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LOGGER OPERATOR'S MANUAL

(P/N 9075) REV B

DESCRIPTION OF LOGGER

The PME 9075 logger is designed to interface with PME's 6533 Temperature Sensing Chain. The picture above shows the 9075 logger and one temperature sensor (node) from the 6533 chain. Logger capacity and endurance depend upon the number of nodes on the chain, the sampling interval, and the capacity of the compact flash card within the logger. With a 128 Meg flash , sampling 41 nodes each minute, the logger capacity is approximately 2 years.

The logger and chain are completely submersible. The logger 'birdcage' is designed to connect to a customer-supplied buoy and cable system. The birdcage has no sharp corners towards the bottom so that 3rd party cables such as fishing lines have a chance to slide over it without snagging.

The heart of the logger is a Persistor CF2 single board computer. PME supplies source code for PME's simple logging program. Customers can adapt this source code to their own purposes. Adaptation is relatively easy, but requires the purchase of inexpensive 3rd party software.

DEPLOYMENT OF THE LOGGER

The logger is designed to be deployed beneath the water surface. However the logger must be brought to the surface to refresh the batteries and obtain the measurements. Customer requirements will vary. Some guidelines are presented here:

- The temperature sensing chain is not intended to be tension bearing. It is intended that this chain be attached via cable ties to a tensioned member such as a cable. Plastic rope can also be used but the rope must not stretch under tension to the point where the attached temperature chain is loaded. The temperature sensing chain should be attached by cable ties located a few inches from each node.

- A simple deployment is to attach a surface buoy via a short length of cable or rope to the top of the birdcage, then attach a cable or rope to the other side of the birdcage with sufficient length to reach a weight on the bottom. The temperature sensing chain is then attached to the cable. In this configuration tension passes through the birdcage, which will support a light tension.

- If large tension is desired then the same arrangement can be used except that the birdcage should be attached parallel to the cable at both its top and bottom points. Care should be taken to attach the birdcage in a way that allows 3rd party snagged lines to be pulled along the chain to the surface.

- The upper end of the temperature sensing chain should be secured to the birdcage with cable ties so that it does not rub or flex in response to currents or wave motions.

- The deployment method must recognize that the logger must be accessed to refresh batteries and obtain measurements.

DATA ACQUISITION

This section presents an over view of data acquisition. Please refer to subsequent sections for specific information.

- Insure that the batteries have sufficient charge for the expected deployment and that the compact flash card has sufficient available storage space for the collected data. Insure that the CF2 clock is set to the desired time.
- Remove the H1 jumper if it is not already removed.
- Move the Power Switch to the 'ON' position.
- Observe that L.E.D. (shown on labeled picture below) flashes 5 times. This indicates that the data acquisition program is operating. One scan of all nodes on the temperature chain will be recorded each minute. This takes roughly 3 seconds of power. The logger and chain will 'sleep' without consuming much power for the remaining 57 seconds. Initially, scans are recorded into RAM memory. Once each 24 hours all scans are moved from RAM memory to compact flash, creating one compact flash file each day.
- Close the logger and deploy the system for the required period of up to a year.
- Recover the system and open the logger.
- Observe the CF2 computer for more than 1 minute. You should see a small L.E.D. flash briefly once each minute. This indicates the point where the system 'wakes up' and acquires data. It is important that the Wake Button be pressed only when the system is asleep. Do this by waiting until the L.E.D. on the CF2 flashes, then

waiting an additional 5 seconds, then pressing the Wake Button within the next 50 seconds.

- The system will awaken in response to the Wake Button. At this time it will save all scans in RAM to compact flash. After this is accomplished the system will continuously flash the L.E.D. (shown on the labeled picture below) indicating that the program is ready for power removal.
- Move the Power Switch to the 'OFF' position.
- Remove the compact flash card and discharged batteries.
- Install new batteries and a new compact flash card.
- The system is now ready for re-use.

DATA PROCESSING

This section presents an over view of data processing. Please refer to subsequent sections for specific information.

- Create a folder at some convenient location using Windows commands.
- Plug the compact flash containing acquired data into the compact flash card reader supplied by PME.
- Use Windows commands to copy the files on the compact flash to the folder you created.
- Use Windows commands to copy ENGUNIT.EXE (supplied by PME) to the same directory.
- Click on ENGUNIT.EXE icon.
- ENGUNIT contains calibration coefficients specific to the temperature chain. It reads all raw data files in the directory and converts them to ASCII files containing temperatures in degrees C. These files will appear in the folder after ENGUNIT.EXE completes its activity.
- Erase files from compact flash card using Windows commands. This card is now ready for re-use.
- Temperature data are now ready for customer-specific processing.

