PME Fast Response Sensors and Systems

Precision Measurement Engineering, Inc. • www.pme.com

RS232/RS485 T-CHAIN User's Manual

2010

Warranty

1-YEAR LIMITED WARRANTY ON T-CHAIN HARDWARE

Precision Measurement Engineering, Inc. (PME) warrant that the T-Chain shall be free of defects in workmanship and materials, under normal use, for a period of one year from the date of shipment. This warranty is made only to the original purchaser. In the event a LakeESP covered by this warranty fails to operate according to our published specifications, return it freight pre-paid to PME or an authorized Service Provider. PME will repair the unit at no charge to the customer, and bear the cost of return shipment. Carefully pack all components, as the customer is responsible for any freight damage.

This warranty does not apply to services or consumable/ expendable items (such as batteries, fuses and ropes) required for general maintenance. Equipment manufactured by other companies (such as meteorology sensors, solar panels, etc) are warranted only to the limit of the warranties provided by their original manufacturer.

PME makes no warranty, either expressed or implied, that the sensors will be operable after they are exposed to adverse environmental conditions, such as bio-fouling, oil fouling, freezing temperatures or others.

This warranty is void if, in our opinion, the T-Chain has been damaged by accident, mishandled, altered, or repaired by the customer, where such treatment has affected its performance or reliability. In the event of such treatment by the customer, costs for repairs plus two-way freight costs (no COD shipments will be accepted) will be borne by the customer. In such cases, an estimate will be submitted for approval before repair work is started. Items found to be defective should be returned to PME carefully packed, as the customer will be responsible for freight damage.

Incidental or consequential damages or costs incurred as a result of the product malfunction are not the responsibility of PME.

For all warranty or non-warranty returns please obtain, complete, and submit a RMA to PME. This RMA form may be obtained at

http://www.pme.com/HTML%20Docs/RMAform.html.

After submission of this from PME will respond with a RMA number. Please place this number on all shipments and related communications.

Revision History

Date	Revision Description
10-JUN-2010	Initial document
15-SEP-2010	Corrected Hyperterminal setup Hardware to none flow control
22-AUG-2011	Added information about RS485
08-NOV-2013	Added PAR bracket and CHLA sensor. Added units.

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1. Introduction to the T-Chain

The RS232/RS485 T-Chain is a single-cable string consisting of a small microprocessor and sensors of various types. This instrument can produce both RS232 and RS485 output. RS232 is bi-directional and can be directly connected to a local PC COM port or other similar platform. Unless the user must operate the T-Chain with over 15 meters of cable between the host computer and the T-Chain, RS232 communication protocol is recommended. The RS485 output can travel up to 1000 meters if cabled via suitable cable but must be connected to a suitable RS485 receiver (not provided by PME).

Most of this document reflects the use of RS232.

RS-232 T-Chains are normally programmed to output a string of measurements in response to a carriage return sent by the host computer on the RS232 communication. This allows the host computer to synchronize T-Chain output.

RS-485 T-Chans have only output connections for RS485. In this case no character can be received from the host computer. RS485 T-Chains are programmed to simply emit the string of measurements repeatedly as long as power is supplied. The host computer will have to implement a more complex method of synchronization.

The T-Chain is completely waterproof and is terminated in an 8-pin underwater connector. This connector is waterproof but not underwater mate-able.

The T-Chain begins with the underwater connector and continues via cable to a small microprocessor and thereafter to the various sensors. T-Chains are always custom built to customer specifications. Customers must specify the types and positions of the sensors they require. Temperature sensors are directly molded onto the cable. They can not be removed except by cutting and their positions can not be changed. Other sensors are however fitted to the T-Chain via short lengths of spur cable that make "Y" connections to the main cable. These sensors can be removed and, if sufficient spur cable length is available, moved to different locations along the main cable.

T-Chains are designed to be secured by cable ties to some other support.

T-Chains are supplied with a wired bulkhead connector. This assembly allows quick connection to a PC COM port for initial tests of the T-Chain. In some cases such as connection to a Campbell data logger within a Campbell enclosure, this wired bulkhead connector can be used directly. In general the customer will, after testing, disassemble the bulkhead wiring and install whatever is necessary for the specific application.

Sensors are connected to the T-Chain in three ways:

- Molded onto the T-Chain at permanent locations
- 'Y' onto the T-Chain
- Connected at the end of the T-Chain

Temperature sensors are the only permanently molded sensors on the T-Chain. The following picture shows a temperature sensor.

There are several other sensors that 'Y' onto the T-Chain. In general the sensors are as shown in the following picture.

The picture shows the main cable that extends from far left to far right, a molded temperature sensor at the right, a 'Y' connection at left, and a sensor (in this case dissolved oxygen) towards the middle. The picture shows a common installation of a sensor. However the cable from the 'Y' point to the sensor can be made longer. In this case the sensor ca be re-positioned along the main cable.

Depth (Pressure) Sensors can be positioned along the cable but often they are placed at the very bottom of the T-Chain. Depth Sensors are the only sensors that are designed to be placed at the end of the cable.

The TChain emits a string of numbers that are separated by spaces. The sequence of these numbers is established by the sequence that sensors are connected to the T-Chain. An entire scan of all sensors on the T-Chain is emitted on a single line, with following lines describing new scans of the T-Chain sensor. The units of measure are described below with each sensor.

0 RS-232 Quick Test

The T-Chain is supplied with a wired bulkhead connector. This assembly is designed to allow the RS-232 T-Chain to be quickly connected to a Windows computer for testing. There is a 9-pin D connector that will plug directly into a Windows COM port. There are also a red and black wire that receive power.

The Windows computer must have a COM port (serial port) and be running a suitable terminal program to view the T-Chain RS232 output.

On Windows 2000 and XP the terminal program Hyperterminal may be found under start\Accessories\Communications\Hyperterminal. For later Windows operating systems Hyperterminal can be purchased from

http://www.hilgraeve.com/hyperterminal/

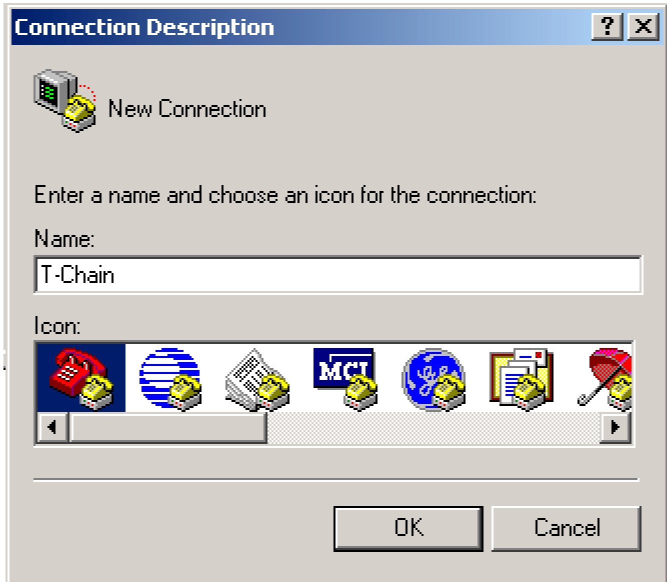
An alternate terminal program can be obtained free at

http://realterm.sourceforge.net/

In addition to a communications program, the Windows computer must have serial COM port. Most modern laptops lack this port. A USB to serial adapter, not supplied by PME, can be purchased for a small cost. In general these must be physically plugged into the computer USB port and the software properly installed prior to using Hyperterminal or another communications program. Follow the manufacturer's installation instructions.

