EXTERNAL SENSORS

TAPS is designed to measure acoustical volume backscattering from zooplankton in the context of a basic physical picture of their environment—depth and temperature. Clearly, other factors are also important and there are times when measurements of additional parameters would be useful. Provision has been made to allow user interface of up to two additional sensors to TAPS. The purpose of this section is to describe the kinds of sensors that are suitable for connection to TAPS and how one goes about accomplishing this.

If certain sensors were specified when TAPS was ordered, setup information will be found in **Appendix 1: Calibration**. If no sensors were specified, or if different sensors are desired now, internal modifications may be necessary. These are not difficult, generally, but may—depending upon the changes required—call for design of simple electronic circuitry or calculation of component values. If you feel this is beyond the scope of your interests and talents, please contact us for assistance.

External sensors come in many shapes and sizes, with unique interfaces and power requirements. TAPS cannot oblige every sort of external sensor but this is what TAPS thinks a suitable sensor might look like:

The sensor must run on DC voltage, preferably 12 V. Most sensors can accommodate input voltages between about 8-15 V. The Instrument Interface PCB is normally setup with a 12 V regulator working off the battery voltage (22 V nominal). If other voltages are required, this regulator can be changed—but both instruments will see the same voltage.

Current drains should be low, in keeping with the nature of an internally-powered system like TAPS. Current drains of about 20-50 mA are common on newer sensors. Up to 250 mA can be supplied to each sensor but this will substantially reduce the operating time of TAPS. You will have to compute the effect of external sensors on TAPS operating life yourself. The nominal (new) battery capacity is 5.7 A-hrs. TAPS draws about 350-400 mA operating, giving a nominal operating life of perhaps 14-16 hours. Adding external sensors will decrease this; e.g., adding a 50 mA sensor and a 100 mA sensor will make the total current draw about 500-550 mA. The nominal operating life will now be about 10-11 hours (or slightly less because the amp-hour rating is based upon a 200 mA load; higher draw currents yield a lower capacity).

The signal output of an external sensor will probably be either a voltage (fluorometers, irradiance sensors, etc.) or a frequency (most SeaBird sensors). The Instrument Interface PCB is designed to accommodate either type of input—the signal output to the CPU card is either a buffered and squared version of the input frequency or the output of a voltage-to-frequency converter. In other words, TAPS always measures frequencies internally. The limit on measurable frequencies is about 40 kHz, higher than normally found on frequency-output sensors. The only restriction on voltage inputs is that the input be non-negative. Only positive voltages can be converted[*].

If your TAPS was ordered set up for particular external sensors, you need only refer to the setup sheet in **Appendix 1: Calibration** to see which sensor goes to which jack on the connector endcap, physically connect the sensors to these jacks, and 'install' these sensors via the PROGRAM command. The layout of the connectors is shown in Fig. 1.

'Installing' sensors involves merely setting a flag in the TAPS non-volatile memory. This ensures that power will be supplied to the Instrument Interface PCB whenever transceiver power is turned on

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[*] Actually, we have adapted this card to a negative output PAR sensor for a customer. Contact us if you need to know how this is done.