UNDERWATER CONNECTOR TO TEMPERATURE CHAIN

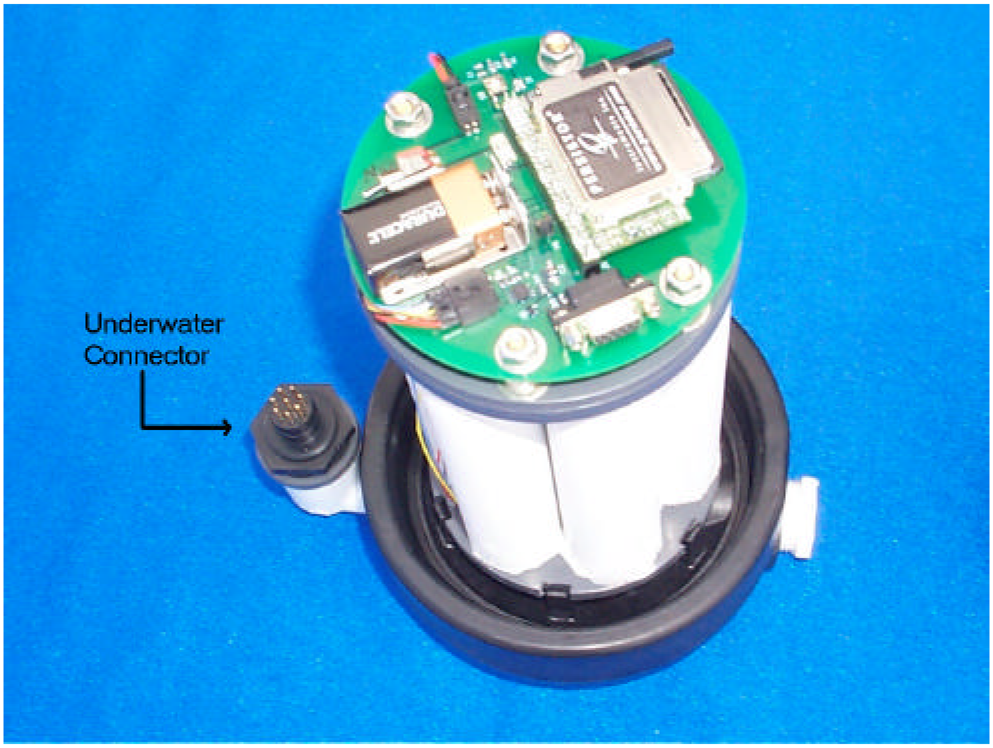
Mate and de-mate the underwater connector by pressing the temperature chain connector straight on and off. Do not twist, even slightly. A small amount of silicone oil can be spread onto the inside of the temperature chain connector to make it slide on more easily. The temperature chain connector has a small bump molded into the outside. This bump must be aligned with the larger diameter pin on the logger connector. Only make or break the connection with logger power off. Press the temperature chain connector onto the logger connector until a 'pop' is heard indicating that the water-tight seal is made. Slide the securing sleeve up over the mated connector and screw onto the logger connector.

Do not allow the underwater connector pins to become wet when the temperature chain is disconnected.

The logger connector is only tightened to 15 inch-pounds of torque. Should it become loose, retighten it by hand only, or by using a torque wrench. Do not use a wrench since this nearly always breaks the connector. 15 inch-pounds is not very tight.

