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Pulsating Bubble Surfactometer (PBS-C)
(Surface Tension Measurement System)
Operator Manual

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1.0 PBS Description

The Pulsating Bubble Surfactometer (PBS-C) is a redesign of the previous model (PBS-B) developed by Electronetics Corporation (no longer in business). The new design has been developed by General Transco, Inc. (GTI). The new system interfaces with a lap top computer in two modes. The General User Interface (GUI) is sent to the lap top which uses a windows browser such as Windows Explorer or Mozilla Fire Fox to display the GUI. The GUI is a control panel that enables the user to control the PBS-C and select the various parameters and start measurements, and change the printer speed during the measurement. The PBS also interfaces with the lap top simultaneously using Tera Term Terminal program or any terminal program that can capture streaming data. The Tera Term program is connected by a RS 232 cable to the PBS and presents the data of Pressure, and Surface Tension to two decimal places and the data number within a cycle and the number of cycles or bubble oscillations. System variables that have been entered into the GUI are also presented in the Tera Term display. The data can be recorded by the Tera Term by following the Logging procedure given in this operator manual. The Log mode only needs to be set up at the beginning of the measurements and will continuously log all items displayed on the Tera Term until the Tera Term is terminated or the Log mode is turned off. The log mode can be used to record different surfactant sample data by logging off and entering a new log with a different file name. The log file can be called up using Note Pad or Windows Word, and an EXCEL file for plotting. Five PBS Plot styles are given for the convenience of the user, but they are not considered to be part of the PBS and are given to the user in the event it may be useful. The current PBS only operates in a fixed bubble ratio mode; otherwise the new system provides the same features as the old system. The system oscillates sinusoidal between the minimum and maximum bubble to simulate the action of alveoli breathing. The measurement of difference pressure are made 50 times per revolution between 0 and 23 revolutions per minute and 25 measurements per revolution, between 24 and 40 revolutions per minute. The response time of the pressure transducer that measures the pressure difference between the inside of the bubble and the outside of the bubble is 1 millisecond. This limits the speed of the bubble oscillation to achieve accuracy of the measurement.

The PBS displays the surface tension of a bubble drawn at the launch point within an acrylic sample chamber that holds approximately 25 micro liters of surfactant. The bubble is formed by reducing the volume within the sample chamber with a positive displacement pump. The piston of the pump extends to the bottom of the sample chamber in order to minimize the mixing of the water with the surfactant in the sample chamber. Since the distilled water (recommended by GTI) interfaces with the surfactant at the sample chamber interface, the pressure within the sample chamber communicates with the distilled water within the pump water block to be detected by the pressure transducer mounted on the side of the water bath. A second pump is connected by the servo linkage to the servo motor which is controlled by the

'Bubble Preset Knob' on the front panel. This enables the bubble within the sample chamber to be adjusted to a minimum bubble.

The microcontroller interfaces with a lap top or desk top computer and the parameters are set in by the user into the GUI. The sequence of operation is to set the Chart Speed first then set the Set Variables. When the header is printed by the printer if the printer is turned on, then the system is ready to Start Measurement. During the measurement process the chart speed can be changed between the 2.5mm/sec, 12mm/sec, and 25mm/sec in any combination.

The PBS microcontroller performs as a network with the IP address of 192.168.1.65, the Lap Top computer should be set up to detect this IP address and have an assigned IP address manually installed of 192.168.1.64, this setup will ensure that the PBS can communicate with the computer. The computer provided with the PBS has been set up at GTI. Other computers can be used by the user, provided they have been set up by their IT person.

The new system like the previous system has a built in paper tape printer that prints the pressure difference across a bubble formed within the surfactant and the calculated surface tension of the surface inside of the bubble. The system also has a water heater that heats from 0 to 50 degrees centigrade. The heater is turned on by the General User Interface (GUI) from the lap top by setting the temperature higher than the ambient temperature. In order for the water heater to operate the heater power button must be turned on. If the heater is set to 0 when Set Variables is clicked on, the heater will be turned off by the computer; if the heater power button is turned off the heater will be turned off by the computer and because there is no power to the heater.

In order to calibrate the system, the motor speed is turned off by setting the speed to 0 RPM, when Set Variables is clicked on. When this is done the system will output the data to the terminal program every 1 second. This enables the users to calibrate the system by adjusting the 'Pressure Adjust Knob'. This calibration is described in the calibration section.

The PBS comes with a 1 year warrantee. Units outside of warrantee, GTI will repair PBS units at a fixed cost, which may vary with inflation. Units must be sent to GTI for the repairs. It is recommended that the packing be saved in order to ship back the PBS if a future repair is needed. The PBS systems are fabricated on a thick aluminum base plate to ensure stability of the measurement and ruggedness during shipping. Only under emergency conditions will GTI support the PBS-C systems on site, and the quoted cost for this service must be paid in advance.

A Laptop computer is included with each order of a PBS unit. The computer is set up at the GTI facility with both the IP addresses and the Tera Term terminal program. Also, the PBS plots are installed in the lap top to enable the ease of initial operation. The users local IT technician can set up additional computers if that is needed. Both the internet cable and the RS232 cable and a USB to RS 232 interface are included with the PBS system. The additional list of accessories is given in the list of delivery items.

2.0 PBS Set Up

Refer to Figure 2.1 and 2.2 for the following description.
The PBS unit requires a source of distilled water. This water should be boiled to remove dissolved air in the water. This is not a requirement, but it may make using the PBS easier, by removing air bubbles in the water. A Set (water bag) with the tubing and cutoff is included in the accessory kit. Water is admitted into the PBS by connecting the Set hose on the center hose connection on the back of the PBS. The flush lever on the front of the unit is used to allow the flow of water into the PBS.

Power is obtained by connecting the power cord in the back connector of the PBS. The PBS can be ordered as 115VAC 50 to 80 Hz or a 220 VAC system. The system voltage can be changed by the user by changing the strapping wire within each of the three linear power supplies if a change is needed. Linear power supplies are used by the PBS in order to obtain the stability of less than 3 millivolts ripple in the DC voltage output.

The internet cable connects in the back of the PBS to the lap top computer. Some computers have RS232 serial connectors, but some Windows 7 based Lap Top Computers do not have an RS232 connector, so an adaptor from USB to RS232 is included in the accessory kit. This adapter includes an installation CD and is to be used by the users that do not have a computer with an RS 232 connector mounted on the computer. The Adapter has been installed in the GTI supplied computer. If another computer is used that requires the adapter, the installation disk must be used.



Figure 2.1 PBS Front View

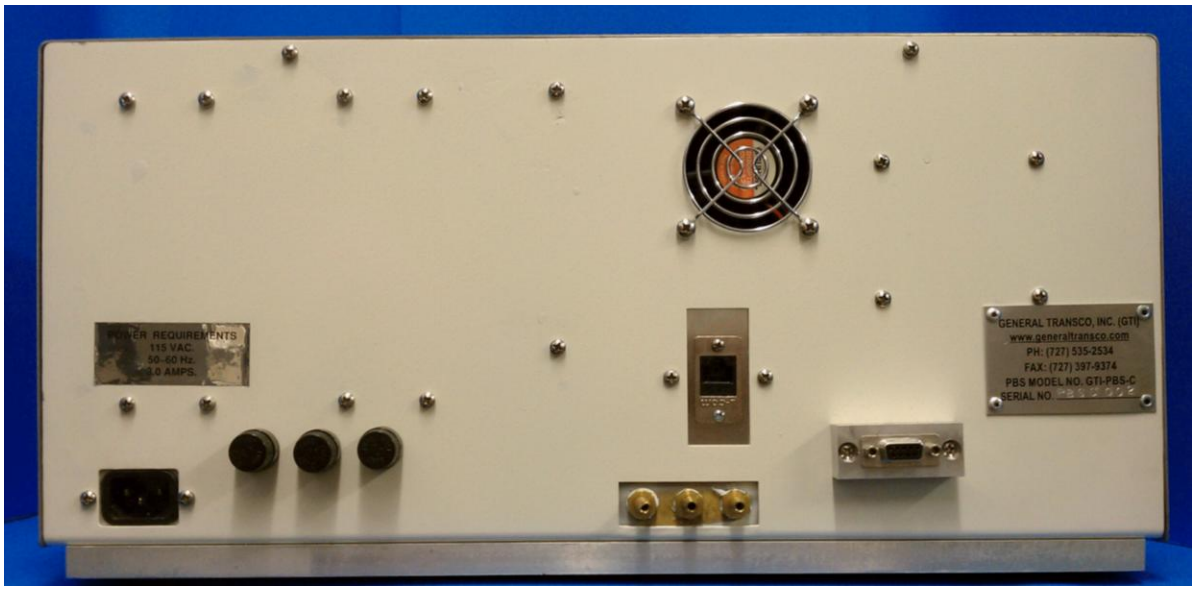


Figure 2.2 PBS Back View

On the back panel there are three fuses, from left to right, the first fuse on the left is the 12 VDC power supply, the second one is to the +5 VDC and the third is to the -5 VDC power supply.

There are three water connections on the back panel, from left to right, the left one is the cooling water inlet or exhaust and the middle one is the source of distilled water from the water bag, and the right one is the cooling water inlet or exhaust. Cooling water can be applied to the PBS-C with an external cooling system.

After the PBS-C connections have been made, the Lap Top Computer should be turned on and the PBS-C power button should be turned on. On the computer desk top there is an icon for the Tera Term (terminal program) and the Fire Fox icon, both icons should be clicked on two times to launch both programs. When these programs are launched the Fire Fox home page is the PBS-C IP address.

2.1 Setting up the Tera Term and Saving the Data to File

To initialize the Tera Terminal program click on the icon located at the start menu.

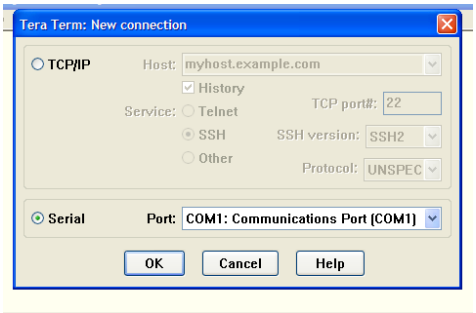


Figure 2.3 First Window that comes up on the Tera Terminal Program

The first window that comes up is shown in Figure 2.3. On this window click on the Serial selection since the program is communicated by the RS232 serial interface, or the serial USB using the adapter provided in the Accessory Kit. The computer provided with the PBS has been set up properly to either COM port 1 or 2 or 3, so that the system will operate correctly. From Figure 2.4 select Setup and then select Serial Port.

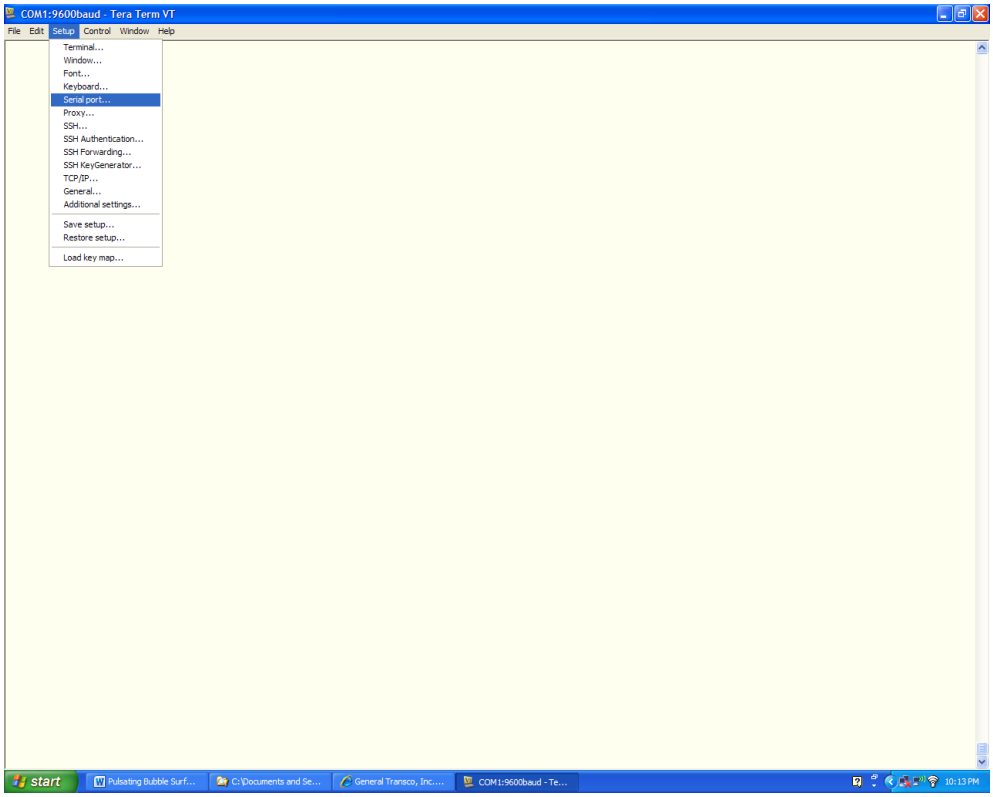


Figure 2.4 From the Setup Menu Select Serial Port

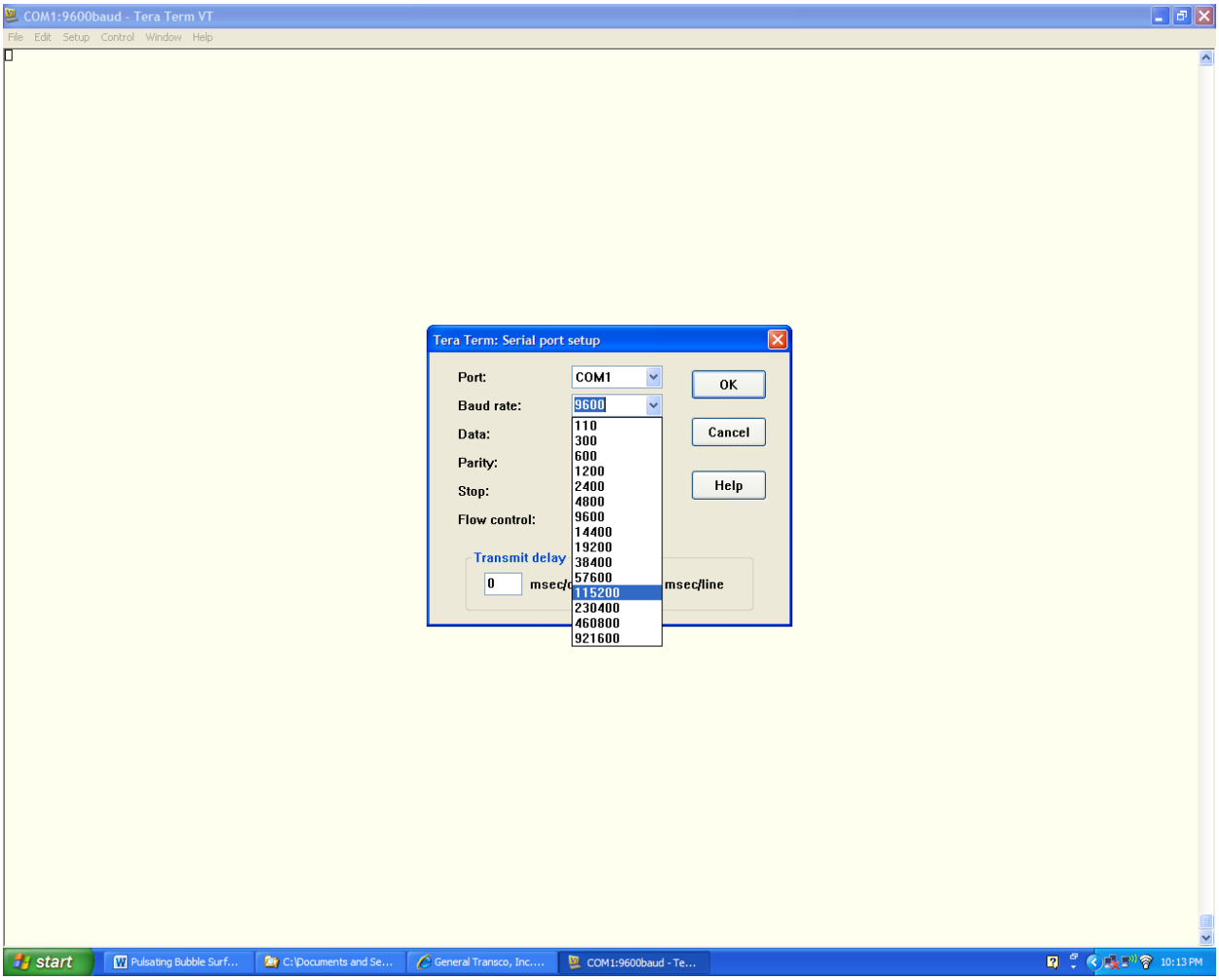


Figure 2.5 From Serial Port select Baud Rate of 115200, this the Baud Rate that the PBS uses to send streaming data to the terminal program

Then select the baud rate of 115200 which is the baud rate of the PBS serial port. Also, select the correct COM port; in this case it is COM1 (this does not have to be done on the PBS supplied unit). The computer that comes with the PBS has the correct COM port selected. Then click OK to exit the communication setup.

Next from the main menu select Setup for a second time and select 'Save setup'. (This will enable the user, when starting to use the Tera Term program to just go to the Setup menu and select 'Restore Setup'.) So for now, select 'Save setup' as shown in Figure 2.6.

