The Temperature 2 Pressure Probe (T2P): Technical Manual

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INTRODUCTION

The University of Texas (UT) has developed a pressure probe to be referred to as 'The Temperature Two Pressure Probe' (Figure 1) or T2P, for short (Flemings et al., 2006). The T2P is composed of interlocking steel cylinders accentuated by a needle shaft housing two porous pressure ports. Within the DAQ Housing of the probe is an IODP-USIO developed data acquisition system (CDAQ) (Meiring, 2008) adapted for the specific uses of the T2P.

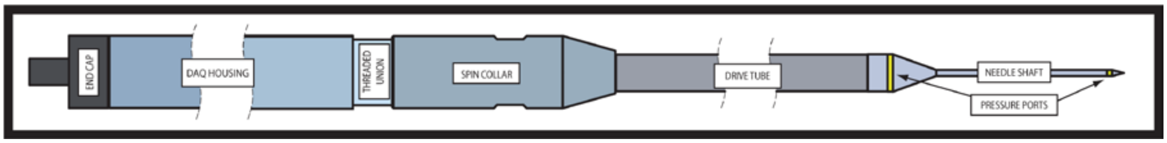


Figure 1: Diagram of Temperature Two Pressure Probe (T2P)

The CDAQ is an inclusive controller for the T2P. It operates an onboard accelerometer, onboard thermistor, and (1) thermistor and (2) analog pressure transducers that sample in-situ conditions at the tip of the probe. The program T2PLOGGR.run is housed on the CDAQ and is initiated by an external computer via serial cable. Once the program is initiated it follows the logic shown in Figure 2. It is terminated by user input. The subsequent data are analyzed by a separate post-processing program (T2PImport.xls).

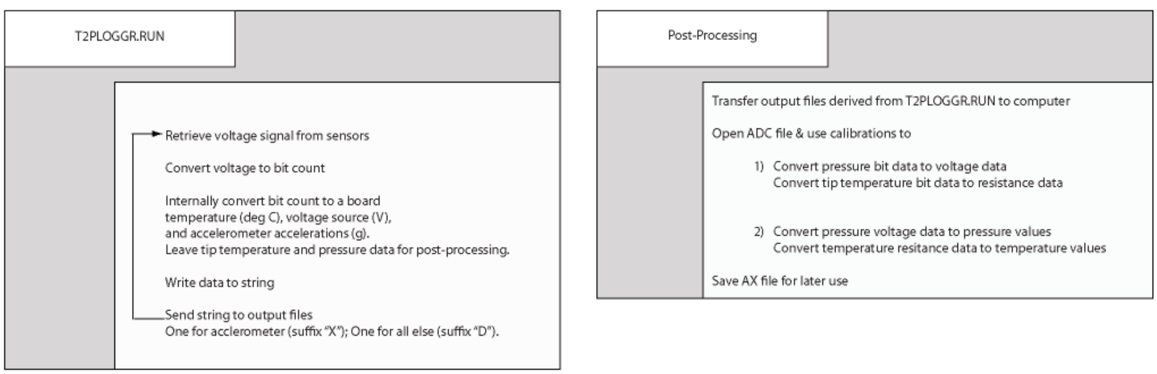


Figure 2: Flow Diagram for T2P Data Acquisition

PART 1:
CDAQ AND THE SOFTWARE

1.1. CDAQ & SOFTWARE OVERVIEW

The Integrated Ocean Drilling Program (IODP) built the CDAQ to be a flexible system for use with variable downhole tools and data types. For this reason, they included a generic code for a data logging program (IODP1D.run). That code was modified to interface with the two pressure transducers and one thermistor on the T2P. The CDAQ was also modified electrically. The user should become familiar with the physical CDAQ and the proper operation of the system as a data logging program (T2PLOGGR.run).

1.2. CDAQ DESCRIPTION

The CDAQ (Fig. 3) is composed of a Persistor, a voltage source, and a circuit board, which houses two analog-to-digital converters. The cable emanating from the 15-pin mdm connection can take many forms and serve different purposes. The cable is a necessary component for the utilization of the CDAQ, but is not truly a part of the system.

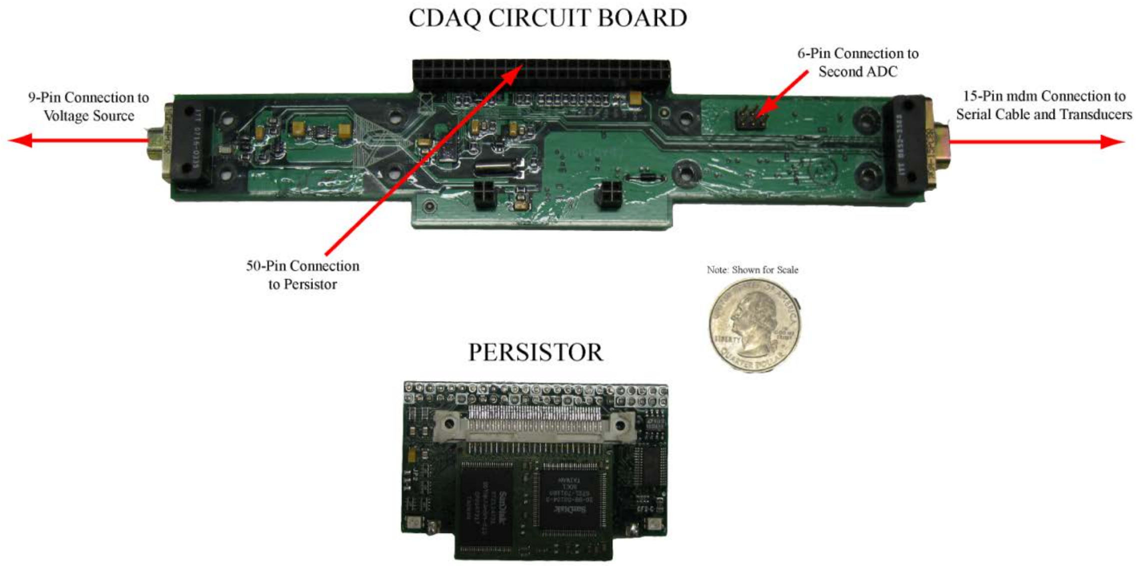


Figure 3: CDAQ System (voltage source excluded)

1.2.1. PERSISTOR

The Persistor is an open-market, single board computer (www.persistor.com). It contains a flash memory card for storage of executables and data files, a microprocessor for interface with peripherals, and the ability to execute programs. We use the CF-2 Persistor model with modifications made by the manufacturer. The flash cards were originally removable, but are now directly attached to the rest of the board because there are space constraints. The data logging program developed by UT, T2PLOGGR.run must be uploaded to any new Persistor purchased.

1.2.2. CIRCUIT BOARD

The circuit board for the CDAQ (Fig. 3) contains all the necessary wiring between peripheral components, the Persistor, and internal elements. The main components on this board are the ADC chips (see below), an accelerometer, and a low pass filter. The low pass filter is set to limit signal input in excess of ~52 kHz.

1.2.3. ANALOG-TO-DIGITAL CONVERTERS

The CDAQ contains two analog-to-digital converters labeled U5 and U7 (Appendix II). ADC-U5 is ratiometric by current for optimization of temperature data, while ADC-U7 is ratiometric by voltage. ADC-U7 is intended for use with analog transducers. Each chip has four channels. We use ADC-U5 for the tip thermistor, board thermistor, and battery voltage. We use ADC-U7 for the analog pressure transducers. During execution of the program T2PLOGGR.RUN, the ADC chips are cycled so that only the chip in use is powered, in order to limit noise effects.

1.2.4. CDAQ DATA CABLE

For connection to a PC, the user must attach a special data cable with a three-pin Fischer plug on one end and a female RS-232 connector. This RS-232 serial connector or a USB connection with an RS-232 adapter is the only connection capable of transmitting or receiving data from the CDAQ. The RS-232 cable is to be used for sending files, receiving files, and executing the provided software. The serial cable is best equipped to operate through the PC program Hyperterminal.

Hyperterminal is a standard windows program found in the communications section of the accessories drop down menu from the start menu (Section 1.3.3). Hyperterminal provides a DOS-like interface where the user is capable of typing commands and viewing program output. The serial cable must be connected to initiate the start of the provided software and to end the program. The program will continually run until the serial cable is connected, Hyperterminal is running and the correct command is provided.

1.2.5. VOLTAGE SOURCE

The intended voltage source for the CDAQ system is a 7.2V, 12AHr Lithium battery. However, the CDAQ has been proven to operate from a 9V battery, or from a 9V DC-regulated voltage source. At the start of the program, the battery voltage is checked, and a warning will prompt if the source is below 7.2V. The battery voltage dramatically and unpredictably decays at voltages below 7.2V. Data can be recovered upon loss of voltage, but we do not advise operation of batteries below this voltage threshold.

1.2.6. TRANSDUCERS

The logging program (T2PLOGGR.run) samples voltage data from one analog thermistor and two analog pressure transducers. The logging program utilizes analog-to-digital converters to convert voltage data to bit counts. The bit count data is written to an output file (Example output in Section 1.4), and later converted to pressure and temperature values via a post-processing program, T2PImport.xls, or in Excel.

1.3. OPERATION OF CDAQ

1.3.1. KEY COMPONENTS

- Persistor
- 9-Pin connection to voltage source
- 15-pin connection to serial cable and transducers
- Cable from 15-pin connection
- Circuit Board

1.3.2. ASSEMBLY OF COMPONENTS

1. Connect Persistor to 50-Pin connection on circuit board

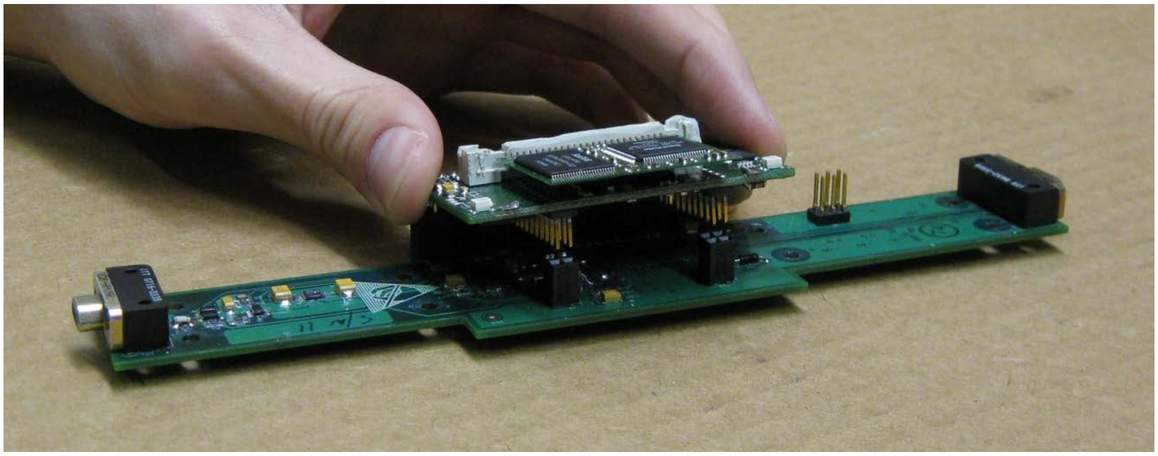


Figure 4: Persistor Insertion into CDAQ Circuit Board

2. Connect data cable to Fischer receptacle from Persistor
3. Connect RS-232 plug on data cable to computer serial port
4. Connect voltage source to electrical outlet, if applicable
5. Connect 9-pin voltage source to circuit board, if applicable

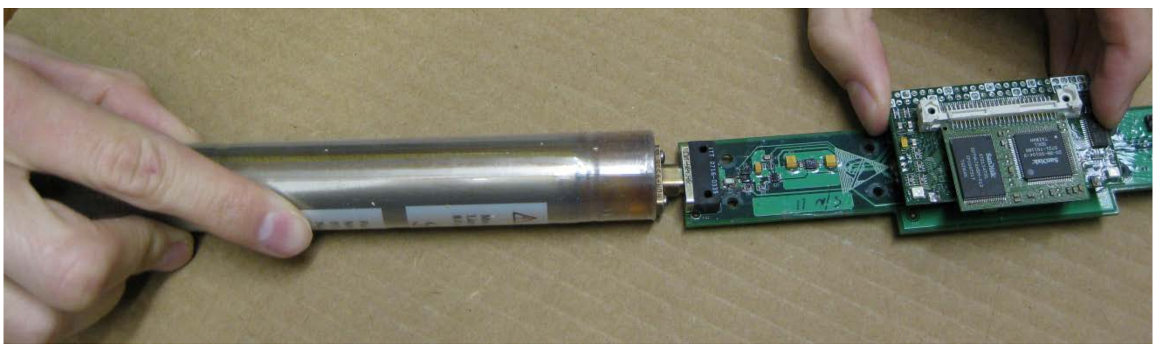


Figure 5: Battery Insertion into CDAQ Circuit Board

1.3.3. CONNECTION TO PC

(Please see Example in Section 1.5 for complete walk-through.)

1. Select Start->Accessories->Communications->Hyperterminal
   a. Provide connection name of your choice
   b. Select - COM1
   c. Select Baud Rate – 9600
   d. Select Data – 8
   e. Select Parity – None
   f. Select Stop Bits – 1
   g. Select Flow Control – None
2. If screen appears as (1) or (2), program operation is normal.

(1)
```
C :\>
```

(2)
```
----------------------------------------------------------------
  Persistor CF21M   SN 07458    PicoDOS V4.03r1      PBM V4.03
  (C) 1998-2007 Persistor Instruments Inc. - www.persistor.com
----------------------------------------------------------------
C :\>
```

3. If program operation is not normal, start a new connection with a different COM selected.

1.3.4. HYPERTERMINAL COMMANDS

Hyperterminal is a command based interface mounted on all windows operating systems (with the exception of windows 7. See web tutorials for obtaining Hyperterminal). There are similar programs on Linux and Mac machines that can be downloaded. Additional information on the program can be found here: http://technet.microsoft.com/en-us/library/cc780754(WS.10).aspx. Hyperterminal when used with the Persistor utilizes the Pico-Dos command prompt (Fig. 6). For information on all the available commands, please reference a Persistor manual (www.persistor.com). The most important commands are listed below. The arrows “<>” contain user typed input. [ENTER] and [SPACE] represent hitting the ENTER and SPACE keys.

