is not covered by excess membrane.
4. Shake off excess KCl and reinstall the sensor guard.
5. A bottomless plastic bottle is provided with the YSI 5739 probe for convenient storage. Place a small piece of moist towel or sponge in the bottle and insert the probe into the open end. This keeps the electrolyte from drying out. The YSI 5720 and 5750 probes can be stored in a B.O.D. bottle containing about 1" of water.
6. Membranes will last indefinitely if properly installed and treated with care during use. The result of poor membrane application or damage is erratic readings. The cause of erratic behavior can be loose, wrinkled or fouled membranes (by algae for example), or bubbles in the probe from electrolyte loss. If any of these signs occur it is good practice to thoroughly flush the reservoir with new KCl and replace the membrane.
7. "Home brew" electrolyte can be prepared by making a saturated solution of reagent grade KCl and distilled water, and then diluting the solution to half strength with distilled water. Adding two drops of Kodak Photo Flo per 100 ml of solution assures good wetting of the sensor, but is not absolutely essential.
8. The gold cathode should always be bright and untarnished. To clean, wipe with a clean lint-free cloth or hard paper. NEVER USE ANY FORM OF ABRASIVE OR CHEMICAL. Rinse the sensor several times with KCl, refill, and install a new membrane.
9. Some gases contaminate the sensor, evidenced by discoloration of the gold If the tarnish cannot be removed by vigorous wiping with a soft cloth, lab wipe, or hard paper, return the probe to the factory for service.
10. H_2S, SO_2, Halogens, Neon, and CO are interfering gases. If you suspect erroneous readings, it may be necessary to determine if these are the cause.
11. If the probe has been operated for extended periods with a loose or wrinkled membrane the gold cathode may become plated with silver. In this event return the probe to the factory for refinishing.

VII. GUARANTEE AND REPAIR

All YSI products carry a one-year unconditional guarantee on workmanship and parts, exclusive of batteries. Damage through accident, misuse, or tampering will be repaired at a nominal charge, if possible, when the item is returned to the factory or to an authorized YSI dealer.

If you are experiencing difficulty with any YSI product, it may be returned for repair, even if the guarantee has expired. YSI maintains complete facilities for prompt servicing of all YSI products.

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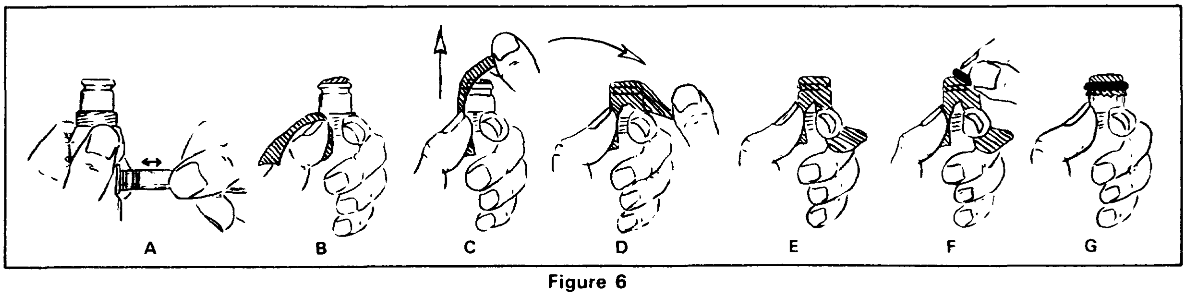


Figure 6

DISCUSSION OF DISSOLVED OXYGEN

Following is a discussion of measurement errors that the Yellow Springs Instrument Company provides with its Model 56 DO Monitor. Not all of the errors apply to the Minimonitor, especially those associated with instrument-component errors. However, the discussions of all errors are included to better understand the propagation of errors.

Instrument Component Errors

- Recorder linearity
  Error = +0.5 percent of full scale of measurement range.

- Range-to-range error
  Switching from 0 to 100 percent to the 10-ppm range.
  Error = 0
  Switching from 10-ppm range to the 0- to 5- or 0- to 20-ppm range.
  Error = +1 percent of reading

- Temperature coefficient (zero setting)
  Error = +0.05 percent for each degrees Celsius difference from 25 °C of the full-scale value of the measurement range.

Nonideal Sensor Behavior

- Background signal varies with sensor temperature. See sensor background error below.

- Temperature-compensation uncertainty
  Error = 0 if readings are taken at the calibration temperature.

  Error = +1 percent of reading if readings are taken with +5 °C of the calibration temperature.

  Error = +3 percent of reading for all other conditions.

Sensor Background Error

Error (ppm)	Error 0 to 100 (percent)	Temperature (°C)
0.28	1.9	0
.14	1.2	10
.07	.8	20
.04	.6	30
.02	.4	40

NOTE: Use of the YSI STANDARD membranes reduces these errors by 50 percent.

Sensor-Calibration Uncertainty

- Barometric pressure effect.--If normal barometric pressure is assumed (+0.5-inch or 12-mm Hg)
  Error = 1.7 percent of reading

- Altitude effect.--If altitude is estimated +500 feet,
  Error = +1.8 percent of reading

NOTE: The two errors above are eliminated if accurate true barometric-pressure data are available.

- Calibration drift with time.--Calibration may drift +3 percent of reading over a 7-day period in 0- to 30-°C samples. In 30- to 45-°C samples, calibration may drift +5 percent. Actual drift during a run can be checked by a postmeasurement-calibration check.

NOTE: In the discussion of measurement errors, YSI uses concentrations of DO expressed in ppm. For all practical purposes, concentrations expressed in ppm are equivalent to mg/L.

Example of a Typical Error Calculation

The following example represents a typical error calculation for a 1-week period of data collection.

Data: Instrument calibrated with a 20-°C sensor on the 0- to 100-percent air-saturation range; elevation estimated at 2000 ±500 feet; normal barometric pressure presumed. Readings taken on the 0- to 10-ppm scale. Highest sample temperature is 25 °C. Lowest sample temperature is 15 °C. Ambient instrument air temperature is 10 to 30 °C. Error calculated for a reading of 6 ppm at 21 °C.

Description	Calculation		Error ppm
Linearity	+0.005 by 10 ppm	=	0.05
Range to range	0	=	- -
Temperature coefficient (zero)	(25 to 10 °C) by 0.0005 by 10 ppm	=	0.08
Background	at 20 °C	=	.07
Temp. comp.	0.01 by 6 ppm	=	.06
Barometer	0.017 by 6 ppm	=	.10
Altitude	0.018 by 6 ppm	=	.11
Drift	0.03 by 6 ppm	=	+.18
	Maximum possible error		0.65 ppm

It is unlikely that errors will sum to produce the maximum possible error. It is more likely that some errors will oppose others to produce a statistical error approximating a root-mean-square error of about one-half the maximum possible error or about 0.3 ppm.