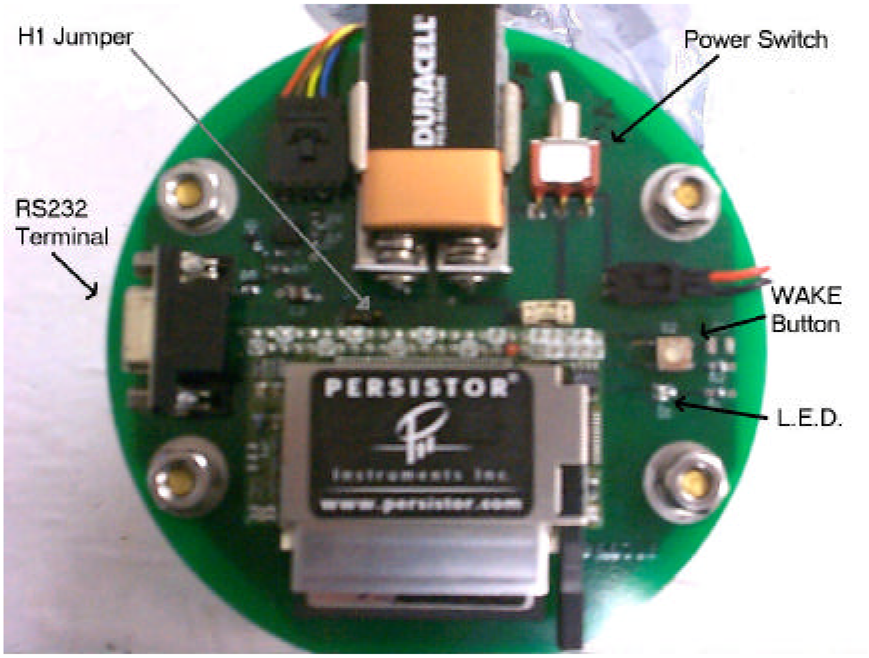
Inspect the U/W connector frequently to insure that it remains tight.

RS232 COMMUNICATION



A host computer is required to use this feature, as well as a terminal program in operation on the host computer. The logger must be opened to make RS232 connection. The computer's serial port should be connected to the DB-9 connector located on the logger circuit board shown in the picture above. The terminal program should be set to operate at 8 data bits, no parity, 1 stop bit, 9600 baud.

PME PROGRAM OPERATION



After the power switch is moved to the ON position the logger software responds in one of two ways depending on if H1 (just above the 9V transistor battery) has a jumper installed. When H1 does not have a jumper installed the software will be in logging mode. In this condition the logger software flashes the D1 LED (next to the push button) five times at roughly 1 second intervals, then starts taking data. The present logger program scans the temperature chain with 1 average, once per minute and saves the data to compact flash once per day. In this mode the software will not respond to any commends except the WAKE button, and will output information showing its operation through the RS232 terminal.

If a jumper is installed on H1 then the software will enter the maintenance mode after the power switch is turned on. In this mode the software will respond to keyboard commands via RS232 and provide RS232 terminal output. When maintenance mode is selected the logger will print a banner when power is applied. It will then accept commands. These commands are:

ACQ Causes the software to begin logging temperature chain data. This is an alternate way to begin logging. If H1 remains jumped and the wakeup button is pressed, the maintenance mode will be re-entered and commands will again be accepted.

BANNER Causes the software to display the power-on banner. This is useful to see the time, date, and logging parameters.

HELP Repeats a list of available commands.

QUIT Exits the logger software into the Pico Dos environment. This is useful if a new program is to be uploaded, or if the time/date are to be set. The logger program can be re-run by turning power off and on.

TEST0 Causes the logger and temperature chain to enter the SLEEP mode for 100 seconds or until the wakeup button is pressed. This is useful for testing current consumption during sleep mode. Exit this test by waiting 100 seconds, or by pressing the wakeup button. Do NOT exit this test by turning power off and on.

TEST1 Causes the logger to save 5000 scans of bogus data to compact flash. These data aren't useful but the test can be used to measure current consumption while writing compact flash. Exit this test by turning power off and on.

TEST2 Uploads and prints raw temperature chain measurements. This command accepts number of nodes and number of averages parameters. For example to see 40 nodes with 1 average enter

TEST2 40,1

Exit this test by turning power off and on.

TEST3 Uploads and prints raw temperature chain difference measurements. The value printed is the difference of the current value from the previous value. This command accepts number of nodes and number of averages parameters. For example to see 40 nodes with 1 average enter

TEST3 40,1

Exit this test by turning power off and on.

TEST4 Uploads and prints raw temperature chain measurements. Similar to TEST2 except that no linefeeds are printed after each row of data. Exit this test by turning power off and on.

TEST5 Uploads and prints temperature chain measurements in degrees C. This command accepts number of nodes and number of averages parameters. For example to see 40 nodes with 1 average enter

TEST5 40,1

Exit this test by turning power off and on.

TEST6 This test cyclically scans the temperature chain without printing results to the screen. This test accepts two parameters, the number of nodes and the delay between reading them. For example to read one node with 400 mS delay between reads enter

TEST6 1,400

This test is useful when measuring current consumption during chain scanning and useful to view temperature chain control waveforms on an oscilloscope. Exit this test by turning power off and on.