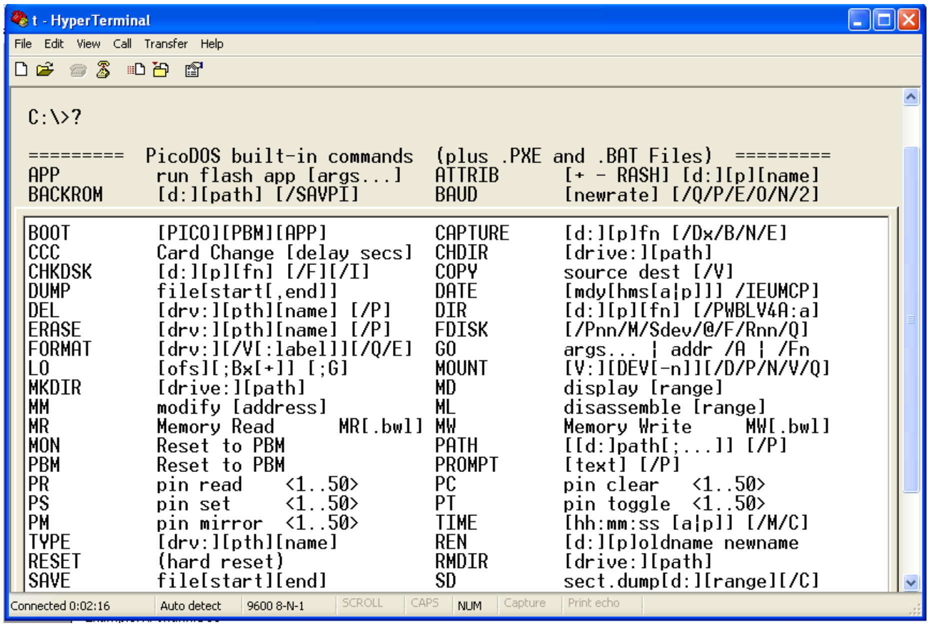


Figure 6: Command-Based PicoDos System

Command	Description
<DIR>[ENTER]	This command will bring up the directory of the flash memory on the Persistor. All transferred programs and data files should be visible with this command. The available and used memory should also be visible.
<DEL>[SPACE]<FILENAME>	This command will permanently delete the selected file from the Persistor memory.
<YS>[SPACE]<FILENAME>	This command will send a file on the Persistor to the PC. After typing this command, Select ‘Transfer’ then ‘Receive File’ in the top toolbar. From the dialog box, Select ‘Browse’ and choose where you want to place the received file. Select ‘Ymodem’ as receiving protocol, then select ‘Receive’. A dialog box will prompt you for a filename then click OK. If you did not do this in the allocated time you will get a ‘Failed’ message and will have to repeat procedure, a little quicker next time. The file transfer dialog box will provide detail on file transfer and when successful, Persistor will send a ‘Complete’ message.
<YR>[ENTER]	This command will enable the Persistor to receive a file from the PC. This is the method for delivering executable files. After typing this command, Select ‘Transfer’ in the top toolbar, then select ‘Send file’. In dialog box, select ‘Browse’, locate file on PC, select ‘Ymodem’ as protocol, and then click ‘Send’. A Ymodem dialog box will open and display status of file transfer. A successful transfer will generate a ‘Complete’ response from Persistor. If you did not finish this process within the allocated time limit, then repeat the process, a little quicker this time.

<XXXX.RUN>[ENTER] — This command will execute a program present on the Persistor. Once an executable is initiated, the Persistor commands are no longer valid and the running program has all control.

1.4. LOGGING PROGRAM: T2PLOGGR.RUN

The logging program for the T2P described below retains much of the original IODP format. The changes made to the internal program are documented in Section 1.8, and a lengthy walk-through of the program is presented in Section 1.5. What follows below is a simple introduction to the program, and description of the available commands.

Once the program is initiated through Hyperterminal, a series of routines begins and the Persistor is capable of controlling all connected peripherals. The initial display is shown below.

1.4.1. PROGRAM START

```
Program: T2PLOGGR.c: Nov 13 2009 18:24:46
Persistor CF2 SN:7458   BIOS:4.3   PicoDOS:4.3
Enabling Accelerometers
The CF-2 date and time are: 01/15/21  01:11:42
Are these values correct [Y] ? n
Enter date and time:  ? 11/13/2009 17:20:00
CF-2 time and date have been adjusted.
File Reference  ? Exp. 322
Output File ? Ex

CURRENT TIME AND DATE: 11/13/09  17:20:12
    PROGRAM VERSION: V1.0
LAST CALIBRATION DATE: 11/13/2009
     FILE REFERENCE: Exp. 322


Commands:
d :  Adjust date and time    e :  End Data Collection
s :  Start Data Collection   i :  Show system Information
p :  Play Back data          ? :  Show this command list
q :  Quit program
CMD:
```

1.4.2. USER COMMANDS

The program then allows for a set of user commands described below.

d: Adjust Date and Time.

You will be prompted for the new date and time setting for the CF-2 real time clock. You may press [Enter] if the displayed values are correct, or you may enter a new date and time in the following format. <mm/dd/yy>[SPACE]<HH:MM:SS>

s: Start Data Collection.

Acquisition will start and the program will display the file status and data in the following format:

```
Starting Data Collection
Opened adtemp.dat
Opened axtemp.dat
```

CMD:

```
17:42:45.04, 1327432.000   25.8    9.7 236914.000 140570.000
17:42:46.04, 1327215.000   25.8    9.7 234061.000 134140.000
17:42:47.04, 1327179.000   25.8    9.7 231393.000 127028.000
```

During collection the program displays the time, tip bit count, board temperature, battery voltage, and bit counts on two channels of U7.

e: End Data Collection.

This command stops data collection and closes the temporary files. If this command is not properly performed, all data from logging session is unavailable.

i: Show System Information

This will show you some information about the system.

CURRENT TIME AND DATE: 11/16/07 16:30:08
PROGRAM VERSION: V1.00
FILE REFERENCE: Site 10TN-3 Hole 1275A

q: Quit Program

This command will cease program operation and return to Pico-Dos.

?: Show this command list

1.4.3. PROGRAM OUTPUT

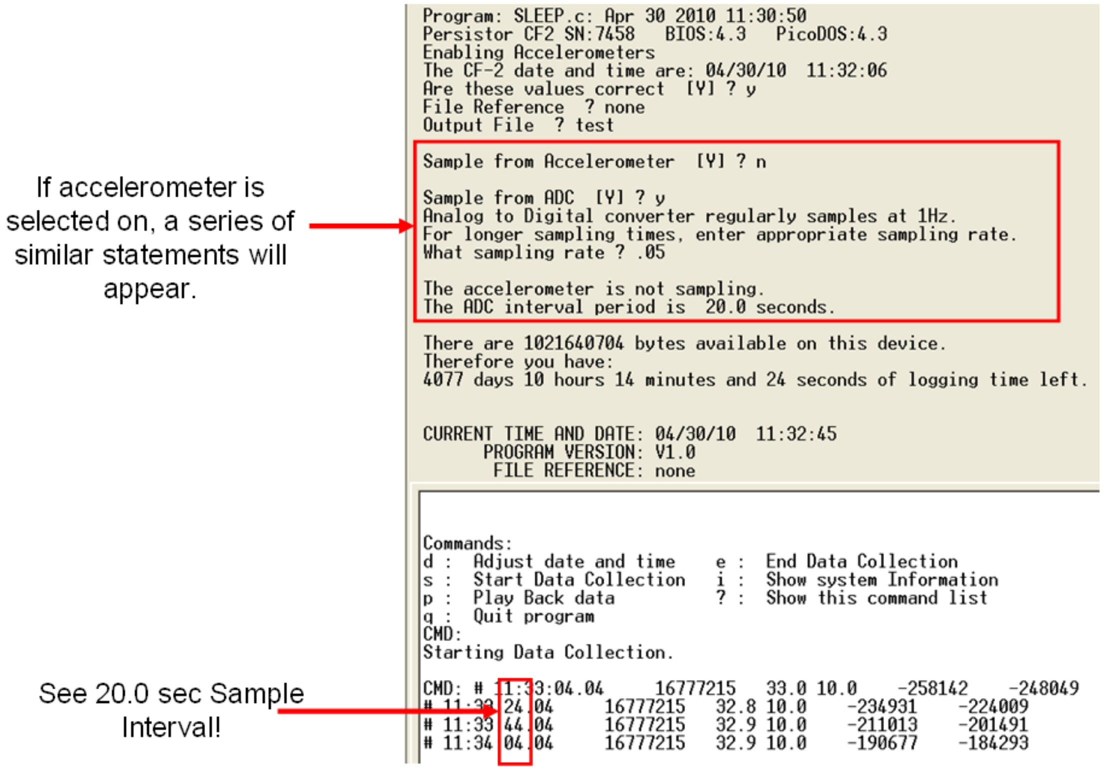
Once a file has been sent to the PC, it is an ordinary text file amenable to data manipulation or importation into various software applications. A typical output file looks like this:

```
ACQUISITION DATE:,,, 11/16/07
 CF-2 SERIAL NUMBER:,,, 7458
 PROGRAM VERSION:,,, V1.0
 LAST CALIBRATION DATE:,,, 11/16/2009
 FILE REFERENCE:,,, Site 10TN-3 Hole 1275A


 GMT TIME, Tip Value, Brd Temp, Batt Volts, U7-Ch. 1, U7-Ch. 2,
 HH:MM:SS  , Counts,  deg C , Volts ,  Counts,   Counts,
 17:42:45.04, 1327432.000   25.8    9.7 236914.000 140570.000
 17:42:46.04, 1327215.000   25.8    9.7 234061.000 134140.000
 17:42:47.04, 1327179.000   25.8    9.7 231393.000 127028.000
 17:42:48.04, 1327138.000   25.8    9.7 228105.000 119980.000
 17:42:49.04, 1327079.000   25.8    9.7 224933.000 113279.000
 17:42:50.04, 1326998.000   25.8    9.7 223267.000 106152.000
 17:42:51.04, 1326900.000   25.8    9.7 221015.000  98966.000
 17:42:52.04, 1327058.000   25.8    9.7 220025.000  91120.000
```

1.4.4 LOGGING PROGRAM: **SLEEP.RUN**

The logging program SLEEP.RUN functions identically to the previous program, T2PLOGGR.RUN with one significant difference. In this logging program, the user is given the option to initiate sampling from the ADC and also the accelerometer. If the user elects to sample from either of the two, they are then given the option to specify a sampling rate below 1 Hz (the standard rate). A sample section with the altered portions highlighted below.

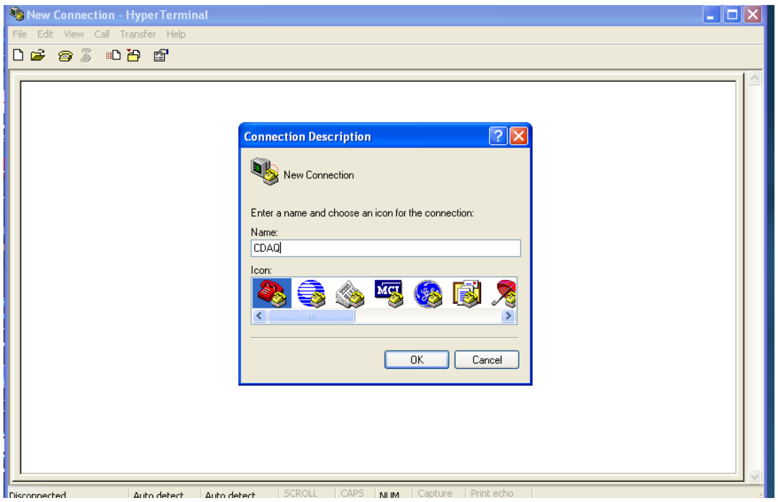


This program is intended to be run when the user is not interested in dynamic pressure effects and might be concerned about memory usage. Such a situation might be a saturated probe sitting shipboard. The user might monitor the water pressure, looking for subtle changes, or perhaps battery decay.

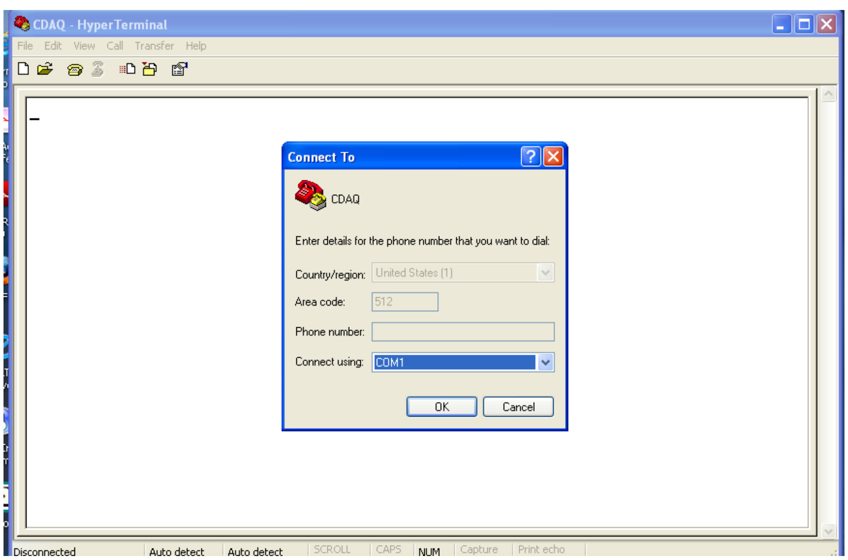
1.5. EXAMPLE OF LOGGING SESSION

The following set of steps is presented to provide a complete walkthrough of the data acquisition process. This example may be helpful for first time use, but does not provide any new information. All relevant information on the operation of the CDAQ system can be found elsewhere in this manual.

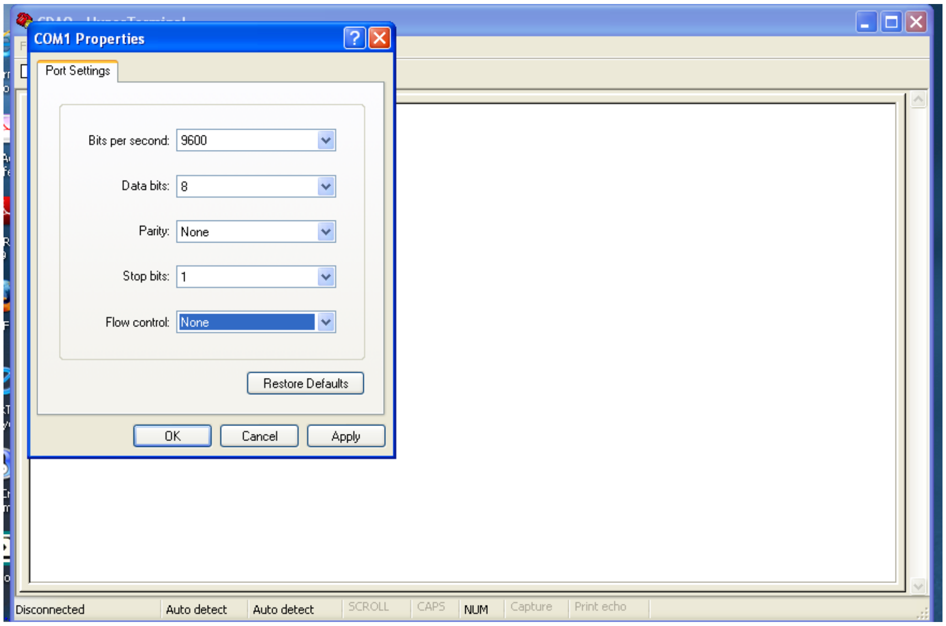
1. Open Hyperterminal from Start→All Programs→Communications→Hyperterminal. Then provide a name for the connection (this is completely arbitrary).