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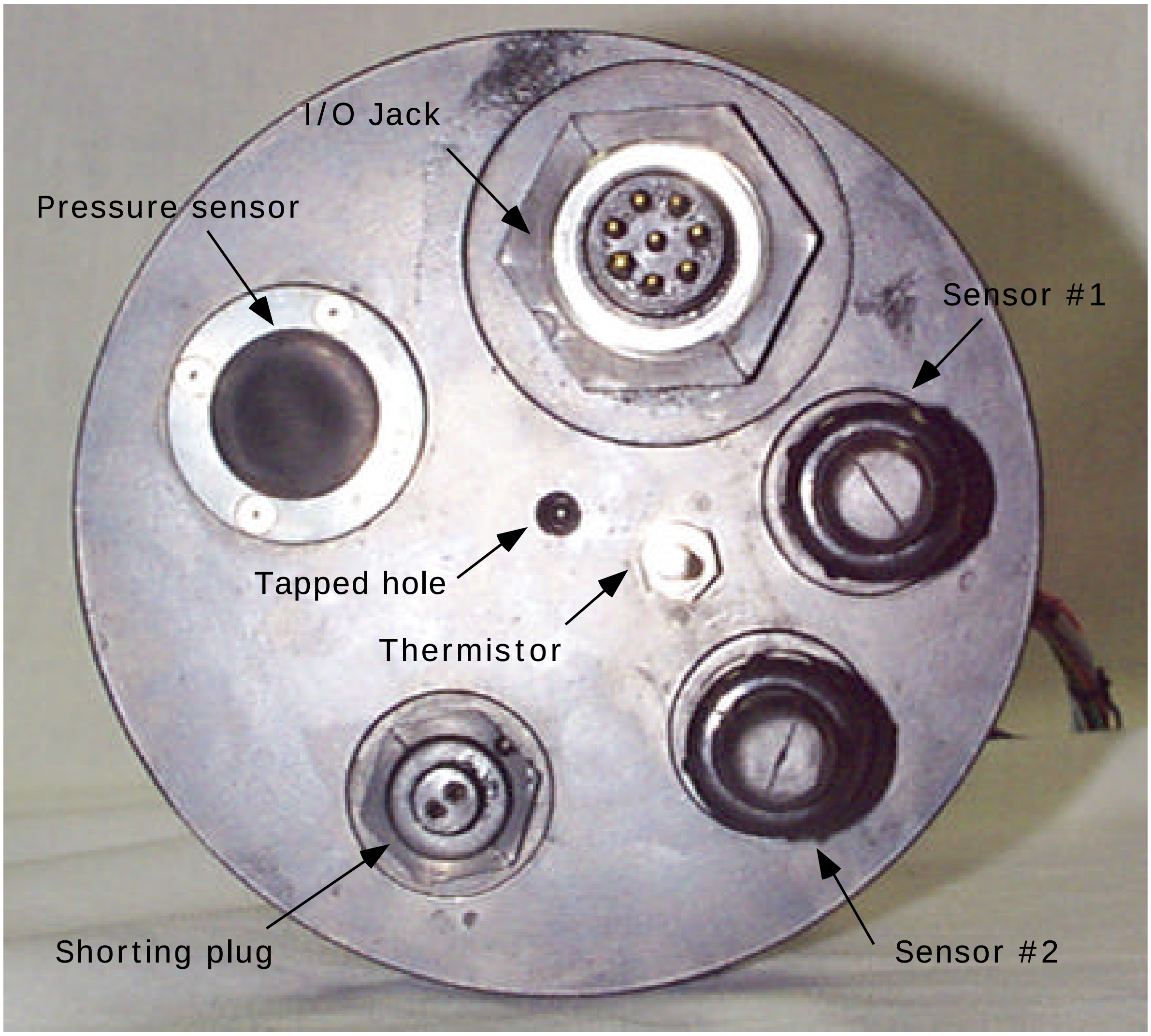

Figure 1. Layout of jacks on the connector endcap.

(see A Typical Cast in the **CAST MODE** section of this manual). This flag also causes the frequency measurement code to be run at the beginning of each data set.

INSTALLING NEW SENSORS

If your TAPS was not ordered setup for particular sensors, the Instrument Interface PCB was <u>not</u> configured and was <u>not</u> installed in TAPS. You will have to configure it and install it. TAPS will have been supplied with a 3-pin and a 4-pin male connector (unless blanks were expressly requested in the order). The wiring of these jacks may or may not fit your sensor; you may have to rewire these jacks. Finally, you will have to supply suitable interconnect cables.

If TAPS was ordered set up for one set of sensors and you wish to change to another type of sensor, you will probably have to reconfigure the Instrument Interface PCB. You may also have to re-wire a jack. And, you may need to provide another interconnect cable.

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It is clearly impossible to tell you how to install every type of sensor here. Instead, the basic steps for configuring the Instrument Interface PCB will be described along with basic steps for calibrating the sensor/PCB combination. Wiring changes, if required, and the layout of the interconnect cable are left to the user to figure out using the wiring diagrams supplied in Appendix 4: Schematics.