PICO DOS PROGRAM OPERATION

Pico DOS is installed on the CF2 computer by the manufacturer. Pico DOS is useful for compact flash card directory services and for setting the CF2 time and date. Pico DOS may be entered via the QUIT command described above.

Pico DOS commands are similar to MS DOS.

DIR	Lists files on the compact flash card.
DEL *.*	Deletes all files on the compact flash card
DATE 09-08-2003	Sets date to 9-AUG-2003
TIME 15:32:00	Sets time to 3:32 PM

It is not recommended to use PicoDOS for anything other than the 4 commands listed above.

Exit Pico DOS to PME logger program by turning power off and on.

FILE NAMING CONVENTION

Files are named by software according based on CF2 time. CF2 time must be set by the user prior to data logging if file names are expected to make any sense. Raw files (*.RAW) are created on the compact flash by PME's Pico DOS software. The file name is the CF2 time when the first scan recorded within the file is taken, expressed in seconds since 01JAN1970 00:00:00 UMT in hexadecimal format. PME's ENGUNIT.EXE program converts *.RAW files to text files (*.TXT). When this is done the hexadecimal raw file name is translated to its UMT file name in a ddmmmyyyy hhmmss format. An example is 08AUG2003 115321.TXT. Since PME's software does not apply local time corrections to the UMT time, any time set by the customer into the CF2 will be carried along without modification.

TRANSFORMATION OF RAW DATA TO ENGINEERING UNITS

The logger records temperature measurements onto compact flash in raw format. The format is concatenated scans where each scan consists of

<4 byte time><2byte node 0><2 byte node 1>…<2 byte node N>

There are no carriage returns or line feeds. The number of scans in a file is selected by the NFILESAVESCANS parameter in PME's logger program. However a file may have less than this number of scans if logger operation is terminated early by pressing the Wake Button.

Files may be transferred to a Windows PC by using the compact flash card reader supplied by PME with the logger. File transfer is simple. The compact flash card reader attaches to your computer's USB port. Run the installation software that will install the driver for the compact flash card reader. Windows will recognize the reader as a disk drive and it will show up as a disk drive. Plug the compact flash into the reader, and use the usual Windows copy activity to move the files into a convenient folder.

PME has performed a 4th order fit to approximately 80 point calibration data that gives approximately 0.020 degree C residuals. The coefficients of this fit are contained within ENGUNIT.EXE program supplied by PME. ENGUNIT.EXE must be placed in the folder that contains the raw data files read from the compact flash. ENGUNIT.EXE reads each file in this folder and writes a corresponding file containing temperatures in degrees C, in ASCII format.

REVIEWING PME CALIBRATIONS

An approximately 80 point temperature calibration is supplied for each node on the chain. These are contained within folders in the 6530 directory supplied by PME. Calibrations are recorded in ASCII format and can be read with any text editor, for example the Windows Notepad. Alternately, plots of calibrations can be viewed using PME's CALPLOT.EXE. Copy CALPLOT.EXE, EOLS.DLL, and WCT32DR3.DLL files to a convenient directory. Copy all the calibration folders in 6530\ to this same directory. Click on the CALPLOT.EXE icon. A dialog will appear. Enter the serial number for one of the calibrations (for example folder SNX00501 enter 501) then press COMPUTE, then press PLOT. A plot of the calibration and its fit residuals will appear.

PME supplied a NODES.PDF file that shows our working notes. This gives the temperature node distances implemented on the temperature chain. Also, there is a hand-written table that shows the serial number of each 6530 assembly (temperature sensing element) placed on the temperature chain, and its sequence from the connector.

BATTERY TYPE

Except for the coin cell, use only Alkaline chemistry Duracell batteries in this logger. Do not mix battery chemistries! Replace all batteries except for the coin cell at the same time with fresh batteries of equal charge. The 9V transistor battery is wired in parallel with 3 sets of 6 D batteries. If all do not contain the same charge then the more charged batteries will try to charge the less charged. Since alkaline batteries are not re-chargeable a significant amount of energy will be lost if the batteries do not all contain equal charge.

Replace the coin cell when its voltage is less than 2.8 Volts.