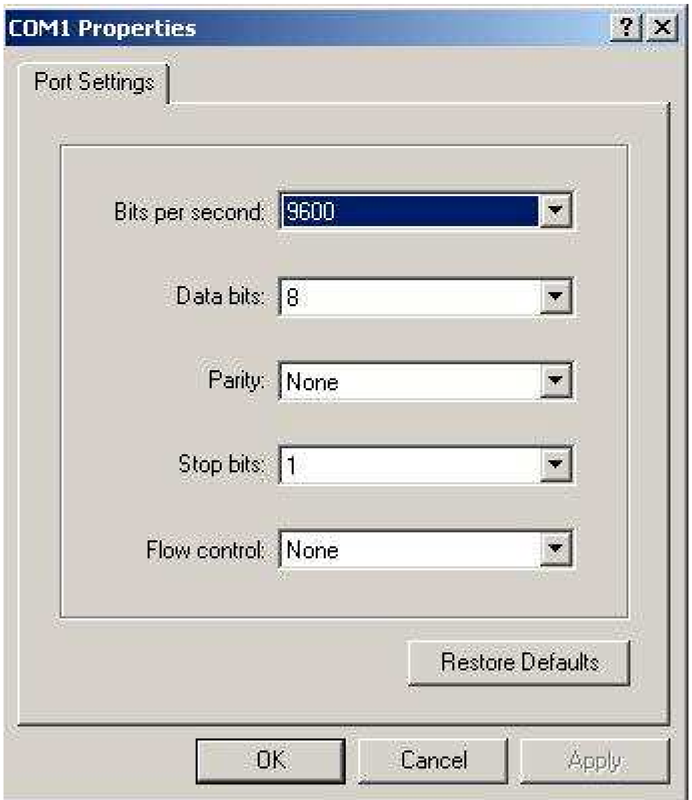
The T-Chain communicates via a RS232 (+/- 5 V protocol) at 9600 Baud, 8 bits, no parity, 1 stop bit. Hyperterminal must be set up for T-Chain communication. Run Hyperterminal, select File\New Connection. A Connection Description dialog box will appear.

In the Connection Description dialog window enter LakeESP in the Name box, then press OK.



A Connect To dialog window will appear. Select the correct COM number for the laptop (usually COM 1) or the USB adapter (could be COM 3 or COM 4 or other) from the Connect using drop down box. Press OK. A Port Settings dialog box will appear.

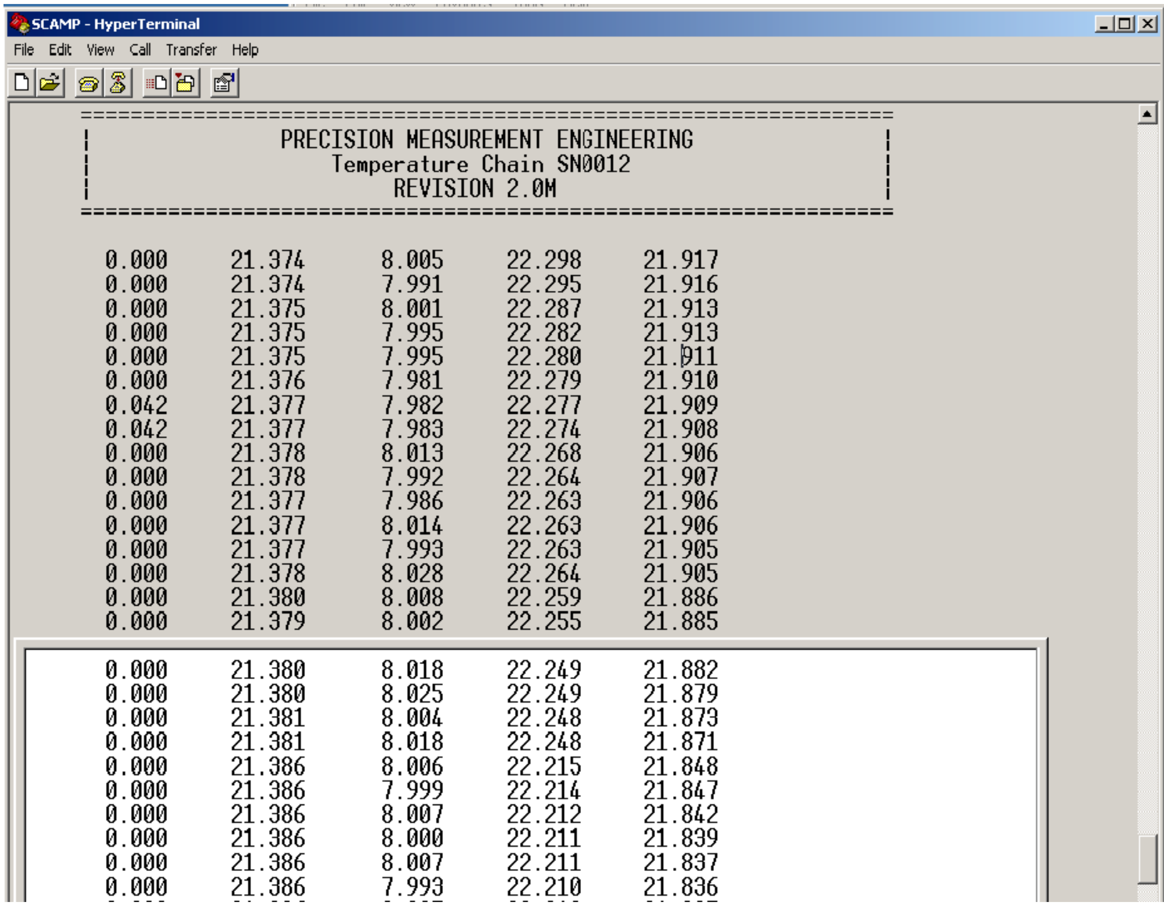
In the Port Settings dialog box select 9600 in the Bits per second drop down box, 8 in the Data bits drop down box, None in the Parity drop down box, 1 in the Stop bits drop down box and None in the Flow control drop down box. Press OK.



Select File\Save. This will save your connection so that it can be reloaded at a future time.

Plug the T-Chain 9 pin connector into the COM port connector. Supply between 9 and 12 Volts to the red and black power wires from the T-Chain bulkhead connector assembly. Connect (+) to the red wire, (-) to the black wire.

Upon connection the T-Chain should print a banner. Thereafter it will print a string of measurements in response to the Enter key press on the computer's keyboard. The screen shot below is an example of what will be presented. The exact display will depend upon the number and type of sensors on the T-Chain



0.000	21.374	8.005	22.298	21.917
0.000	21.374	7.991	22.295	21.916
0.000	21.375	8.001	22.287	21.913
0.000	21.375	7.995	22.282	21.913
0.000	21.375	7.995	22.280	21.911
0.000	21.376	7.981	22.279	21.910
0.042	21.377	7.982	22.277	21.909
0.042	21.377	7.983	22.274	21.908
0.000	21.378	8.013	22.268	21.906
0.000	21.378	7.992	22.264	21.907
0.000	21.377	7.986	22.263	21.906
0.000	21.377	8.014	22.263	21.906
0.000	21.377	7.993	22.263	21.905
0.000	21.378	8.028	22.264	21.905
0.000	21.380	8.008	22.259	21.886
0.000	21.379	8.002	22.255	21.885
0.000	21.380	8.018	22.249	21.882
0.000	21.380	8.025	22.249	21.879
0.000	21.381	8.004	22.248	21.873
0.000	21.381	8.018	22.248	21.871
0.000	21.386	8.006	22.215	21.848
0.000	21.386	7.999	22.214	21.847
0.000	21.386	8.007	22.212	21.842
0.000	21.386	8.000	22.211	21.839
0.000	21.386	8.007	22.211	21.837
0.000	21.386	7.993	22.210	21.836

If this response does not occur, check software installation and setup, and check electrical connections. If these are all correct, contact PME.