APPENDIX II.--INSTRUCTIONS FOR OPERATING THE CAMPBELL SCIENTIFIC CR10 MEASUREMENT AND CONTROL MODULE WITH THE U.S. GEOLOGICAL SURVEY MINIMONITOR, ANALOG-VOLTAGE MODEL

This document describes the components necessary for operating the Campbell CR10 Measurement and Control Module (CR10) with the U.S. Geological Survey Minimonitor Analog-Voltage Model. This document also covers the component hookup, operating and programming the CR10, and reading data using an IBM-compatible personal computer (PC) and support software. The only items covered are those relating to the hookup and operation of a CR10 with a Minimonitor that has as many as six analog-voltage channels. The description used in this manual is for the operation of a Minimonitor that has four analog-voltage channels. Operation of the CR10 is covered in "CR10 Measurement and Control Module Operator's Manual."

The U.S. Geological Survey Minimonitor was initially designed and built to operate a punched-paper-tape recorder. Analog voltages representing measurements were available for input to satellite data-collection platforms and other data-telemetry instrumentation. Electronic circuitry for operating the punched-paper-tape recorder has been removed from the analog-voltage model of the Minimonitor.

Components Needed

Various hardware and software components listed below are needed to install, operate, service, and maintain a Minimonitor analog-voltage model and a Campbell Scientific CR10 data logger.

1. U.S. Geological Survey Minimonitor analog-voltage model that has four channels (measuring systems) available with as many as eight channels available on an expanded version. A voltage output of 0 to 5 volts is available for each channel.

2. Campbell Scientific CR10 Measurement and Control Module with CR10WP Wiring Panel.

3. Campbell Scientific CR10KD Keyboard and Display for communication with the CR10.

4. Campbell Scientific EM10-64 with 64K RAM (29,900 data values); provides additional data storage for the CR10, which is factory-installed and internal to the CR10. This item is not necessary but is included on CR10 data loggers provided by the HIF.

5. Campbell Scientific SM192 Solid State Storage Module. This provides storage of programs and data with internal battery backup to prevent loss of stored data from memory. Programs are transferable to the CR10.

6. Campbell Scientific SC532, which is a 9-pin peripheral, to RS232 Interface. This provides communication interface between a PC and Campbell Scientific storage modules. A Campbell Scientific SM-232A - Storage Module - RS232 Interface may be substituted.

7. Campbell Scientific PC208 telecommunications software for IBM-PC and data-logger support software. Three 5-1/4-inch floppy diskettes and (or) two 3-1/2-inch floppy diskettes contain the software.

8. Minimonitor to CR10 Interface. This is a voltage-divider network that reduces the 0- to 5-volt Minimonitor analog voltages to 0 to 250 millivolts for read-out by the CR10. A four-channel unit handles up to four channels from the Minimonitor.

9. Campbell Scientific SC12. This is a two-peripheral connector cable for data loggers. It is a communication cable between Campbell Scientific modules, keyboards, and interfaces.

10. Campbell Scientific SC25PS, which is an RS232 ribbon cable with pins to pins/socket. It is an SC532-to-computer communication cable. The type of connector on the computer end depends on the connector on the computer to be used.

11. Batteries with a nominal value of 12-volts dc. Do not exceed 15 volts with the Minimonitor. The CR10 and the Minimonitor may be powered separately, but negative posts of both batteries must be connected with an insulated wire, minimum size 12 gage (AWG).

12. Power cable for the Minimonitor. It connects the Minimonitor to a battery.

13. Power cable for the CR10. It connects the CR10 to a battery.

14. Small screwdriver for calibrating the Minimonitor and connecting wires to the CR10WP wiring panel.

15. Test boxes for the Minimonitor. They replace sensors on the Minimonitor and generate fixed signals as an aid in troubleshooting.

16. Volt-ohmmeter capable of reading millivolts. It is used as an aid in calibrating and troubleshooting.

17. Calibrating solutions, which are necessary for calibrating the Minimonitor signal conditioners.

18. Shelter. Enclosure to protect the instruments from the weather. Sensors in the river also need protection from damage by debris. Sensors need to be accessible for cleaning and calibration.

19. Manual--*Operating manual for the U.S. Geological Survey Minimonitor, revised 1988, analog-voltage model.*

20. Manual--*CR10 Measurement and Control Module* - Operator's Manual - with sections - SM192/SM716 Storage Module Preliminary Instruction Manual, SC532 9-pin peripheral to RS232 Interface Instruction Manual, and PC208 Datalogger Support Software Instruction Manual.

21. U.S. Geological Survey Open-File Report 83-681--*Guidelines for the use of Water Quality Monitors.*

INSTALLATION

After a site has been selected and all necessary instrumentation and components are accumulated, installation can proceed as described below.

1. Turn off power when connecting or disconnecting all components.

2. Connect items as shown in figure 24. Connect power cable to CR10WP wiring panel as shown in figure 25. Connect batteries last. Before connecting batteries, make sure all switches are off and all connections are properly made. Although the Minimonitor and CR10 are protected against accidental reversal of battery polarity, it is wise not to let this happen. Accidentally connecting battery power to other terminals may cause damage to the instruments. If a second battery is to be used for the CR10, connect an insulated wire, minimum size 12 AWG, to the negative posts of the Minimonitor and CR10 batteries.

3. Figure 26 shows the connection diagram and schematic for the Minimonitor CR10 interface, four channels. The interface is necessary to reduce the Minimonitor analog-voltage output of 0 to 5 volts to CR10 input of 0 to 250 millivolts. The CR10KD keyboard and display are generally removed (disconnected) after the instrument is placed in operation. For ease in installation, the Minimonitor CR10 interface may also be connected to the CR10WP at the office and then connected to the Minimonitor at the field site. All diagrams refer to a Minimonitor with four channels (four sensing systems). Operating from one to six channels can easily be inferred.

Calibration Of The Minimonitor Measuring System

Calibration of the Minimonitor-to-CR10 system can be accomplished by using one of several methods:

- Use a voltmeter that measures 0 to 5 volts to calibrate the Minimonitor independently and separately from the CR10. Refer to the Minimonitor manual for this method. Figure 27 shows locations of output voltages to be measured.

- Use a voltmeter measuring 0 to 250 millivolts on the CR10WP wiring panel to measure the interface output voltages. These voltages need to be multiplied by a factor of 20 to correspond to values output by the Minimonitor.

- Use the CR10 as a voltmeter and read the voltages in each channel using the CR10KD keyboard and display. The values read here range from 0 to 250 millivolts and need to be multiplied by a factor of 0.02 to correspond to the values, in volts, shown in the Minimonitor manual. This method is described in number 8 in the section "Starting up the initial installation," which is found later in these instructions.

- Use the CR10 read-out of engineering units, which have been generated by use of multipliers and offsets from the analog voltages. This method is described in number 9 in the section "Starting up the initial installation," which is found later in these instructions.