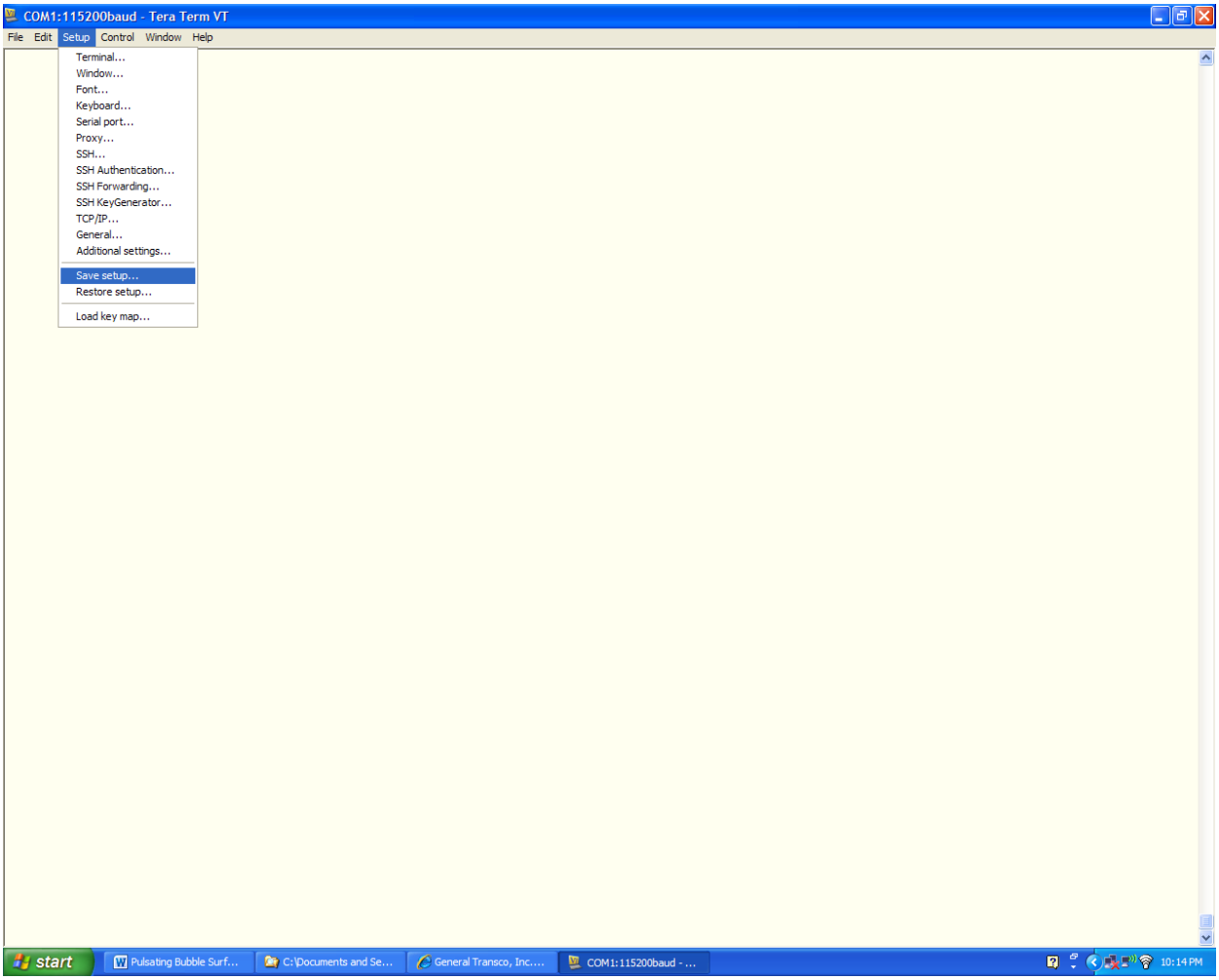


Figure 2.6 Open the Setup for a second time and select Save setup.

Next in Figure 2.7 change the file name to one that is easy for the user to remember. The file name used here is PBS Setup. When setting up the Tera Term in the future the user will select Serial in the first window that comes up and then from the main menu go to 'setup' and select 'Restore setup' and select the 'PBS setup' file and click OK.

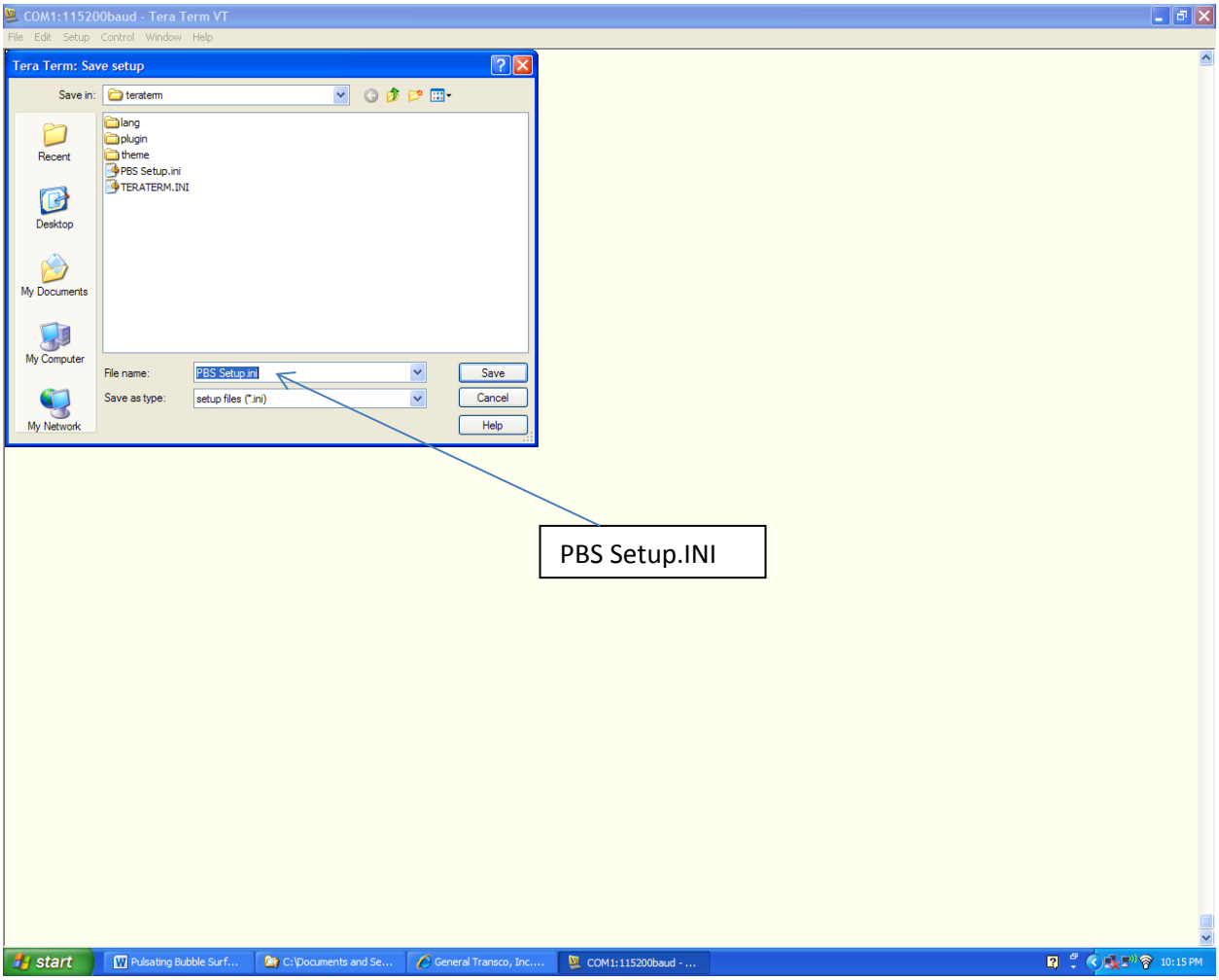


Figure 2.7 Change the File Name to one of the user's choosing, here it is PBS Setup

In Summary; when starting the Tera Term program select 'serial selection' on the first window that comes up. Then go to the main menu and select Setup, then click on Restore setup, Figure 2.8. A window will come up see Figure 2.9, select the PBS setup and click Open. The Tera Term is now ready to accept data from the RS232 Serial Port.

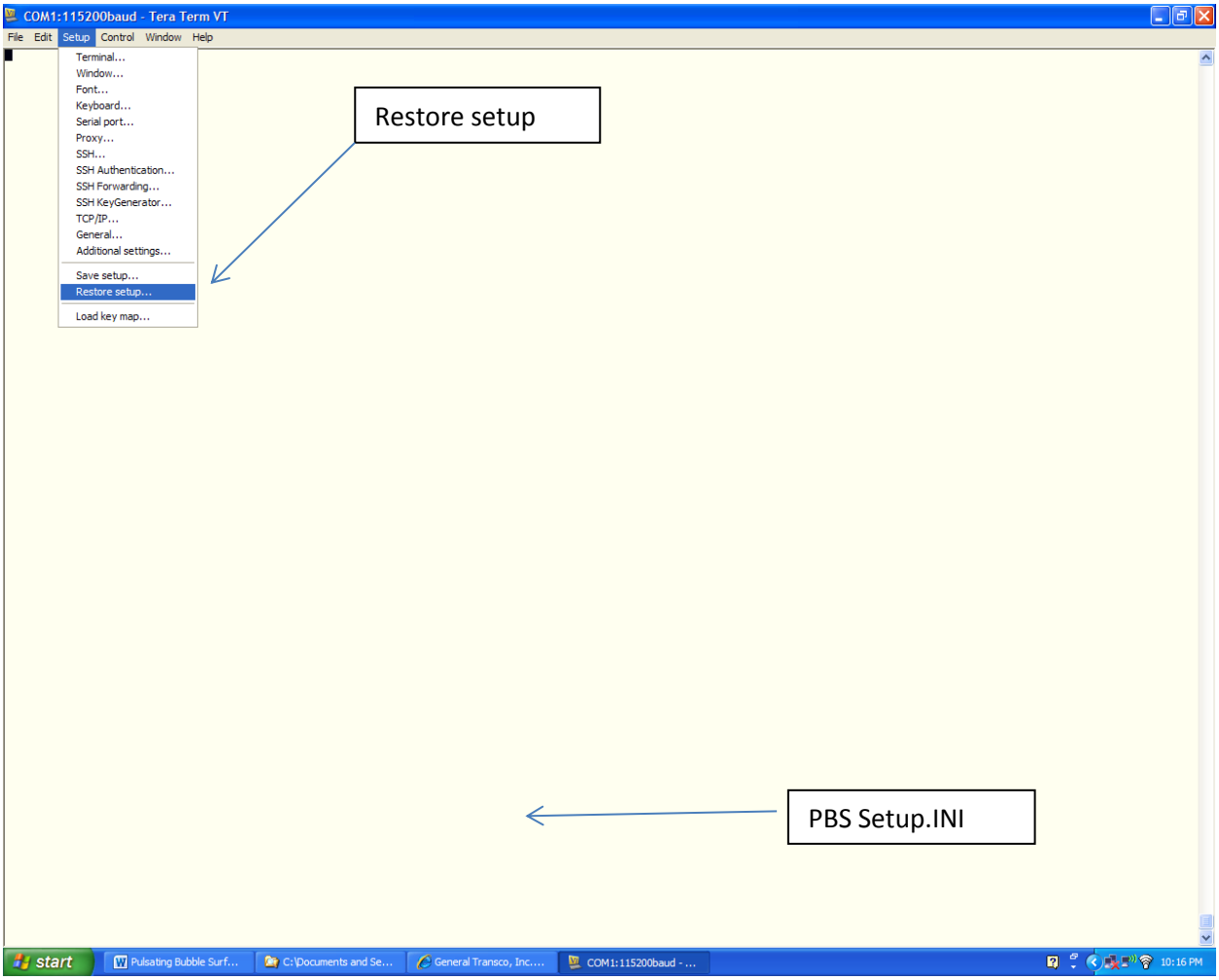


Figure 2.8 When starting up the Tera Term Terminal Program go to the Main Menu and select Restore setup

Logging data or Saving Data to a user file can be done by going to the File on the main menu and selecting Log, Figure 2.10. A window comes up in which the user can select the file name and location on the computer to store the data, in the Figure 2.11 the selected area is My Documents. Check Append and Plain Text. Tera Term Log is the name that comes up, but the user can change the name to the one that best describes the data run, including the lot, date or number of the run. In Figure 2.12 the name PBS Data log has been selected, but the user can compose any name desired. Click Save and the file is now linked to the Tera Term and it will log everything that it received from the PBS as long as the Tera Term is operating, unless the user goes through the same procedure and changes the file name.

When running multiple runs the PBS does not need to be turned off, it is only necessary to push the reset button. If multiple runs with the same settings are made this can be done by Stop Measurement and Start Measurement and keeping track of the sequence of the measurements.

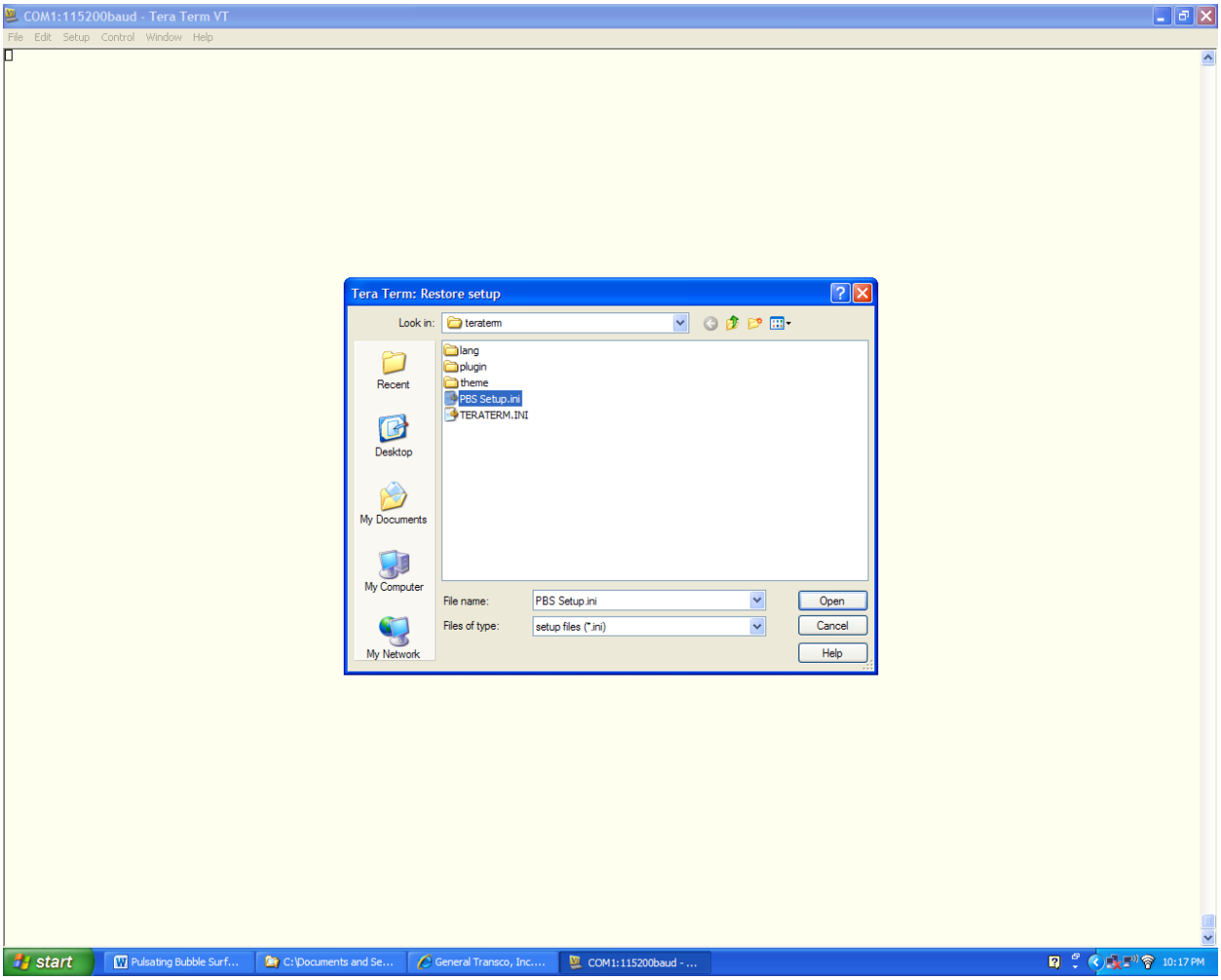


Figure 2.9 Go to PBS setup file and highlight it and Open the File; this sets up the Tera Term