0 Sensors

Sensor	Unit of Measure	Range	Initial Accuracy	Stability	Time Response	Attachment
Temperature	degree C	-2 to 36	+/- 0.010	approx +/- 0.030 deg C/year	< 5 seconds	molded
Dissolved Oxygen	umol/l	0 to 800	+/- 10% or 10 umol/l whichever is greater	TBD	TBD	‘Y’
Depth	Meters @ 1gm/cc	0 to 40 0 to 90 0 to 190	slope: 1% FS offset: 5% FS	+/- 1%/year	< 5 seconds	end of T-Chain
pH	pH units	4 to 12	TBD		TBD	‘Y’
PAR	umol/(s * m^2)	0 to 2500	+/- 5%	+/- 2%/year	< 1 second	‘Y’
Conductivity	uS/cm	Selectable up to 200,000	10%	TBD	< 5 seconds	‘Y’
CHLA	ug/l	0 – 5 0 – 50 0 – 500	Not calibrated	TBD	<5 seconds	‘Y’

Temperature

Temperature sensors are molded onto the T-Chain. They have available response over the –2 to 36 degree C range. However they are normally calibrated only over 0.5 to 36 degrees C. Special arrangements must be made with PME when the T-Chain is ordered if the sensor is to be operated below 0.5 degrees C .

This sensor features rapid time response since the actual sensing element, a thermistor, extends outside the potting material. This thermistor is enclosed in a thin walled inconel tube. This is the silver tube in the cavity in the above picture. This sensor has a digital output with service electronics potted at each node.

Under normal use this sensor will require no cleaning.

PME calibrates this sensor. The TChain emits temperature in degrees Celsius units.

Dissolved Oxygen

The Dissolved Oxygen sensor is an optode that measures lifetime-based luminescence quenching of fluorescence of a thin membrane. DO sensors are ‘Y’ connected to the T-Chain and can be removed for calibration or cleaning.

This sensor will require cleaning. The frequency of cleaning will depend upon the amount of algae growth or other fouling. The typical cleaning interval in surface layers of fresh water lakes is 1 month with longer intervals if the sensor is deployed below the photic zone.

PME calibrates this sensor. The TChain emits dissolved oxygen in ug/l units.

Depth

The depth sensor is typically connected at the lower end of the T-Chain. There are 3 ranges available, 5, 10, and 20 bar full scale. This sensor is an absolute pressure sensor that produces depth by converting pressure into depth units using

P = rho * g * h

P = measured pressure in Pascal (1 bar = 100000 Pascal)
rho = density of pure water at 4 deg C (1000 Kg/m^3)
g = standard accelleration of Earth's gravity (9.80665 m/sec^2)
h = the depth in meters

Since the depth sensor is an absolute device it senses atmospheric pressure as well as the pressure of the water column. Normally the T-Chain output is as shown above and it is left to the user to adjust the value produced for local atmospheric pressure, the actual average density of the water column, and to adjust for variation in barometric pressure if desired. PME calibrates this sensor.

In actual use the deployment distance of the pressure transducer will be somewhat uncertain and will depend upon things such as the depth that the system anchor sinks into the sediment. The normal procedure will be to deploy the sensor, measure the depth, adjust the sensor output by water column density, and then add a constant number to give the correct initial depth.

PME calibrates this sensor. The TChain emits depth in meters of water assuming 1 gm/cm^3 density units.

pH

The pH sensor is a SensorEx S222CD sensor which PME mounts, digitizes, and connects into the T-Chain. The S222CD is a sealed double junction pH sensor. The sensor is inexpensive and can be replaced in PME's mounting, saving the cost of replacing the mounting. PME performs the calibration of this sensor using 3 standard solutions.

PAR

The PAR (Photosynthetically Active Radiation) sensor is a Li-Cor LI-192 sensor, which PME mounts, digitizes, and connects into the T-Chain. This sensor must be dismounted prior to return to Li-Cor for calibration. PME does not perform calibration of this sensor, but implements the calibration supplied by LiCor.

The T-Chain is supplied with the PAR sensor connected and operational. However the sensor must be attached to the T-Chain by the customer since the attachment bracket is too large to be conveniently shipped. The customer will provide PVC cement for this purpose. The customer must glue the pipe supplied by PME as shown in the picture below. The sensor bracket is then attached to the T-Chain by threading cable ties through the holes in the bracket and securing them to the T-Chain cable.

The TChain emits PAR in umol/(s m^2) units.

Conductivity

The conductivity sensor is a electrode-less sensor. The range of this sensor is selectable. The sensor is useful in salt water situations such as estuaries where location of the transition zone is desired. The sensor lacks sensitivity for normal fresh water lake use but has sufficient range for sea water and hyper-saline lakes. The range of the sensor should be provided to PME at the time the T-Chain is ordered.

PME calibrates this sensor. The TChain emits conductivity in uS/cm.

CHL-A

The CHL-A sensor is a Turner Designs Cyclops 7 optical sensor that has been adapted to PME's T-Chain. This sensor has 3 ranges. A range must be selected prior to installing on the T-Chain. Sensor range can not be changed thereafter without disassembling the sensor.

CHL-A sensors are not calibrated by PME. However the T-Chain does emit the units of ug/l. These are based upon the sensor range and are only approximate. More accurate calibration must be done by the customer via a correlation of T-Chain output and concurrent sampling of the nearby water.

This optical sensor flows light into the nearby water and measures emissions. The measurement volume is quite near the surface of the sensor, but there are slight measurement errors from reflections in the far-field. Attempt to mount this sensor with any reflecting structures not in its field of view.

This sensor is sensitive to fouling and should be cleaned by wiping gently by hand as often as local conditions require.

This sensor is not calibrated. The TChain emits CHL-A in ug/l units.


CYCLOPS-7

4. Connections & Communication

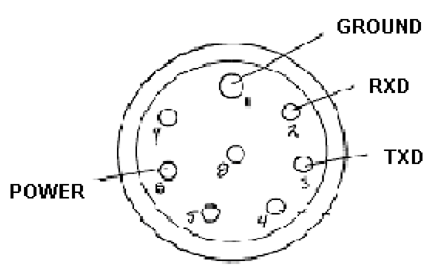
The table below shows the pin-out of the PME T-Chain underwater connector and bulkhead connector. The T-Chain is DCE.

RS-232 T-Chain and RS-485 T-Chain

Circuit Function	T-Chain Connector/ Bulkhead Connector Pin #	Bulkhead Wiring Harness Connection (P/N6738)
Power and RS232 ground	1	DB-9 pin 1 & Black wire
RS232 RXD (T-Chain receive from host)	2	DB-9 pin 3
RS232 TXD (T-Chain transmit to host)	3	DB-9 pin 2
RS485 YD(+)	4	(not connected)*
RS485 ZD (-)	5	(not conected)*
Power to T-Chain	6	Red wire
(not used)	7	(not connected)
(not used)	8	(not connected)

*The customer must add appropriate wiring for RS-485 connection.

The bulkhead connector has numbers molded next to each pin. The T-Chain connector is the mirror image and has pin numbers as shown in the following sketch.