In the following instructions, please refer to the Instrument Interface schematic, the Instrument Interface parts layout, and the backplane wiring diagram as necessary. These may be found in Appendix 4: Schematics.

References to components by component number correspond to markings on the printed circuit board as shown in the figure below:

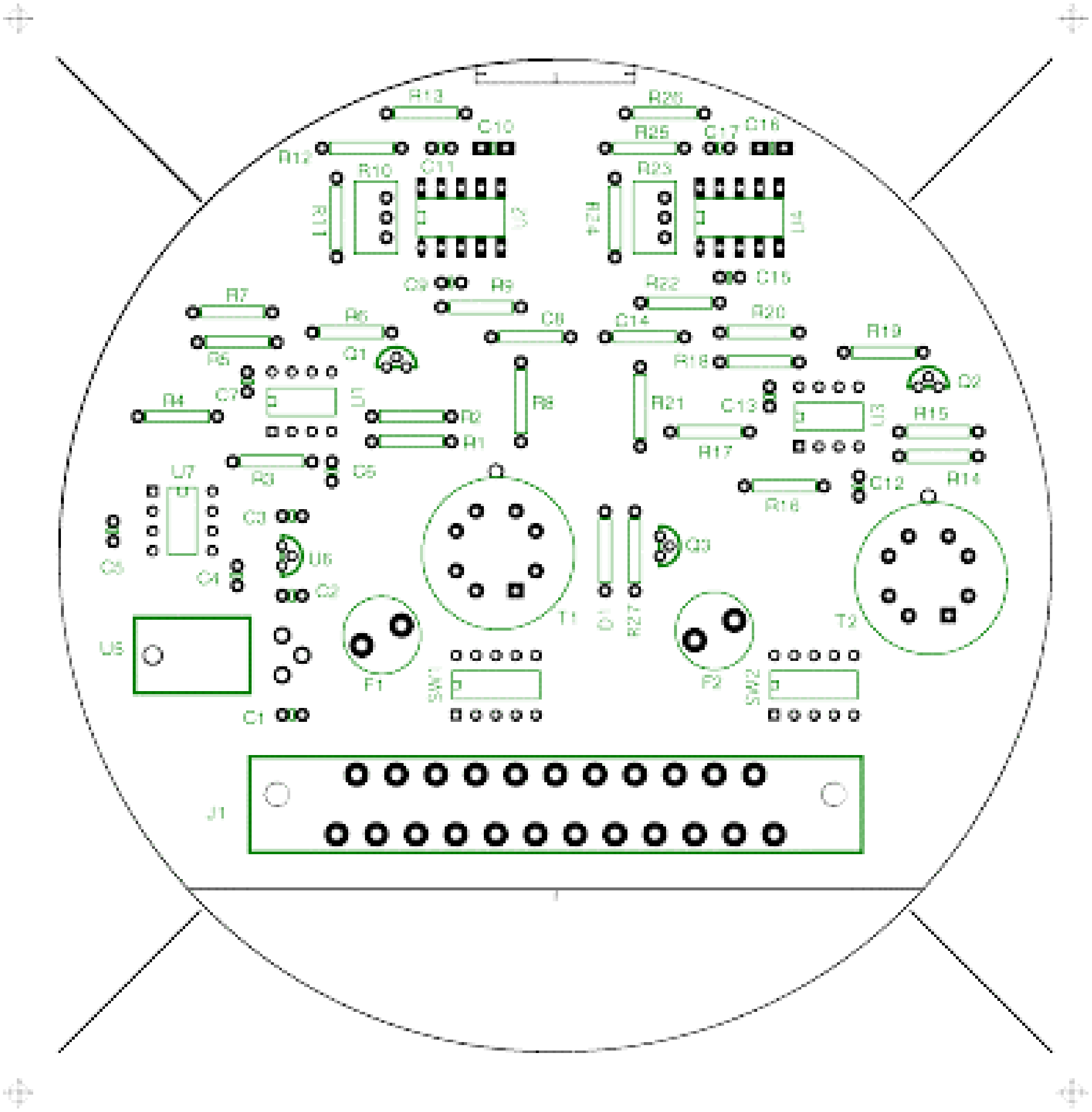

Figure 2. Layout of Instrument Interface printed circuit card showing component locations.