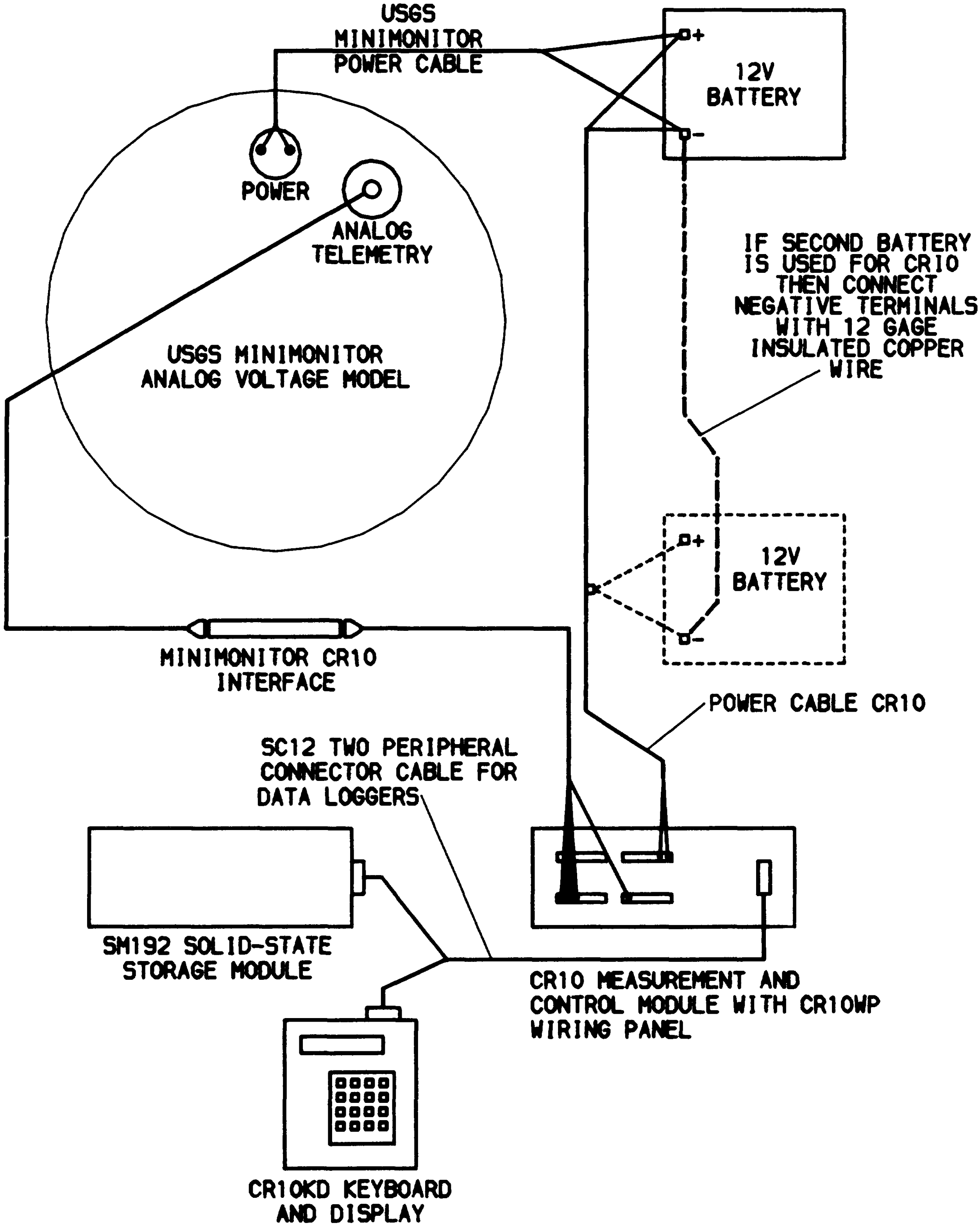


Figure 24.--Connection layout.