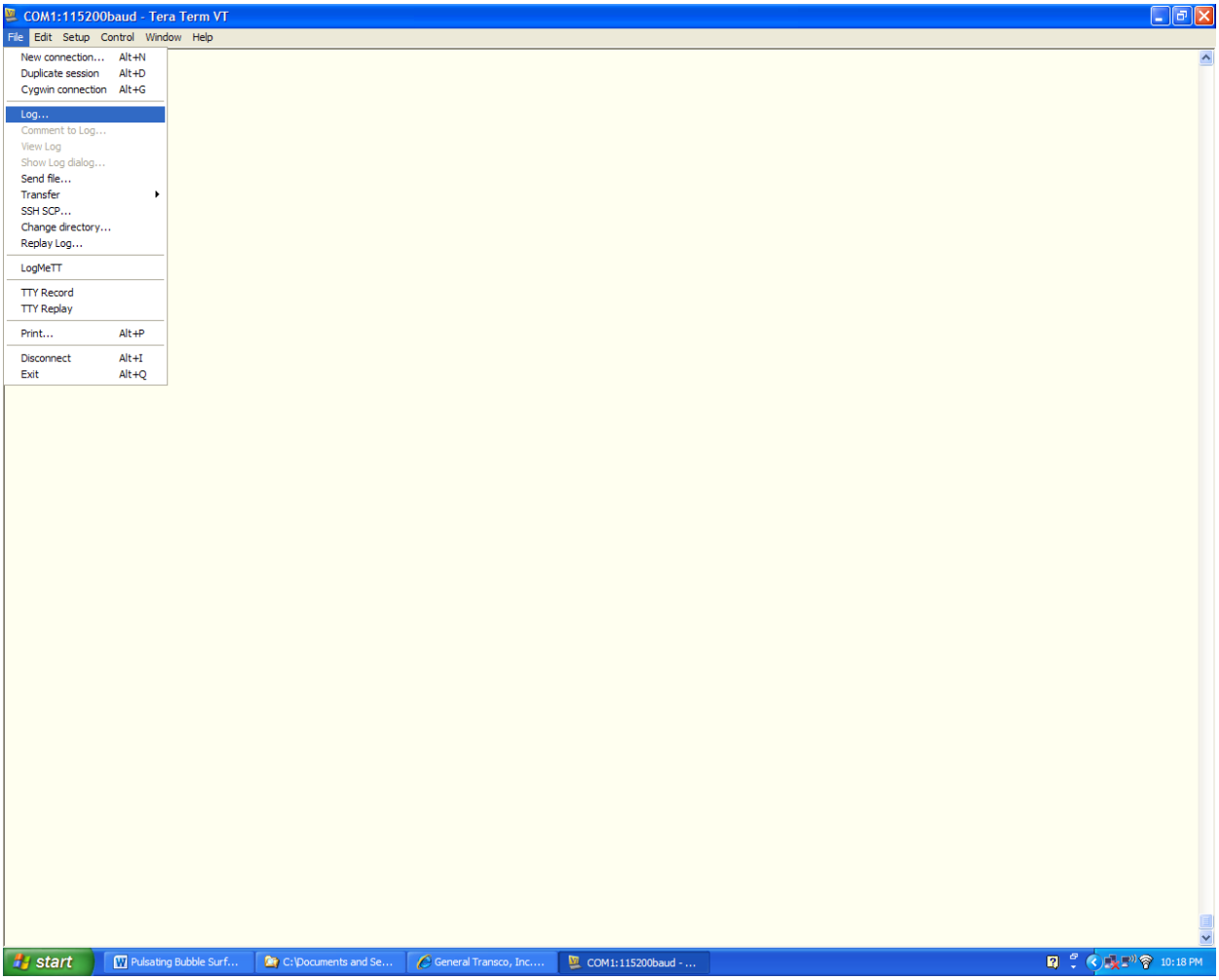


Figure 2.10 To Log (Save) the Streaming Data from the PBS go to File

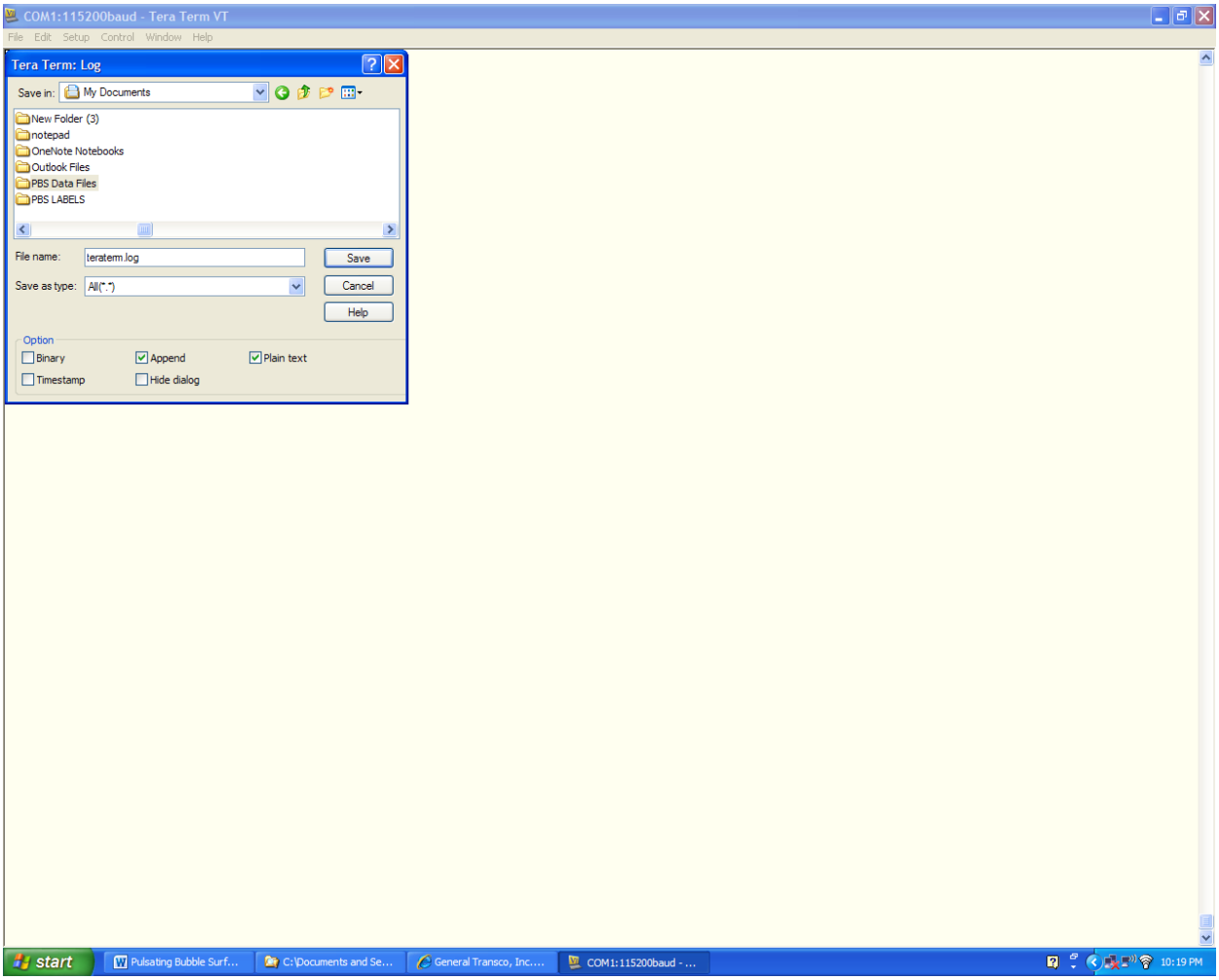


Figure 2.11 Select the Folder and Subfolder

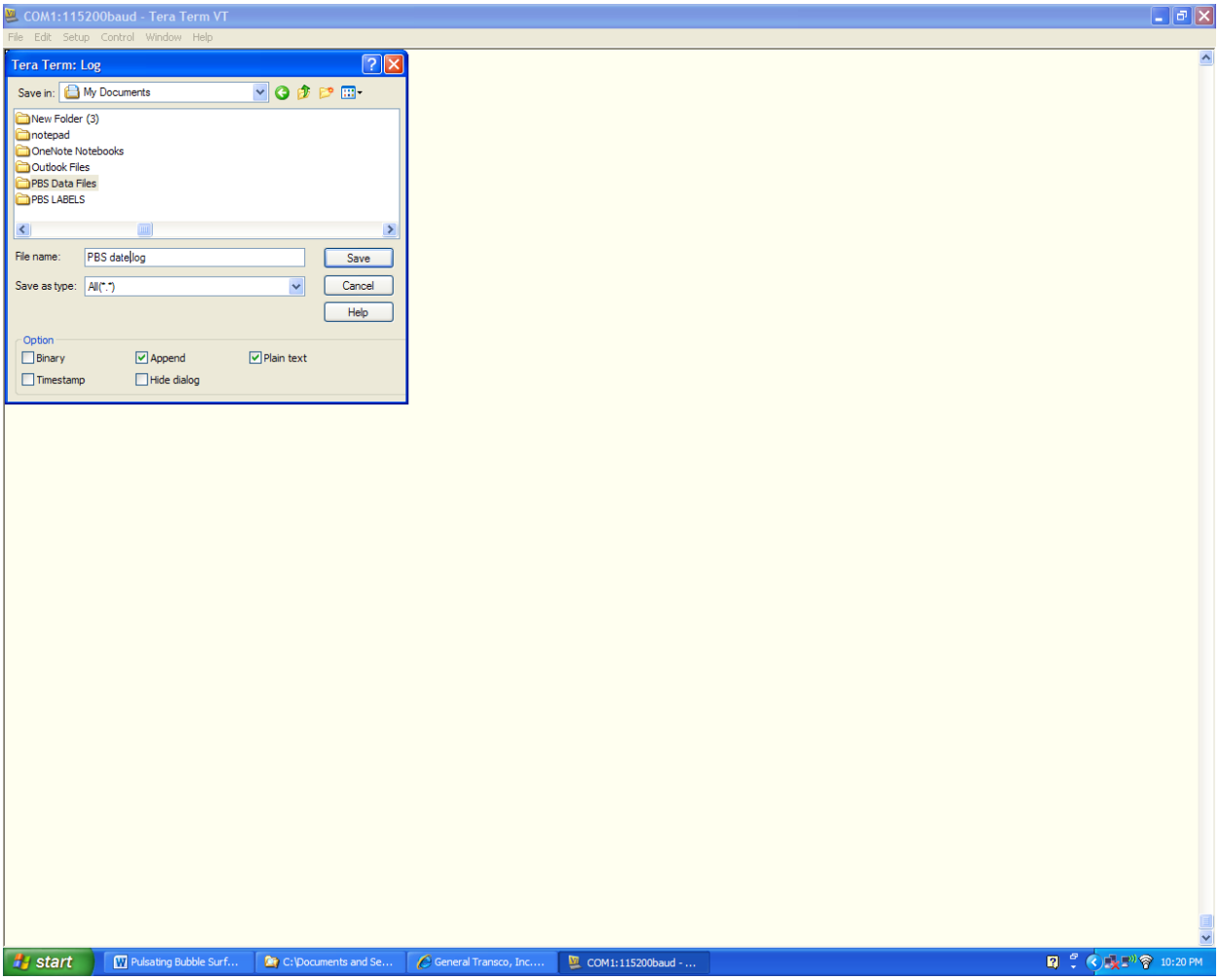
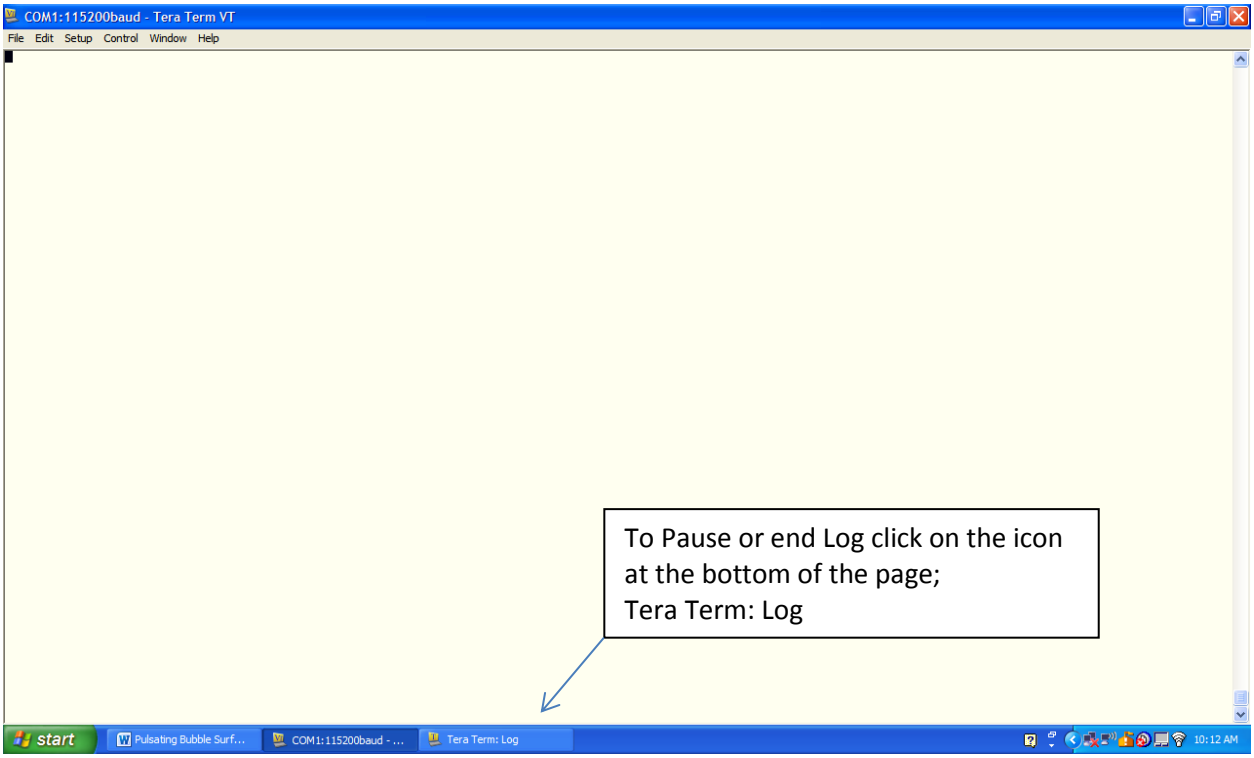


Figure 2.12 Select a Name for your File Describing your Data Collection Run, the Tera Term will store data to this file as long as it is turned on unless you change the file

The logging function can be paused or closed by clicking the Tera Term: Log icon at the bottom of the page when logging has been selected. This gives the user the ability to close the log file and establish a new file for another sample test without closing the Tera Term program or resetting the PBS. The Tera Term terminal program gives an easy to use terminal program for calibrating the PBS system and collecting data from surfactant samples. When the user goes through the procedure several times it will become very easy to use.



2.13 Tera Term: Log at the bottom of the page is the icon used to Pause or Close the Logging Function

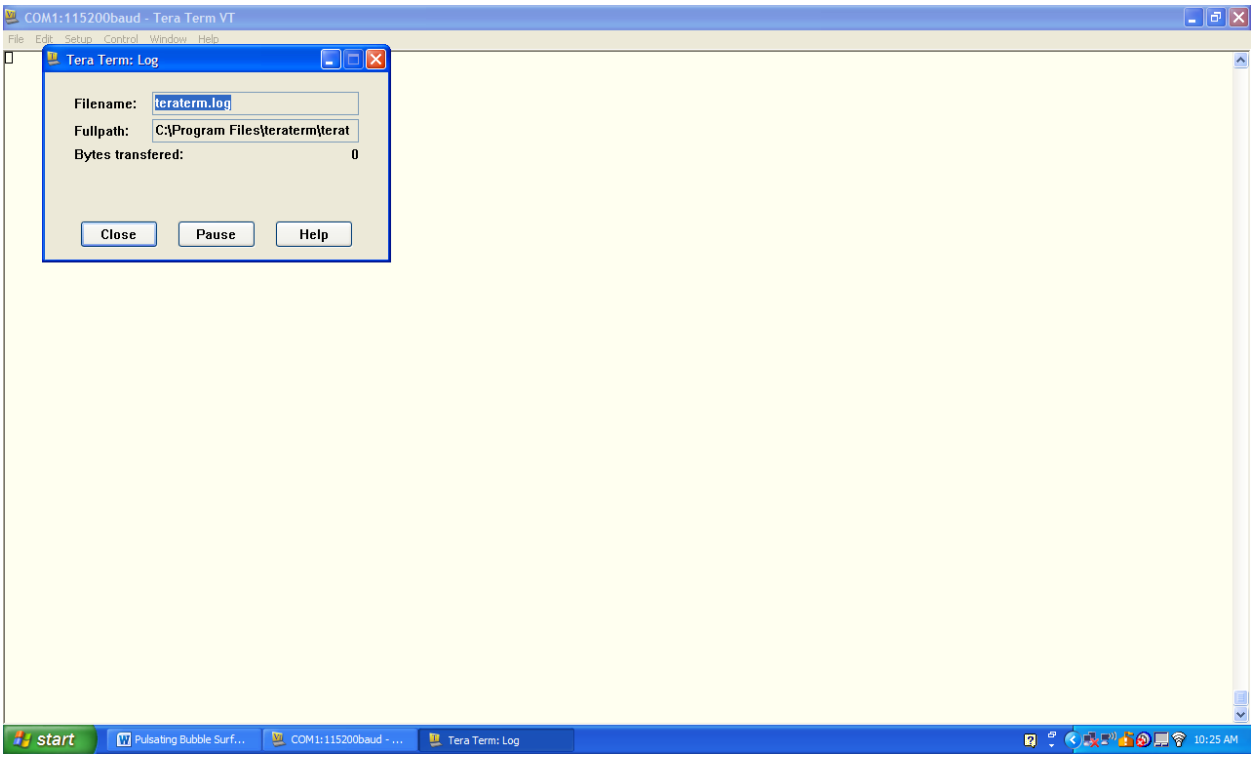


Figure 2.14 Select either Pause or Close to control the logging function

3.0 PBS Calibration

3.1 Introduction

The Pulsating Bubble Surfactometer (PBS) Pressure Calibrator is specifically designed for the PBS. It is not necessary for daily calibration of the system, but it is useful for verification of the linearity and calibrating the range of the pressure transducer and the associated electronics and computer analog to digital converters, described in the Analog Board calibration.