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PICKING A CHANNEL

If only a single sensor is to be installed and the number of pins on the sensor's connector matches one of the jacks (3 or 4 pin) on TAPS, it would behoove you to choose that channel to configure. It is necessary to select a channel prior to configuration, however, as the Instrument Interface PCB contains two identical interface circuits. Usually, this involves picking the channel with a matching I/O jack.

If neither of the supplied jacks matches the sensor you have picked, look first to see if a suitably-contrived interconnect cable will suffice to connect the sensor to TAPS. TAPS jacks are configured with POWER, GROUND, and SIGNAL pins. The extra SIGNAL GROUND pin on the 4-pin connector is connected to power common as is GROUND, thus there are only 3 pins active. Any sensor with more active inputs/outputs may not be suitable for interfacing to TAPS. (Basically, you are on your own. This might be time to contact us and ask for help, however.)

PROVIDING POWER

The first step is to ensure that the proper voltage will be supplied to the sensor. If +12 V is unsuitable for your sensor (and the desired voltage is within the range provided by TAPS), you will have to replace the +12 V voltage regulator, U5, with a suitable similar device.

Configuring the PCB to supply power to this sensor requires two steps:

1. Set switch #1 on dip-switch SW1(sensor 1) or SW2 (sensor 2) to ON (rocker down). This connects regulated DC voltage to the sensor.

2. Install a suitable fuse (LittleFuse Micro fuse or equivalent) in F1 or F2.

FREQUENCY-OUT SENSORS

If your sensor provides a sinewave frequency output (SeaBird standard) as the signal, you will need to do the following:

1. Set switch #2 on dip-switch SW1 or SW2 to ON and switch #3 on the same dip-switch to OFF. This connects the signal input line to the frequency-shaping circuits.

2. Set switch #4 on dip-switch SW1 or SW2 to ON and switch #5 to OFF. This connects the output of the frequency-shaping circuit to the computer input.

3. Install a 10k 1/4 watt resistor in R7 (channel 1) or R20 (channel 2). If necessary, remove the resistors in R12 and R13 (channel 1, or R25 and R26 for channel 2). This disables the voltage-to-frequency converter circuit, reducing unwanted noise.

No calibration is required, however it would be prudent to verify that the output of the sensor does indeed produce TTL-level outputs. TAPS can be assembled outside the pressure case to allow access to the backplane wiring and test points.

To test, connect a computer to TAPS and start a terminal program. Do not connect the sensor to the appropriate jack on the endcap. Install the shorting plug. Connect a voltmeter to either the backplane or the sensor jack on the endcap.

Enter TEST mode (press <CRTL>-X) and select the instrument test. This will connect power to the sensor; verify proper voltage on the appropriate pins of the jack. Hit ENTER to stop the test and verify that the voltage drops to zero.

Connect the instrument to the jack on the endcap. Connect an oscilloscope probe between the frequency out pin on the backplane and ground and another between the signal input pin and ground. Enter TEST mode and select the instrument test. You should see a 0-5 V signal on the oscilloscope at the frequency of the sensor input. You should also see the frequency of the sensor displayed (in Hz) on the computer screen.

Exit TEST mode and remove the shorting plug. Reassemble TAPS.

VOLTAGE-OUT SENSORS

These sensors require more effort to install as the voltage-to-frequency converter must be almost completely configured and an input network designed. This is not trivial, but not really all that difficult.

If your sensor provides a voltage output as the signal, you will need to do the following:

1. Set switch #3 on dip-switch SW1 or SW2 to ON and switch #2 on the same dip-switch to OFF. This connects the voltage input line to the voltage-to-frequency converter input network.