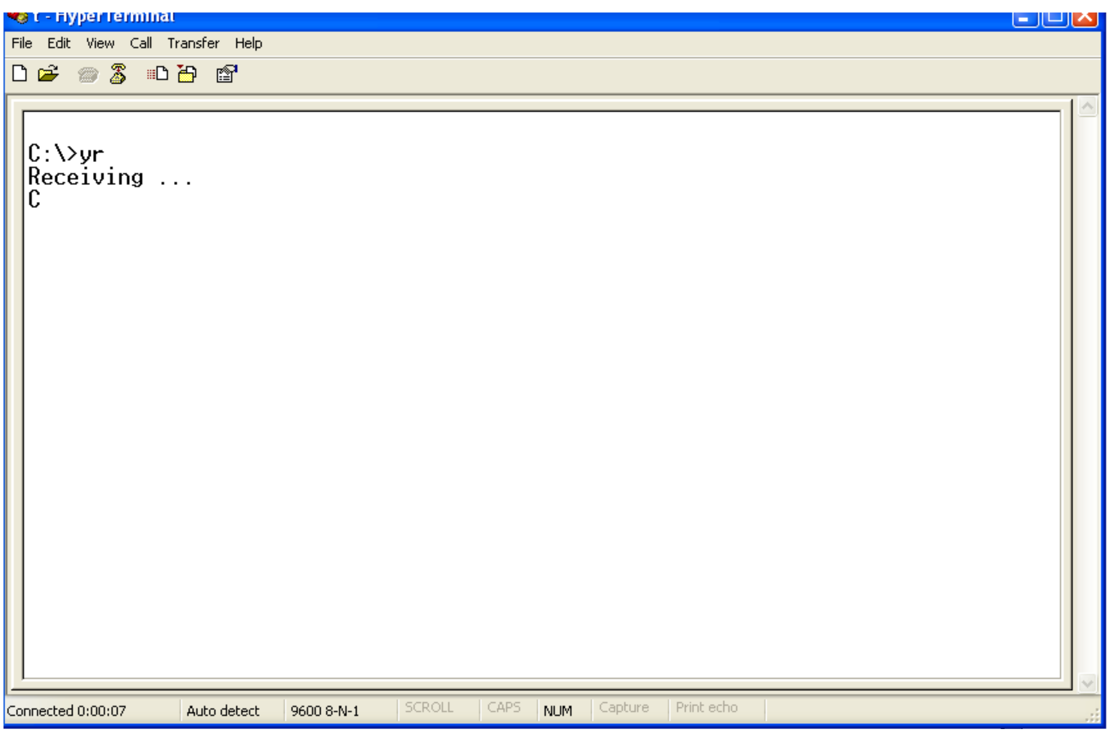
2. Select the port on the computer your CDAQ is attached to. This is typically COM1 by default, but may be different, especially if a serial to USB connector is being used.



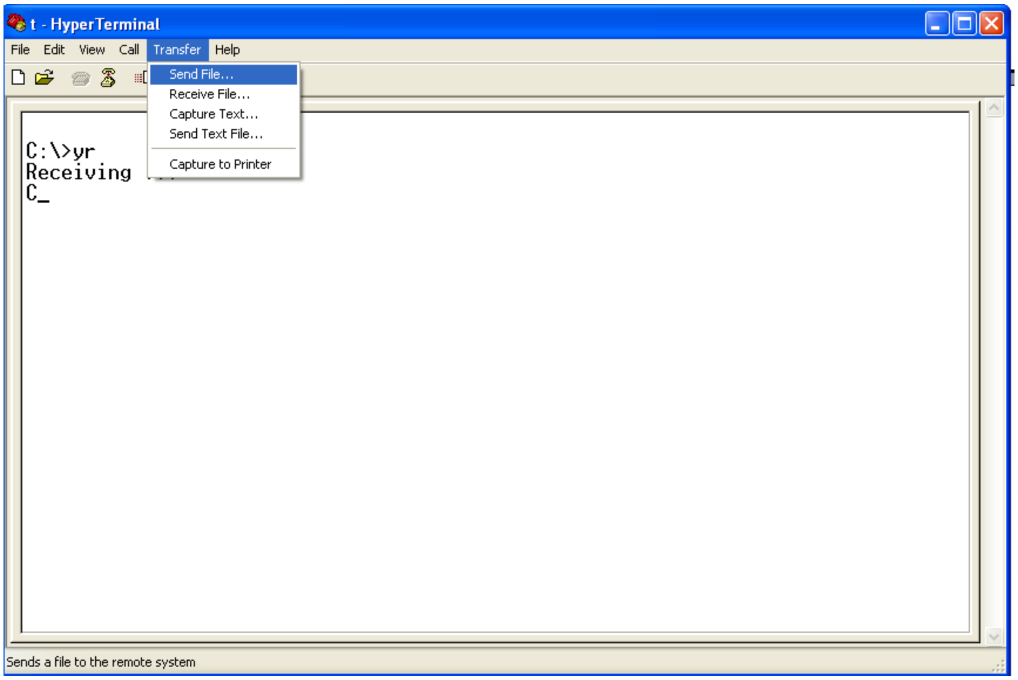
3. Apply the following connection settings.



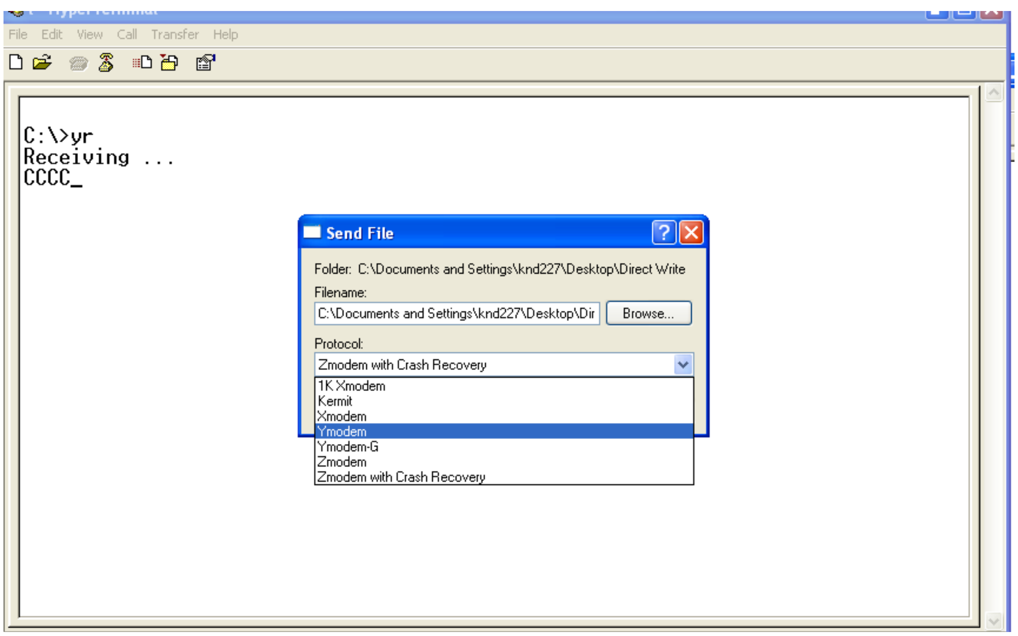
4. Persistor is operational when hitting [ENTER] returns the C:\> prompt.
To upload logging program type <yr> to receive file on Persistor. Otherwise, proceed to step 7.



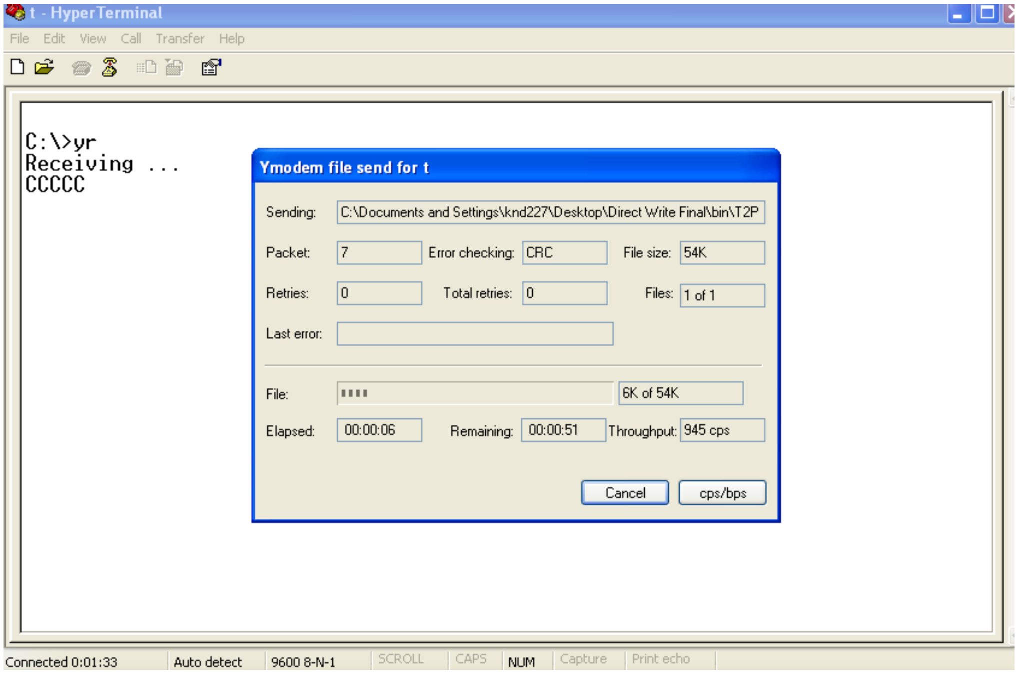
5. The file is ready to be received, but still requires action form the user. Once the transaction has started, click on the transfer toolbar, and then Send File from the pull down menu.



6. Browse to the desired destination for the executable and select “Ymodem” as the receiving protocol.

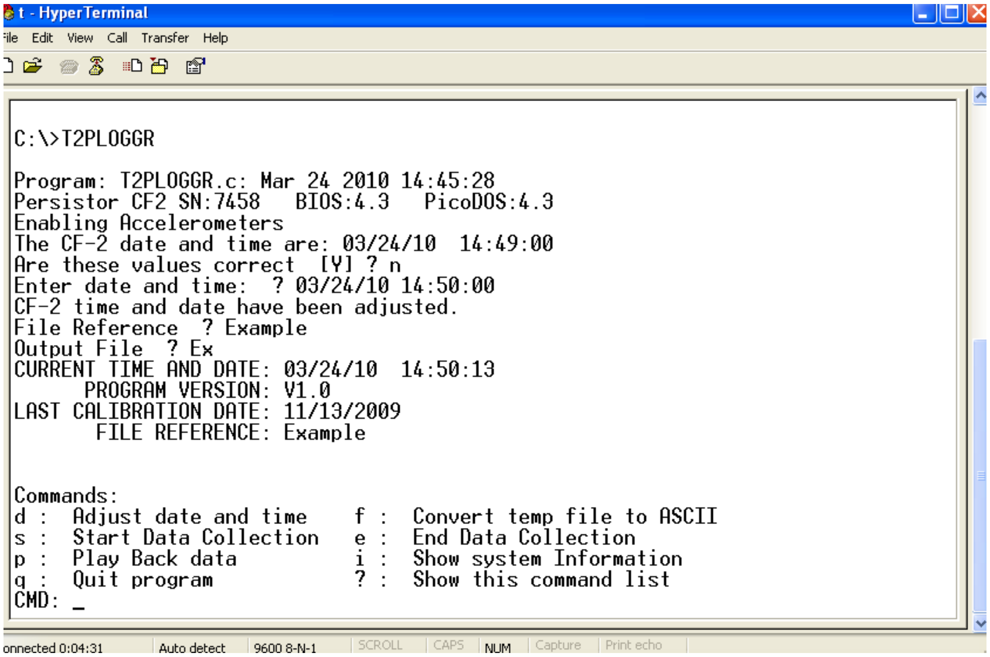


6. A dialog will pop up displaying the progress of the transaction.

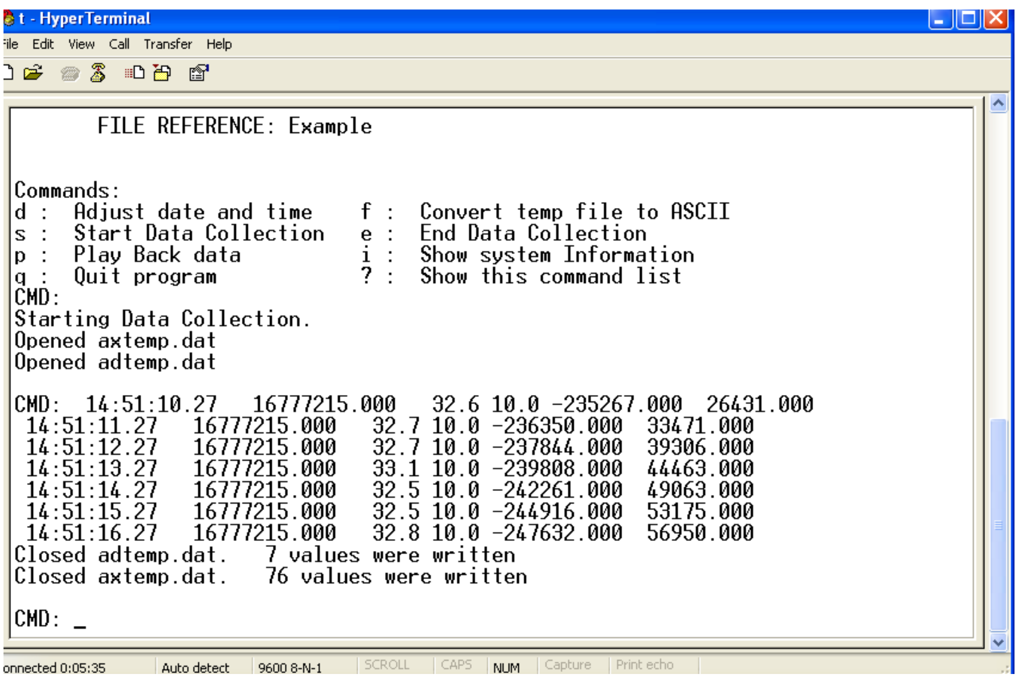


7. The program for logging data is then entered <T2PLOGGR> and the program is initiated.
Type <N> if a new time must be established. Type the new time and date in this form: <mm/dd/yy>[SPACE]<HH:MM:SS>
Type a File Reference of your choosing. This file reference will be displayed on the output file, and may be used for determining the contents of a file or specifying a description of the subsequent file.
Type an output file name of your choosing (limit to 7 characters).