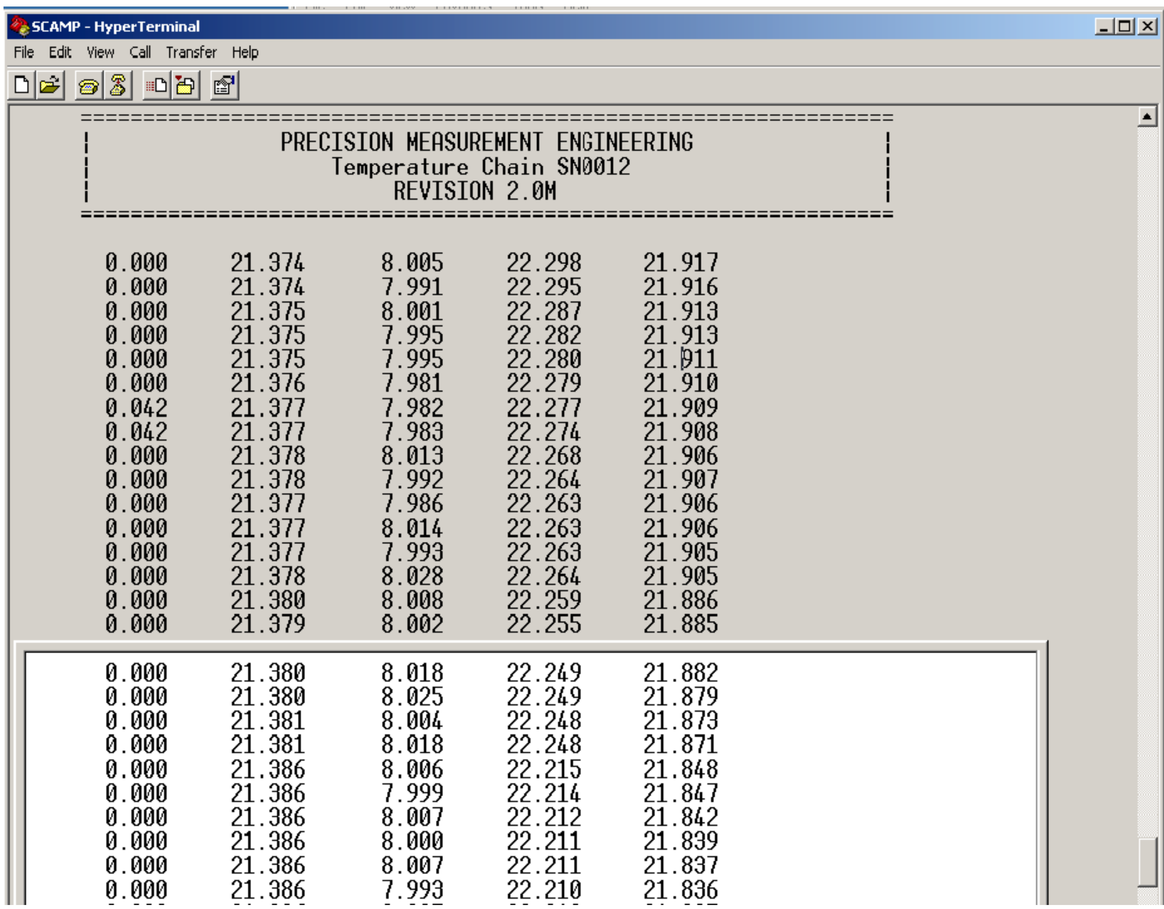
LOOKING INTO TCHAIN CONNECTOR

The communication parameters are

Parameter	Value
Baud rate	9600
# Bits	8
# Parity Bits	None
# Stop Bits	1

The RS-232 T-Chain is Data Communication Equipment and obeys the RS232 signaling voltage protocol by supplying +/- 5 Volts. The T-Chain can both send and receive. Data transmission distance is greater than 3 meters using this protocol. The RS-485 T-Chain obeys RS-485 protocol.

The T-Chain sends a banner each time the power is turned on. RS-323 T-Chains thereafter wait for a carriage return character to be sent from the connected equipment. Upon receipt of this character the T-Chain responds with an ASCII string of numbers and spaces terminated by carriage return and line feed characters. RS-485 T-Chains simply emit measurement strings while power is applied. An example is shown below.



The ASCII string displays the output of each sensor on the T-Chain in the order that the sensor is connected along the chain. ‘Y’ connected sensors are presented at the location given by the ‘Y’ connection and not at the actual location of the sensor. Only numeric output is presented. The units are those that are appropriate for the specific sensor.

Numeric output is made according to the C-language statement

```
printf(" %10.3f",((float)TNode[j]))
```

which produces floating point numbers in 10 character wide columns.

Connected equipment can synchronize to the RS-232 T-Chain output by the use of the carriage return which is sent to the T-Chain. Connected software will first empty it's input buffer, then send the carriage return character, then examine the data being returned from the T-Chain until a carriage return followed by a line feed character are received. Connected software will then parse the buffer based upon the space characters or based upon column numbering into sub-strings of single numbers and convert these ASCII representations into float or double types for storage within the connected equipment.

Connected equipment must synchronize to RS-485 T-Chain output by software examination of the character string being received from the T-Chain. Software will empty it's input buffer. It will then receive characters until a carriage return followed by a line feed are received. Characters arriving thereafter will be placed into the input buffer until the next carriage return followed by a line feed character are received. Connected software will then parse the buffer based upon the space characters or based upon column numbering into sub-strings of single numbers and convert these ASCII representations into float or double types for storage within the connected equipment.

5. Electrical Requirements

The T-Chain requires no less than 9 VDC and no greater than 20 VDC. Input voltage should not contain substantial high frequency variation.

The measurement of temperature within the T-Chain is done using thermistors shielded within inconel tubes. These tubes are not connected to the electric ground within the T-Chain for corrosion reasons. These tubes therefore take on the electrical potential of the surrounding water. There is a very slight capacitive coupling between the tubes and thermistors. It is important therfore that the electrical potential of the surrounding water be maintained the same as the electrical potential on the T-Chain ground. T-Chains without pressure transducers have a ground contact located at the end of the chain. This is normally sufficient but the connected equipment must also implement good grounding to the water.

T-Chains consume electrical current from the connected power supply. The amount of current does not depend on the connected voltage to a significant degree. It does however depend strong upon the number and type of sensors connected. The following table and notes are intended to give an approximation of the current demand, which should be computed as the sum based on the sensors. The actual demand should be measured when the T-Chain is received.

Some sensors demand a continuous current. Others have substantially high demands but only for brief periods following receipt of a carriage return character by the T-Chain. Connected power supplies must be able to supply peak current demand. Normally this is not a problem for battery operated devices, but if there are long wires between the T-Chain and the battery, their inductance may limit the peak currents. Connected equipment must be designed to supply peak current demands.

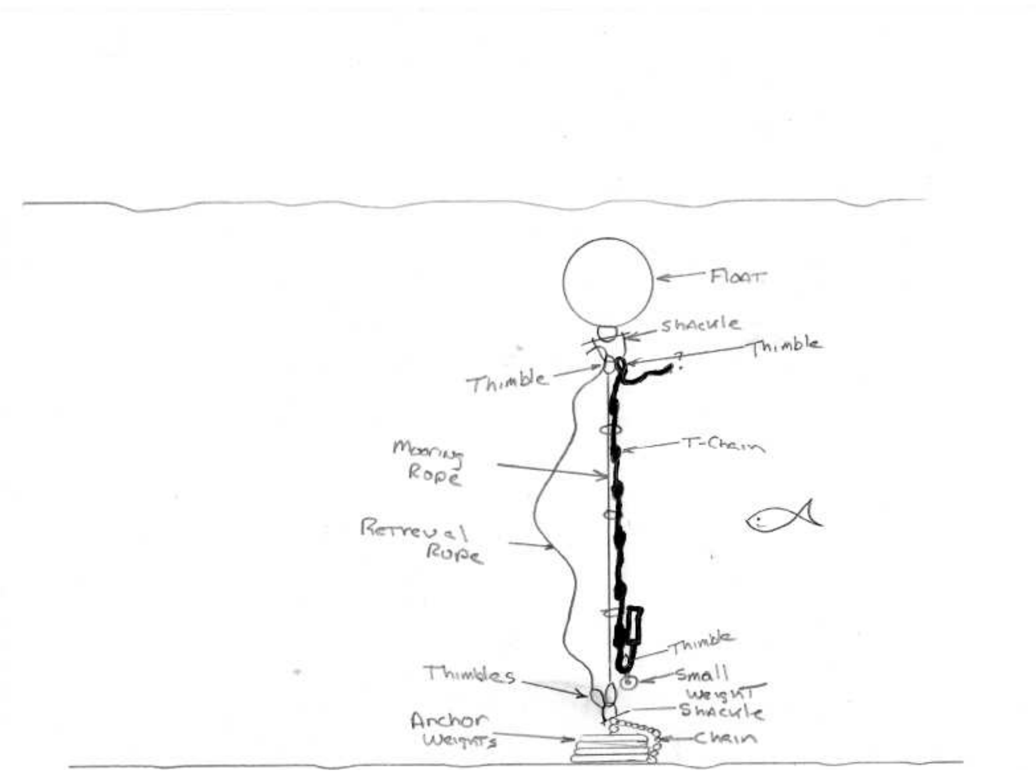
The table below gives sensor voltage and current requirements. Idle current is consumed at all times besides measurement time. Measurement current is consumed at measurement time.