BATTERY LIFE

The logger contains three battery packs. These are:

- Coin cell

- 9V transistor battery
- 9V D cell (3 paralleled packs of 6 D cells)

The lifetime of the coin cell is unknown at present. This is a 3 Volt battery and provides back-up of the clock on the CF2. The voltage of this battery should be checked from time to time.

9V transistor battery. Capacity of this Duracell alkaline battery is 0.56 Amp-hours. This battery is paralleled with the D cell pack and is intended to provide power in the event that momentary disconnection of the D cells (which are mounted on spring contacts) occurs due to acceleration of the logger.

9V D cells. Capacity of each of three packs of Duracell alkaline is 14.25 Amp-hours giving 42.75 Amp-hour capacity if all packs are filled.

There are three states that the logger uses during data logging. These are:

- Sleep
- Acquiring temperatures
- Writing compact flash.

In Sleep mode the logger consumes 6.5 uA. This mode may be tested using “TEST2”. The logger consumes 18 mA while reading the 41 node temperature chain. This mode may be tested using “TEST6 1,400”. The logger consumes 62 mA when writing the flash and takes about 15 seconds to write 5000 scans. This mode may be tested using “TEST3”.

The logger takes 2 seconds to wake up, read NAVG=1 scans of the temperature chain and return to sleep. The logger takes approximately 4 seconds to write 1440 scans to compact flash. An example budget for battery use for a mission of NAVG=1, with 1 scan per minute, and 1 save to compact flash per day is:

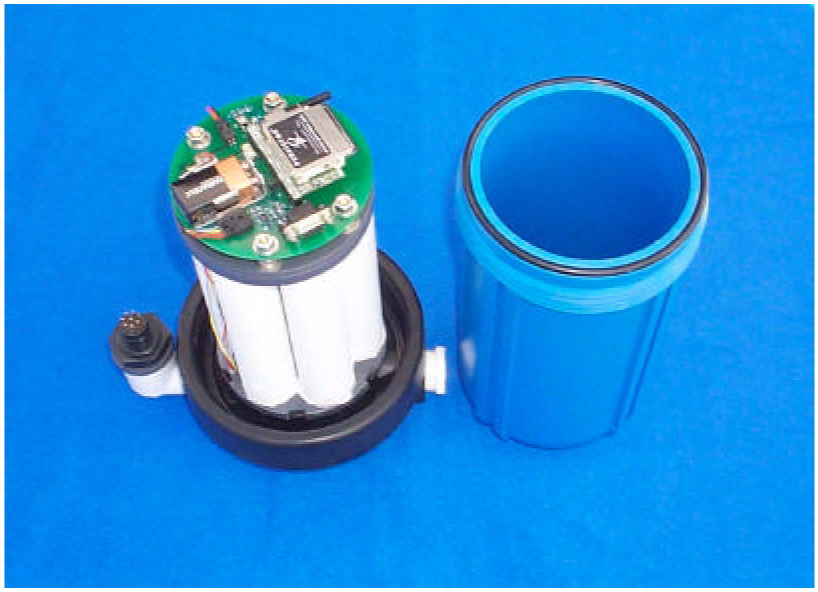
AHscan = 1440 (scans/day) * 2 (seconds) * .018 (Amp) * 1/3600 (hour/second) = 14E-3 (A-H/day)
AHsleep = 24 (hours/day) * 6.5E-6 Amp = 1.56E-4 (A-H/day)
AHflash = 4 (seconds/day) * .062 Amp * 1/3600 (hour/second) = 6.9E-5 (A-H/day)

AHdaily = 15E-3 A-H

Battery capacity is 3 packs at 14.25 A-H each pack plus .5 A-H contained by the 9V transistor battery. This gives a total of roughly 43 A-H. This is enough capacity to provide roughly 8 years of operation for the mission described above.