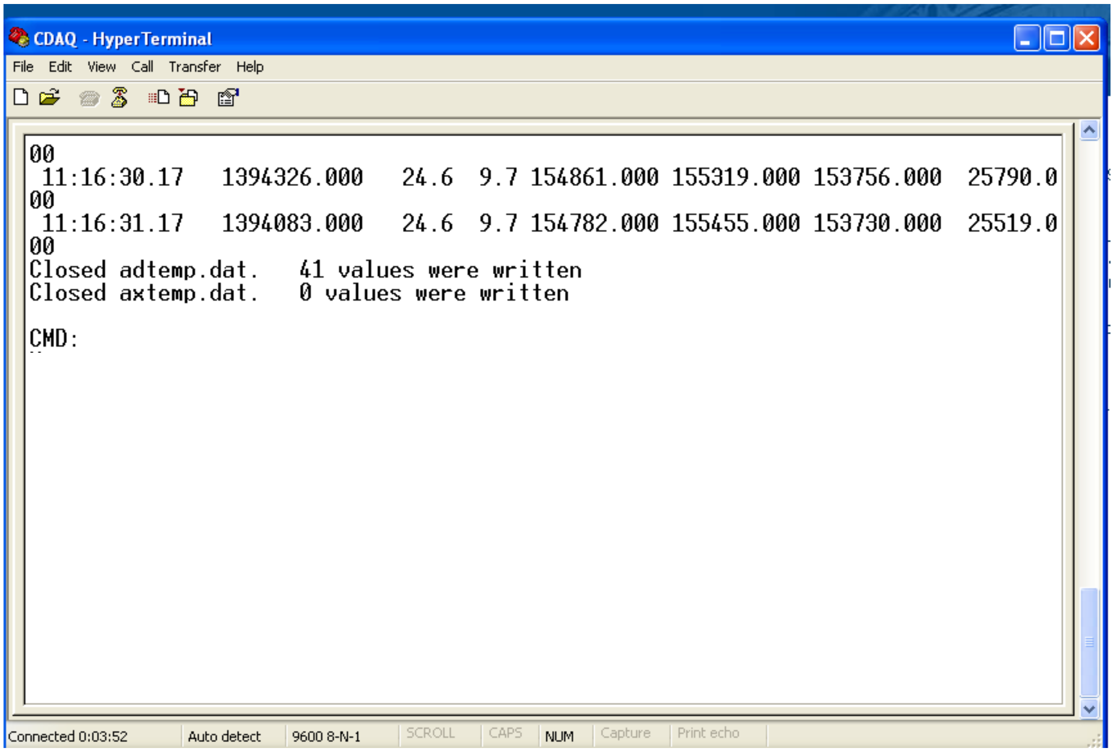
Warning: If you make a mistake, hit [BACKSPACE]. Use of the arrow key, will crash T2PLOGGR.run and return user to PICO-DOS. If T2PLOGGR.run crashes, simply restart it



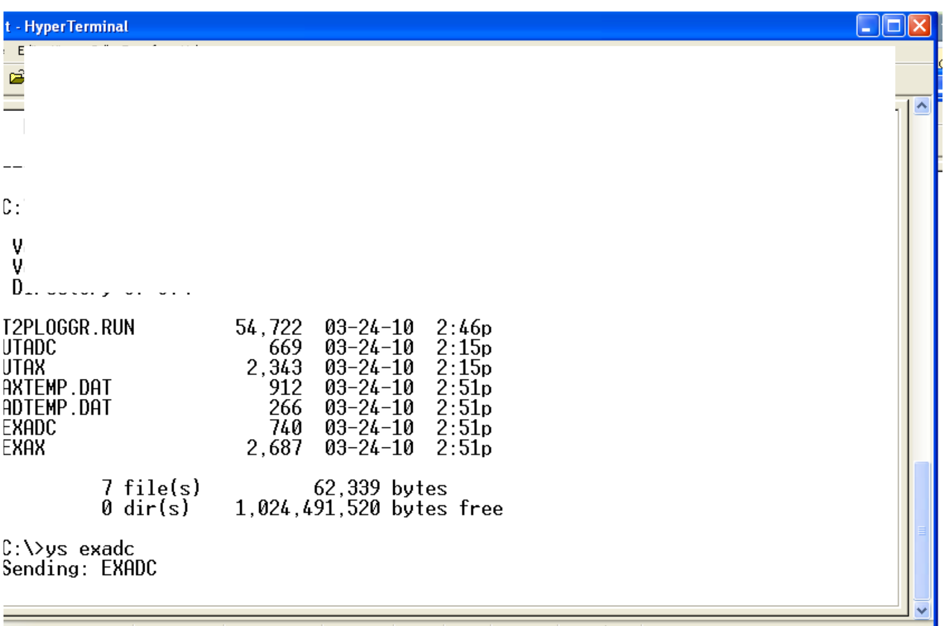
8. The <S> command starts data logging.
The column headers are removed, but will appear in the data file.
Once logging starts two files are created of the name given with suffixes x and d.
The x file contains accelerometer data and the d file contains all else.



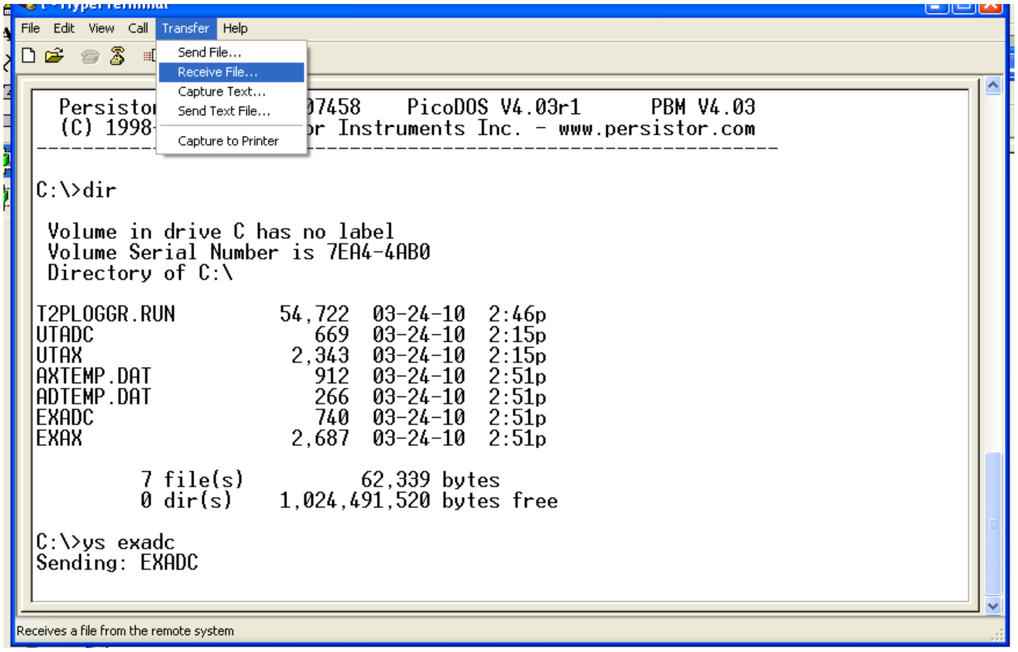
9. The <E> command will stop the logging session.



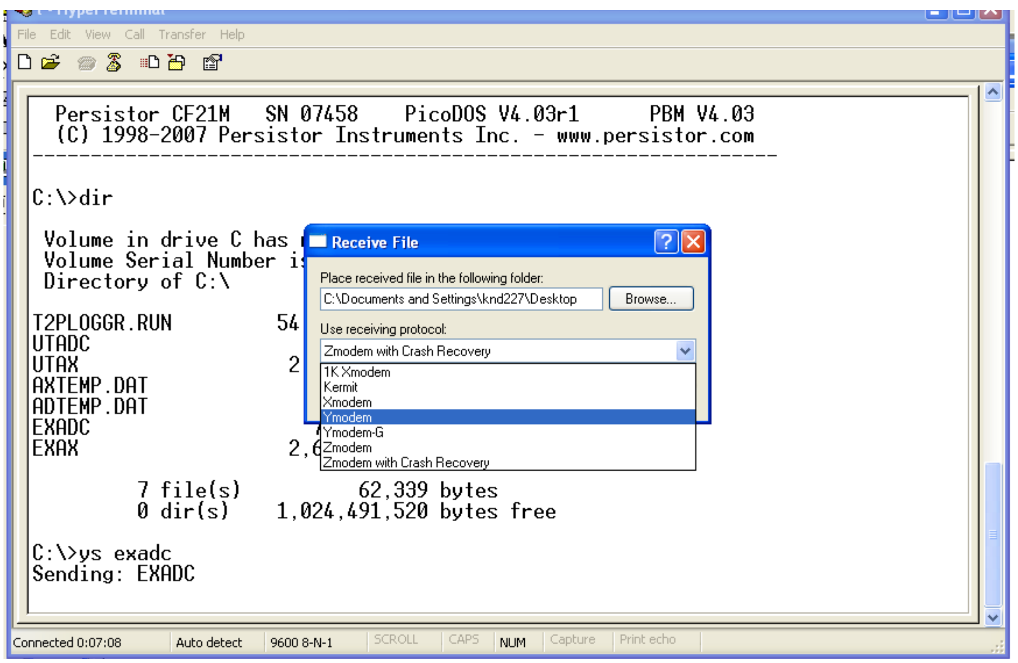
10. A <Q> command will end the logging program and return to the Persistor main screen.
From this point, the logging program can be restarted or the created files can be sent to the host computer.
To re-run T2PLOGGR, proceed to step 4.
To display all the files on the disk type <DIR>
To send the created file, type <YS>[SPACE]<Name of File>



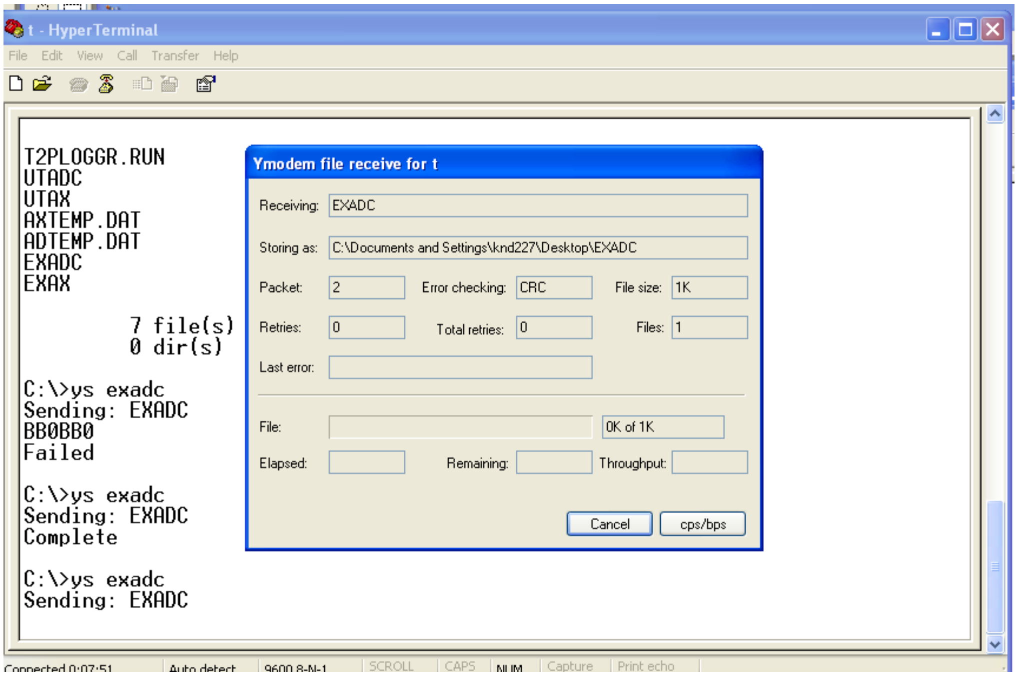
11. The file is ready to be sent, but still requires action form the user. Once the transaction has started, click on the transfer toolbar, and then Receive File from the pull down menu.



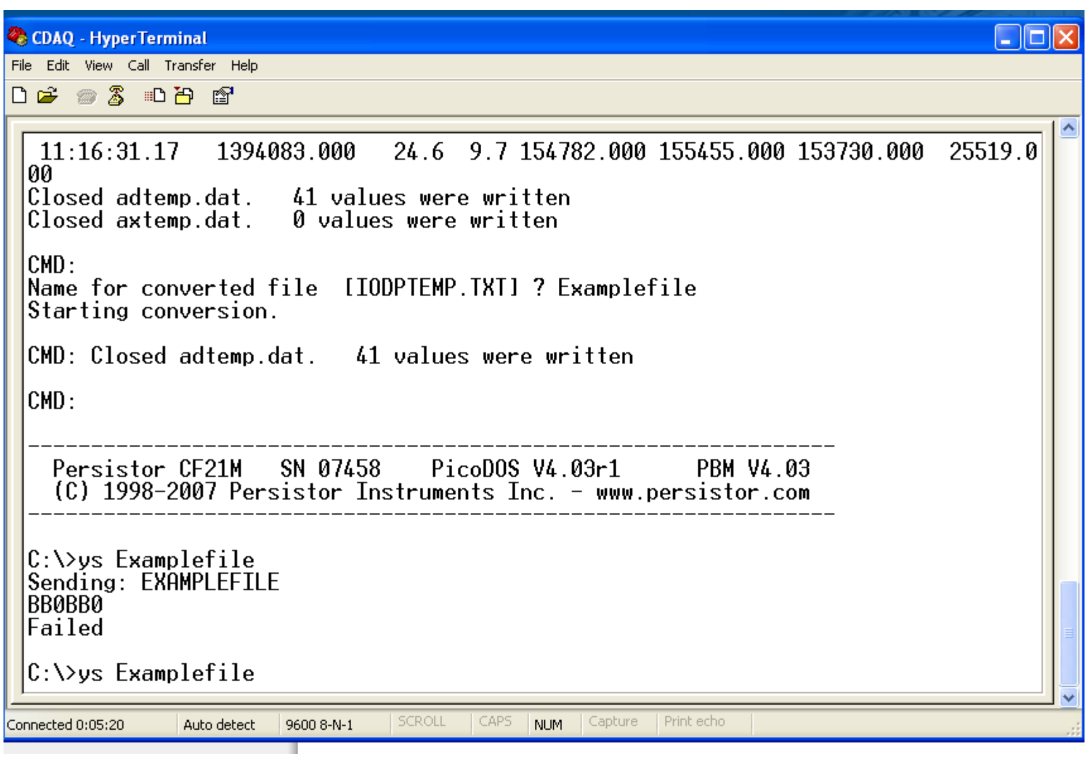
12. Browse to the desired destination for the sent file and select "Ymodem" as the receiving protocol.



13. A dialog will pop up displaying the progress of the transaction.



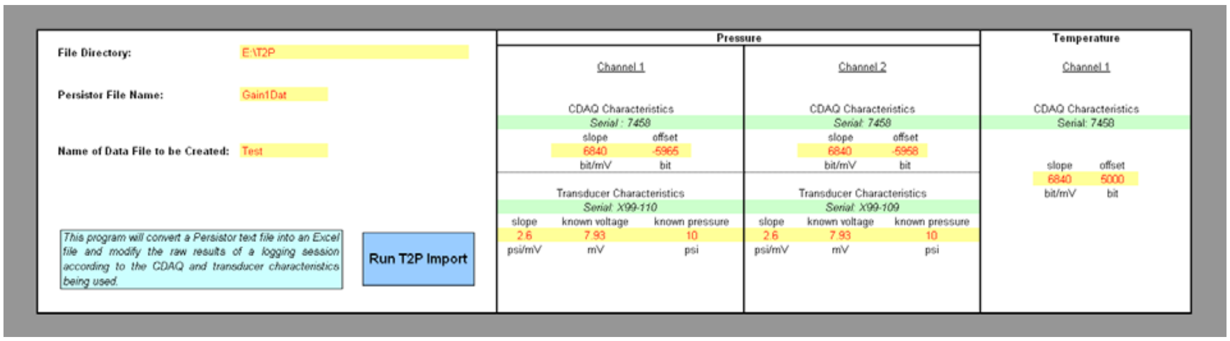
14. If the entire clicking process is not completed during the allotted time window, the transaction will cease and a failed message will be displayed. Please return to step 9 and perform the process quicker.



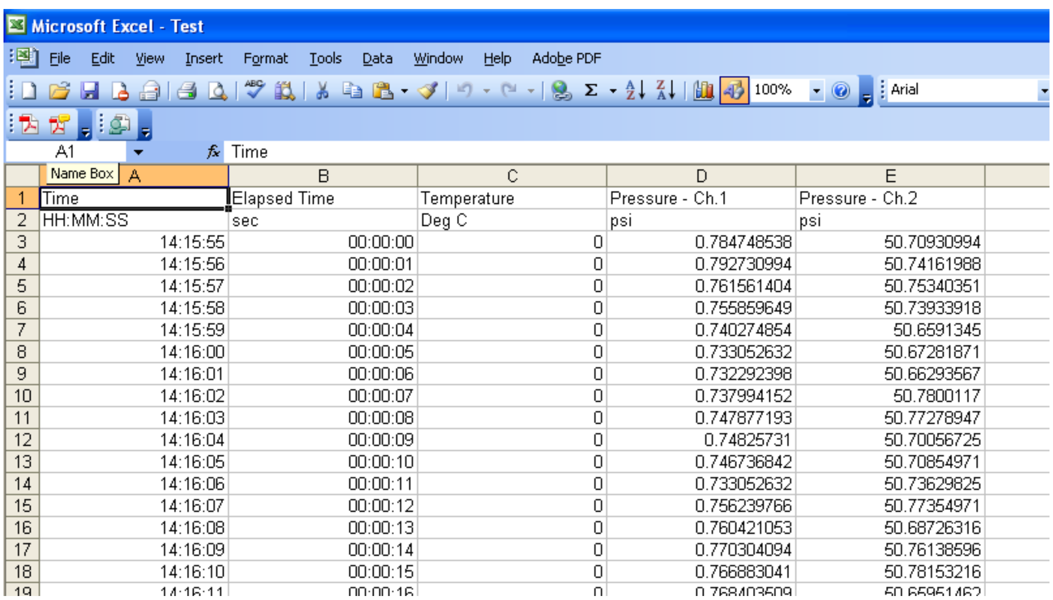
15. The CDAQ data cable can be removed from the host computer or the CDAQ at any time. It will neither harm the logging session, nor terminate the session. The CDAQ will cease logging if the power is disconnected, but logging to this point will be retained. It is safest to disconnect power at the PICO-DOS screen or when the user sees: “C:\>”.