2. Set switch #5 on dip-switch SW1 or SW2 to ON and switch #4 to OFF. This connects the output of the frequency-to-voltage converter to the computer input.

3. Install the input network R8/C8-R9/C9 (for channel 1, or R21/C14-R22/C15 for channel 2). The details of this network depend upon the input voltage range (0-V_{max}, where V_{max} can be 0.1 V to 10 V at the input to U2 or U4). For a 0-10 V sensor, the input network might be a pair of 10K resistors and 0.1 μF capacitors configured as an input lowpass filter. See the AD537 data sheet for more information (a datasheet can be downloaded at `www.analog.com`).

4. Install the resistors R10/R11 (for channel 1, or R23/R24 for channel 2) to set the full-scale output frequency to 10 kHz (recommended). Stable 0.01 μF chip capacitors have been installed in C10 and C16 already and should be used if possible.

Refer to the AD537 data sheet for details on selecting these resistors. Basically, however, the series combination of R10/R11 should be made equal to 1000 * V_{max} in ohms. For a maximum input voltage of 5 V, the resistance of R10 and R11 should be about 5000 ohms. Pick a 1% standard value for R11 somewhat less than this: say, 4.42KΩ. Use a metal-film precision resistor for minimum noise. Then pick a standard value for a cermet potentiometer such that at mid-range the sum of potentiometer R10 and fixed resistor R11 is 5000 ohms; R10 might be 1000 ohms.

5. Install R12/R13 (for channel 1, R25/R26 for channel 2).

To test the power connections, connect a computer to TAPS and start a terminal program. Do not connect the sensor to the appropriate jack on the endcap. Install the shorting plug. Connect a voltmeter to either the backplane or the sensor jack on the endcap.

Enter TEST mode (press <CRTL>-X) and select the instrument test. This will connect power to the sensor; verify proper voltage on the appropriate pins of the jack. Hit ENTER to stop the test and verify that the voltage drops to zero.

Calibration of this configuration is also required. Connect a variable power supply to the signal-in pin and the ground pin on the sensor jack (or backplane). Set the voltage to the sensor V_{max}. Install the shorting plug on TAPS (if not already installed) and select TEST mode. Select the instrument test.

Adjust R10 to obtain 10.00 kHz at V_{max} and approximately 0 Hz at zero input. Use the frequency readout on the computer to make this calibration.

It would be prudent to measure the frequency at several values of input voltage to check the linearity of the conversion.

Exit TEST mode and remove the shorting plug. Reassemble TAPS.

INSTALLING THE SENSOR

The new sensor(s) must be ‘installed’ in TAPS by reprogramming it to recognize that a sensor has been connected. This involves setting a flag that is checked whenever TAPS turns on the acoustic transceivers to see if sensor power should also be supplied and sensor frequencies measured.

With TAPS connected to a computer in terminal mode and the shorting plug installed, press <CTRL>-P to enter the programming dialog. Select appropriate mode and operating parameters. When you come to the section concerning external sensors, enter the code number best describing your sensor in the correct channel (1 or 2). Save this setup for future use.

Note that it is not necessary to install the sensor even if it is programmed. This does slow down TAPS data collection but no particular harm will be done.

Likewise, it is not necessary to program an external sensor even though it is connected. It will not be powered and no data will be read but no particular harm will be done. This might be kept in mind when the physical setup is such that removing external sensors is difficult but their data is not always desired (or the attendant time delays).

DATA CONVERSION

Converting the data obtained from external sensors to the proper engineering units is the responsibility of the user, in general. If the sensor is a frequency-output device, the sensor manufacturer will normally supply equations for converting the frequency to the proper units. The value measured and reported by TAPS will be the sensor frequency.

Voltage output sensors will also normally be provided with conversion equations. First, however, the frequency measured by TAPS must be converted back to a voltage. If the suggested configuration was installed, the actual sensor voltage is found from

$$V = \text{Fmeas} * V_{\text{max}} / 10{,}000$$

where Fmeas is the frequency measured by TAPS. If some other maximum frequency than 10,000 Hz was selected, replace this number with the actual frequency used.