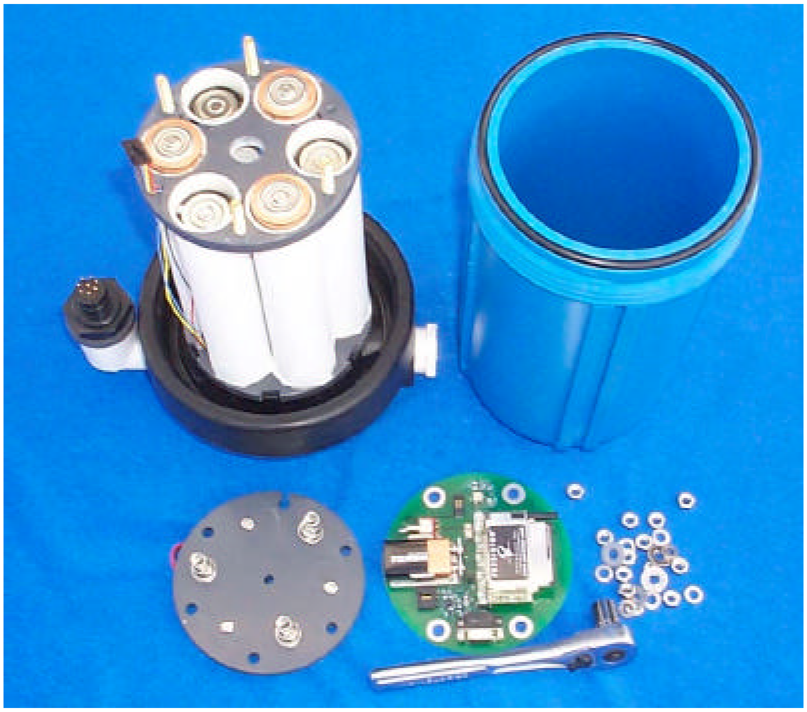
The logger may be operated with only the coin cell and 9V transistor battery. One, two, or all three D packs may be populated with batteries as well. If populating less than three D packs, be sure the proper adjacent battery tubes are chosen. Each pack contains 6 batteries, 3 in each associated tube. The tube association is established by jumpers at the bottom of the tubes. These can’t be seen without disassembly of the battery pack structure. The best way to establish the proper tubes is to place the batteries, then measure the voltage that develops from the exposed ends of the batteries in each pack. If zero Volts is observed then the wrong pair of tubes have been populated.

BATTERY / COMPACT FLASH REPLACEMENT



MATERIALS NEEDED – 7/16” deep socket wrench, 1/2" socket wrench, knife(or some other tool for cutting cable ties), replacement cable ties, replacement compact flash card, replacement D cell batteries, replacement 9v battery.

1) Only perform replacement in dry weather.
2) Insure that no washers or nuts become lost.
3) Bring the logger to the surface
4) Cut cable ties holding the temperature sensing cable to the birdcage.
5) Remove four 1/4-20 bolts holding logger pressure housing to birdcage and remove pressure housing from birdcage. Take care not to stress the temperature sensing cable.
6) Hold pressure housing vertical with black lid topmost. Unscrew blue canister from black lid. It is important the black lid be topmost or water in the threads will run down into the interior when the seal is broken.
7) Invert the lid/electronics and carefully wipe threads and seals with a paper towel to remove all water droplets. Wipe canister threads and o-ring dry.
8) It is important that the wake button not be pressed during data acquisition. Observe the LED on the CF2 (NOT the LED on the main circuit board). It comes on briefly just as the CF2 awakens for data acquisition. Press the wake button (labeled S2) no less than 4 seconds after the LED flashes. The L.E.D. (labeled D1) adjacent to the button on the main circuit board should begin flashing regularly within about 5 seconds. If this does not happen repeat the process. One or two tries should be sufficient.
9) When D1 is flashing regularly move power switch to ‘off’ position.
10) Unplug 2 pin and 5 pin connectors. Release four 1/4-20 nuts and 4 lock washers. Remove nuts and washers. Remove circuit board. Release additional 8 nuts, 4 lock washers, and 4 flat washers.. Remove top battery plate.



11) Remove 'D' batteries. Remove 9V transistor battery.
12) Install fresh 'D' batteries and 9V transistor battery. All batteries must be same manufacturer and chemistry.
13) Re-install top battery plate being sure to align the notch with the wire bundle. Replace washers, nuts. Tighten nuts firmly but do not over-tighten. Re-install circuit board, washers, and nuts. Tighten nuts firmly. Plug connectors.
14) Install 9 Volt battery. Note this must be same manufacturer and chemistry type as 'D' cells installed.
15) Remove and replace compact flash card.
16) Move power switch to 'on' position. L.E.D. D1 should flash 5 times. At this time the logger has begun logging operations. The L.E.D. must flash 5 times or measurements are not being recorded.
17) Inspect o-ring and sealing surfaces for debris or scratches.
18) Screw blue canister into black lid, being careful that the o-ring remains in proper position. Tighten firmly by grasping canister with legs and turning lid.
19) Re-mount canister in birdcage with washers and bolts.
20) Re-tie temperature sensing cable to birdcage.
21) Replace birdcage in deployment position.
22) Insure that no washers or nuts have been lost or left out.