16. To view the file, first navigate to the directory specified during the HyperTerminal transmission. Then open the files using a simple text editing program like WordPad.

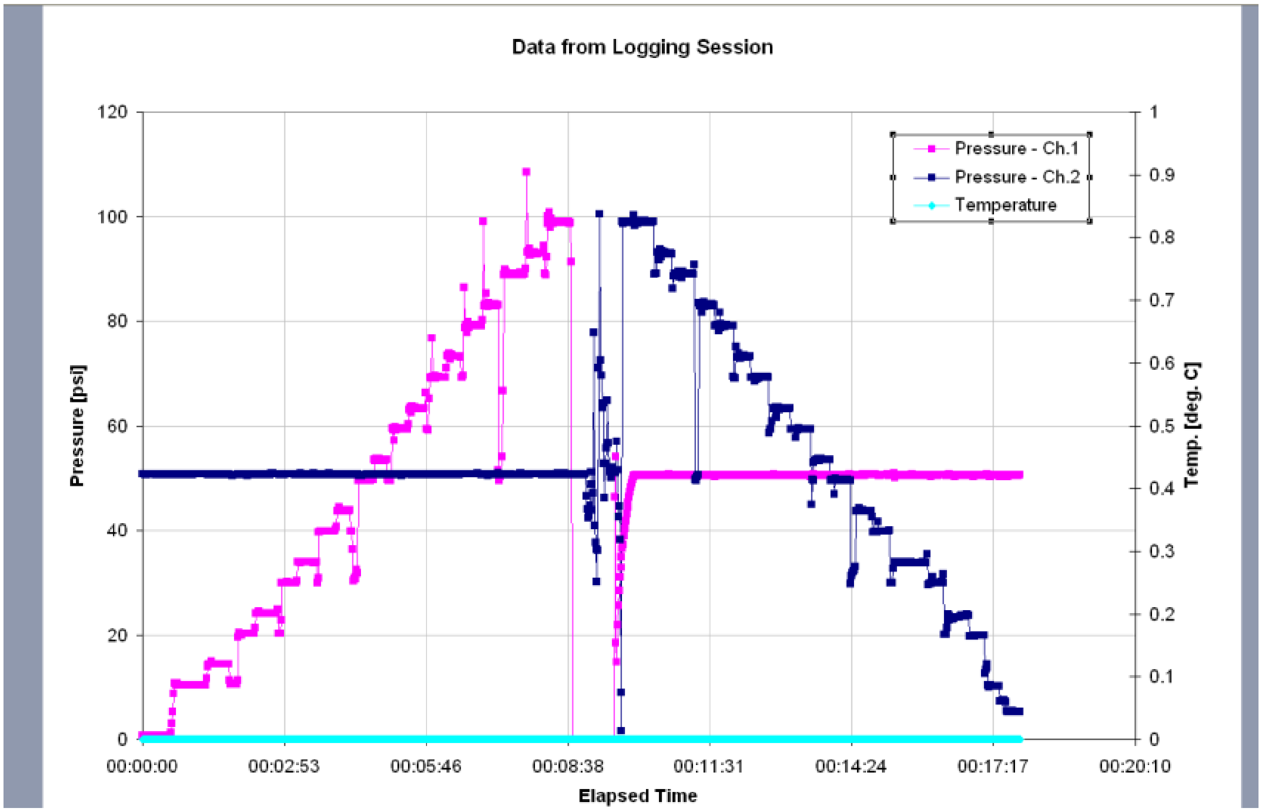
17. Once the file is on the host computer, it can be manipulated or processed like any standard data file. However, we have developed a simple script to convert the data into an excel file. The file is called T2PImport.xls, and is shown below. The script allows for adjustment of calibrations. The user must direct the script to the appropriate directory, provide the file name, and the name of the new excel file. The excel file will be created in the same directory.



18. Typical spreadsheet and graphic output is shown below.



	A	B	C	D	E
1	Time	Elapsed Time	Temperature	Pressure - Ch.1	Pressure - Ch.2
2	HH:MM:SS	sec	Deg C	psi	psi
3	14:15:55	00:00:00	0	0.784748538	50.70930994
4	14:15:56	00:00:01	0	0.792730994	50.74161988
5	14:15:57	00:00:02	0	0.761561404	50.75340351
6	14:15:58	00:00:03	0	0.755859649	50.73933918
7	14:15:59	00:00:04	0	0.740274854	50.6591345
8	14:16:00	00:00:05	0	0.733052632	50.67281871
9	14:16:01	00:00:06	0	0.732292398	50.66293567
10	14:16:02	00:00:07	0	0.737994152	50.7800117
11	14:16:03	00:00:08	0	0.747877193	50.77278947
12	14:16:04	00:00:09	0	0.74825731	50.70056725
13	14:16:05	00:00:10	0	0.746736842	50.70854971
14	14:16:06	00:00:11	0	0.733052632	50.73629825
15	14:16:07	00:00:12	0	0.756239766	50.77354971
16	14:16:08	00:00:13	0	0.760421053	50.68726316
17	14:16:09	00:00:14	0	0.770304094	50.76138596
18	14:16:10	00:00:15	0	0.766883041	50.78153216
19	14:16:11	00:00:16	0	0.768403509	50.65951462


Data from Logging Session
Pressure - Ch.1
Pressure - Ch.2
Temperature
Pressure [psi]
Temp. [deg. C]
Elapsed Time
120
100
80
60
40
20
0
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
00:00:00
00:02:53
00:05:46
00:08:38
00:11:31
00:14:24
00:17:17
00:20:10

1.6. CALIBRATION

Calibration of the CDAQ is composed of three parts. There is a calibration of the analog-to-digital converters, a calibration on the CDAQ bit count output, and a calibration on the transducers used. Each type of calibration will be addressed separately.

Calibration of internal components can only be performed with the CDAQ Calibration Box. The remaining two calibrations could be combined into one. We choose to calibrate voltage to bit (CDAQ calibration) and then voltage to psi (transducer calibration) to maintain a general flexibility among CDAQ's, channels, and transducers. As an alternative, one could calibrate psi to bit for a particular channel on a specific CDAQ. This combined method produces similar results as the direct method. The difference is primarily in the offset, with the example below being a 5 psi difference or 5% over the 100 psi range. This difference can be avoided with pre-deployment zeroing exercises like the response check.

The case is presented for the Transducer # 7648 below:

Calibration Equation with CDAQ connected (CDAQ#14 in Ch.1), converting Bit Count to PSI (Direct Method):

PSI = 3.5112e-3*Bit + 79.4

Calibration Equations as separate components (Combined Method):

PSI = 12.28*mV + 65.7 (Transducer) AND Bit = 3427.81*mV – 2699.87 (CDAQ Bit Output)

=> PSI = 3.5836e-3*Bit + 75.4

1.6.1. CALIBRATION OF INTERNAL COMPONENTS

The logging program, T2PLOGGR.run has gain=1. Implementation of gain would match the span of the reference voltage Vref of the ADC to the voltage range of the transducer being used. This is typically performed to improve resolution. This gain is not implemented in T2PLOGGR.run, and so the voltage difference on different channels is analyzed identically regardless of the transducer being used.
The logging program GAIN64.run is identical to T2PLOGGR.run except the gain on Channels 1 and 2 of U7 (ADC 2 i.e. the pressure channels) has been set to 64. Likewise GAIN32.run has gain=32.

1.6.2. CALIBRATION OF CDAQ BIT OUTPUT

Pressure Channels

The CDAQ calibration was performed in the following manner. A known voltage was applied to the channel under test while running the logging program. After maintaining the voltage for twenty seconds while the logging program recorded bit counts, the voltage was adjusted to the next value and the process repeated, until a range of voltages corresponding to transducer output was covered. The twenty readings over each twenty second window were averaged as a single bit count value. A total of ten values were obtained and plotted against their corresponding voltage values. We performed a linear regression on the data to develop EQ-1.

Bit Count = Slope * Voltage [mV] + Offset [EQ – 1]

Temperature Channel

Calibration of the thermistor-dedicated channel differed in only one significant way. Instead of monitoring the voltage across the channel, the resistance was monitored. A linear regression was again performed on the data.

Bit Count = Slope * Resistance [kOhms] + Offset [EQ – 2]

An alternative method of CDAQ calibration is used by IODP. The method involves a calibration box and software interface for instituting strict linear models at the Analog to Digital converter level.

Table 1: CDAQ Calibrations

CDAQ Serial #	ADC Channel #	Slope	Offset	R^2
11	U7-1	3418.01 Bit/mV	-2876.29 Bit	0.99999995
11	U7-2	3418.54 Bit/mV	-2856.57 Bit	0.99999996
11	U5-2	122195.288 Bit/kOhms	-1722.17 Bit	0.999998
13	U7-1	3427.96 Bit/mV	-1755.59 Bit	0.999991
13	U7-2	3428.274 Bit/mV	-1730.4 Bit	0.99999
13	U5-2	121997.08 Bit/kOhms	-1474.9 Bit	0.999997
14	U7-1	3427.81 Bit/mV	-2699.87 Bit	0.99999998
14	U7-2	3428.35 Bit/mV	-2693.04 Bit	0.99999998
14	U5-2	122275.63 Bit/kOhms	-2543.69 Bit	0.999998

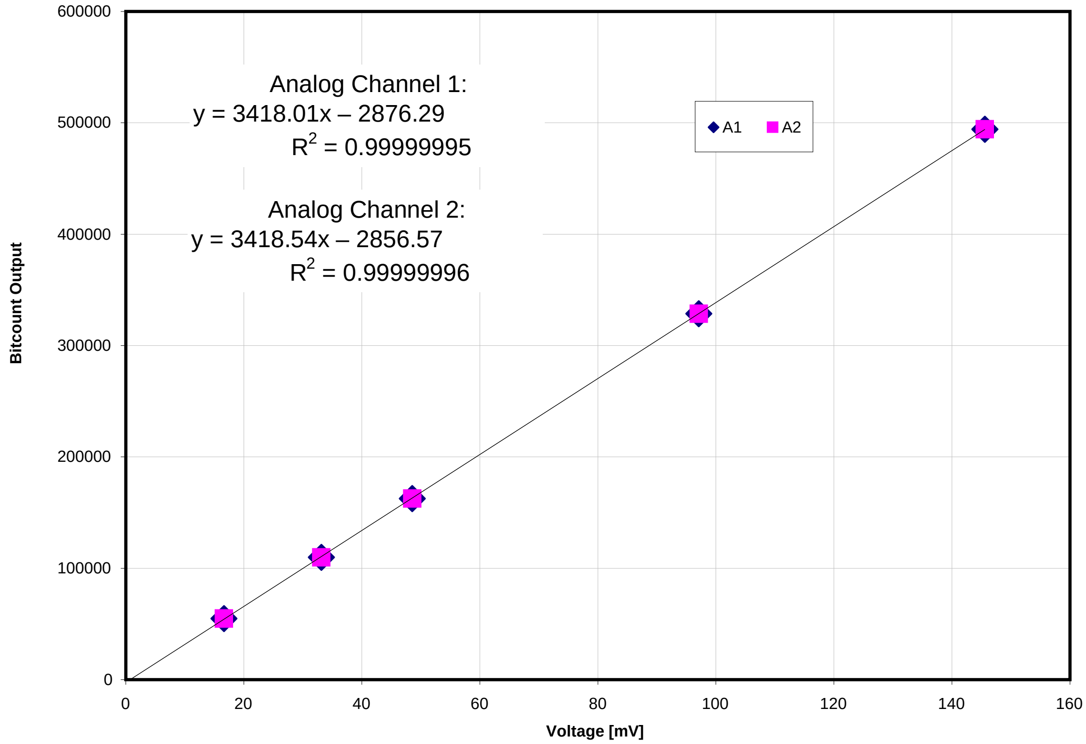


Figure 7: Voltage to Bit Count Mapping for ADC – U7 (S/N #11)
Channels are labeled A1-A2 to denote analog.

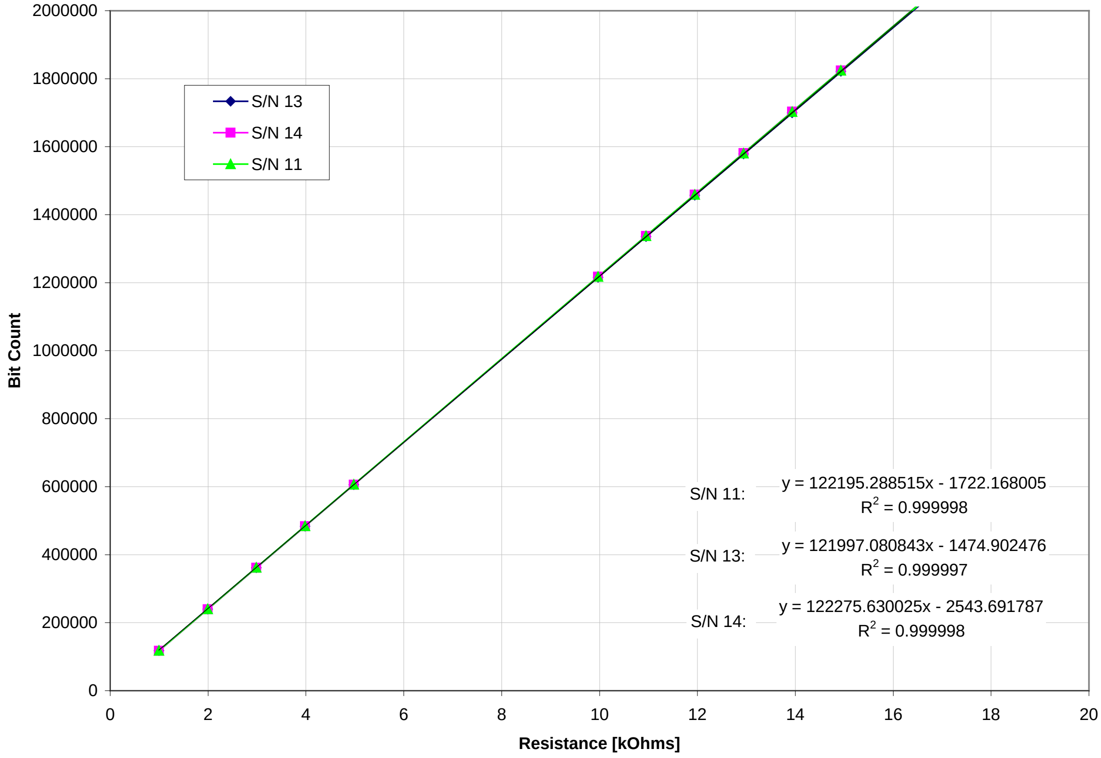


Figure 8: Resistance to Bit Count mapping for Channel 2 of ADC – U5

1.6.3. CALIBRATION OF TRANSDUCERS

The last calibration step in the data acquisition process is to develop a conversion from voltage/resistance to a scientific unit of measurement (PSI, Deg. C). This calibration step will be unique for every transducer used and the preference of the user. The user should consult the manufacturer of the transducer in operation, but as an example we present our pressure transducer calibration process.