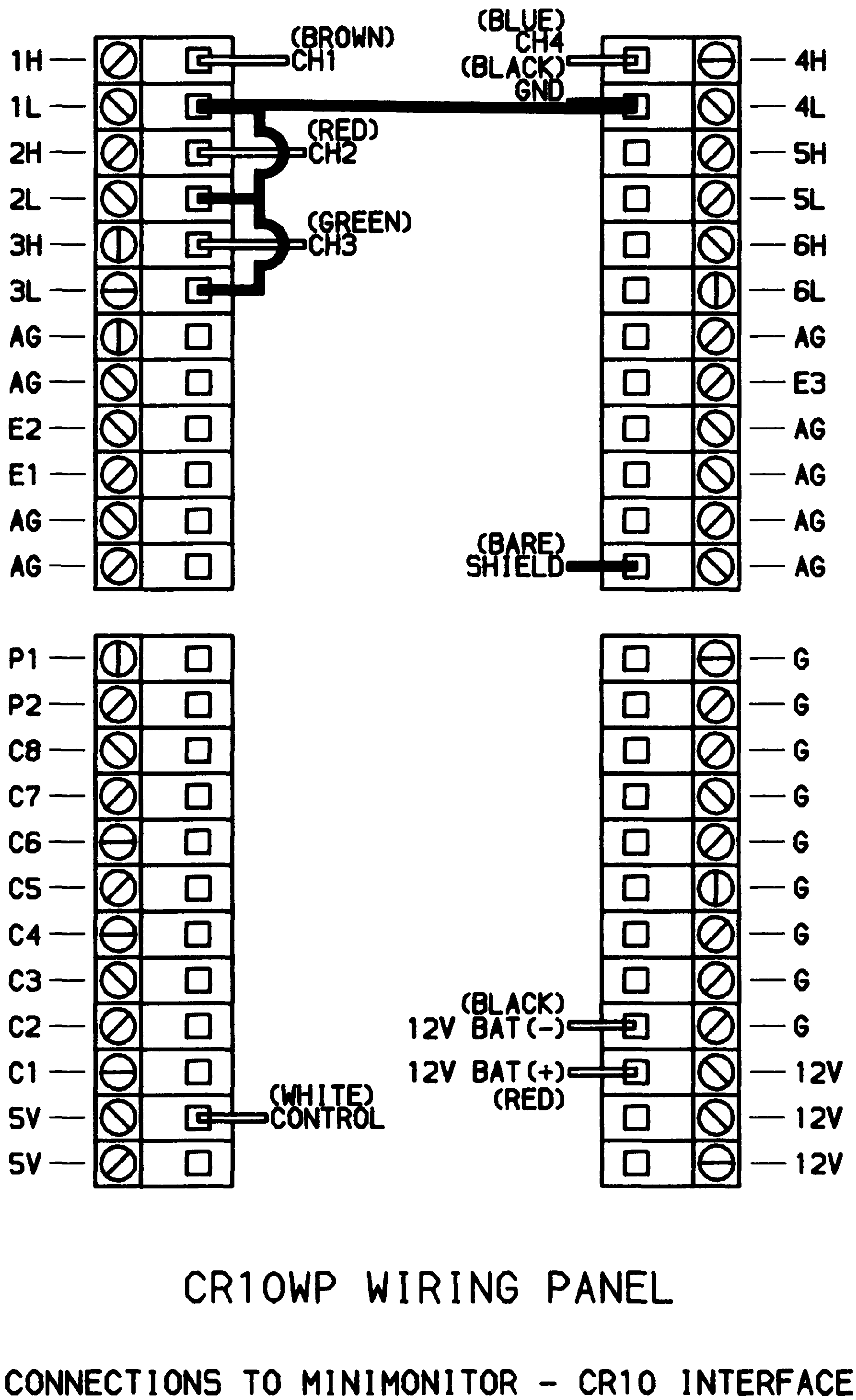
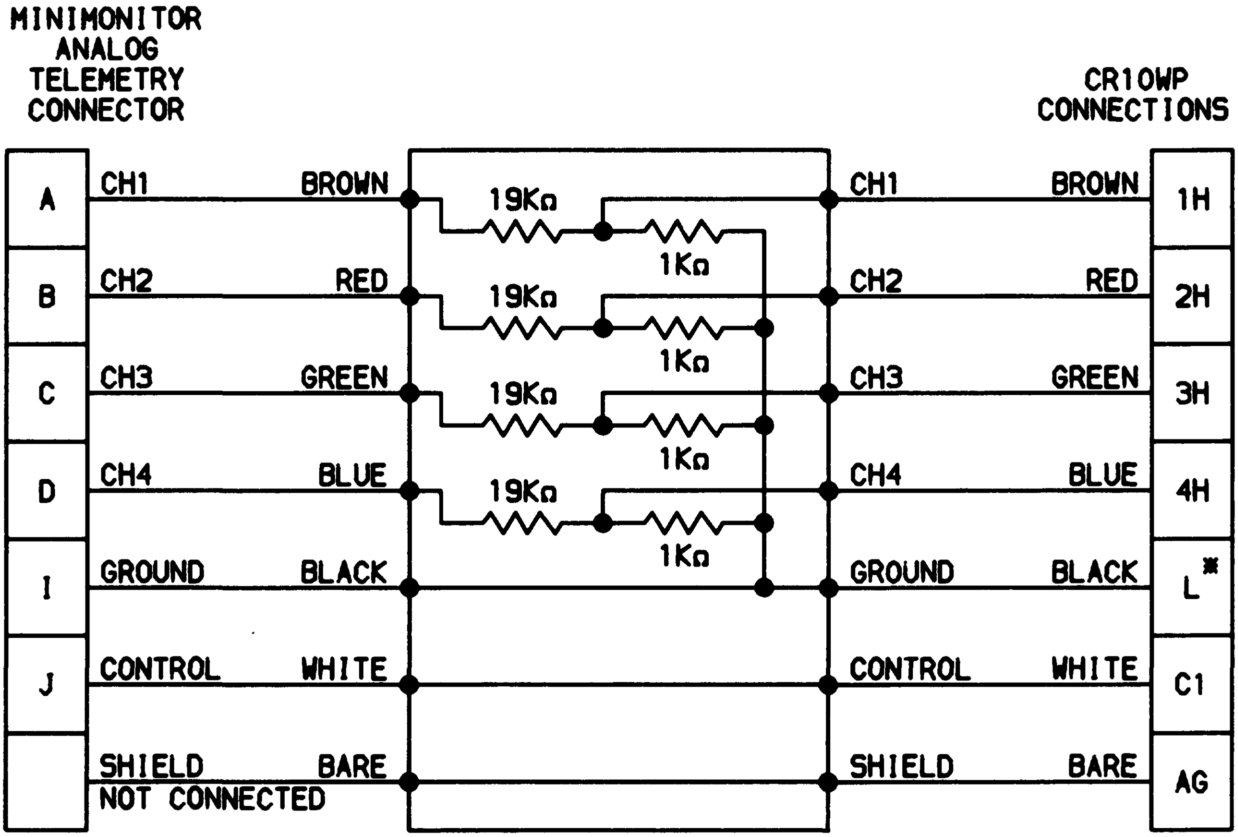


Figure 25.--CR10WP wiring panel connections for four-channel Minimonitor.



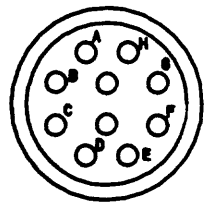
*GROUND MUST BE CONNECTED TO 1L, 2L, 3L, AND 4L. CONNECT THIS WIRE TO ONE OF THE L'S THEN CONNECT ALL 4 TOGETHER.

IF A SEPARATE BATTERY IS USED TO POWER THE CR10 THEN AN INSULATED WIRE, MINIMUM SIZE 12 AWG, NEEDS TO BE USED TO CONNECT THE NEGATIVE POSTS OF THE MINIMONITOR AND CR10 BATTERY.

THIS VOLTAGE DIVIDER NETWORK ACCEPTS 0 TO 5 VOLTS DC FROM THE MINIMONITOR ANALOG TELEMETRY CONNECTOR AND PROVIDES 0 TO 250 MILLIVOLTS TO THE CR10WP WIRING PANEL.

Figure 26.--Connection diagram and schematic for Minimonitor-to-CR10 interface. This applies to a four-channel Minimonitor.

SOCKET	CHANNEL
A	1
B	2
C	3
D	4
E	5
F	6
G	7
H	8
I	COMMON/GROUND
J	CONTROL/TURN ON



TOP VIEW
USGS MINIMONITOR ANALOG
TELEMETRY CONNECTOR

Figure 27.--Analog-telemetry connector location diagram.

Programming The CR10

For the Minimonitor-to-CR10 system to collect and store data, the Minimonitor has to be turned on by the CR10 at selected time intervals. The Minimonitor, at these time intervals, provides analog voltages proportional to each characteristic or property being measured. The Minimonitor has to remain on long enough to allow the analog voltages to stabilize. The suggested time for the Minimonitor to remain on before the voltages are recorded by the CR10 is approximately 45 seconds if DO is being measured. This allows the DO measuring system stirrer to come on and a stable output to be generated. If DO is not used, the turn-on period may be considerably shorter. For Minimonitors measuring temperature and specific conductance, the recommended time on to stabilize analog voltage is 10 seconds.

The CR10 needs to be programmed to do the following:

- Turn on the Minimonitor at a specific time interval.
- Wait (delay) for a specified period and then measure analog voltages (specified range) from the Minimonitor.
- Convert the voltage measurements to engineering units (specified values).
- Store (record) these engineering values in CR10 internal memory. Store values in the SM192 internal memory, provided the SM192 is connected to the CR10 and the CR10 is programmed to make the transfer.
- Turn off the Minimonitor until the next time interval.

If the CR10 experiences loss of power, it will lose stored data and programs and will be inoperative. The SM192, because of internal battery backup, will have the data and programs. After restoration of power, programs will have to be reloaded into the CR10.

The CR10 may be programmed manually, using the CR10KD keyboard and display and entering the desired program keystroke by keystroke. The program also may be loaded into the CR10 from the SM192 after first loading the program into the SM192 from a PC or a previously programmed CR10.