DISTRIBUTED FILES

The temperature logger is supplied with various files. These are:

\9075\OPMANUAL.DOC	this operator's manual
\6530\…	a group of files contain calibrations for each node
\6530\CALPLOT.ZIP	a plotting program to view calibrations
\9079\CHAIN.ZIP	CF2 operational software, C source, CodeWarrior project
\9079\ENGUNIT.ZIP	ENGUNIT.EXE C source, Visual C++ project
Persistor software	various utilities for the CF2

MODIFICATION OF PME SOFTWARE

PME grants license to the original customer to modify PME software for the purposes of controlling loggers purchased from PME. PME grants license to the original customer to modify PME software for the purpose of computing engineering units from data obtained by loggers purchased from PME.

The customer must supply the proper software tools to modify PME's software. For the logger software: Metrowerks Codewarrior Development Studio for Palm OS, Version 9 for Windows. For ENGUNIT.EXE :Microsoft Visual C++ Version 6.

Modifications of PME software
are not supported by PME. PME may be contracted, at additional cost, to provide modifications or other support information.

WATER LEAKAGE INTO LOGGER ELECTRONICS

The electronics within the logger are not designed to survive contact with water. If water breaches the seals and enters the logger the logger electronics will most likely be destroyed. If water is detected inside the logger, immediately remove all batteries including the coin cell located beneath the CF2 computer. Leave the logger open and allow it to dry completely. Return the logger to PME for damage assessment.

WHEN THE LED DOESN'T FLASH 5 TIMES AT POWER ON

If the L.E.D. D1 does not flash 5 times when the power is turned on then the logger program is not in operation and measurements will not be recorded. In this case do the following:

1) Check jumper H1. If this is jumped then the logger has entered maintenance mode. To begin logging, turn power off, remove jumper H1 and turn power on again.
2) If H1 is not jumped then the CF2 program has crashed, probably due to untimely pressing of the wake button. Program operation can not be recovered by simply turning power off and on due to the presence of the back-up battery. Turn power off. Carefully unplug the CF2 from its three connectors. Wait a while for charge to dissipate. Carefully plug the CF2 back into the connectors being sure it is aligned properly. Jumper H1. Turn power on. Use QUIT command to enter Pico DOS. Use the Time and Date commands described above to set current time and date. Turn power off. Remove jumper H1. Turn power on. Normal 5 flash operation should be observed at this time.

SPECIFICATIONS

Feature	Specification
Initial Absolute Accuracy	+/- 0.010 degrees C with sub-ranged calibration
Initial Relative Accuracy	+/- 0.005 degrees C
Thermal noise	0.00015 degrees C (not including 16 bit quantization noise)
Resolution	1 part in 2^16 (approximately 0.0005 degrees C)
Range:	0 to 36 degrees C
Thermal response time constant	2 seconds
Storage temperature range	–2 to 45 degrees C

MOORING AND TEMPERATURE CHAIN DESIGN CONSIDERATIONS

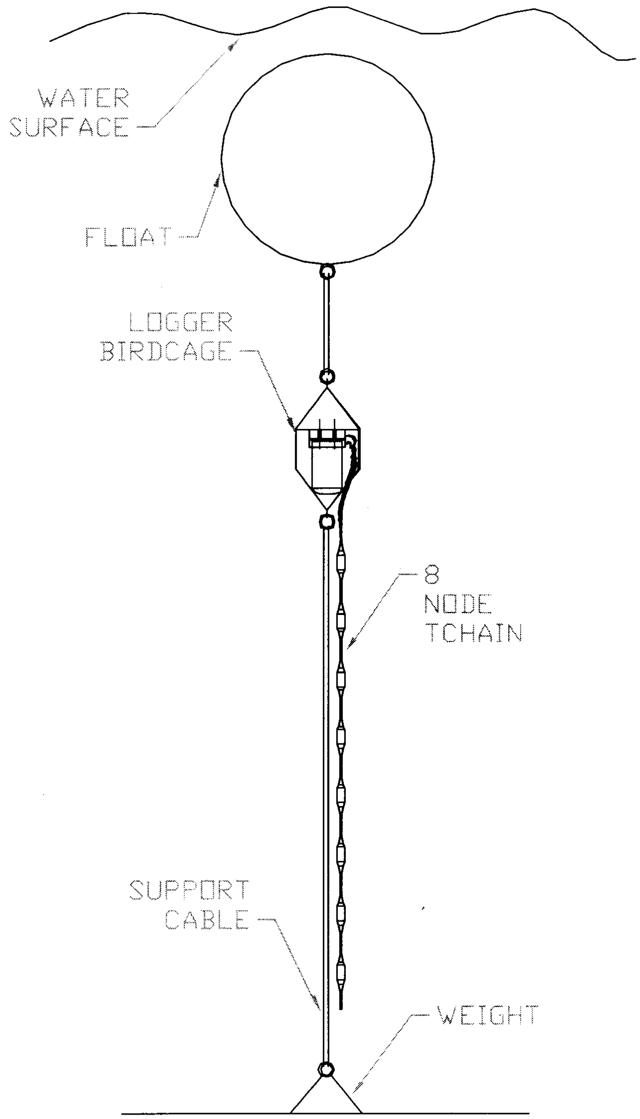
PME constructs temperature chains to customer specifications. It is up to the customer to specify various distances used for constructing the temperature chain so that the customer's temperature measurement goals are achieved.