SENSOR	Input Voltage (Volt)	Idle Current (mA)	Measurement Current (mA)	Measurement Time (second)
RS232 Computer	9 to 20	30	n/a	always on
temperature	9 to 20	0.3	0.5	0.4
oxygen	9 to 20	1.5	30	0.04
depth	9 to 20	TBD	TBD	0.4
pH	9 to 20	TBD	TBD	0.4
PAR	9 to 20	TBD	TBD	0.4
Conductivity	9 to 20	2	30	0.8

6. Deployment

Deployment of the T-Chain is the customer's responsibility. Deployment arrangements should be designed so that the T-Chain never is tensioned.

It is difficult to anticipate all the possible deployments that customers might use. However one simple example depolyment is a bottom anchor with a sub-surface float. This example will be discussed below to point out common problems and solutions.



The table below shows a bill of materials for a typical sub-surface buoy mooring. These are discussed subsequently.

Qty Used	Description
55	tchain rope,12-strand polyester, 3/8"x600ft (182m)
5	thimble, 3/8", 316ss, heavy duty (for tchain rope)
1	Float,subsurface,45#(20kg) lift,14"plastic
1.5 meter	Chain, 1/4", 316ss (around anchors)
40	cable ties, 7 inches (black, UV stabilized nylon), 40 lb
3	shackle, 3/8", 316ss, "D", wide
1	weight, 2.5kg (5-lb) plate (lower end of T-Chain)
2	weight, 25 Kg (50 pound) plate (anchor)

Rope, Shackles, Thimbles

Multi-strand rope with good UV resistance is recommended. Thimbles should be used at each end to resist abrasion as the mooring flexes due to water motions. Multi-strand ropes should be used since theses can be braided to form very strong connections to the thimbles as shown in the picture below. Two types of shackles are listed in the table depending on where they are used.

Rope manufacturer's provide elongation under tension specifications, but beware that these specifications often do not include initial weave compression. Ropes can stretch significantly more from 0 to 50 Kg tension than they do from 50 to 100 Kg.

Float

Subsurface floats are exposed to continuous water pressure. Foam floats will gradually absorb water and loose buoyancy. PME recommends a hard plastic float such as shown in the picture below.

Chain, Anchors

PME recommends that anchors be constructed of 'plates' such as are used by weight lifters. These iron discs can be individually carried and large weight anchors can be assembled just prior to deployment. Weights are placed in the bottom of a small boat, then chained into a stack on a piece of plywood bridged over the boat bow, then shoved over the side. (Note that care must be taken that no personnel are tangled with any rope or cable connected to the anchor at this time!!)

When determining anchor weights the weight in air must be adjusted by the buoyancy when the anchor is placed in water. Iron weights retain 87% of their air weight when placed in water. Concrete, depending on the type, is much worse retaining perhaps only 50% of its air weight. Stone is similar.

Attachment of the T-Chain

It is tempting to tightly attach the T-Chain to the mooring rope. If the T-Chain is to be tightly attached, the rope must be pre-stretched. PME recommends that T-Chains be only loosely attached. The T-Chain should be passed over a thimble and secured to the float as shown in the picture above. It should be then loosely cable tied to the mooring rope. A lower thimble should be used and a light weight connected. The mooring rope will be stretched tightly when deployed and the light weight will pull the T-Chain down along side.

Retrieval Rope

A second rope should be installed from float to anchor. It should be woven with a thimble and shackled at the anchor, but may be simply tied at the float end.

There should be extra rope beyond the length from float to anchor. The purpose of this rope is to haul the anchor back when the system is recovered. It is true that the mooring rope could be used for this purpose, but the T-Chain will be attached at the time the anchor is being lifted. This rope/T-Chain assembly can not be passed through a pulley or onto a winch. If the anchor is being hauled by hand, the rope/T-Chain will tend to be pulled against the boat rail and the T-Chain could be damaged. If a separate retrieval rope is used, the mooring rope/T-Chain can be carefully lifted from the water while the retrieval rope carries the tension.

System Weight

The entire system must sink but the float must have sufficient buoyancy to lift the T-Chain. The weight of the T-Chain can be approximated by

Total weight in fresh water (grams) = 23 * Nnodes + 40.83 * Nmeters
Total weight in sea water (grams) = 23 * Nnodes + 37.99 * Nmeters

Other Moorings

Customer designs of moorings should include considerations such as those presented above.

7. Maintenance

The T-Chain should be re-calibrated once yearly. PME performs calibration of some of the sensors but others such as PAR must be returned to the manufacturer for calibration. Customers can not re-calibrate T-Chains. These must be returned to PME for re-calibration.

Oxygen sensors located in the photic zone should be cleaned by gently brushing or wiping the sensing point. This should be done monthly or more frequently depending on local conditions.

Conductivity sensors should be wiped clean from time to time depending on local conditions.

pH sensor service interval is yet to be determined.

Appendix 1: Reprogramming The RS-232 T-Chain

The T-Chain contains a small microprocessor running a program that coordinates sensor measurements, calculates engineering units, and produces the RS232/RS485 output. This program can be changed thru the RS232 communication, but not thru the RS485 communication since RS485 has only output.

Each time that power is applied to the T-Chain it waits a brief period before beginning the sensor program. If, during this time, any RS232 input is received from the host computer the T-Chain will enter a different part of the program (called the monitor) that implements loading features.

PME will supply the new program. A customer can not create programs. Follow the instructions below to install the new program.

1. Open Hyper Terminal and adjust the Comm setting to **9600 baud, 8n1**. Once the terminal is setup. In File -> properties-> settings -> ASCII Setup, change **Line Delay to 50 milliseconds. Make sure 'Send line ends with line feed' is checked.**

2. Connect the T-chain to the computer and turn its power on. You will notice a **?** appear on screen for 2 seconds then the PME banner will come on screen. The **?** is the monitor program waiting for an input from the keyboard. Press the Enter key. If you miss it just cycle power and try again.

3. Once you have entered the monitor you will see the **?** as a cursor. From here you can use these commands to do various operations we need.

4. Type **C** to get a checksum value. Note the value because it will be proof that we have changed the T-chain's memory.