For this task, a dead weight tester was used. The 200 psi transducer was connected to the dead weight tester (http://www.ametekcalibration.com/UK/Products/Pressure_calibrators.aspx?ProductID=PROD108&m=ecom_catalog). The dead weight tester utilizes a series of weights to generate the desired pressures on the transducer. The initial pressure was applied and the voltage output from the transducer recorded. Then additional weight was applied to the system creating a new pressure and the resulting voltage was recorded. This process was followed from 10psi-100psi in increments of 10 psi ascending and descending. A linear regression analysis was performed on each transducer's data. It is recommended that this task be performed with any new transducer to be used with the CDAQ.

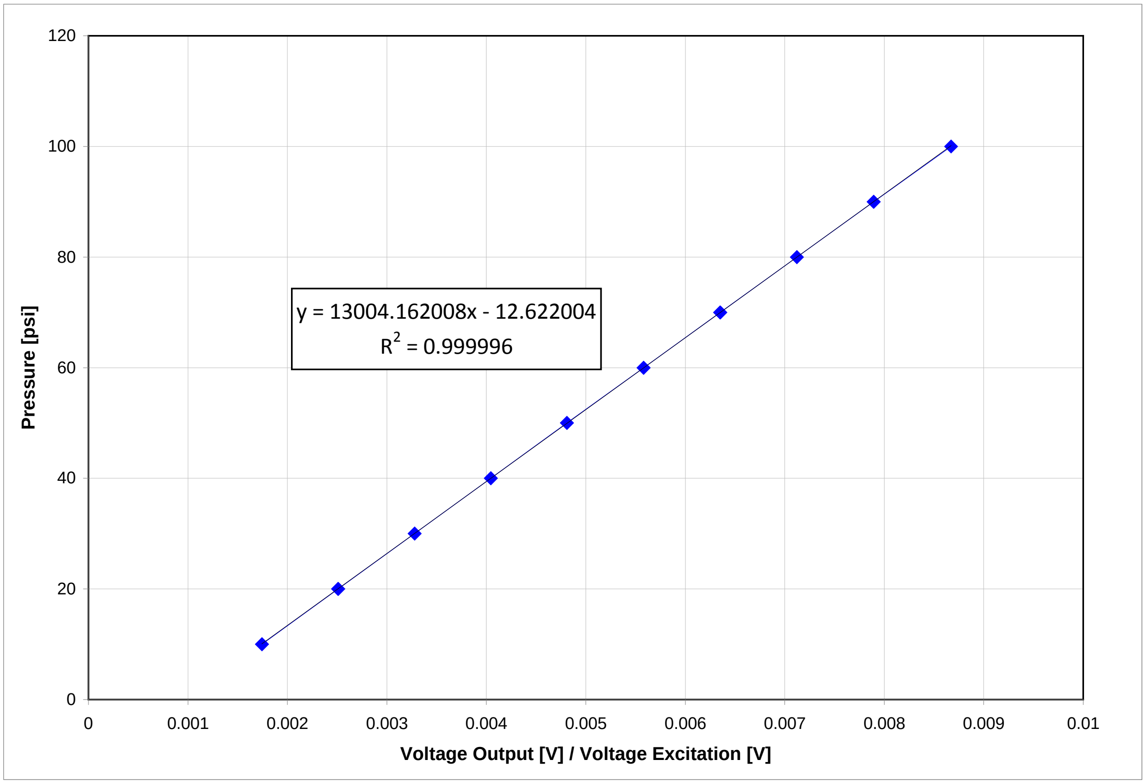
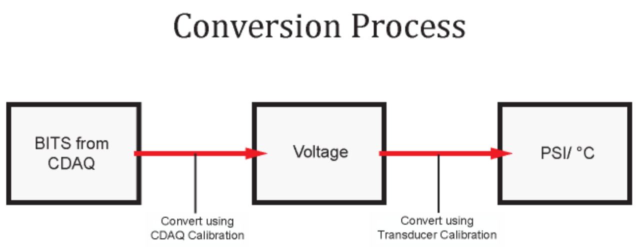


Figure 9: Example Calibration for Pressure Transducer X82-71

1.7. POST-PROCESSING OF DATA



To accomplish the final conversions of data to scientific units of measurement (PSI, Deg. C), an Excel script was created (T2PImport.xls). The script takes a space and comma delimited text file produced from the logging program (T2PLOGGR.run), then uses the calibration factors determined in Sections 1.6 to output temperature and pressure data. The file version of the data is displayed in a tabular and graphical form as part of the excel file. Other forms of data processing could be performed on the data file; the user need only determine the calibration factors to perform a successful conversion.

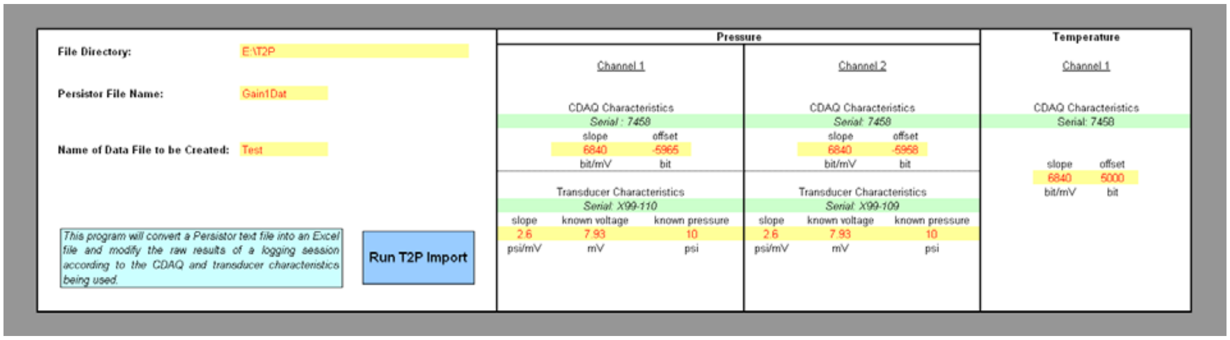


Figure 10: Screen Shot of T2P Post-Processing Script

1.8. ELECTRICAL MODIFICATIONS

According to the original IODP electrical schematic (Appendix II), the 15-pin mdm (Micro-miniature D Metal Sub connector) connection contained wiring for a dedicated thermistor on Ch.2-U5 and a standard channel from each of the ADCs (Ch.3-U5, Ch.1-U7). The remaining two channels on ADC U5 were unavailable for use, as they were already dedicated to the monitoring of the circuit board temperature and the battery voltage. The remaining three channels on the ADC U7 could be made available through connection on the 6-pin header (J4) of the circuit board (Fig. 3).

Sampling of the analog pressure transducers is performed by ADC U7. Space constraints on the inside of the T2P dictated that the 6-pin header not be utilized. Instead, the circuit was rewired so that Ch.2-U7 was accessible from the 15-pin mdm connection instead of the original Ch.3-U5.

The rewiring was accomplished by removal of the resistors, R16 and R19 (Fig. 11). Then, a jumper wire was soldered as to connect pins from the 6-pin header to the circuit going to the 15-pin mdm to Ch.3-U5 (Fig. 11). The combination of these steps effectively stopped the circuit from Ch.3-U5 to the mdm cable, and then re-routed the circuit from Ch.2 of the 6-pin header to the mdm 15-pin connection. These modifications enabled sampling from channels (1) and (2) of the ADC U7 with a single connection from the 15-pin mdm.

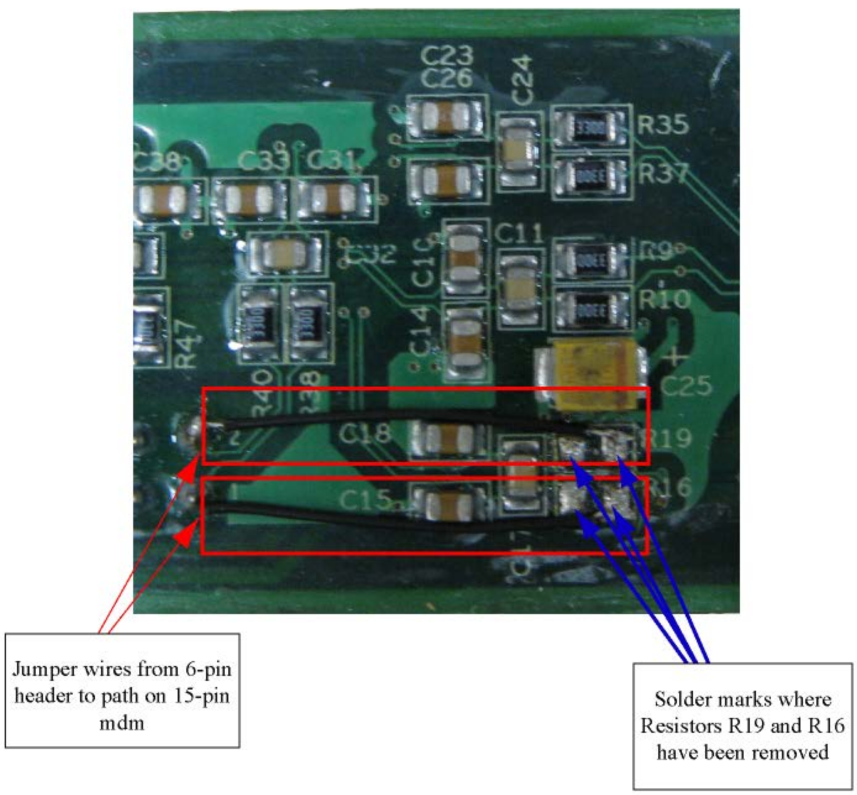


Figure 11: Backside of CDAQ Circuit Board showing Electrical Modifications

1.9. TEMPERATURE EFFECTS

In previous tools, temperature effects have played a role in the reliability of data. The lowering of temperature is believed to result in altered electrical characteristics and known to induce mechanical shrinking. As a means of understanding the specific temperature effects of the CDAQ a series of experiments were performed.

The experiment was designed to mimic the downhole environment of the tool. Therefore, a constant pressure was applied to a transducer by a long tubing system. The tubing, the transducer, and the CDAQ were all placed in a refrigerated room for a period of 15 minutes as the temperature approached 5 °C. The assembly was then removed from the refrigerator and allowed to reach room temperature. Several other experiments were performed, but this particular example characterized real conditions most approximately. Results of that experiment are presented below as Figure 12.

As determination of the temperature dependence, a linear regression was performed on the tip temperature versus the tip pressure. The tip pressure recorded a constant pressure, so any pressure changes should be a direct result of the temperature differences. The pressure dependence appears to very mild. It could easily be ignored and not significantly affect any data analysis.

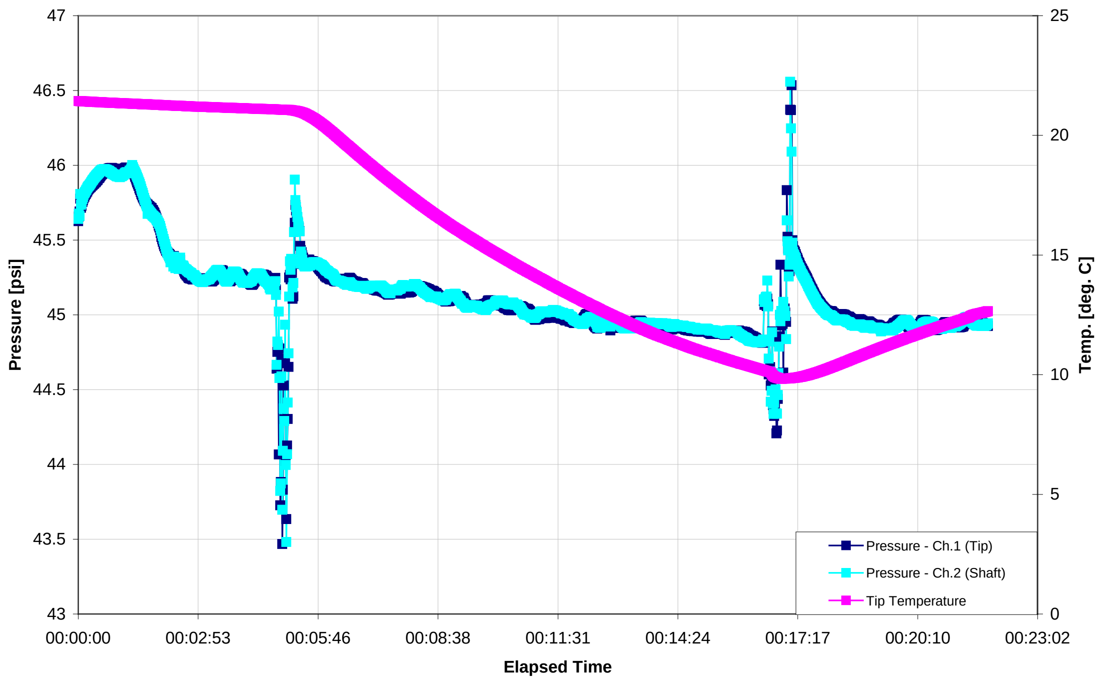


Figure 12: Data from Temperature Experiment

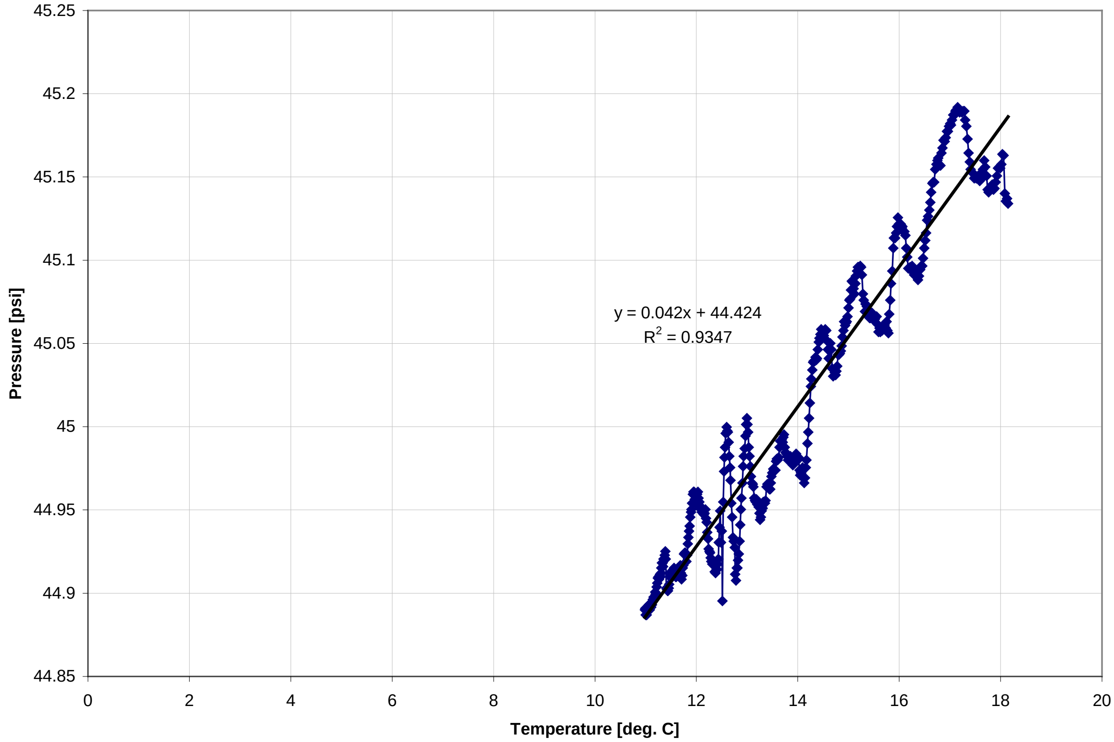


Figure 13: Temperature Dependence of CDAQ

1.10. SOFTWARE MODIFICATIONS TO IODP1D.RUN

The logging program, IODP1D.run, originally packaged with the CDAQ is available to users on our website http://www.ig.utexas.edu/resources/downhole/tech.htm. Program operation of T2PLOGGR.run differs from IODP by initiation of the second ADC (U7). During a data collection routine, data is transferred from ADC-U5, then ADC-U5 is powered down, ADC-U7 is powered up and data is transferred. ADC-U7 is powered down, ADC-U5 is powered up and the routine loops. This loop was instituted according to the guidance of the USIO engineering team. The team determined that if both ADCs were operational simultaneously, they would cause excessive noise interference.