The table below lists limits that must be considered when designing a specific temperature chain and mooring.

Feature	Specification
Minimum length of cable between measurement point on any two nodes	0.5 meter
Maximum length of cable between measurement point on any two nodes or between the top node and the logger	30 meters
Maximum depth of any node	150 meters
Maximum tension on logger birdcage	50 Kg
Maximum depth of logger	5 meters
Mechanical	Temperature chain is not weight-bearing

The Logger is designed for sub-surface deployments. It is provided with a 'bird cage' that contains the waterproof logger unit and allows attachment points to the customer's mooring. The logger/bird cage and one node are pictured below.

The customer will typically connect his mooring cable and float to the holes provided at either end of the birdcage, and connect the temperature chain as shown in the picture. An example sub-surface mooring is shown in the sketch below.

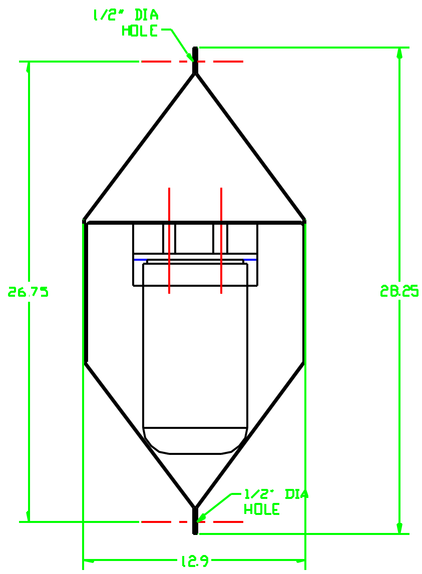


In this example data are recovered from the logger by snagging the buoy with a drag line, then lifting the buoy and logger into the boat.

Note that the temperature chain in the example does not carry the tension between the weight and the float. This tension is carried by the cable shown. A stainless cable is recommended since plastic ropes are very elastic and may stretch, allowing the temperature chain to come into tension. The temperature will be damaged by tension. Multiple cable ties between each node are recommended to attach the temperature chain to the cable.

In the example all temperature measurement nodes are located beneath the logger. If measurements between the buoy and the birdcage are desired then the logger/birdcage can be installed upside down from the orientation pictured. The temperature node cable will exit the logger towards the surface in this condition. Nodes can be attached to the cable between the logger and buoy and even onto the buoy if some suitable attachment points are provided. The temperature chain cable can be looped 180 degrees and provided with a no-node length to go past the upper nodes, then continue with nodes beneath the logger and towards the weight on the bottom.

The birdcage is provided with ½" diameter holes at each end. Holes are separated by 26 ¾".



Other mooring arrangements might be envisioned where the logger/birdcage does not carry the float tension but hangs in some way next to the mooring. This might allow data to be recovered without lifting the entire chain. Designs such as this must be conceived and implemented by the customer.

PME supplies logger, birdcage, and temperature chain. Other mooring materials such as float, weights, cable, and other items must be supplied by the customer.

In every case, the customer must consider the various lengths of temperature chain cable required to implement their desired measurement scenario. These lengths must be specified to PME at the time the temperature chain is ordered. PME provides a form for this specification.