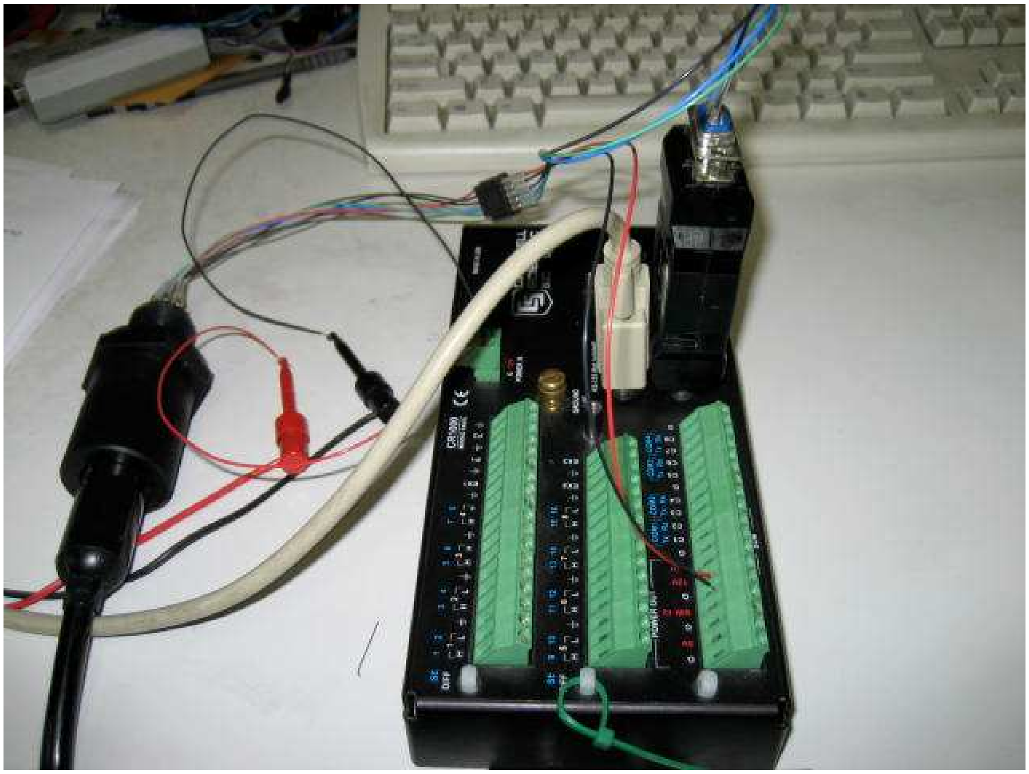
5. Type **E 1100 FBFF**. This is the erase command. You'll be erasing the memory that the t-chain program is located in. Erasing will take a couple seconds. A little display will show progress on screen.

6. Type **C** again. This will prove that the memory is in fact cleaned out.

7. Type **U**. Then click in hyper terminal's command bar. **Transfer -> Send Text File**. Select the file **"6358-004B.TXT"** . This will immediately start the re-programming process. Be sure to let it run completely to it's finish. If the code stops scrolling, press and hold the enter button for a few seconds. You'll know when it's done when the ? comes back. Reprogramming may take 2-3 minutes. If the program has not finished loading but you are seeing 'FFFF', press **Q** to exit

8. Once it's all done you can either type **G** or cycle the power. This will start the t-chain with the new program.

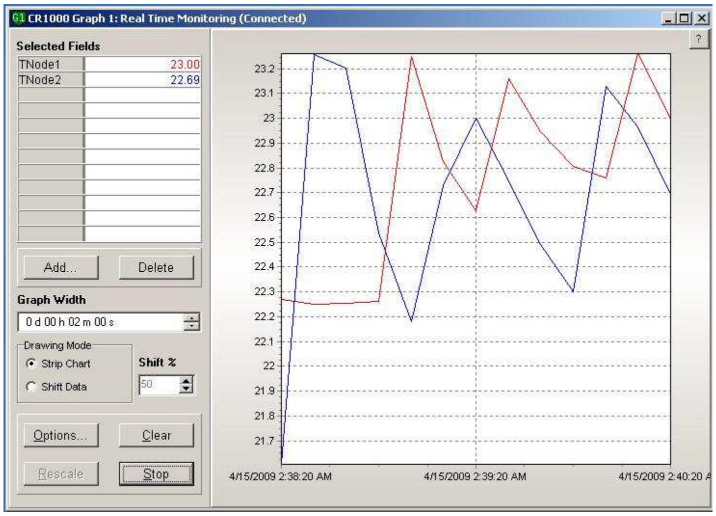
Appendix 2: Connecting the RS-232 T-Chain to a Campbell Scientific Logger



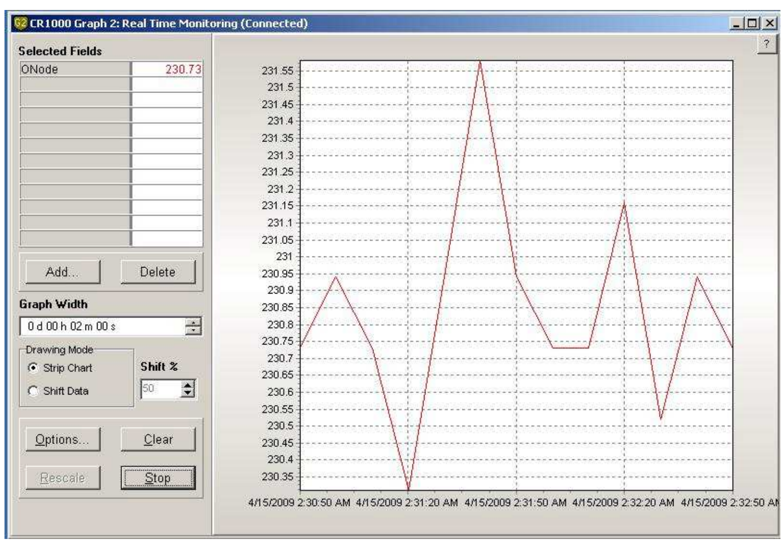
With the use of a Campbell SC32B adapter real-time T-chain data can be displayed.

With the program shown below the CR1000 can operate the T-chain and then parse the data string to display each sensor's data. Then with the use of LoggerNet real-time charts can display the incoming data.

The picture below shows a graph of the 2 temperature sensors that are installed on the T-chain.



Here is a picture of the Dissolved Oxygen sensor also installed on the T-chain.




```
'CR1000 Series Datalogger
'PME T-Chain Operator

'date: 16-APR-2009
'program author: Garren

'Declare Public Variables
Public PTemp, batt_volt, TNode1, TNode2, ONode, PNode
Public SerialOutput As String * 25
Public SerialInput As String * 50
Public TrimString As String * 50
```

```
Public Split(4) As Long
Public Splitter As String *20

'Define Data Tables
DataTable (Test,1,-1)
        DataInterval (0,10,Sec,5)
        Minimum (1,batt_volt,FP2,0,False)
        Sample (1,PTemp,FP2)
        Sample (1,TNode1,IEEE4)
        Sample (1,TNode2,IEEE4)
        Sample (1,ONode,IEEE4)
        Sample (1,PNode,IEEE4)
EndTable

'Main Program
BeginProg
  Splitter=CHR(32)&CHR(32)&CHR(32)
  Scan (2,Sec,0,0)
        PanelTemp (PTemp,250)
        Battery (Batt_volt)
        SerialOpen (COMME,9600,0,0,10000)
        SerialOutput=CHR(13)
        SerialOut (COMME,SerialOutput,"",0,1000)
        SerialIn(SerialInput,COMME,10,13,400)
        TrimString= Trim(SerialInput)&Splitter
        SplitStr (Split(1),TrimString,Splitter,4,5)
        TNode1 = Split(1) 'Converts number into engineering unit
        TNode2 = Split(3) 'Converts number into engineering unit
        ONode = Split(2)   'Converts number into engineering unit
        PNode = Split(4)  'Converts number into engineering unit
        CallTable Test
  NextScan
EndProg
```

Hardware Installation

This section describes how to install a PME T-Chain I/O cable assembly into a Campbell enclosure and how to connect the T-Chain to the CR1000 data logger. The CR800 series and CR3000 data loggers have the same connections.

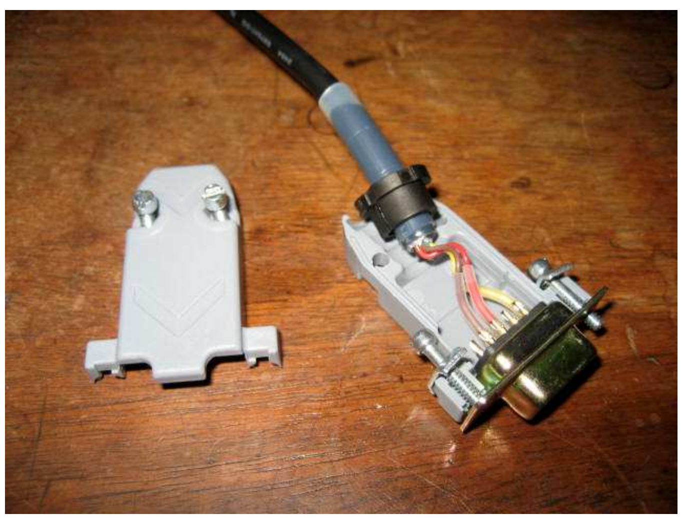
It assumes that the Campbell enclosure has the 1.7” diameter standard hole that Campbell uses for its sealable conduit.