Following are three ways to program the CR10 for a Minimonitor that has four channels. The first way is a step-by-step or keystroke-by-keystroke program. The second way (p. 78) is a program formatted for those familiar with CR21 programming. The third way (p. 81) is the format generated by Campbell EDLOG software available in Campbell's PC208 data logger support software. After the CR10 is programmed, start up the initial installation as described beginning on p. 85.

Step-By-Step Program

Four-Channel Minimonitor Program

KEY	DISPLAY WILL READ
*	00:00
1	01:00
A	01: 0.0000
5	01: 5
A	01:P00
92	01:P92
A	01:0000
0	01:0
A	02:0000
15	02:15
A	03:00
30	03:30
A	02:P00
86	02:P86
A	01:00
41	01:41
A	03:P00
87	03:P87
A	01:00
1	01:1
A	02:0000
9	02:9
A	04:P00
86	04:P86
A	01:00
1	01:1
A	05:P00
95	05:P95
A	06:P00
86	06:P86
A	01:00
2	01:2

Step-By-Step Program

Four-Channel Minimonitor Program (continued)

KEY	DISPLAY WILL READ
A	07:P00
95	07:P95
A	08:P00
92	08:P92
A	01:0000
0	01:0
A	02:0000
1440	02:1440
A	03:00
30	03:30
A	09:P00
86	09:P86
A	01:00
3	01:3
A	10:P00
95	10:P95
A	11:P00
91	11:P91
A	01:00
11	01:11
A	02:00
30	02:30
A	12:P00
86	12:P86
A	01:00
41	01:41
A	13:P00
87	13:P87
A	01:00
1	01:1
A	02:0000
18	02:18
A	14:P00
86	14:P86
A	01:00
1	01:1
A	15:P00
95	15:P95
A	16:P00
95	16:P95
A	17:P00
86	17:P86
A	01:00
51	01:51
A	18:P00
96	18:P96
A	01:00
71	01:71
A	19:P00
*	00:00
3	03:00

Step-By-Step Program

Four-Channel Minimonitor Program (continued)

KEY	DISPLAY WILL READ
A	01:P00
85	01:P85
A	01:00
1	01:1
A	02:P00
2	02:P2
A	01:00
4	01:4
A	02:00
24	02:24
A	03:00
1	03:1
A	04:0000
14	04:14
A	05: 0.0000
1	05: 1
A	06:0.0000
0	06: 0
A	03:P00
36	03:P36
A	01:0000
14	01:14
A	02:0000
1	02:1
A	03:0000
9	03:9
A	04:P00
33	04:P33
A	01:0000
9	01:9
A	02:0000
2	02:2
A	03:0000
9	03:9
A	05:P00
36	05:P36
A	01:0000
15	01:15
A	02:0000
3	02:3
A	03:0000
10	03:10
A	06:P00
33	06:P33
A	01:0000
10	01:10
A	02:0000
4	02:4
A	03:0000

Step-By-Step Program

Four-Channel Minimonitor Program (continued)

KEY	DISPLAY WILL READ
10	03:10
A	07:P00
36	07:P36
A	01:0000
16	01:16
A	02:0000
5	02:5
A	03:0000
11	03:11
A	08:P00
33	08:P33
A	01:0000
11	01:11
A	02:0000
6	02:6
A	03:0000
11	03:11
A	09:P00
36	09:P36
A	01:0000
17	01:17
A	02:0000
7	02:7
A	03:0000
12	03:12
A	10:P00
33	10:P33
A	01:0000
12	01:12
A	02:0000
8	02:8
A	03:0000
12	03:12
A	11:P00
95	11:P95
A	12:P00
85	12:P85
A	01:00
2	01:2
A	13:P00
86	13:P86
A	01:00
10	01:10
A	14:P00
77	14:P77
A	01:0000
20	01:20
A	15:P00
70	15:P70

Step-By-Step Program

Four-Channel Minimonitor Program (continued)

KEY	DISPLAY WILL READ
A	01:0000
4	01:4
A	02:0000
9	02:9
A	16:P00
95	16:P95
A	17:P00
85	17:P85
A	01:00
3	01:3
A	18:P00
10	18:P10
A	01:0000
13	01:13
A	19:P00
86	19:P86
A	01:00
10	01:10
A	20:P00
77	20:P77
A	01:0000
200	01:200
A	21:P00
70	21:P70
A	01:0000
1	01:1
A	02:0000
13	02:13
A	22:P00
95	22:P95
A	23:P00

Formatted Like a CR21 Program

Four-Channel Minimonitor Program

```
*       1                                  Table 1 Programs
01:     5                                  Second Execution Interval

01:     P92   0, 15, 30                    If time, min into 15-min interval,
                                            Then Do

02:     P86   41                           Do, Set high Port 1

03:     P87   1, 9                         Loop, Delay, Loop Count

04:     P86   1                            Do, Call Subroutine 1

05:     P95                                End, End of Loop

06:     P86                                Do, Call Subroutine 2

07:     P95                                End, End If Time

08:     P92   0, 1440 30                   If time, 0 min into 1440 min, Then Do

09:     P86   3                            Do, Call Subroutine 3

10:     P95                                End, End If Time

11:     P91   11, 30                       If flag, If Flag 1 is High, Then Do

12:     P86   41                           Do, Set High Port 1

13:     P87   1, 18                        Loop, Delay, Loop Count

14:     P86   1                            Do, Call Subroutine 1

15:     P95                                End, End of Loop

16:     P95                                End, End If Time

17:     P86   51                           Do, Set low Port 1

18:     P96   71                           Serial output, SM192/SM716
*       3                                  Table 3 Subroutines

01:     P85   1                            Subroutine, Subroutine Number

02:     P2    4, 24, 1, 14, 1, 0           Volts (differential), Reps, 250 mV 60
Hz                                          Rejection Range, Input Channel, Input
                                            Location, Multiplier, Offset

03:     P36   14, 1, 9                     Z=X*Y, X Loc, Y Loc, Z Loc

04:     P33   9, 2, 9                      Z=X+Y, X Loc, Y Loc, Z Loc

05:     P36   15, 3, 10                    Z=X*Y, X Loc, Y Loc, Z Loc
```

Formatted Like a CR21 Program

Four-Channel Minimonitor Program (continued)

06:	P33	10, 4, 10	Z=X+Y, X Loc, Y Loc, Z Loc
07:	P36	16, 5, 11	Z=X*Y, X Loc, Y Loc, Z Loc
08:	P33	11, 6, 11	Z=X+Y, X Loc, Y Loc, Z Loc
09:	P36	17, 7, 12	Z=X*Y, X Loc, Y Loc, Z Loc
10:	P33	12, 8, 12	Z=X+Y, X Loc, Y Loc, Z Loc
11:	P95		End, End of Subroutine
12:	P85	2	Subroutine, Subroutine Number
13:	P86	10	Do, Set high Flag 0 (output)
14:	P77	20	Real time, Option (Hour-Minute)
15:	P70	4, 9	Sample, Reps, Starting Location
16:	P95		End, End of Subroutine
17:	P85	3	Subroutine, Subroutine Number
18:	P10	13	Battery voltage, Input Location
19:	P86	10	Do, Set high Flag 0 (output)
20:	P77	200	Real time, Option (Julian Day)
21:	P70	1, 13	Sample, Reps, Location
22:	P95		End, End of Subroutine