To calibrate the system first insert an empty sample chamber into the sample chamber holder. Then using the flush knob to flush water into the sample chamber and fill the water bath until the sample chamber bubble launch area is below the water level, and can be seen clearly through the microscope. If air bubbles are formed on the walls of the sample chamber flick the top of the sample chamber with the tip of your finger while simultaneously flushing the system. This process will break the air bubbles loose and clear the sample chamber. Insure that the Bubble Preset knob is turned all the way clock wise. Then turn the Pressure Preset Knob counter clock wise to form a bubble in the sample chamber's launch area at the bottom of the vent tube. Set the bubble to a maximum bubble and adjust the horizontal wheel at the bottom center of the PBS to raise or lower the scope. Set the bubble so that the maximum bubble fits into the reticle. Then remove the sample chamber and set the water level inside the water bath so that the **bottom** of the meniscus is even with the horizontal marks on the reticle (while looking through the microscope). Insure that you are looking at the bottom of the meniscus. Then set the pressure to zero looking at the Lap Top display and Tera Term pressure read out, using the 'Pressure Zero Knob'. The PBS internal computer does not print out negative numbers because the Analog to Digital Converters only operate on positive voltage levels. So the adjustment of the pressure must insure that the unit is adjusted at the threshold of a zero setting. This can be verified by setting it to a point where the second decimal place is oscillating between 0.00 and 0.01. If the pressure calibrator is used for this process or for verification the user can set the pressure calibrator to -1cm of water and adjust the Pressure Zero Knob for a reading at the Lap Top Display of 1.00. When the correct reading at the Tera Term the lock must be set by the user on the 'Pressure Zero Knob' to prevent accidental movement.

In Summary: Calibration is performed by adjusting the Pressure Zero knob on the front panel and observing the output on the associated Lap Top or Desk Top computer using the Tera Term terminal program that is provided in the software data package. This test should be conducted at the beginning of each measurement session and sometimes during the day should the session extend to the entire day. The calibration process verifies the setting of the pressure transducer circuits when set to zero on the computer display corresponding to zero (0) cm of water on the pressure calibrator. When the pressure calibrator is set to -4cm of water the reading at the computer display should read 4.00+/-0.02. It may be easier for the user to set the pressure calibrator to -1cm water and adjust the pressure zero knob for 1.00 on the display.

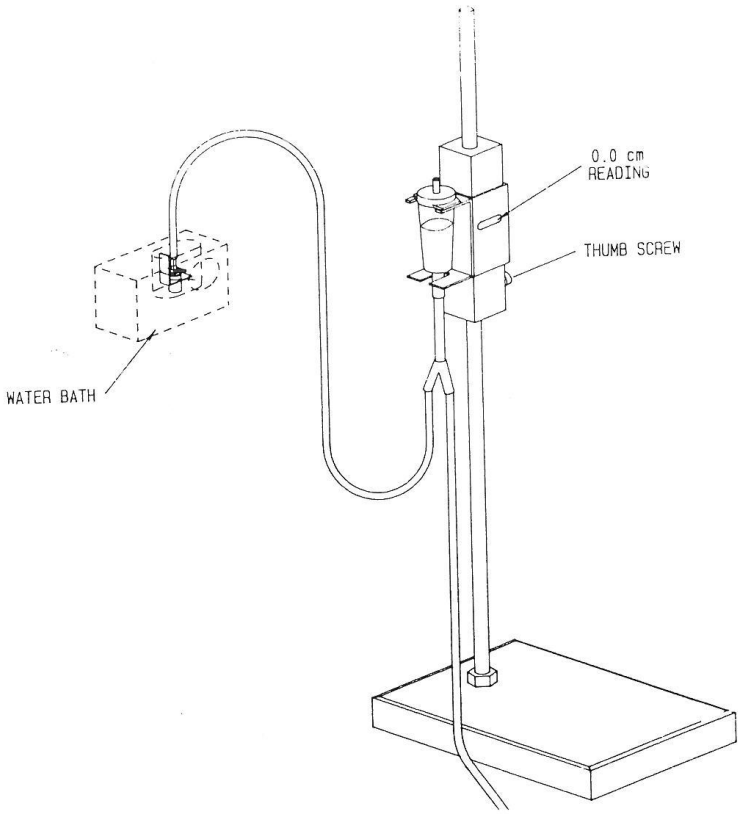


Figure 3.1 Pressure Calibrator set at zero cm water.

3.2 Calibrator Assembly

The pressure calibrator is a water column and is included within the PBS support kit. The unit is partially assembled and needs to be fully assembled using the following directions.

1. Loosen the thumb screw and remove the slide assembly from the rod.
2. Install the rod into the base and tighten the locking nut until the rod is securely fastened.
3. Attach the slide assembly into the rod at any convenient location and tighten the thumb screw.
4. Snap the water column assembly into position.
5. Should the slide assembly loosen with use, it may be adjusted. Simply turn the base plunger counter clockwise using a standard slot head screwdriver.

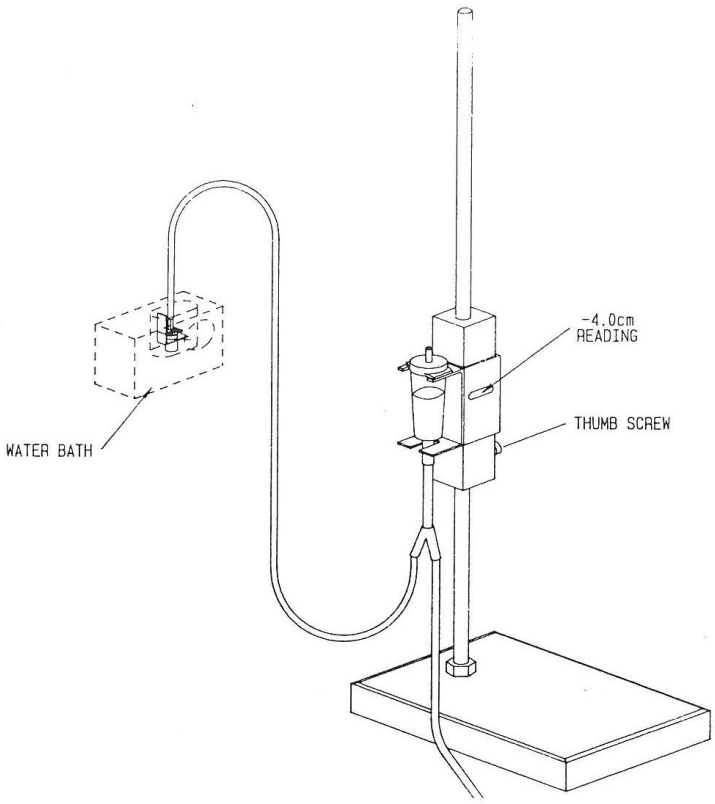


Figure 3.2 Pressure Calibrator set to -4cm of water.

3.3 PBS Theory of Operation

The Pulsating Bubble Surfactometer is a simulator that simulates the alveoli in the lung. It may be used for many other applications but its primary function is to measure the surface activity of lung surfactant. It provides an indication of the activity of the phospholipid molecules within the surfactant by measuring the dynamic surface tension.

The system functions by measuring the pressure difference across the surface of a bubble that is oscillating sinusoidal at a given rate greater than 0 and up to and including 40 revolutions per minute (the default is 20 rpm). This bubble is formed within the sample fluid within the sample chamber cavity Figure 3.3 at the base of the capillary vent. The bubble is formed and oscillated by changing the volume inside the sample chamber cavity; the volume change is implemented so that a minimal exchange of fluid takes place between the sample chamber and the water chamber below. This minimizes the effects of sample fluid dilution and diffusion, which enables a longer, more stable measuring period for each sample.



Figure 3.3 Actual size of a Sample Chamber

The pressure inside the sample chamber communicates directly with the water chamber where it is measured by a pressure transducer. This transducer is very sensitive and accurate, having effectively no volumetric change across full scale due to a pressure sensitive simiconductor type measurement mechanism. The transducer is referenced to the atmosphere, thus measuring the difference between atmospheric pressure and water chamber pressure, which is gauge pressure. The microcontroller reads the pressure from the output of the transducer amplifiers and calculates the surface tension 50 times per revolution for revolutions per minute (rpm) up to 23 rpm and 25 times per revolution up to 40 revolutions per minute. The sample rate and the data samples per minute are determined by the settling time of the pressure transducer which is 1 millisecond.

3.4 Calibration Procedure

The following is a procedure for calibrating the Surfactometer.

1. The first step is to connect the water source to the center connection on the back of the PBS.
2. Turn on the power switch on the front panel.
3. Then depress the flush valve to allow the water bath to fill with the distilled water.
4. Then lower the water bath and install an acrylic sample chamber in the sample chamber holder.
5. Raise the water bath to the top position and depress the flush valve while thumping the sample chamber to cause the air bubbles to escape through the air vent at the top of the sample chamber (boiled distilled water will eliminate air bubbles).
6. Then use the bubble adjust knob to draw a bubble. Increase the bubble to the large bubble size, see Figure 3.4.
7. Adjust the location of the reticle so that the bubble fits the reticle. The adjustment is made with the reticle adjust wheel located at the bottom middle of the front panel.
8. When the bubble fits the reticle remove the sample chamber.
9. Adjust the water level so that the bottom of the meniscus is aligned with the two arrows on the reticle.
10. Call up the General User Interface (GUI) using the Fire Fox web browser and Click on Set Paper Chart with the speed set to 2.5mm/sec.
11. When the second GUI comes up select the 0 rpm for the motor speed.
12. Click on Set Variables.
13. Turn on the Tera Term program.
14. When the third GUI comes up on the Fire Fox web browser, click on Start Measurement.
15. Observe the Pressure readings on the Tera Term output.
16. Adjust the Pressure Zero knob on the front panel until the pressure reading shows 0 and changes from 0.00 to 0.01 readings. The system is now calibrated in pressure.
17. Temperature has been calibrated in the factory and does not need calibration by the user.

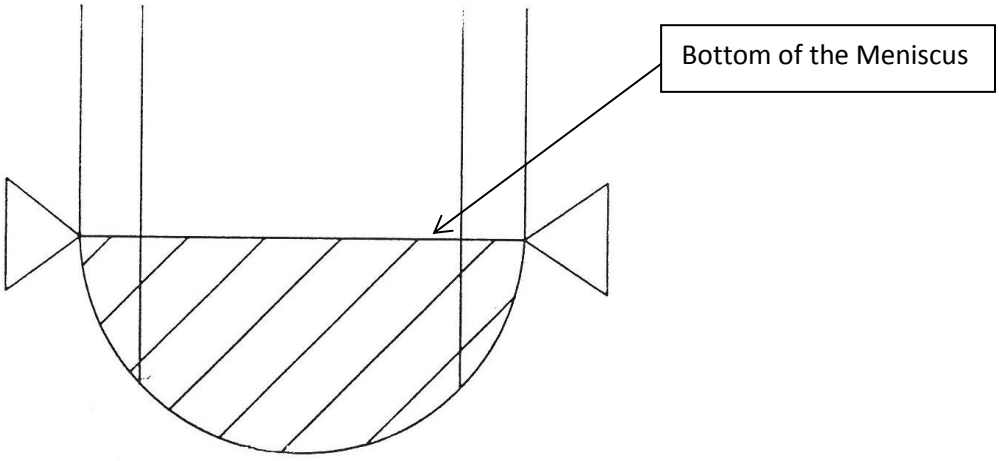


Figure 3.4 Zero Water Level

After the system has been calibrated the system calibration can be verified with the Pressure Calibrator. This is done by attaching the sample chamber that is part of the pressure calibrator in the sample chamber holder within the water bath. The following procedure needs to be followed.

1. Set the pressure calibrator to the 0 cm reading.
2. Insert the pressure calibrator sample chamber into the sample chamber holder within the water bath.
3. Depress the Flush valve knob to allow water to flow into the pressure calibrator.
4. Fill the water calibrator's chamber half full and ensure that there are no air bubbles in the tube.
5. Now set the pressure calibrator to 1 cm of water.
6. Loosen the thumb screw (Figure 3.2) on the side of the calibrator and move the calibrator on the slide so that the reading on the Tera Term display reads 1.00.
7. When you get a reading of 1 within +/- .01 tighten the thumb screw on the side of the calibrator.
8. When the calibrator is moved to the 0 cm it should read 0.00 on the terminal display, when -1cm the reading should be 1.00, when -2cm the reading should be 2.00 and when -3cm should read 3.00 and when -4cm should read 4.00 . These readings are expected to be within +/- .02 of the respective reading.
9. When the calibration verification is complete remove the sample chamber leaving the sample chamber gasket in place on top of the sample chamber holder. You are now ready to make measurements.

4.0 Running a Surfactant Test Sample

This section addresses the testing of a test sample of surfactant. It is assumed that the user has successfully calibrated the Pulsating Bubble Surfactometer and the system is working correctly. As part of the Accessory Kit there is a small syringe with a very small capillary to insert the

surfactant into the sample chamber. The sample chamber must be clean or new and unused and the water in the PBS distilled and boiled to remove absorbed air. This water can be stored in the plastic bag that is also provided in the Accessory Kit. The bag of water must be elevated at least 3 feet above the top of the PBS.

4.1 Water Bath Preparation

With the sample chamber out of the system and the water bath elevated to its highest position, fill the water bath by depressing the flush valve. The water should not be above the vent of the sample chamber when it is inserted. Then lower the water bath (by sliding the water bath down) and insert the sample chamber into the sample chamber holder. Insure that the sample chamber gasket is in place at the top of the water tube nut before inserting the sample chamber. A specially designed tweezers has been provided in the Accessory Kit to hold the sample chamber to make it easier to insert. Raise the water bath and draw a minimum size bubble using the bubble preset knob turning in the counter clock wise direction. You are now ready to click on 'Start Measurement'.

4.2 Procedure for Operation of the PBS

The PBS is connected to the computer by an internet cable and an RS232 cable. If the computer you are using (or the one provided by GTI) does not have a RS232 serial port then use the USB to RS232 Adapter provided in the Accessory Kit. The internet cable will enable the PBS to transmit its General User Interface (GUI) to the lap top or desk top computer using Fire Fox web browser or other explorer program. The RS232 cable connection enables the PBS to stream data as it is generated from the PBS internal computer. This data can be stored (Logged) in a file that the user defines when prompted by the Tera Term terminal program. The Tera Term program is included in the Accessory Kit, and a copy has been set up in the computer that GTI provides.

In summary, the PBS is controlled by the GUI using Fire Fox on an external off the shelf computer and data is provided using the Tera Term terminal program which shows the selections made and the temperature if selected and the data generated. Tera Term also logs the data in a file. This logging process only has to be set up once at the beginning of the series of tests and as long as the Tera Term program is operating it will store everything it receives from the PBS. The Tera Term Log can be turned on and off and restarted under the same of different file name, without turning off the Tera Term program.

GTI has provided a series of 5 data plot programs on EXCEL for the user's convenience. These programs are interactive with the data that the user downloads to the EXCEL program. Descriptions of these programs are given in section 6.0.

4.3 General User Interface (GUI)

The General User Interface (GUI) is shown in Figure 4.3 and shows the parameters that can be selected. The PBS has three GUIs the first one has to be called up by the user either using the IP address of 192.168.1.65 or this address can be stored in the favorites and can be called up from the favorites, which is easier. The computer that is provided with the PBS has been set up for the user, just click on the home icon. But if another computer is used and the user is not able to connect to the PBS then a change to the properties of the network connection will be required. The IT person will have to set the IP address for outgoing to 192.168.1.65 and for the incoming to 192.168.1.64, this is shown below in Figure 4.1 and 4.2. First the selection of all network connections is made, then high light the wired adapter and highlight the internet protocol (TCP/IP) and selects properties shown in Figure 4.1. Then in Figure 4.2 select "use the following IP address" and insert the IP addresses shown. Then click OK and exit the files. The computer will now connect to the PBS without further problems.