The 6738 RS-232 T-Chain I/O Cable Assembly can also be used with a 1” diameter custom-drilled hole. In this case the washers are not installed.

INSTALL THE BULKHEAD CONNECTOR TO THE ENCLOSURE

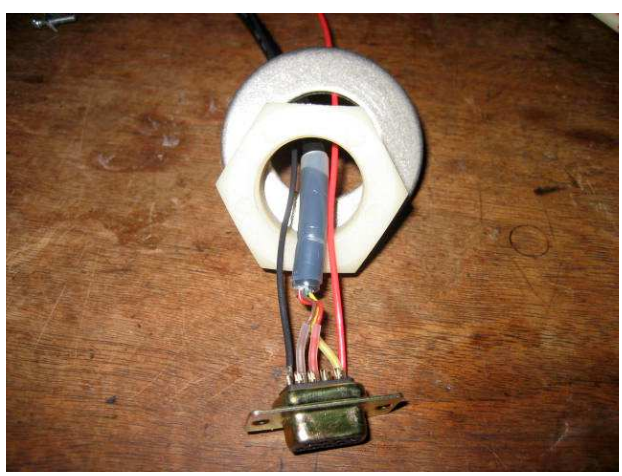
Remove the Campbell PVC pipe fitting from the hole punched in the bottom of the logger enclosure. Inside the enclosure is a threaded cap that can be unscrewed from the outside PVC pipe.

Remove the backshell of the DB-9 connector (connector assembly supplied by PME) by unscrewing the two screws holding it together. (photo below)



Feed the DB-9 connector end of the I/O cable through the enclosure's hole. (left photo) The connector assembly is supplied with two washers already installed on the wire. (right photo)

Carefully feed the bare DB-9 connector through the metal 2” OD washer first and then through the hex nut. Make sure the wires attached to the DB-9 connector do not break. (photo below)



At this time, check to see if the smaller washer (approximately 1.7” OD) will fit within the hole of the enclosure. If the washer does not fit, then remove it and file or grind it down until it does. Be careful not to nick the cable. Alternately, the hole in the Campbell enclosure can be filed a little larger. If the hole is 1” diameter (custom-drilled), then do not use washers.

Place a light coating of silicone adhesive (PME supplied DAP Household Adhesive Sealant or similar one) between the outer washer and the enclosure. (photo below) The intent here is to seal the washer to the enclosure. *Be careful that no adhesive flows between the connector and the washer*. The connector has an o-ring that accomplishes the seal at this point. If the hole is 1” diameter (custom-drilled), then do not use washers or the silicone adhesive.

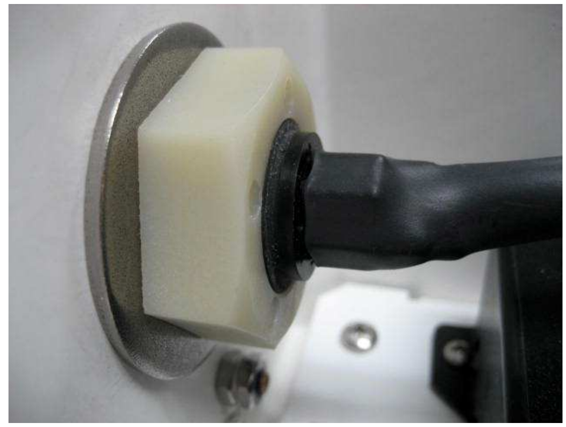
Press the bulkhead connector and washer against the enclosure and adhesive.

Install the inner washer, larger washer and nut onto the cable assembly. (left photo)

Make sure the inner, smaller washer fits snugly within the hole. Tighten the nut very firmly by hand, enough to engage the o-ring seal in the connector and to resist rotation when the T-Chain is plugged/unplugged. (right photo)

PME does not recommend the use of a wrench since the connector will not withstand a high level of torque. If a wrench is used, then do not tighten beyond 40 in-lbs. Over-tightening will definitely break the bulkhead connector so be careful.

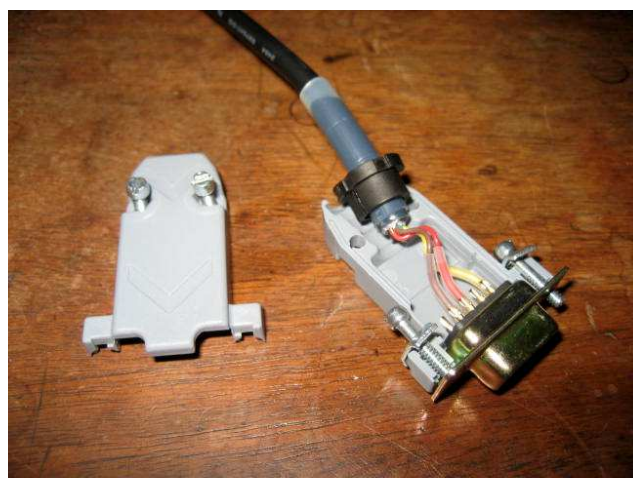
Wipe off any excess silicone around the washer.



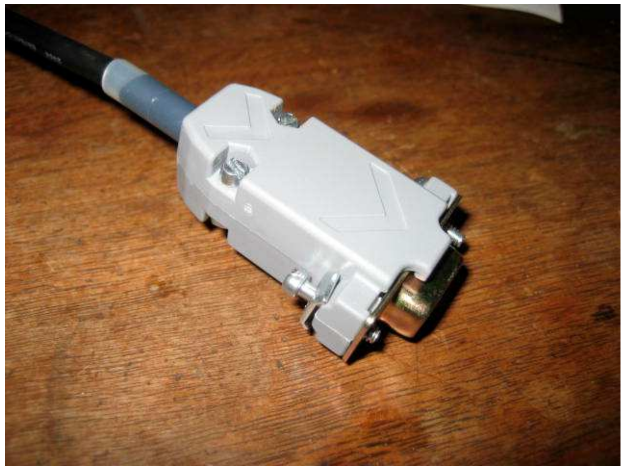
REINSTALL BACKSHELL ON DB-9 CONNECTOR

Place the DB-9 connector onto half of the backshell with the stress relief clip around the shrink tubing of the cable. (left photo)

Install the screws through the holes in the connector and onto the other half of the backshell. Notice that the screws going through the holes in the DB-9 connector are not threaded the whole length of the shaft. (right photo)



Place the other half of the backshell in position on the bottom half. Insert the nuts into the grooves on the bottom side and tighten the screws such that the backshell clamps down on the shrink tubing. (photo below)