Formatted Like a CR21 Program

Four-Channel Minimonitor Program (continued)

Input Locations:

1:MULT #1	2:OFFSET #1	3:MULT #2	4:OFFSET #2
5:MULT #3	6:OFFSET #3	7:MULT #4	8:OFFSET #4
9:OUTPUT #1	10:OUTPUT #2	11:OUTPUT #3	12:OUTPUT #4
13:BATTERY	14:INPUT #1	15:INPUT #2	16:INPUT #3
17:INPUT #4			

Final Storage:

15-min output

01+313 02+hRmN. 03+MM Ch1 04+MM Ch2 05+MM Ch3 06+MM Ch4

Daily output

01+319 02+Day of Year 03+Battery Voltage

Storage Capacity:

Number of Items per Day: 6*96+3 = 579
Capacity of CR10 Final Storage: 5332/579 = 9.2 days*
Capacity of SM192 Storage Module: 96488/579 = 166 days

---

* (Standard CR10 w/48K memory)
(CR10 w/64K memory: 29908/579 = 51 days)

Formatted from Campbell EDLOG Software (PC208)

Four-Channel Minimonitor Program

```
Flag Usage:
     Flag 1 high - Activate Calibration Mode

Input Channel Usage:
     1D - Minimonitor Channel 1
     2D - Minimonitor Channel 2
     3D - Minimonitor Channel 3
     4D - Minimonitor Channel 4
          (D = Differential Input)

Control Port Usage:
     1 high - Activate Minimonitor

Output Array Definitions:
     15-min output
          1 - Array ID (0313)
          2 - Time (hour-minute)
          3 - Minimonitor Channel 1 (engineering units)
          4 - Minimonitor Channel 2 (engineering units)
          5 - Minimonitor Channel 3 (engineering units)
          6 - Minimonitor Channel 4 (engineering units)


     Daily Output (at 2400 hr)
          1 - Array ID
          2 - Day of Year (Julian Date)
          3 - Battery Voltage

*      1       Table 1 Programs
  01: 5        Sec. Execution Interval

01:  P92       If time is
  01: 0        minutes into a
  02: 15       minute interval
  03: 30       Then Do

02:  P86       Do
  01: 41       Set high Port 1

03:  P87       Beginning of Loop           THIS PROVIDES A DELAY TO ALLOW THE
  01: 1        Delay                       MINIMONITOR TO TURN ON AND STABILIZE
  02: 9        Loop Count                  READINGS BEFORE RECORDING VALUES

04:  P86       Do
  01: 1        Call Subroutine 1

05:  P95       End

06:  P86       Do
  01: 2        Call Subroutine 2

07:  P95       End
```

Formatted from Campbell EDLOG Software (PC208)

Four-Channel Minimonitor Program (continued)

```
08:  P92        If time is
  01: 0         minutes into a
  02: 1440      minute interval
  03: 30        Then Do

09:  P86        Do
  01: 3         Call Subroutine 3

10:  P95        End

11:  P91        If Flag/Port               SETTING THIS FLAG (1) HIGH PUTS THE
  01: 11        Do if flag 1 is high       MINIMONITOR INTO CALIBRATION MODE.
  02: 30        Then Do                    READINGS ARE UPDATED EVERY 5 SECONDS.

12:  P86        Do
  01: 41        Set high Port 1

13:  P87        Beginning of Loop
  01: 1         Delay
  02: 18        Loop Count

14:  P86        Do
  01: 1         Call Subroutine 1

15:  P95        End

16:  P95        End

17:  P86        Do
  01: 51        Set low Port 1

18:  P96        Serial Output
  01: 71        SM192/SM716

*      3        Table 3 Subroutines

01:  P85        Beginning of Subroutine
  01: 1         Subroutine Number

02:  P2         Volt (DIFF)
  01: 4         Reps
  02: 24        250-mV, 60-Hz rejection range
  03: 1         IN Chan
  04: 14        Loc [:INPUT #1 ]
  05: 1         Multiplier
  06: 0         Offset

03:  P36        Z=X*Y
  01: 14        X Loc INPUT #1
  02: 1         Y Loc MULT #1
  03: 9         Z Loc [:OUTPUT #1]
```

Four-Channel Minimonitor Program (continued)

```
04:  P33        Z=X+Y
  01: 9         X Loc OUTPUT #1
  02: 2         Y Loc OFFSET #1
  03: 9         Z Loc [:OUTPUT #1]

05:  P36        Z=X*Y
  01: 15        X Loc INPUT #2
  02: 3         Y Loc MULT #2
  03: 10        Z Loc [:OUTPUT #2]

06:  P33        Z=X+Y
  01: 10        X Loc OUTPUT #2
  02: 4         Y Loc OFFSET #2
  03: 10        Z Loc [:OUTPUT #2]

07:  P36        Z=X*Y
  01: 16        X Loc INPUT #3
  02: 5         Y Loc MULT #3
  03: 11        Z Loc [:OUTPUT #3]

08:  P33        Z=X+Y
  01: 11        X Loc OUTPUT #3
  02: 6         Y Loc OFFSET #3
  03: 11        Z Loc [:OUTPUT #3]

09:  P36        Z=X*Y
  01: 17        X Loc INPUT #4
  02: 7         Y Loc MULT #4
  03: 12        Z Loc [:OUTPUT #4]

10:  P33        Z=X+Y
  01: 12        X Loc OUTPUT #4
  02: 8         Y Loc OFFSET #4
  03: 12        Z Loc [:OUTPUT #4]

11:  P95        End

12:  P85        Beginning of Subroutine
  01: 2         Subroutine Number

13:  P86        Do
  01: 10        Set high Flag 0 (output)

14:  P77        Real Time
  01: 20        Hour-Minute

15:  P70        Sample
  01: 4         Reps
  02: 9         Loc OUTPUT #1

16:  P95        End

17:  P85        Beginning of Subroutine
  01: 3         Subroutine Number
```

Four-Channel Minimonitor Program (continued)

```
18:  P10        Battery Voltage
  01: 13        Loc [:BATTERY  ]

19:  P86        Do
  01: 10        Set high Flag 0 (output)

20:  P77        Real Time
  01: 200       Julian Day

21:  P70        Sample
  01: 1         Reps
  02: 13        Loc BATTERY

22:  P95        End
```

Input Location Assignments (with comments):

```
 Key:
 T=Table Number
 E=Entry Number
 L=Location Number

 T:  E:  L:
 3:  3:   9:  Z Loc [:OUTPUT #1]
 3:  4:   9:  Z Loc [:OUTPUT #1]
 3:  5:  10:  Z Loc [:OUTPUT #2]
 3:  6:  10:  Z Loc [:OUTPUT #2]
 3:  7:  11:  Z Loc [:OUTPUT #3]
 3:  8:  11:  Z Loc [:OUTPUT #3]
 3:  9:  12:  Z Loc [:OUTPUT #4]
 3: 10:  12:  Z Loc [:OUTPUT #4]
 3: 18:  13:  Loc [:BATTERY  ]
 3:  2:  14:  Loc [:INPUT #1 ]
```