In addition, the program now directly writes sampled data to ASCII text files. The IODP program wrote data to a binary file that was stored locally in a temporary file and converted to an ASCII file at the user's desire. This modification reduces the time required to retrieve data and circumvent data loss as a result of power outage.

It should be noted that a time stamp is applied at the beginning of the loop, but data is physically collected several milliseconds after this time stamp. Therefore, "instantaneous data" on different channels truly represents different data at different times.

The described changes and the resulting program presented in this manual, T2PLOGGR.run were products of the PC application MetroWerks Codewarrior (www.freescale.com/codewarrior). For user's interested in editing the software, please reference this application.

Comments have been included throughout the source code, and we attach the original IODP program description as Appendix III. To edit software, install the Codewarrior package and apply all the correct settings as described by the Persistor manufacturer (www.persistor.com). Then, find the source code folder and open the Codewarrior project file (IODP_acel.mcp). This project file then allows access to all the components of the source code. The separate components are shown in Table 2 along with descriptions and primary changes.

If the user desires to make additional edits to any of the codes, the executable program needs to be re-built. All built programs will be saved in the bin folder. It is then the user's responsibility to upload the newly created executable to the Persistor according to the steps outlined in steps 1-6 of Section 1.6.

Table 2: Source Code Listing

Name of File/Folder	Description	Primary Changes
CS5534lib.c	Source code for the commands of the Analog to Digital Converter. The Analog to Digital Converter responds directly to 32-bit and 8-bit hexadecimal inputs, and thus this file appears primarily as machine language.	New Hexadecimals were added to power down the Analog to Digital Converter.
CS5534lib.h	Header file for sharing of variables.	None
IODP1D.APP	Built program from the original IODP source code. The APP extension cannot be used with PICO-DOS.	None
IODP1D.RUN	Built program from the original IODP source code. The RUN extension files are those to be used with PICO-DOS.	None
IODP_accel.c	Source code for the Accelerometer routines.	None
IODP_accel.h	Header file for sharing of variables	None
IODP_Accel.mcp	Project File for access to source codes through Codewarrior.	None
IODP_Accel.old.mcp	Relic project file. Upon codewarrior this was renamed to watch the differences in Codewarrior versions accessed by different users.	None
IODP_ADC.c	Source code for the Analog to Digital Routines.	The timing sequence for sampling was adjusted to sample on the channels stated in this manual. The output statement was adjusted.
IODP_ADC.h	Header file for sharing variables	Several new variables were added.
IODP_CalConstant.h	Header file with stored values for use if user desires to internally calibrate Analog to Digital Converters.	None
IODP_Paro.c	Source code for Digital Pressure Transducer routine.	No longer appears in the main source code or sampling routine.
IOD_Paro.h	Header file for sharing files	None
T2PLOGGR.c OR SLEEP.c	Main source code. All other arguments are called from this code and accessed in their respective codes.	Initial output to the screen upon program initiation was altered and an additional function for the determination of available memory was added. Two files are created to store Program Output.
GAIN32.c	Same as T2PLOGGR.c except with gain = 32x.	Increased gain on Channels 1 & 2 on ADC-2 to 32x.
GAIN64.c	Same as T2PLOGGR.c except with gain = 64x.	Increased gain on Channels 1 & 2 on ADC-2 to 64x.
bin	Folder for storing built programs.	None

APPENDICES

I. PARTS LIST

Part Name	Length	Diameter	Material
Complete Tip Assembly			
Threaded Tip Insert	1.35"	0.23"	Stainless Steel
Small Porous Ring	0.20"	0.24"	sintered SS
Thin Wiring Tube	11"	.06"	Stainless Steel
Tip Thermistor			Misc.
Needle	8.375"	0.24 to 1.42"	Stainless Steel
Large Porous Ring	0.2"	1.42"	sintered SS
Transducer Block	3.2"	1.42"	Stainless/Copper Coat
Threaded Hex Standoff	1.875"	0.25"	Steel
Pressure Transducer	1.75"	.375"	Stainless Housing
Body			
Drive Tube	42.75"	1.43"	Stainless Steel
Drive Tube Backing Plate	30"	0.86"	Aluminum
Backing Plate Tip Bracket	0.5"	0.93"	Aluminum
Backing Plate Aft Bracket	0.5"	0.93"	Aluminum
5 Pin Fischer Connector	1.41"	0.349	Aluminum etc
plug			
receptacle			
Drive Tubet Wiring Harness	6"	N/A	Misc.
Fischer Retainer	1.1"	1.1"	4140 Steel
Drive Tube Nut	2.75"	2.0"	4140 Steel
Spin Collar	8.5"	2.75"	Steel
Drive Tube Threaded Union	9.5"	2.75"	Steel
Fischer Washer	0.2"	1.36"	?
Fischer Receptacle (19 pin)	1.06"	0.58"	Misc.
Greene Tweed (GT) Pass-through	1.56"	0.75"	Misc.
GT Strain Relief	1.2"	0.75"	Steel
Wire harness from GT Pass-through to CDAQ	~10"	N/A	Misc.
CDAQ Housing	30"	2.75"	Stainless Steel
1/2 round spacer	1.7"		Al
threaded rod-T/U to CDAQ	8-32	2.5"	
15 Pin MDM Bracket	0.25"	2.5"	Aluminum
CDAQ mdm bulkhead			Aluminum

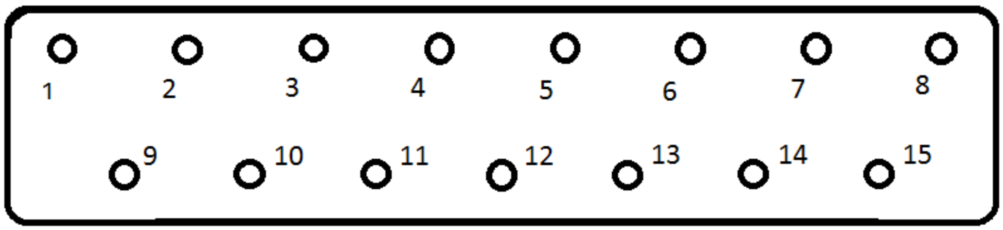
#8 nylon spacers	1/2"		nylon
CDAQ			
CDAQ Mount			Aluminum
CDAQ clamshell			fiberglass?
CDAQ clamshell spacers	1/2"		Aluminum
Electronics cover	12.5"		Delrin
Small electronics cover	2.6"		Delrin (2 pcs ea.)
Wiring harness to endcap-IE4			
battery compression plug			Delrin + SS spring
Endcap			Stainless Steel
Endcap conn plate-IE4			Stainless Steel
IE4M dummy plug			
IE4 retaining nut (male)			
3 pin Fischer connector			
plug			
receptacle			

O-Rings (Size)	Material	Hardness	ID	OD	Width
Probe Needle Tip (inside) (206)	Buna		1/2	3/4	1/8
Transducer Block					
Small (003)	Buna	70	1/16	3/16	1/16
Medium (014)	Buna	70	1/2	5/8	1/16
Large (214)	Buna	90	1	1 1/4	1/8
Transducer (006)	Buna	70	1/8	1/4	1/16
Drive Tube Nut					
Inner (218)	Buna	70	1 1/4	1 1/2	1/8
Outer (224)	Buna	70	1 3/4	2	1/8
GT Pass-through (016)	Buna	90	5/8	3/4	1/16
Threaded Union (224)	Buna	90	1 3/4	2	1/8
Endcap (224)	Buna	90	1 3/4	2	1/8
Endcap conn plate (118)	Buna	70	7/8	1 1/16	3/32

II. CDAQ & T2P WIRING SCHEMATICS

Greene Tweed wiring assembly

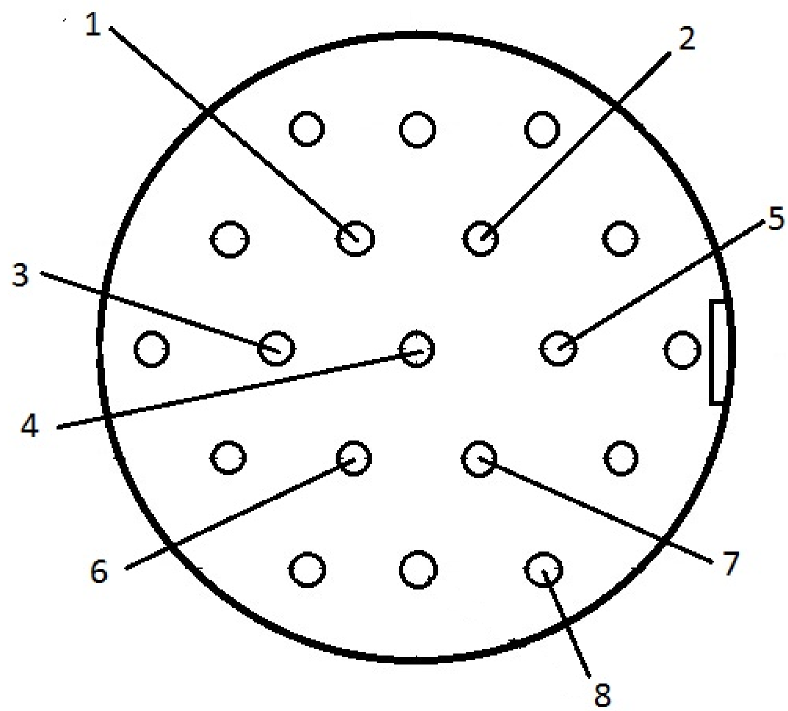
15 pin mdm back side



1 Pressure 2^+ -black 5 Tip thermistor 1 -yellow 7 Pressure 1^- -blue 8 Excitation$^+$ -violet
9 Pressure 2^- -grey 12 Tip thermistor 2 -wht/brn 14 Excitation$^-$ -wht/org
15 Pressure 1^+ -wht/yel

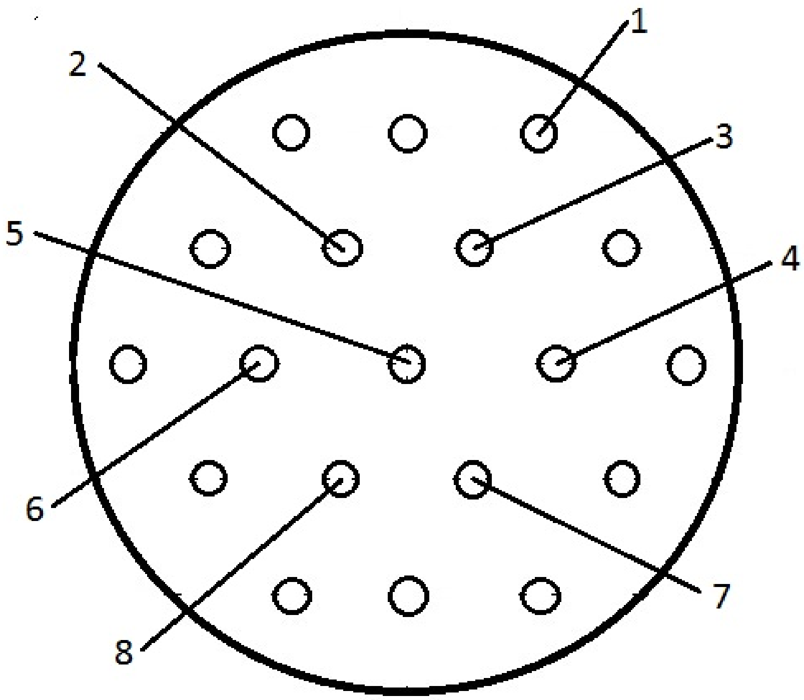
Greene Tweed pass-through

CDAQ side



1 Pressure 2^- -grey 2 Pressure 2^+ -black 3 Thermistor 2 –wht/brn
4 Tip thermistor 1 –yellow 5 Pressure 1^+ -wht/yel 6 Excitation$^+$ -violet 7 Pressure 1^- -blue
8 Excitation$^-$ -wht/org

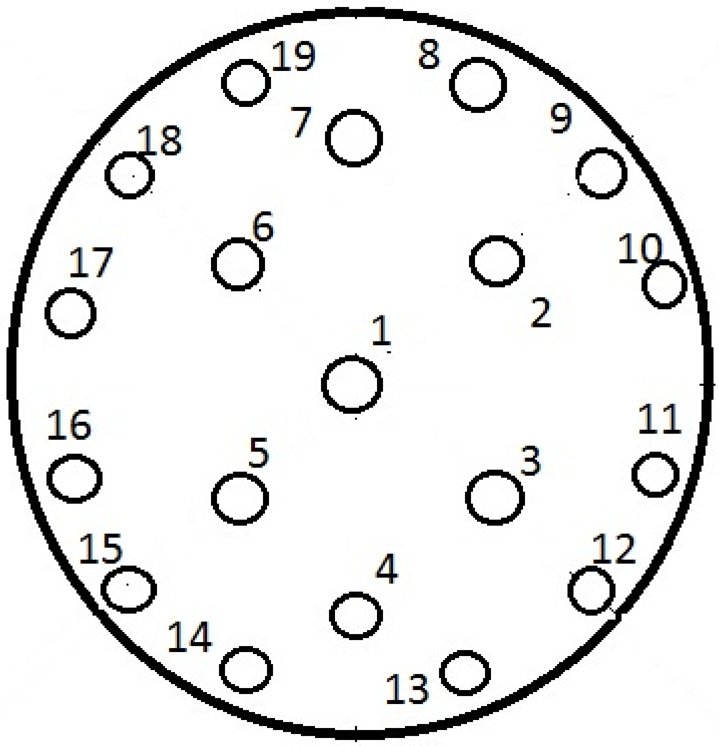
Greene Tweed pass-through
Tip side



1 Excitation$^-$ -wht/org   2 Excitation$^+$ -violet   3 Pressure 1$^-$ -blue
4 Pressure 1$^+$ -wht/yel   5 Tip thermistor 1 –yellow   6 Tip thermistor 2-wht/brn
7 Pressure 2$^+$ -black   8 Pressure 2$^-$ -grey