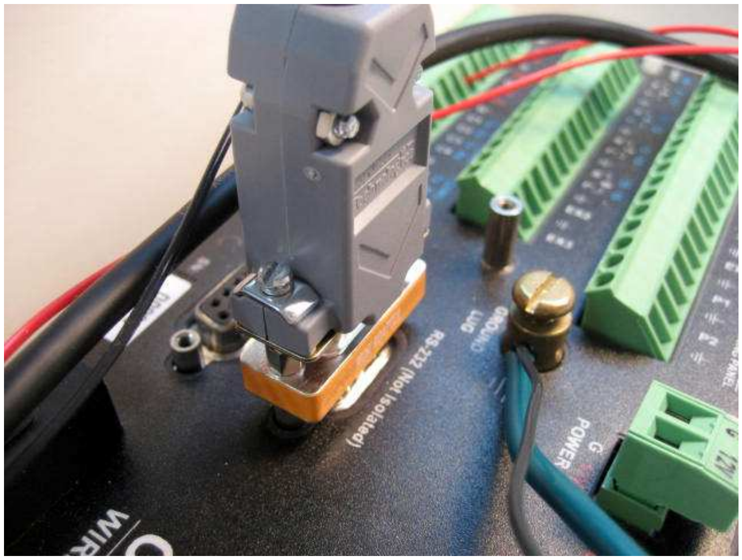


ELECTRICAL CONNECTION TO RS-232 PORT

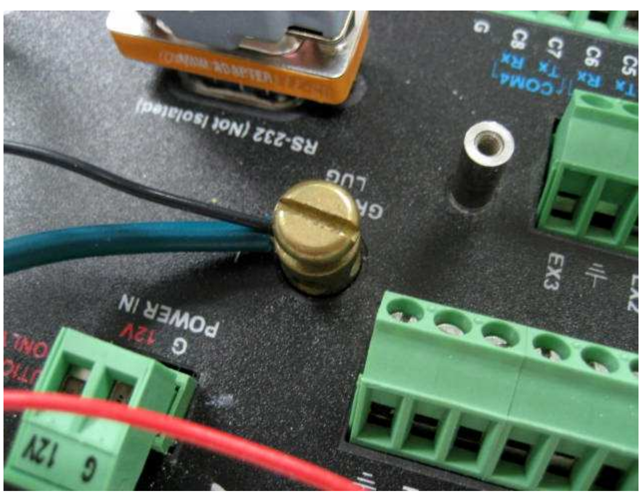
DO THE FOLLOWING CONNECTION WITH ALL POWER OFF!!

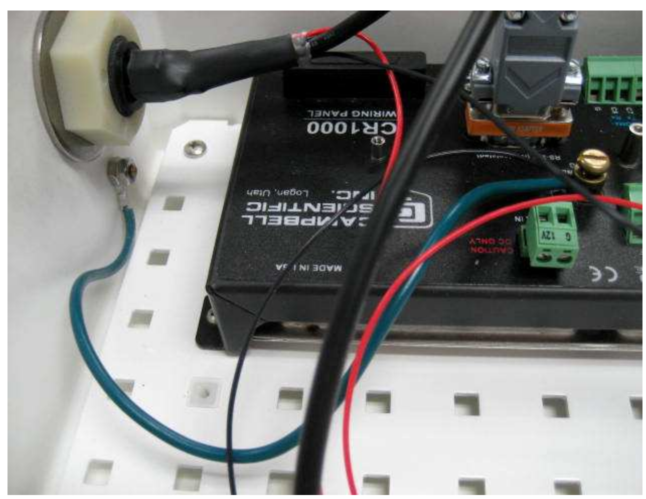
Plug the male-to-male null adapter onto the RS-232 port and tighten the screws to hold it in place. (photo below)

Next, plug the DB-9 connector into the male-to-male null adapter and tighten the screws so the connector will not dislodge when pulled. (photo below)

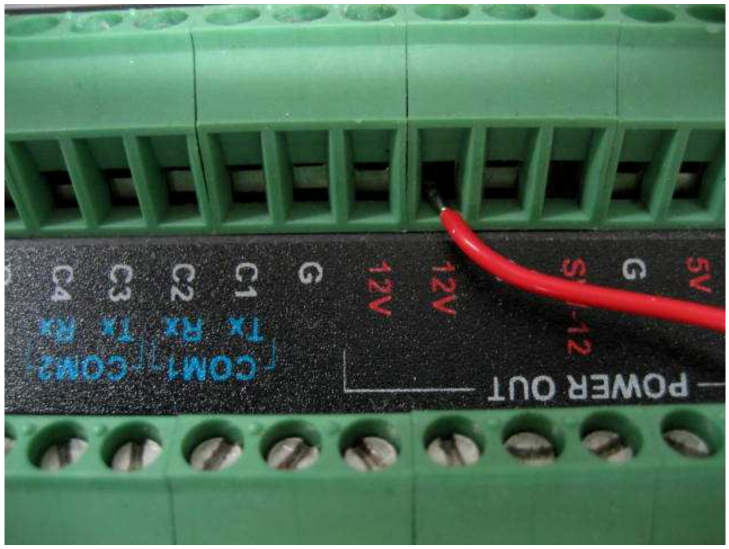


Install the black wire (T-Chain power return), from the T-Chain cable assembly, to the GROUND LUG on the logger. (left photo) The Campbell teal-colored ground wire should also be connected to this lug and to the screw below the hex nut. (right photo)





Install the red wire (T-Chain Power), from the T-Chain cable assembly, to either the 12 V or SW-12 V ports (this depends on what type of power configuration you are using). Back the screw off so that the tinned part of the bare wire can easily slide into place. Tighten the screw onto the bare wire. Gently pull on the wire to make sure it will not come out. (photo below)



DO NOT CONNECT THE T-CHAIN TO THE BULKHEAD CONNECTOR WITH THE LOGGER POWERED. Doing so can electrically harm the T-Chain.

The T-Chain can also be connected to the logger using the SMD-SIO1 module purchased separately from Campbell Scientific. Contact them for more information.

DO NOT CONNECT THE T-CHAIN TO THE COM PORTS! The T-Chain will not work with the four COM ports (1-4) on the logger. Contact Campbell Scientific for more information.

INSTALLING THE DUMMY PLUG

DO NOT DISCONNECT THE T-CHAIN FROM THE BULKHEAD CONNECTOR WITH THE LOGGER POWERED. Doing so can electrically harm the T-Chain.

Check for debris inside the dummy plug and on the outside of the bulkhead connector. Clean the surfaces if required (wipe with a napkin or paper towel). Debris can lead to a bad seal between the plug and bulkhead.

Note that pin 1 of the bulkhead connector is larger than the rest of the pins. Pin 1 will align with the dots on the outside of the dummy plug. Align the dummy plug with pin 1 of the bulkhead and slide on the dummy plug. There is a notch on the bulkhead connector above pin 1 to help align the dummy plug. (photos below)

Air can get trapped inside the dummy plug so take a flathead screwdriver and carefully jam it between the plug and bulkhead threads. Twist the screwdriver such that the air is allowed to escape. (photo below)

Next, firmly press the dummy plug against the bulkhead connector making sure it is all the way against the bulkhead threads.

Finally, install the locking sleeve for the dummy plug. Slide the sleeve over the plug with the threads pointed toward the bulkhead connector (away from the enclosure). Once the sleeve passes over the ring on the plug, then gently twist the sleeve on to the threads of the bulkhead. There is no need to overtighten the locking sleeve – doing so can damage it.

T-CHAIN INSTALLATION

DO NOT CONNECT THE T-CHAIN TO THE BULKHEAD CONNECTOR WITH THE LOGGER POWERED!

These steps are similar to the ones used in the section, Installing the Dummy Plug.

Check for debris inside of the underwater connector and on the outside of the bulkhead connector. Clean the surfaces if required (wipe with a napkin or paper towel). Debris can lead to a bad seal between the underwater connector and the bulkhead connector.

Note that pin 1 of the bulkhead connector is larger than the rest of the pins. Pin 1 will align with the dots on the outside of the T-chain's underwater connector. Align the underwater connector with pin 1 of the bulkhead connector and slide on the underwater connector. There is a notch on the bulkhead connector above pin 1 to help align the underwater connector.

Air can get trapped inside the underwater connector so take a flathead screwdriver and carefully jam it between the underwater connector and bulkhead connector threads. Twist the screwdriver such that the air is allowed to escape.

Firmly press the underwater connector against the bulkhead connector making sure that it is all the way against the bulkhead threads.

Finally, slide on the locking sleeve for the underwater connector. Once the sleeve passes over the ring on the underwater connector, gently twist the sleeve on to the threads of the bulkhead connector. There is no need to overtighten the locking sleeve – doing so can damage it.

OVERALL VIEW INSIDE ENCLOSURE