Input Location Labels:

1:MULT #1	6:OFFSET #3	11:OUTPUT #3	16:INPUT #3
2:OFFSET #1	7:MULT #4	12:OUTPUT #4	17:INPUT #4
3:MULT #2	8:OFFSET #4	13:BATTERY	
4:OFFSET #2	9:OUTPUT #1	14:INPUT #1	
5:MULT #3	10:OUTPUT #2	15:INPUT #2	

To manually load the CR10 with a program, connect a CR10KD, and provide power to CR10WP (positive lead first). Enter the program included in these instructions as follows:

	Display Reads
Power On	HELLO then 48 or 96

Enter in accordance with included program. To load the program from an SM192, refer to number 3 of the section "Starting up the initial installation." To load the program into an SM192 from a PC, refer to section "CR10 data-logger support using a personal computer."

Starting Up The Initial Installation

NOTE: Pressing the star (*) key followed by the zero (0) key returns the CR10 to the log data mode.

To start up initial installation, perform the steps listed:

1. Connect all instruments as shown in figures 24 and 25 connection layout and CR10WP wiring panel connections. Check to determine that the Mini-monitor ON-OFF switch is off. Connect power last. When the battery is connected, the CR10 is powered. The following programs can be obtained by referring to the Campbell Scientific CR10 operator's manual. The CR10KD display, when powered, shows the word "HELLO." The CR10 goes into a self-test after which either the number 48 or 96, depending on the amount of internal memory, appears if the self-test is completed successfully.

2. Set the date and time in the CR10. Using the CR10KD, press the following keys in sequence for the results shown.

Key	Display will read
* (Star)	00:00
5	00:00:00
A	05:00

Enter last two digits of current year (yy)

A	05:yy

Enter correct digits for the current Julian Day (ddd).

A	05:ddd

Enter current time in 24-hour format (hours and minutes).

A Clock starts when this is pressed. (To synchronize, enter next minute above current time and wait for seconds to reach 0. Press A key).

The CR10KD now shows the current time in 24-hour format.

3. Load the program from the SM192. Press the following keys in sequence for the results shown:

Key	Display will read
*	00:00
D	13:00
71	13:71
A	71:00
21	71:21
A	13:0000

The CR10KD shows 13:00.

Programs are loaded into the storage module (SM192) by the following means:

- PC208 (Data-logger support software) program SMCOM. An ASCII file of a CR10 program is transferred to the SM192 and retained in memory.

- A program can be transferred from an operating CR10 to a storage module and retained for transfer to other CR10's.

4. Record time interval. Press the following keys in sequence for the results shown:

Key	Display will read
*	00:00
1	01:00
1	01:1
A	01:P92
A	01:0000
A	02:0000

Enter recording time interval in minutes.
Example: One-half hour = 30 minutes. Shortest allowable interval with example program is 2 minutes.

A	03:30

Display shows 03:30.

5. Set calibration-mode time interval. This provides the length of time that the CR10 powers the Minimonitor for calibration purposes. Press the following keys for the results shown:

Key	Display will read
*	00:00
1	01:00
13	01:13
A	13:P87
A	01:01
A	02:0000

Enter the calibration-mode time interval in the number of 5-second intervals. Example: For 1 minute enter 12 or for 5 minutes enter 60. If 12 is entered:

A	14:P86

NOTE: Set the calibration-mode time interval less than the recording time interval.

6. Enter multipliers and offsets. Multipliers and offsets convert analog voltages to engineering units. Press the following keys in sequence for the results shown:

Key	Display will read
*	00:00
6	06:0000
1	06:1
A	01:0.000

```
Enter the multiplier value for channel 1 if 0.2.
        C              :0.000
        D2             :.2
        A            01:.20000
        A            02:0.0000

Enter the offset value for channel 1 if 0.
        C              :0.0000
        0              :0
        A            02:0.0000
        A            03:0.0000
        C              :0.0000

Enter the multiplier value for channel 2 if 1.
        1              :1
        A            03:1.0000
        A            04:0.0000

Enter the offset value for channel 2 if 0.
        C              :0.0000
        0              :0
        A            04:0.0000
        A            05:0.0000

Enter the multiplier value for channel 3 if 1.
        C              :0.0000
        1              :1
        A            05:1.0000
        A            06:0.0000

Enter the offset value for channel 3 if 0.
        C              :0.0000
        0              :0
        A            06:0.0000
        A            07:0.0000

Enter the multiplier value for channel 4 if 1.
        C              :0.0000
        1              :1
        A            07:1.0000
        A            08:0.0000

Enter the offset value for channel 4 if 0.
        C              :0.0000
        0              :0
        A            08:0.0000
```

Multiplier and offset values for Minimonitor CR10 program are included in the following:

Multiplier and offset values for Minimonitor-to-CR10 program

Parameter	Range	Multiplier	Offset	Analog voltage (mV)
Temperature	0-50 °C	0.2	0	0-250
Specific Conductance	0-100 µS/cm	0.4	0	0-250
	0-1,000 µS/cm	4	0	0-250
	0-10,000 µS/cm	40	0	0-250
	0-100,000 µS/cm	400	0	0-250
pH	0-10	.04	0	0-250
	0-12	.04	0	0-250
Dissolved Oxygen	0-5 mg/L	.02	0	0-250
	0-10 mg/L	.04	0	0-250
	0-20 mg/L	.08	0	0-250

7. Compile the program. This places the previous values in the program and starts the program. Press the following keys for the results shown:

Key	Display will read
*	00:00
0	Log 1

8. Read voltages. This allows the user to observe the analog voltages (reduced by a factor of 0.05) from the Minimonitor. This activity allows calibration by voltage. Readings are updated every 5 seconds and range in value from 0 to 250 millivolts.

Key	Display will read	
*	00:00	
6	06:0000	
14	06:14	
A	14:XXXX	Voltage in channel 1 from last program execution.
D	00:000000	
1	10:000000	
A	14:XXXXX	Current value of channel 1 in millivolts.

The voltage of channel 2 in millivolts.

A	15:YYYYY

The voltage of channel 3 in millivolts.

A	16:ZZZZZ

The voltage of channel 4 in <u>millivolts</u>.

A	17:VVVVV

NOTE: Pressing the key B will back up the voltage reading to the previous channel.

9. Read engineering units. This allows the user to convert analog voltages by using multiplier and offset values. If desired, to obtain engineering units, these readings may be used to calibrate the Minimonitor.

Key	Display will read	
*	00:00	
6	06:0000	
9	06:9	
A	09:XXXXX	Engineering value from last program execution.
D	00:000000	
1	10:000000	
A	09:XXXXX	Current engineering value for channel 1.

The engineering value for channel 2.