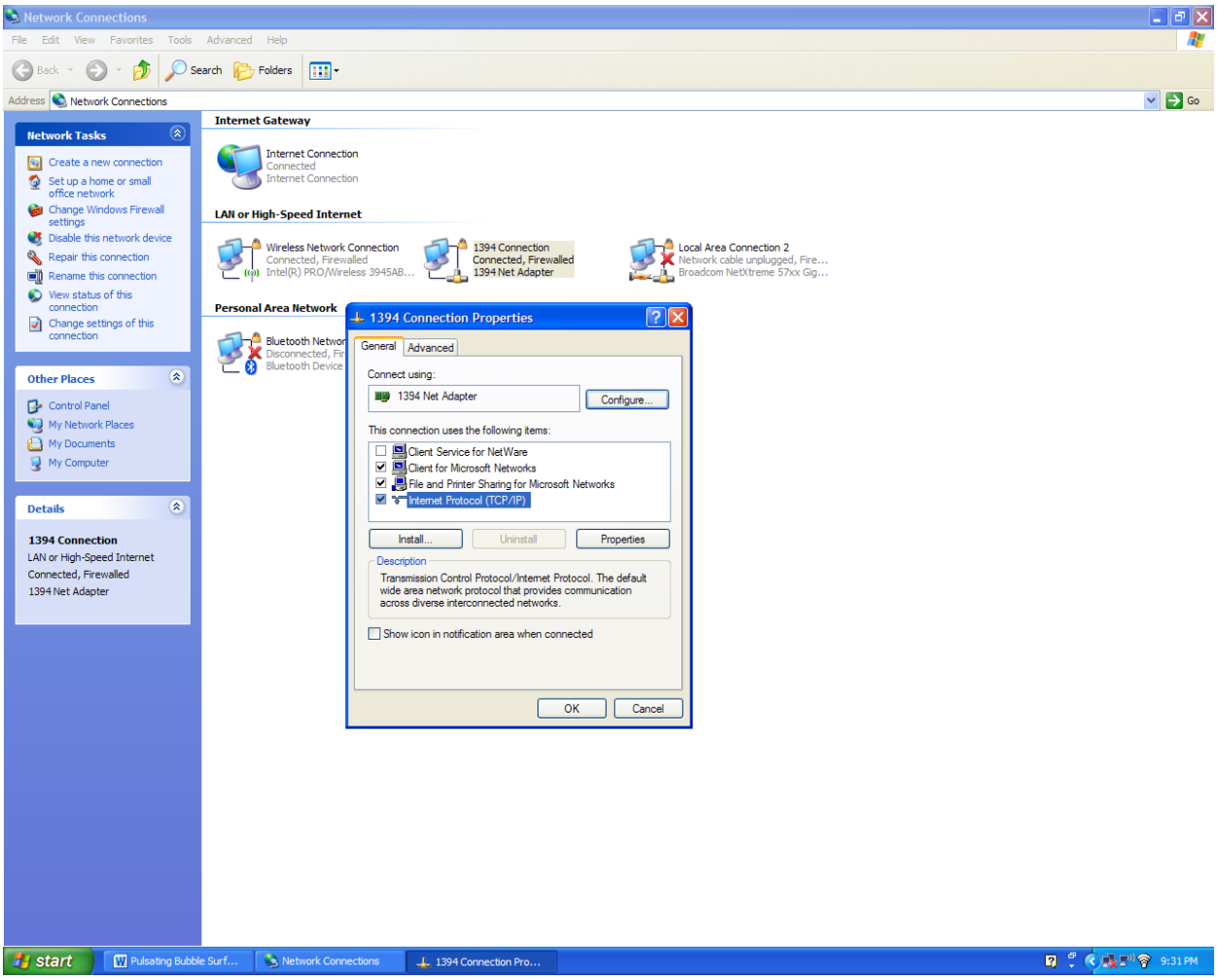


Figure 4.1 First Selection to Set Up the Computer Connection

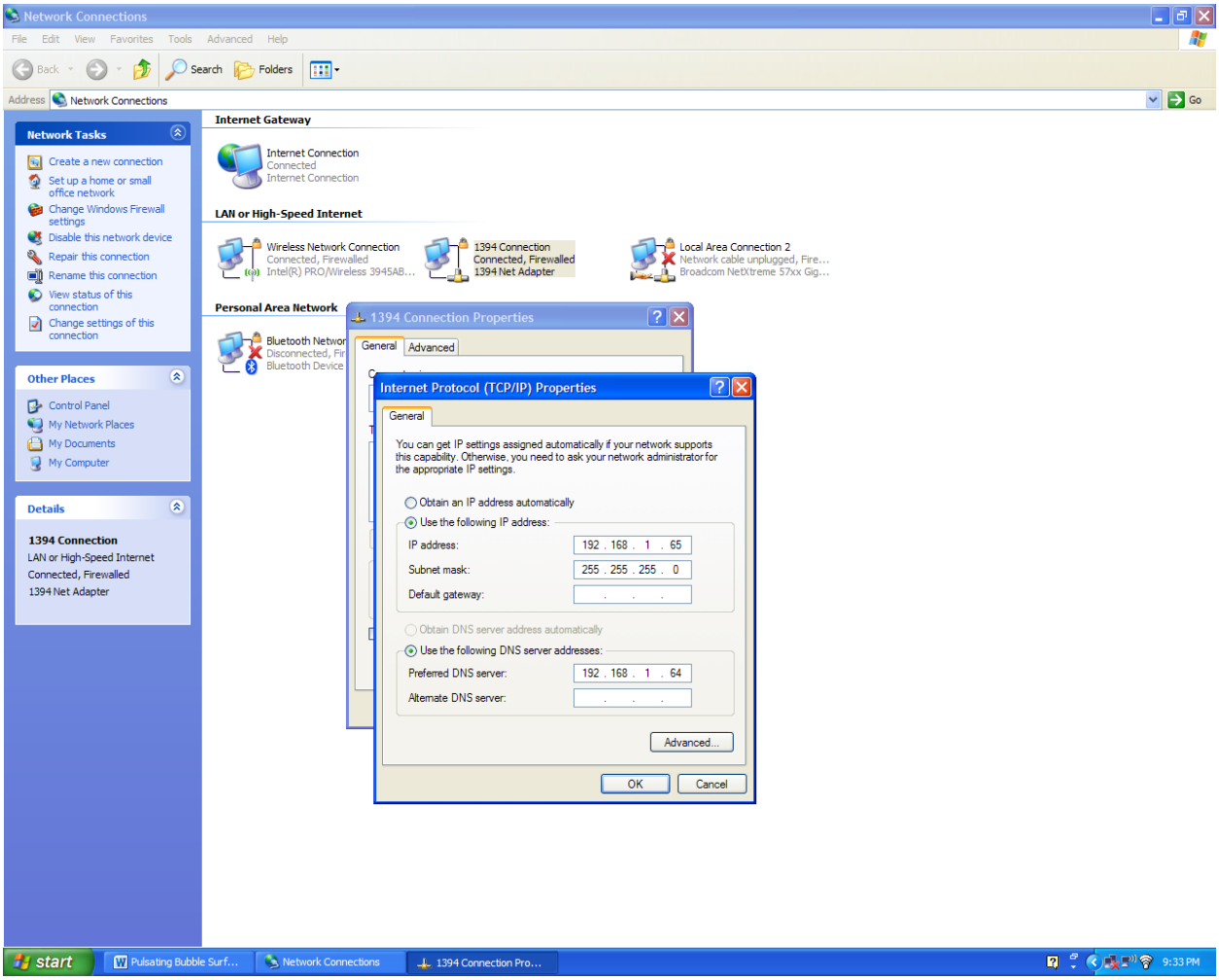


Figure 4.2 Second Selection to Set Up the Computer Interface

The General User Interface (GUI) is used with the Tera Term (Terminal Program). When the PBS is reset the initialization of the system is sent to the terminal program shown in Figure 4.3. This will always look the same and it shows that the various systems are initiated and that the network link has achieved a static IP bind. The next step is to go to the IP address on the web brower program which brings up the first GUI shown in Figure 4.4. This IP address is stored in the Favorites and the home icom as General Transco, Inc. The GUI is used to control the PBS system and select the operating parameters:

1. Pulsation rate slider (0 to 40 rpm)
2. Temperature Slider (0 to 50 deg C)
3. Paper tape printer ON/OFF (Combo Box)
4. Water column pressure range (Combo Box)
    a. 0 to -2cm
    b. -2 to -4cm
    c. 0 to -4cm
5. Set Variables

6. Paper Chart Speed (Combo Box)
    a. 2.5mm/sec
    b. 12mm/sec
    c. 25mm/sec
7. Set Paper Chart
8. Start Measurement

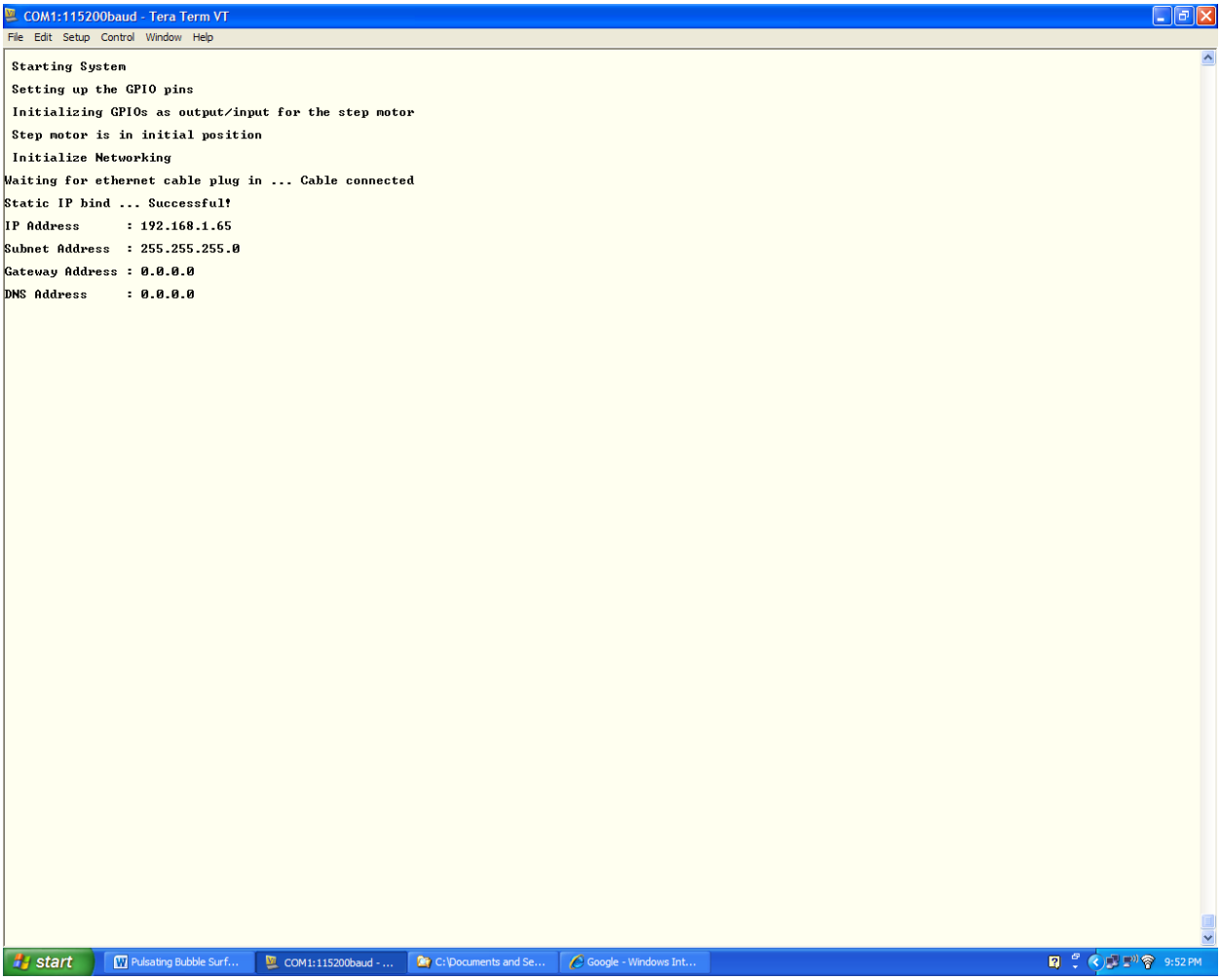


Figure 4.3 Initial Terminal Display

On the first GUI the temp will read 27.45 deg C, this is not the correct reading and it is there to let the user know that the GUI is downloaded. That is, when the IP address is first called up from the Favorites menu the user should click on the refresh symbol at the top of the browser page, in the event that the screen pops up from the cookies. When this is done the temperature reading will be a blank until the web page is downloaded from the PBS. Before the parameters are selected the paper speed is selected and 'Set Paper Chart' is clicked on. Then a second GUI like the first comes up. Even if the other selections are made on the first GUI when the second GUI comes up Figure 4.5 the selections will have to be made again, except

for the chart paper speed. Each time the GUI comes up the default values will be on the GUI but the values that was set in before the Set button was clicked on is the value set into the system computer program. Then select Set Variables. The variables are then set and the paper tape printer will print out the header if the paper tape printer has been turned on at the second GUI. A third GUI comes up Figure 4.6 and this is the GUI that allows the start measurement to be pressed. During the measurement a different paper tape speed can be selected and the Set Paper Chart can be selected to change the chart speed. If either 12 mm/sec or 25mm/sec is selected the printer will print out a tick mark at the minimum bubble, and numerical values at four locations minimum bubble, maximum bubble and half way in between. This is done up to 24 rpm and after that only two numerical values will be printed at the minimum and maximum bubble. The default for the paper speed is 2.5 mm/sec and a tick mark is printed at the minimum bubble.

The Terminal program, Figure 4.7 will receive the set up data and if the Logging is set up all of this information will be sent to the file for storage. If the Heater front panel switch is turned on the temperature displayed on the second GUI will start updating. On the terminal program the temperature will start displaying as the temperature rises to the level selected. When the selected temperature level is reached the system will show the message on the terminal program as follows
'Start Measurement'
Temperature on the GUI will show the actual temperature on the third GUI (if heater is energized). When Start Measurement is seen on the terminal program the measurement is ready to start. If the heater is not on, or the temperature was set to 0 in the second GUI then the heater will be turned off and the temperature will not be controlled.

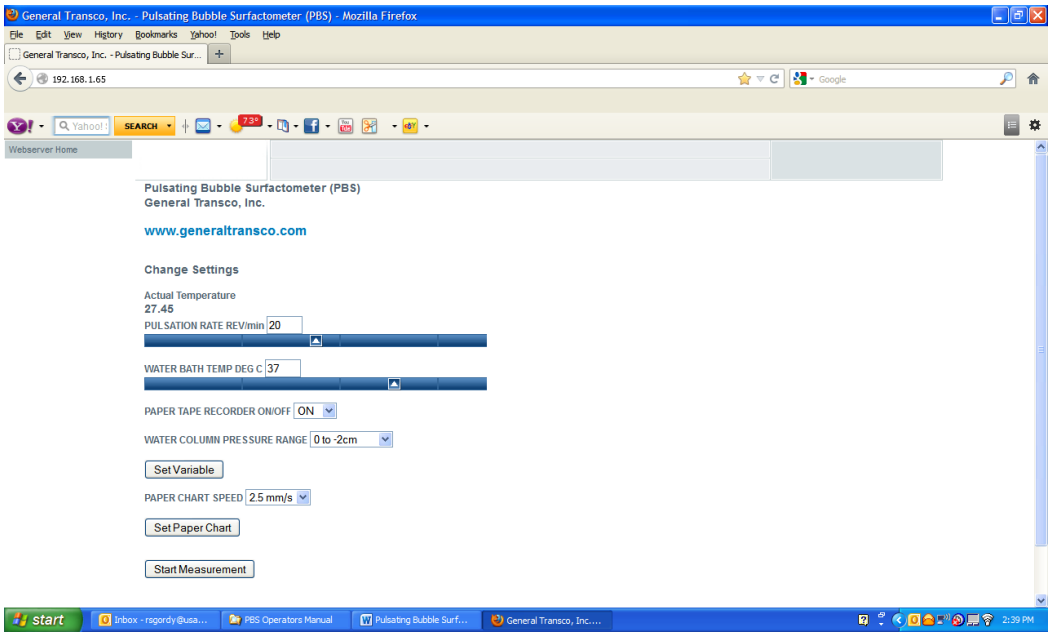


Figure 4.4 First General User Interface (first GUI) used to select the chart speed then select Set Paper Chart

However, if the system has the heater on and the system is left in the mode of being ready for a measurement then the temp will continue to control at the value selected within +/- 1degree. When the start measurement is selected the button on the third GUI will change to Stop Measurement and the system will start operating to make the measurements and the data will be displayed on the terminal program, Figure 4.8 and will be stored in the file selected by the user if the logging function is used. The data will also be plotted by the paper tape printer if it is turned on.

If it is desirable to change the speed of the paper a different speed can be set into the third GUI during the measurement and the Set Paper Chart is clicked on. The GUI will refresh as part of sending this command to the PBS and the new GUI that comes up will show the Start Measurement instead of stop measurement. When the Start Measurement is click on in this case the measurement will stop and the display will show Stop Measurement. The measurement can be turned on and off as many times as necessary and the paper speed can be changed as many times as needed during a measurement. Each time the paper chart speed is changed within the measurement a notation is given on the data output and displayed on the Tera Term. Some experience with the system will clarify the procedure.