19 pin Fischer receptacle

Back side



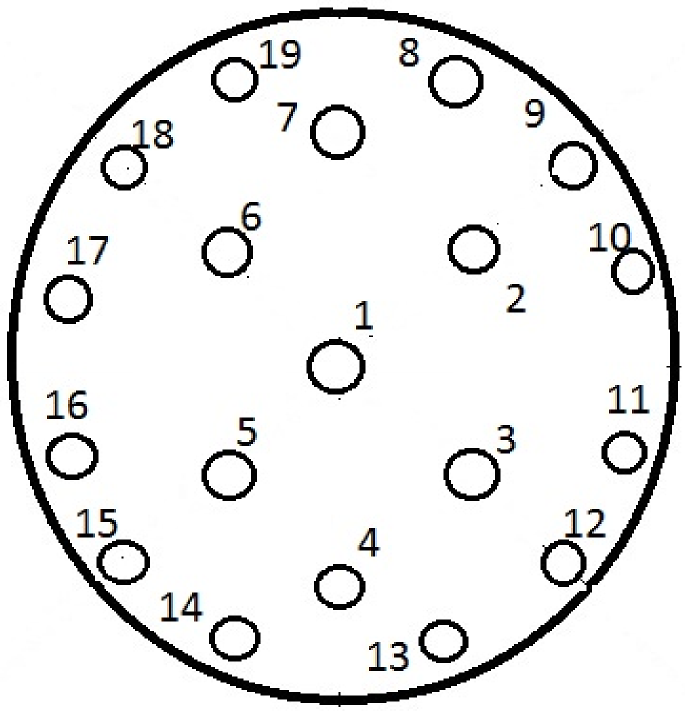
1 Tip thermistor 1 –yellow   2 Tip thermistor 2 –wht/brn   3 Pressure 2^- -grey

4 Pressure 2^+ -black   5 Pressure 1^+ -wht/yel   6 Pressure 1^- -blue

7 Excitation$^+$ -violet   18 Excitation$^-$ -wht/org

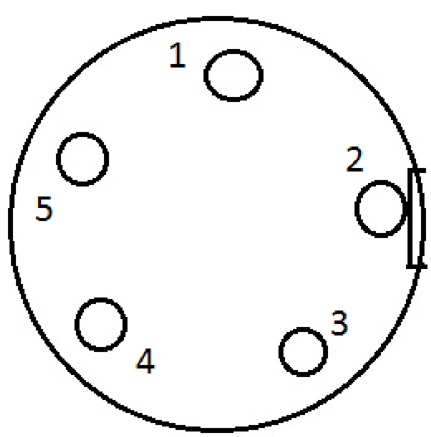
Drive tube wiring cable (curly)

19 pin Fischer plug



1 Tip thermistor 1 –yellow 2 Tip thermistor 2 –wht/brn 3 Pressure 2^- -grey
4 Pressure 2^+ -black 5 Pressure 1^+ -wht/yel 6 Pressure 1^- -blue
7 Excitation$^+$ -violet 18 Excitation$^-$ -wht/org

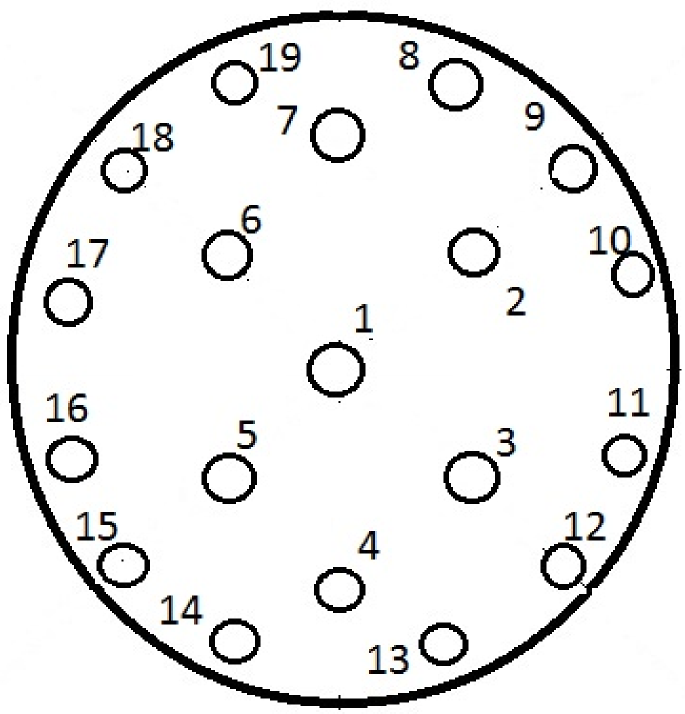
5 pin Fischer receptacle



1 Excitation$^-$ -black 2 Thermistor –white 3 Pressure$^+$ -green 4 Pressure$^-$ -white
5 Excitation$^+$ -red

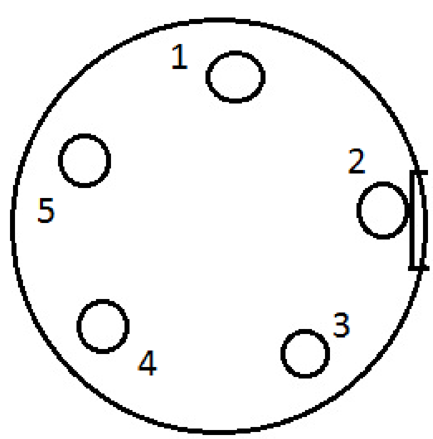
Drive tube wiring cable (straight)

19 pin Fischer plug



1 Tip thermistor 1 –grn/blk 2 Tip thermistor 2 –green 3 Pressure 2^{-} -white
4 Pressure 2^{+} -red 5 Pressure 1^{+} -wht/blk 6 Pressure 1^{-} -red/blk
7 Excitation^{+} -blue+black 18 Excitation^{-} -org+org/blk

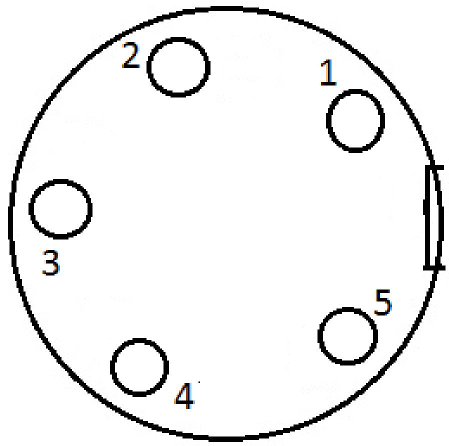
5 pin Fischer receptacle



1 Excitation^{-} -org or org/blk 2 Thermistor –grn or grn/blk 3 Pressure^{+} -red or wht/blk
4 Pressure^{-} -white or red/blk 5 Excitation^{+} -blue or blk

Pressure transducer

5 pin Fischer plug

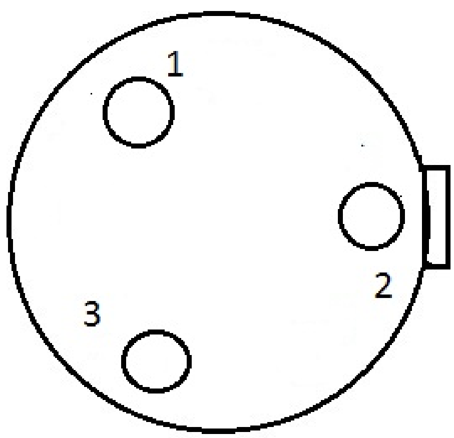


1 Excitation^{+} -red 2 Excitation^{-} -black 3 Thermistor –white 4 Pressure^{+} -green
5 Pressure^{-} -white

CDAQ

3 pin Fischer receptacle

Back side

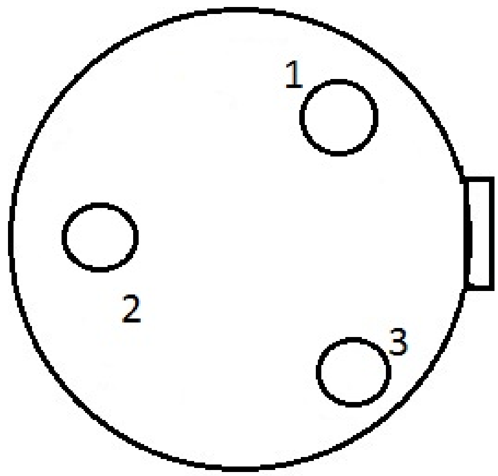


1 Ground –green 2 Receive –orange 3 Transmit –red

End Cap Connector Plate

3 pin Fischer plug

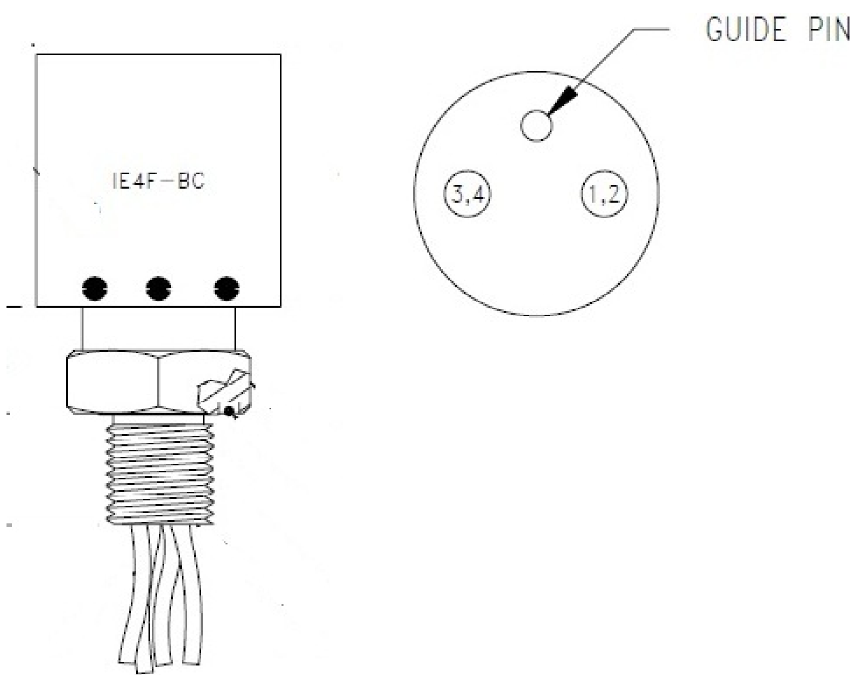
Back side



1 Ground –green 2 Receive –orange 3 Transmit –red

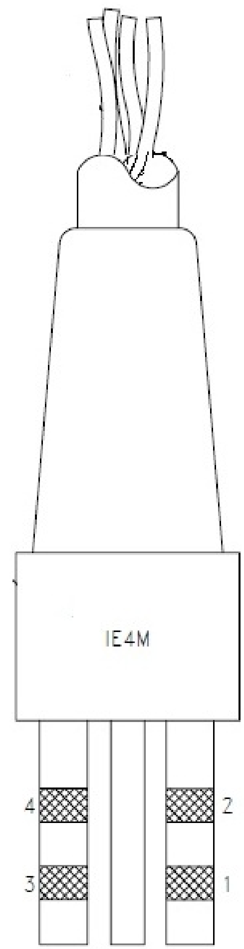
IE4F connector

Back side wires

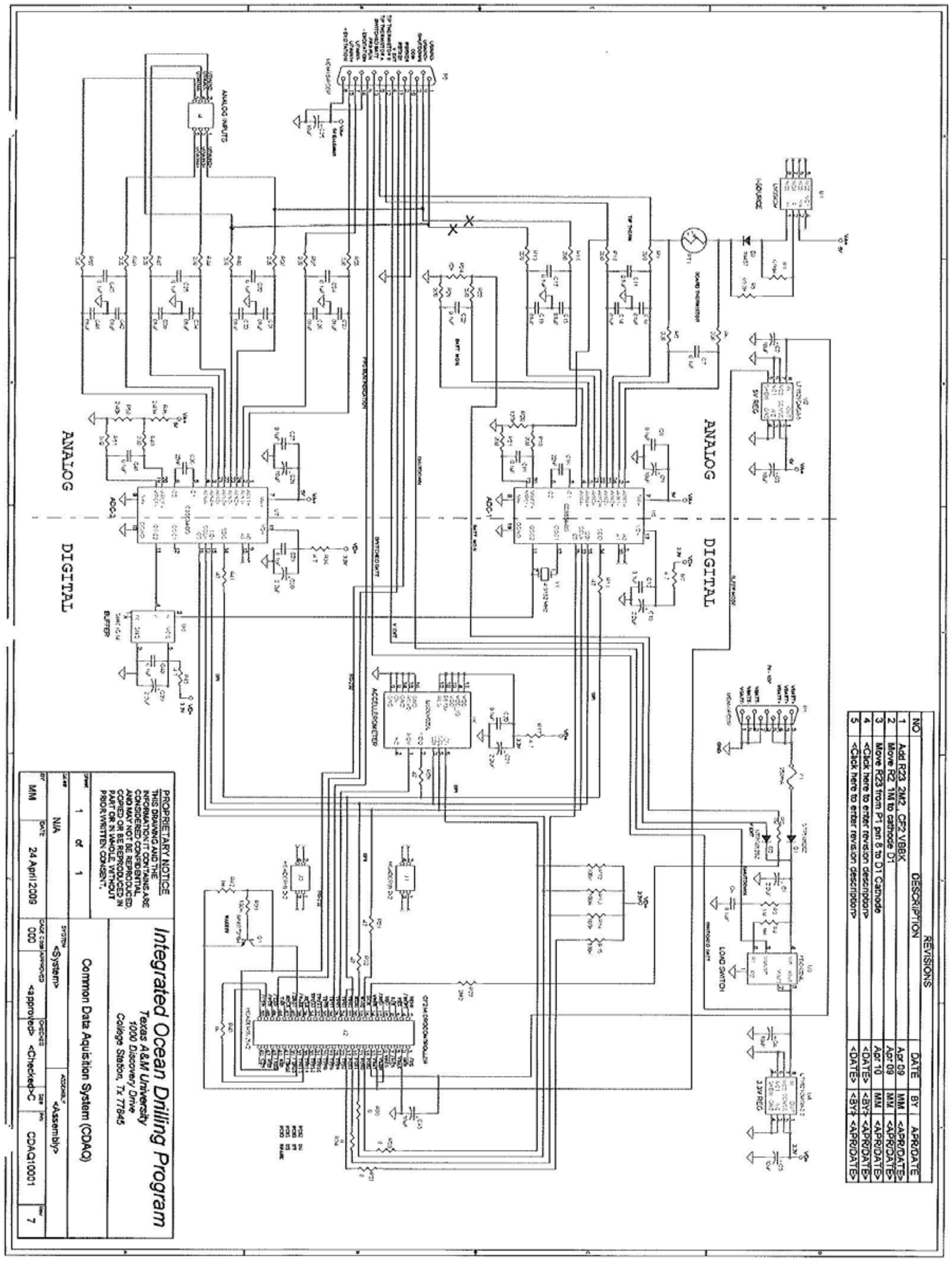


Black (1) –to red (TX) from Fischer plug White (2)–to orange (RX) from Fischer plug
Red (4) – to green (GND) from Fischer plug

IE4 Data Cable



Black (1) –to orange (TX) from serial (pin 2)   White (2)–to red (RX) from serial (pin 3)
Red (4) – to green (GND) from serial (pin5)


ANALOG
DIGITAL
ANALOG
DIGITAL
REVISIONS
NO
DESCRIPTION
DATE
BY
APRDATE
1 Add R23 2M2, CF2 VBBK
2 Move R2 1M to cathode D1
3 Move R23 from P1 pin 8 to D1 Cathode
4 <Click here to enter revision description>
5 <Click here to enter revision description>
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Integrated Ocean Drilling Program
Texas A&M University
1000 Discovery Drive
College Station, Tx 77845
Common Data Aquisition System (CDAQ)
<System>
<Assembly>
N/A
24 April 2009
MM
<approved>
<Checked>
CDAQ10001
7

III. ACKNOWLEDGEMENTS

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