A	10:XXXXX

The engineering value for channel 3.

A	11:YYYYY

The engineering value for channel 4.

A	12:ZZZZZ

NOTE: Pressing the key B backs up the reading to the previous channel.

10. Calibrate the Minimonitor. Refer to related chapters in the body of this manual. Use step 8 or 9 above to observe calibration values. This may be accomplished any time the CR10KD is connected.

NORMAL STATION SERVICE

NOTE: Pressing the star (*) key followed by the zero (0) key will return the CR10 to the log data mode. When visiting the station, normal service would consist of the following.

1. Perform a visual check of condition of station.
2. Connect CR10KD.
3. Check date and time on CR10.
4. Read Minimonitor values.
5. Measure stream values.
6. Clean and service sensors.
7. Check Minimonitor calibration.
8. Check the battery voltages.
9. Troubleshoot, if necessary.
10. Remove SM192 (Replace with another SM192 if available).
11. Remove CR10KD.

The steps listed above are described more fully below.

1. Inspect the station for damage or any condition that affects the data being collected. This includes sensors out of water, vandalism, and so forth.

2. Connect CR10KD using the indicated cable and connector. If no SM192 is in place, another SM192 may be connected to the same cable. The user may see meaningless numbers or characters. Press the star (*) key followed by zero (0) key for display to show LOG1.

3. Check date and time as follows. Press the following keys:

Key	Display will read
*	00:00
5	05: Time in hours, minutes, seconds
A	05: Last two digits of the year
A	05: Julian Day
*	00:00
0	Log 1

   The last two keys return the CR10 to the log data mode.

4. Read Minimonitor values. Log these values. Refer to numbers 8 and 9 of the section "Starting up the initial installation." Return the CR10 to the log data mode.

5. Measure stream values. The use of portable measuring instruments to determine stream values close to the Minimonitor sensors can provide important information on how well the system is collecting correct data.

6. Clean and service Minimonitor sensors. Refer to related chapters in the body of this manual for cleaning and other servicing instructions. When finished, replace sensors in stream.

7. Check Minimonitor calibration by reading stream values in the same manner as described in step 4 above to determine if significant shifts in values exist as compared to those read from the portable equipment. Readings may be made with test boxes to determine if drift in the electronics has occurred. Recalibration is necessary if pH and DO sensors have experienced drift. Temperature and specific-conductance sensors normally do not experience significant drift.

8. Battery voltages may be checked with a voltmeter.

9. Refer to related chapters in the body of the manual as an aid in troubleshooting and detecting some problems common to the Minimonitor.

10. Remove the SM192. Connect this unit to a PC for recovery and summary. Return the SM192 to the station. Remember that the CR10 loses its program and data if power is lost but the SM192 does not. An extra SM192 connected to the CR10 prevents loss of data when the original SM192 has been removed.

11. Remove the CR10KD. Determine that the CR10KD display shows Log 1 before removal. If not, press the star (*) key followed by the zero (0) key. The display then shows Log 1, indicating the CR10 is in the log data mode.

Using A Personal Computer for CR10 Data-Logger Support

An IBM PC, models XT or AT, or a hardware-compatible PC is required to use Campbell Scientific's PC 208 data-logger support software. The various components are connected as shown in figure 28. Refer to PC208 data-logger support software instruction manual for assistance in loading and using software. The programs listed below are applicable:

- EDLOG - Data-logger program editor
- TERM - Terminal emulator
- TELCOM - Data-collection program
- SPLIT - Data split/merge program
- SMCOM - Storage module communications (SM192/716)

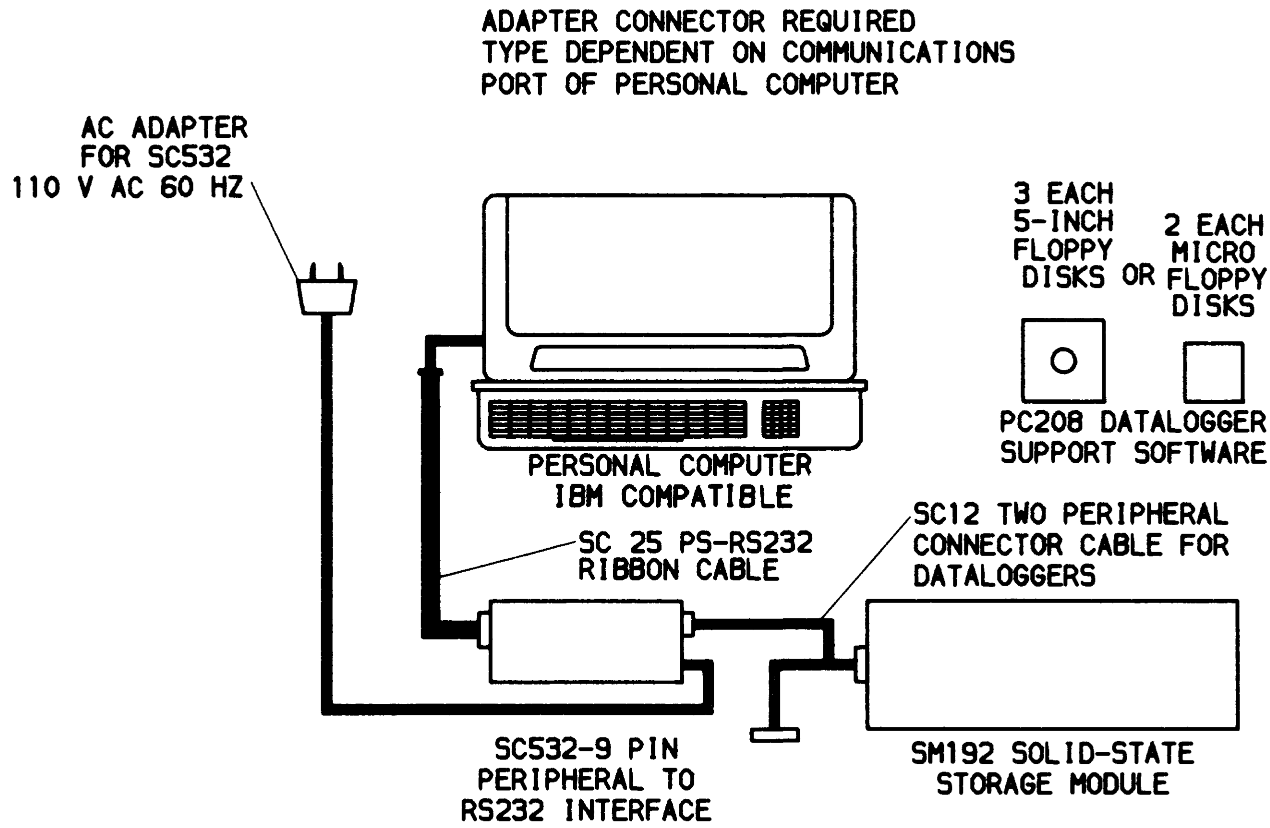


Figure 28.--Connection layout for SM192 CR10 and personal computer.