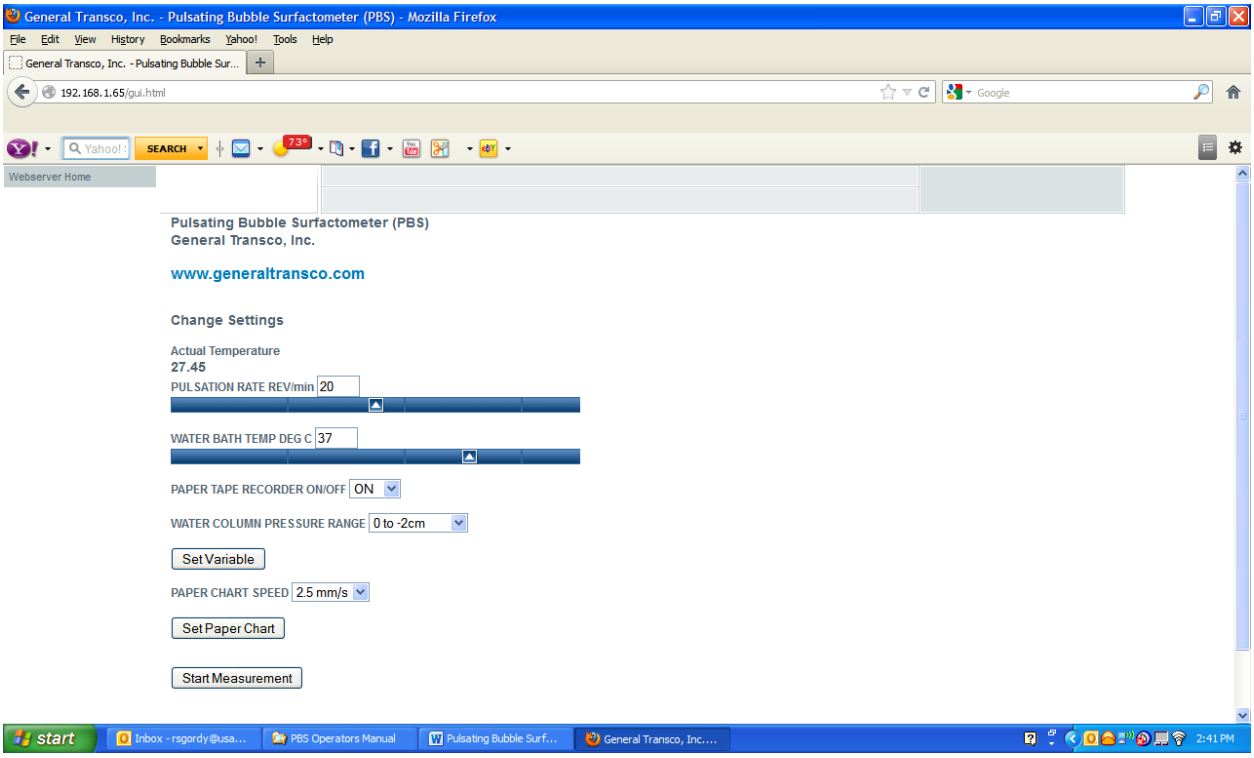


Figure 4.5 Second GUI, the selected chart speed will not show on this GUI, it is used to set the other variables then click on Set Variables

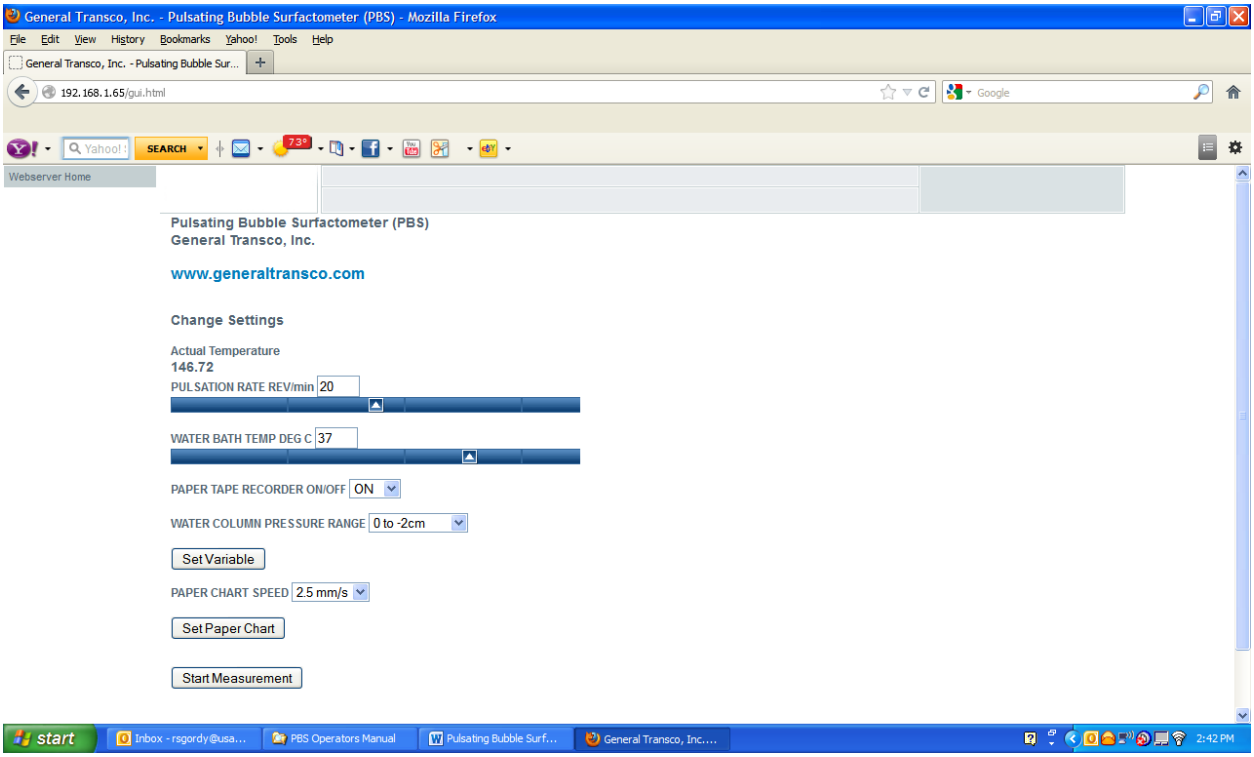


Figure 4.6 Third GUI does not show the variables that were selected; it is used to Start Measurement and change the Chart Speed

The data shown in Figure 4.7 is not meaningful data but is only used to show what can be expected on the display. Actual measurements will be in pressure between 0 that -4 cm of water and Surface Tension between 0 and 80 mili Newton's/meter (mN/m). The read out of the terminal program only shows positive numbers for pressure. The plotting programs provided calculate the time elapsed from the measurement number, rate of pulsation, and revolutions or cycles from the data. The plotting program is described in Section 6.0. The Logging of Data is described in Section 5.0.

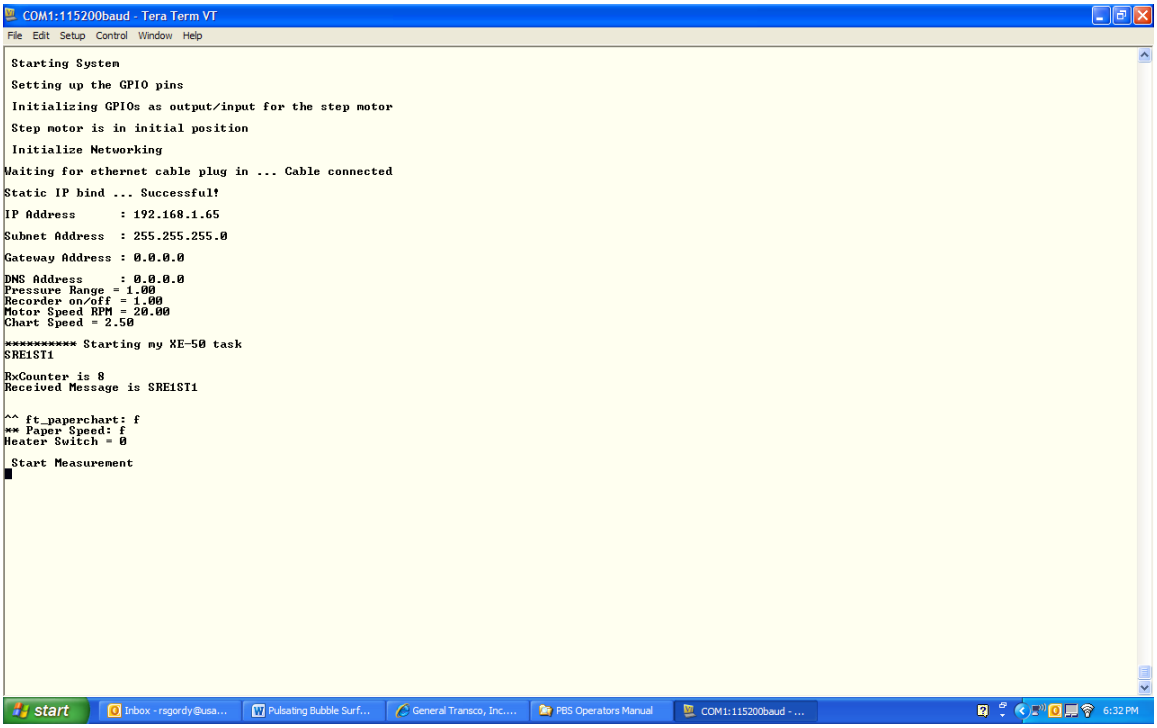


Figure 4.7 Terminal Program Showing the Selected Parameters and waiting to Start Measurement

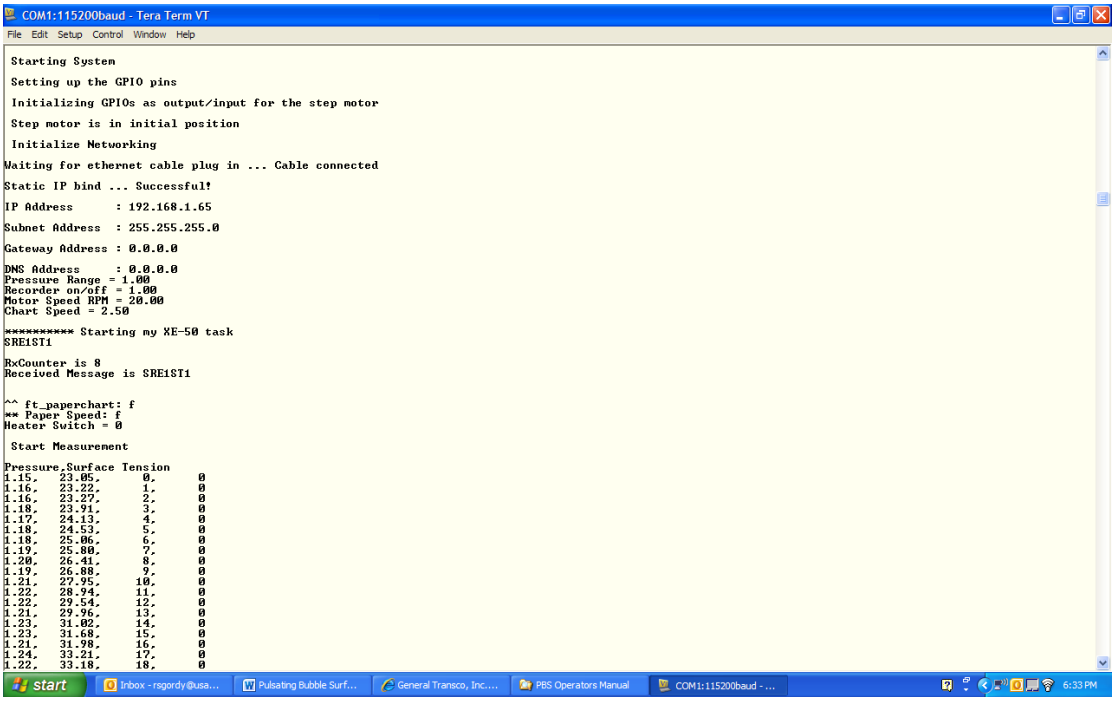


Figure 4.8 Terminal Program Displaying Measurements of Pressure, Surface Tension, Measurement Number and Pulsation Number

4.4 Operating with the Heater Turned On

A water bath heater is provided to heat the surfactant from 0 to 50 degrees C. When the heater is set to 0 it is turned off even if the front panel switch is turned on. Also, if the ambient temperature is higher than the actual temp the heater will not be turned on. There is a provision for cooling the water bath with a laboratory external water cooling systems (not provided). The connections for the external water cooling system are on the back of the PBS and the water is directed to the water bath cooling header.

When the Heater is turned on by depressing the yellow switch on the front panel and setting the temperature on the second GUI slider, then when the Set Variables is clicked on the PBS will turn on the heater and the temperature will be displayed on the third GUI and the temperature will be displayed on the Terminal Program.

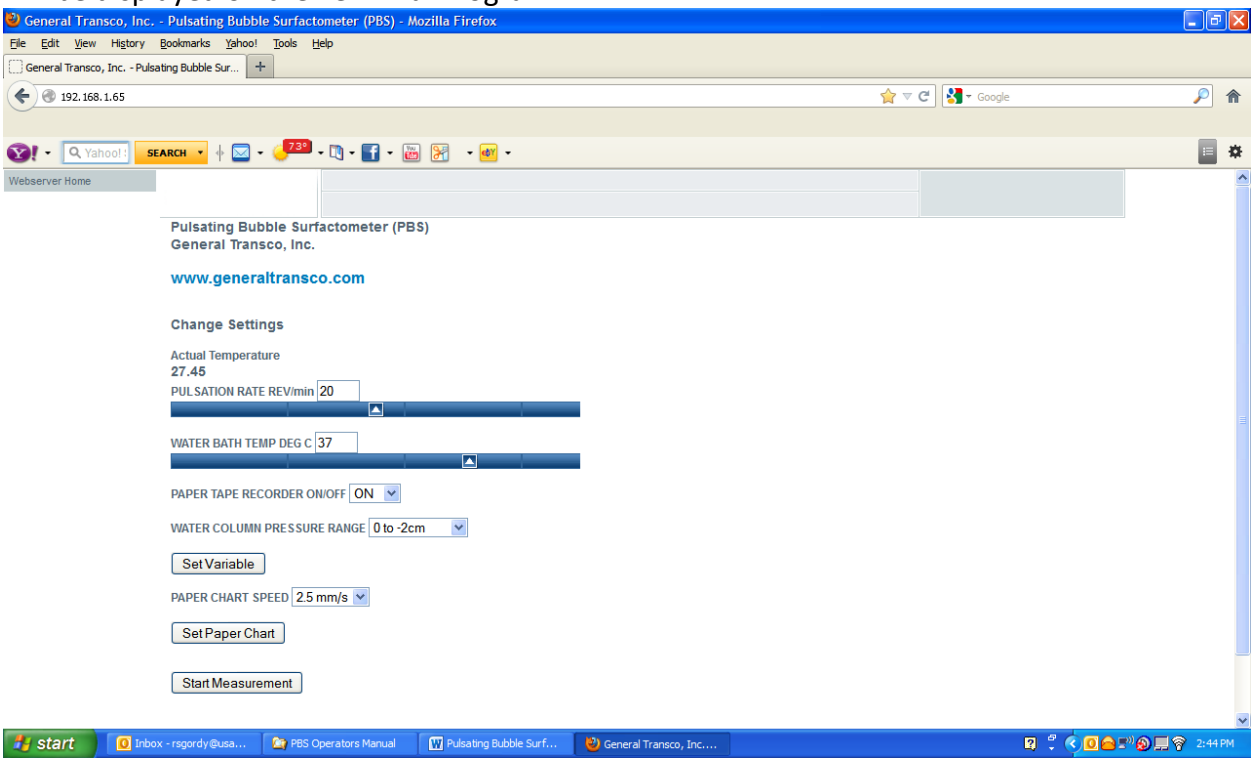


Figure 4.8 First GUI shows the default temperature of 37 degrees C

The second GUI default temperature of 37 degrees C and the front panel yellow heater switch was turned on. Set Variables was clicked on and the third GUI came up. In Figure 4.9 the Terminal Program displays the temperature every second showing the increase in temperature as the heater warms the water bath. When the temperature reaches the temperature that is set in the second GUI which in this case is 37 degrees C, the Terminal Display shows that the PBS is now ready for the measurement to start, Figure 4.10. The User clicks on the 'Start Measurement' button and the Terminal Program Displays the data being generated by the PBS. At this time the temperature is being controlled by the PBS to an accuracy of +/- 1 degree C,

however there is no display of the temperature on the third GUI or on the Terminal Program. The reason for the lack of display during this time is that the measurements are intense and the outputting of the temperature data slows down the PBS from its primary task of processing the data and outputting it to the terminal program. The Lap Top or Desk Top computer stores the data using the terminal program and this does not affect the PBS.

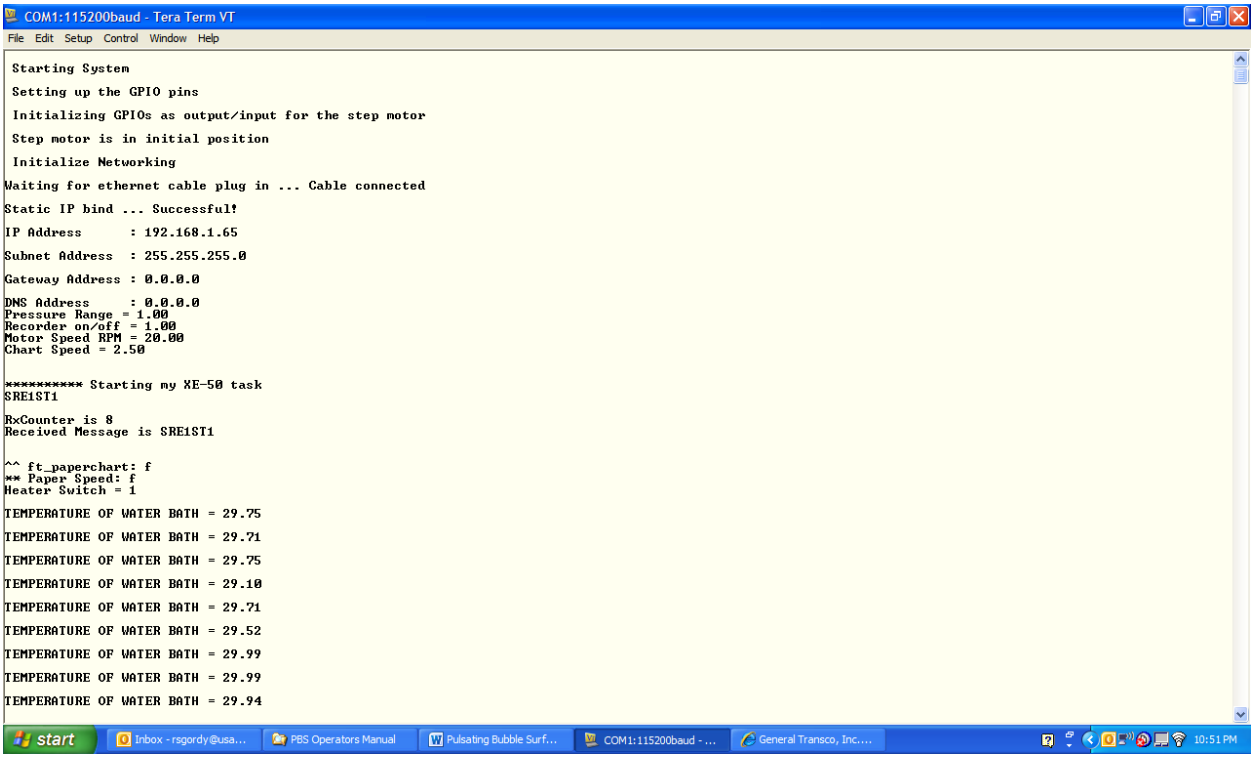


Figure 4.9 When the Set Variables is clicked on in the First GUI the Terminal Program starts displaying the Temperature of the Water Bath

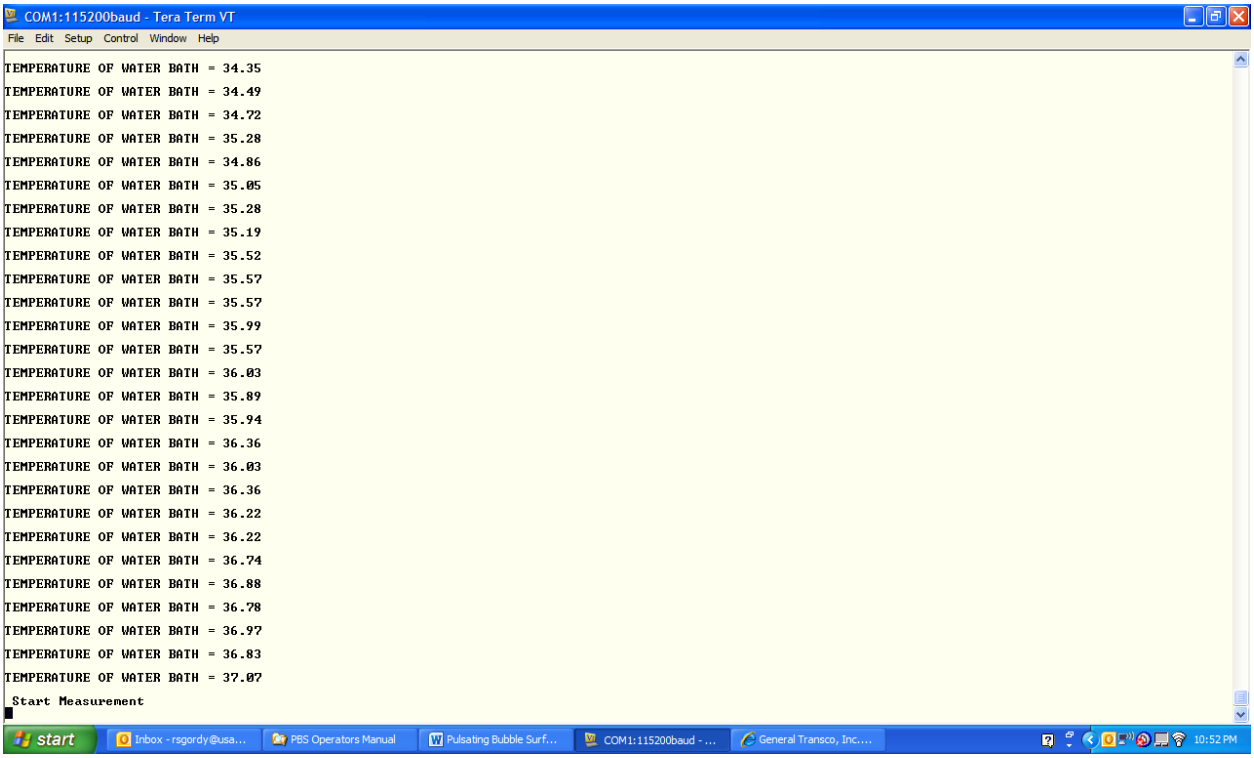


Figure 4.10 When the temperature of the Water Bath comes up to the Programmed Temperature the Terminal program shows that the PBS is ready to make measurements.

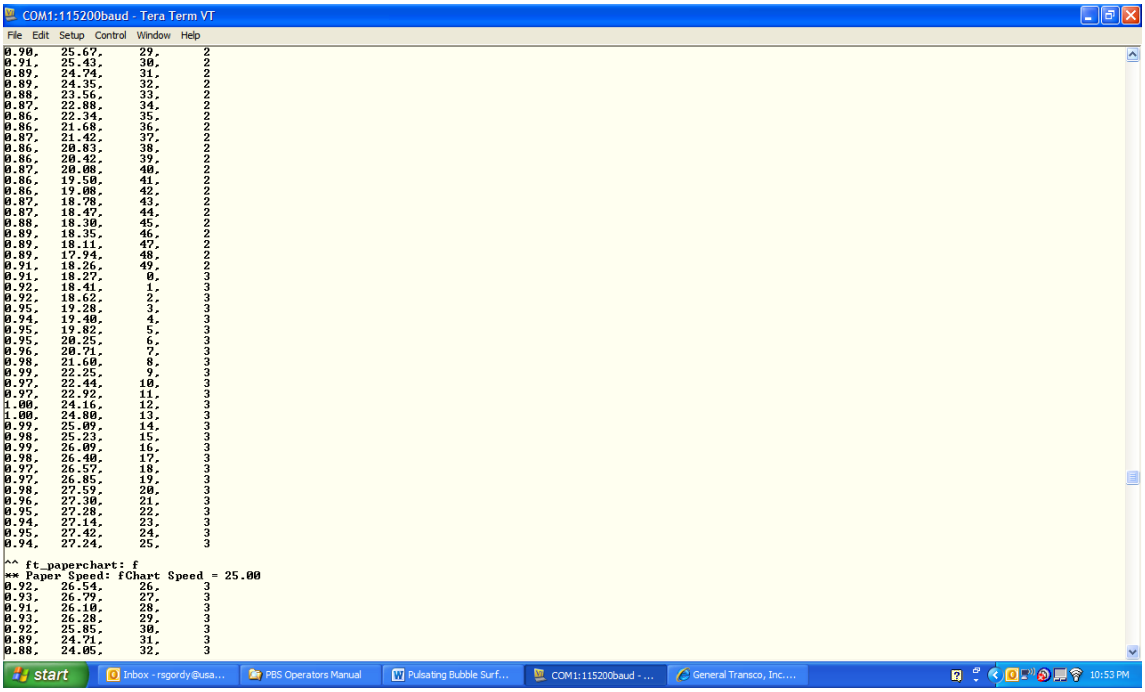
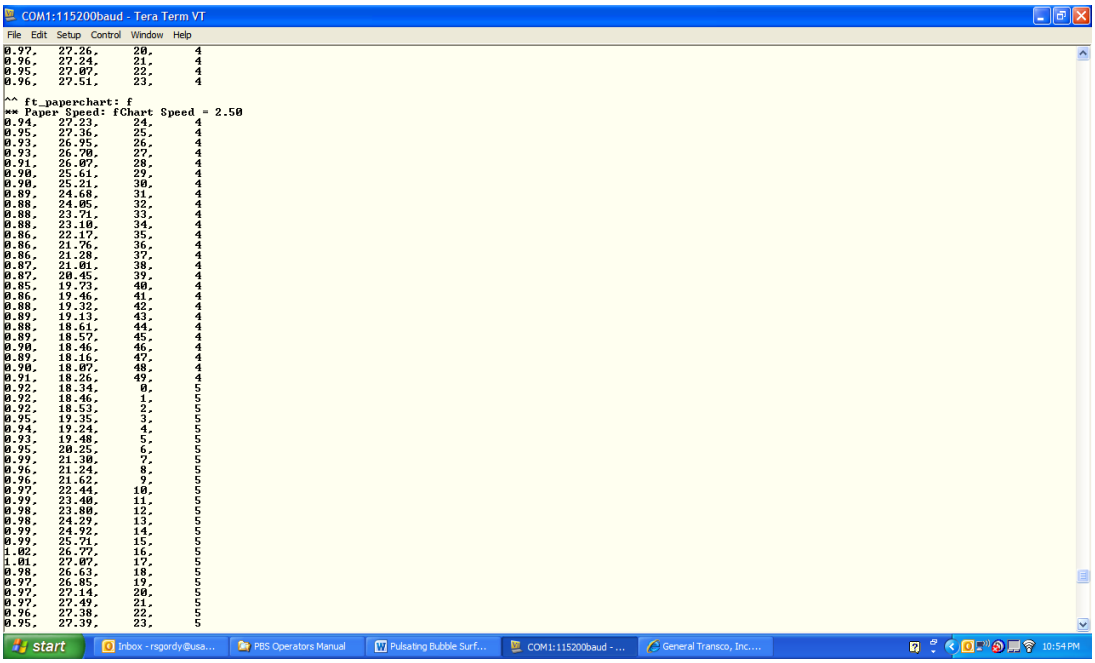


Figure 4.11 When the Chart Speed is Changed the Terminal Data shows the change.



4.12 When the Chart speed is changed back to 2.5mm/sec the Terminal shows the change.

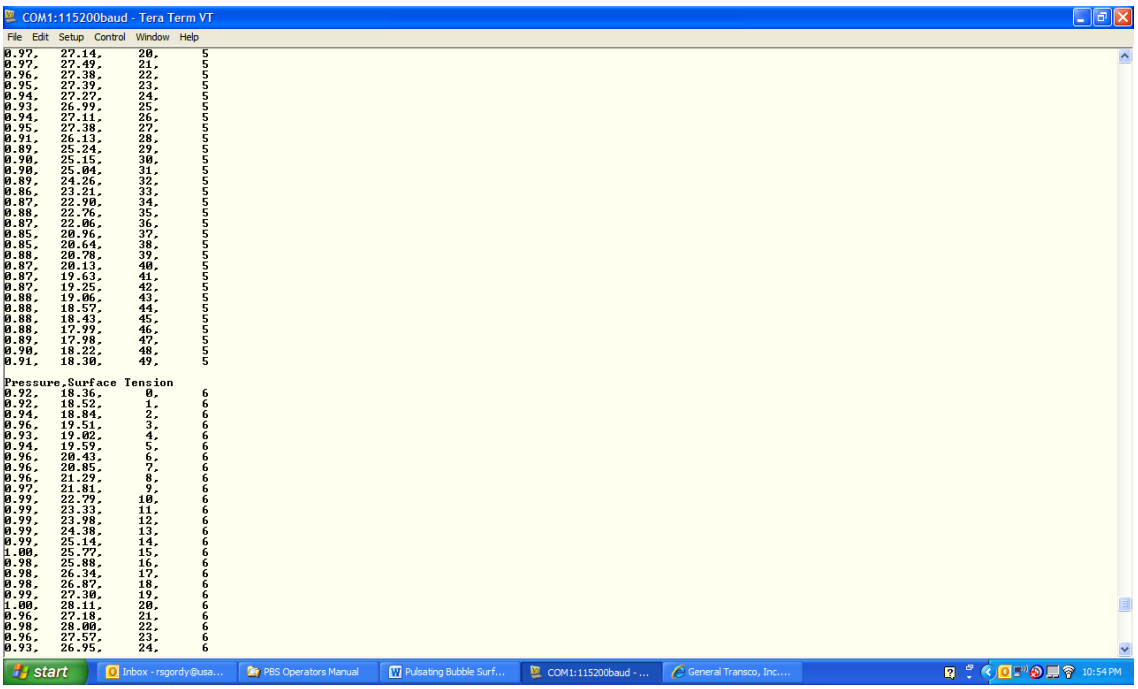


Figure 4.13 When the Measurement is Stopped and Started again the point is flagged with new headings

4.5 Printer Output

The printer output in Figure 4.14 shows two graphs, one for the Difference Pressure and one for the Surface Tension. The Difference Pressure has three selectable scales from the GUI 0 to-2cm of water, -2cm to -4cm of water and 0 to -4cm of water. The surface tension has only one scale of 0 to 80 mili Newtons/meter(mN/m). The graph of the surface tension has a tick mark at the minimum bubble. The speed of the paper output from the printer has three speeds 2.5mm/sec, 12mm/sec, and 25mm/sec. The 12mm/sec and 25mm/sec scales also print out the tick marks at the minimum bubble and a numeric value at four points of the bubble size, at minimum bubble, maximum bubble and half way between for pulsation rates of greater than 0 and less than 24 rpm. For bubble rates greater than 23 or up to 40 rpm the numerical print out is at minimum and max bubble.

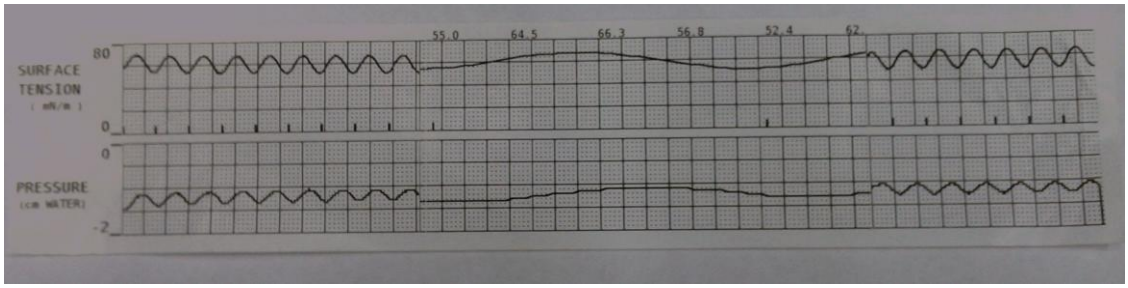


Figure 4.14 Image of printer output showing the change in printer speed from 2.5 mm/sec to 25mm/sec

The speed of the printer can be changed after the measurement has started to any of the three rates without stopping the measurement mode. There is a short pause between changes of approximately one second due to the time needed for the printer to reset its parameters after the command is given. The method of changing the printer speed during the measurement is to set the speed in the 'Set Chart Speed' combo box on the third GUI and then click on 'Set Paper Chart'. The printer will switch to the selected paper speed. If for instance it is desired to go from 2.5 mm/sec to 25mm/sec and then return to 2.5mm/sec, the user would select the 2.5 mm/sec which is the default in the first GUI and then at the third GUI would click on start measurement. When the user is ready, the user would select the 25mm/sec in the combo box and then click on 'Set Paper Chart'. When the GUI comes back up it will always have the default settings in the combo box so when the user wants to return to the 2.5mm/sec setting, the user just has to click on the 'Set Paper Chart' button on the GUI. When the user wants to stop the measurement just click on the Start or Stop Measurement button depending on the number of times the speed of the printer has been changed. The first time the Start Measurement button is clicked on it will come up as Stop Measurement, but if the paper speed is changed the default GUI will come up as Start Measurement even though the measurement is still in process. This is of no consequence, since if the button is clicked on it will stop the measurement.

The printer can be turned on or off, but if it is turned on there must be paper in it or the system will not operate. If the printer is turned on and there is no paper in it, the printer will generate

an error that will stop the system. The system can be operated without paper but the printer selection has to be turned off. The data will still stream to the terminal program and the data can be plotted using a plot program such as EXCEL.

5.0 Plotting Data

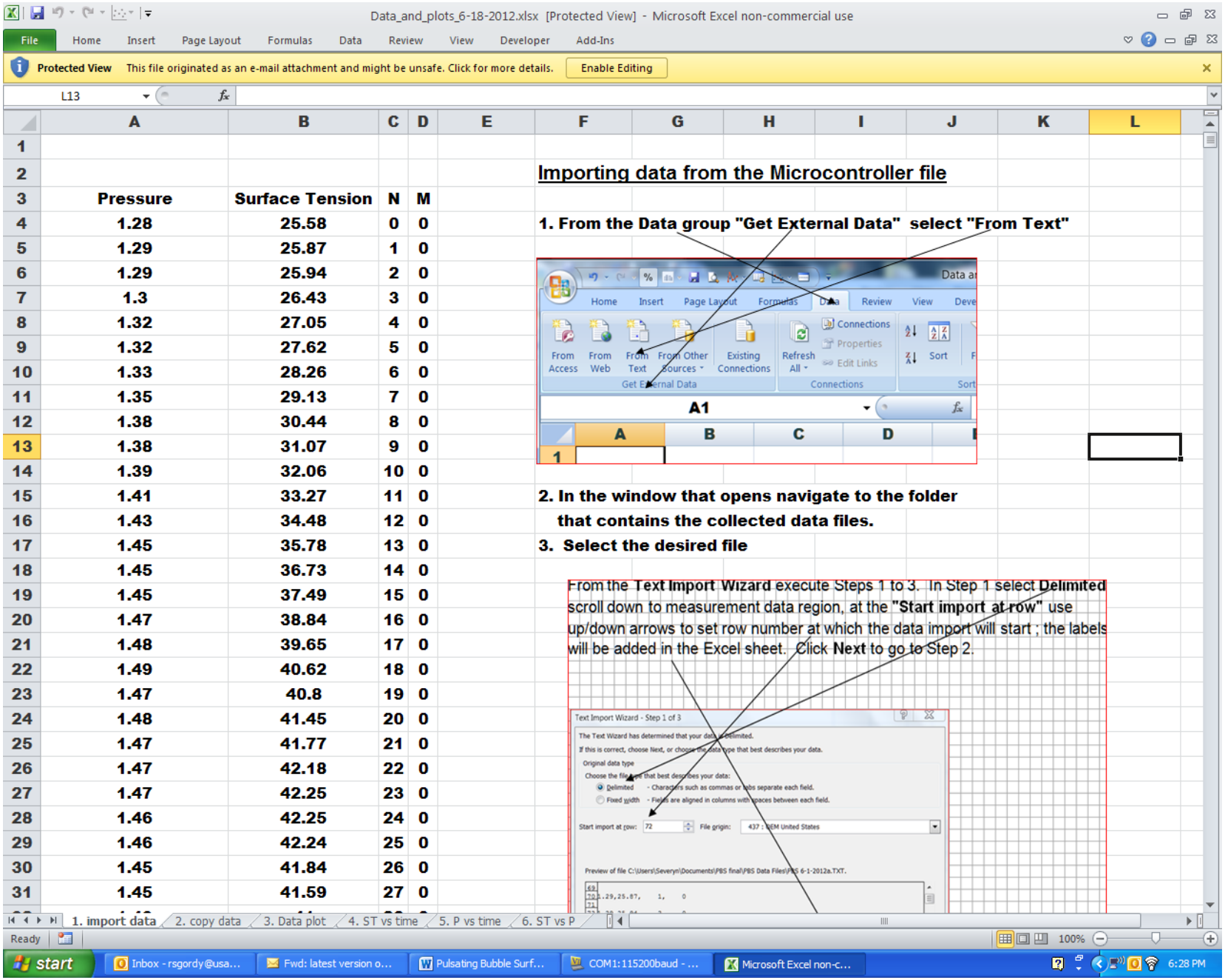
The EXCEL Data Plot Programs provided by GTI are composed of interactive plots using custom subroutines called micros. This set of plot programs were developed by Severyn Zoledziowski E.D., Ph.D. with the support of R. Stephen Gordy Ph.D. PE, all rights are reserved by GTI. The plots are provided by GTI at no cost to the user. The use of these plots are to be used by the user at the users own risk and GTI takes no responsibility for their use. GTI believes that these plots will be very useful and hopes that the user can make good use of them. Data shown in the following plots and in the EXCEL files are nonsense data and are not representative of actual Pulmonary Surfactant. Surfactant data is proprietary to the company formulating the surfactant and there is no attempt in the presented data to infringe on valid surfactant data.

The following plots consist of an Import Data page, a Copy Data page, and 5 plot pages. The import data page can accept the entire file from the Tera Term program data file and automatically send this to the Copy Data page. The Copy Data page is where the user/analyst selects the part of the data that is to be plotted; this may be one or more cycles of data. This file is automatically provided to each of the plot pages. Directions to use the EXCEL system of plots are given on each of the respective pages for the convenience of the user. The EXCEL plot package is included in the CD that comprises this Operators Manual.

5.1 Import Data Page

The first page or the Import Data Page is shown in Figure 5.1. The data is shown on the left side of the page and the instructions are shown on the right side of the page. The instructions lead the user through the steps needed to up load the data from the file that the Tera Term terminal program stored the streaming data. This file is separated by commas and is compatible with the EXCEL program. The program that is described on the right side of Figure 5.1 are the EXCEL program.

The Import Data Page will transfer all of the data that is stored in the file that the Tera Term has been storing data received from the PBS. Therefore the Startup and the Setup and the Temperature output and the Paper Printer confirmation and the data will be transferred. In the ‘Copy Data Page’ the user selects the data that will be used from the ‘Import Data Page’, therefore multiple plots can be made and stored by the user, using different sets of data from the ‘Import Data Page’.



Pressure	Surface Tension	N	M
1.28	25.58	0	0
1.29	25.87	1	0
1.29	25.94	2	0
1.3	26.43	3	0
1.32	27.05	4	0
1.32	27.62	5	0
1.33	28.26	6	0
1.35	29.13	7	0
1.38	30.44	8	0
1.38	31.07	9	0
1.39	32.06	10	0
1.41	33.27	11	0
1.43	34.48	12	0
1.45	35.78	13	0
1.45	36.73	14	0
1.45	37.49	15	0
1.47	38.84	16	0
1.48	39.65	17	0
1.49	40.62	18	0
1.47	40.8	19	0
1.48	41.45	20	0
1.47	41.77	21	0
1.47	42.18	22	0
1.47	42.25	23	0
1.46	42.25	24	0
1.46	42.24	25	0
1.45	41.84	26	0
1.45	41.59	27	0

Figure 5.1 This is the first page of the Import Data Page

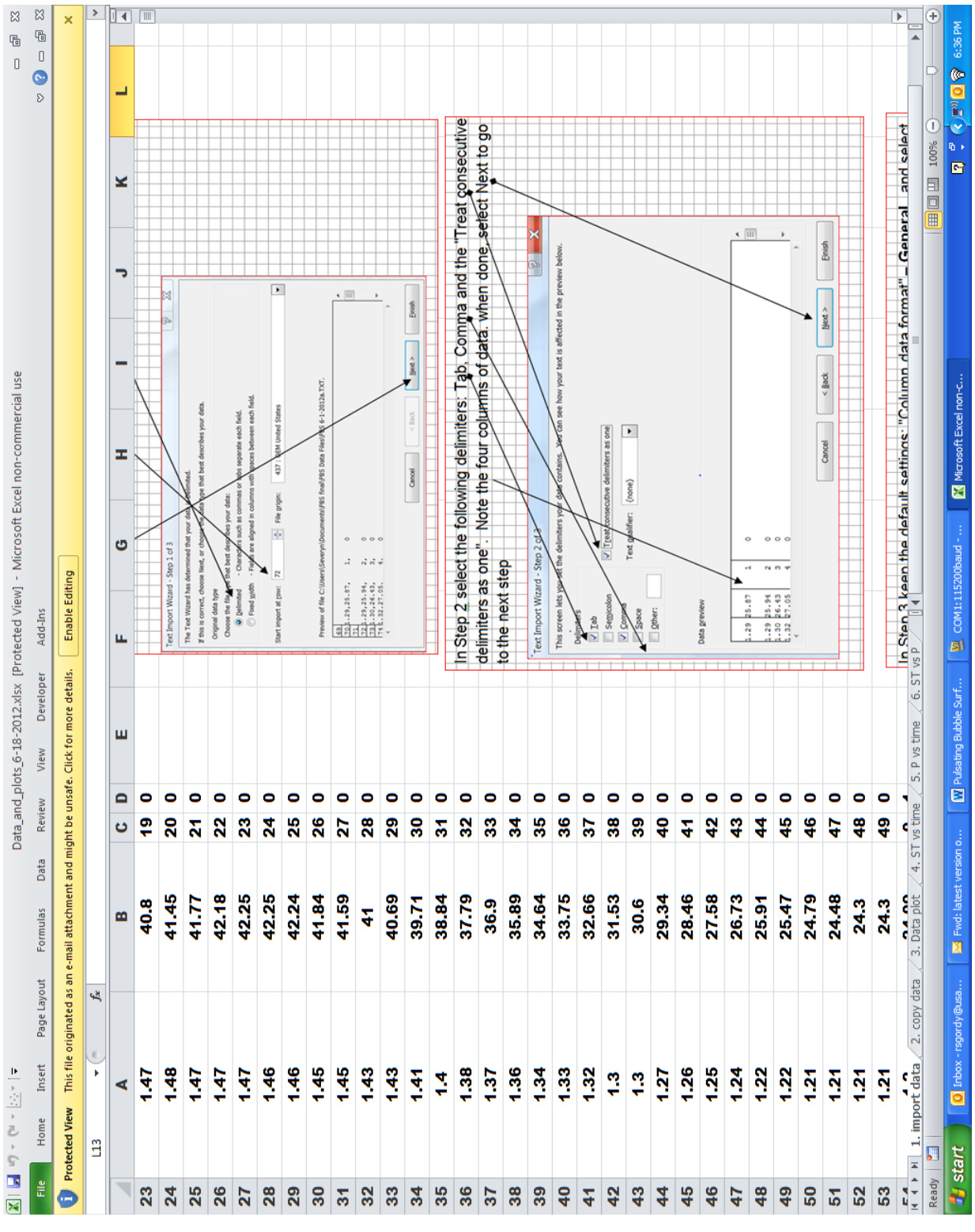
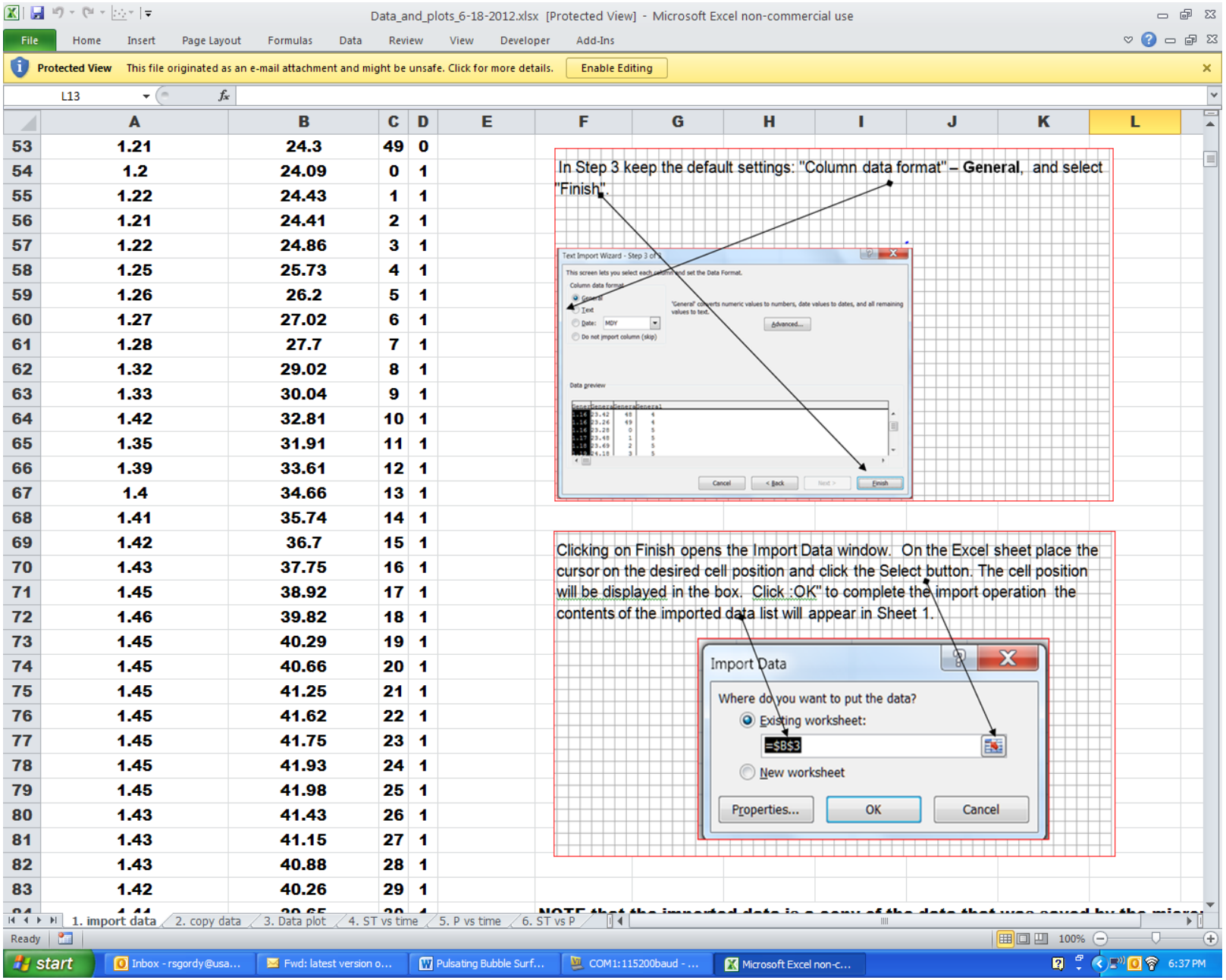
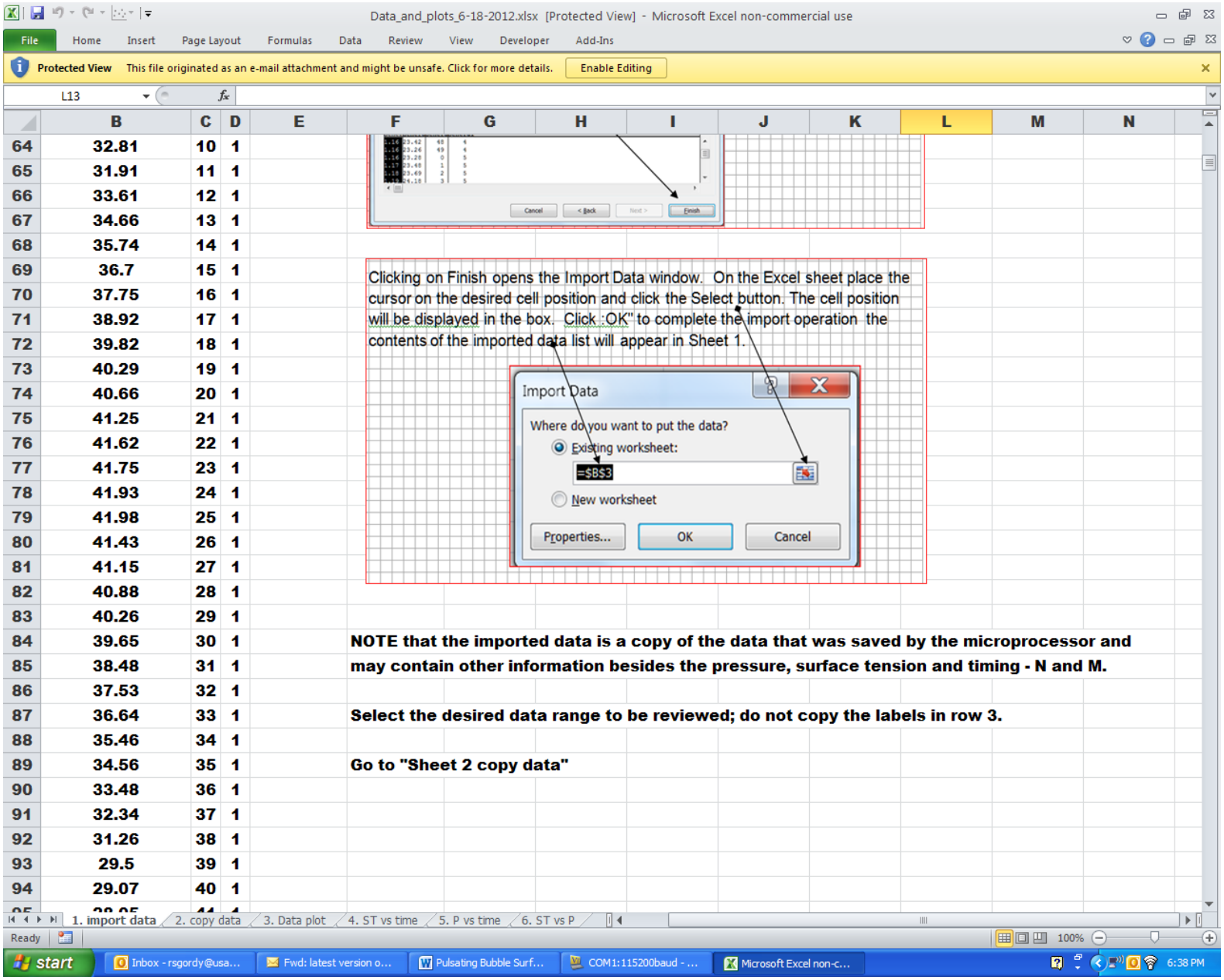


Figure 5.2 Second Page of the Import Data File



	A	B	C	D
53	1.21	24.3	49	0
54	1.2	24.09	0	1
55	1.22	24.43	1	1
56	1.21	24.41	2	1
57	1.22	24.86	3	1
58	1.25	25.73	4	1
59	1.26	26.2	5	1
60	1.27	27.02	6	1
61	1.28	27.7	7	1
62	1.32	29.02	8	1
63	1.33	30.04	9	1
64	1.42	32.81	10	1
65	1.35	31.91	11	1
66	1.39	33.61	12	1
67	1.4	34.66	13	1
68	1.41	35.74	14	1
69	1.42	36.7	15	1
70	1.43	37.75	16	1
71	1.45	38.92	17	1
72	1.46	39.82	18	1
73	1.45	40.29	19	1
74	1.45	40.66	20	1
75	1.45	41.25	21	1
76	1.45	41.62	22	1
77	1.45	41.75	23	1
78	1.45	41.93	24	1
79	1.45	41.98	25	1
80	1.43	41.43	26	1
81	1.43	41.15	27	1
82	1.43	40.88	28	1
83	1.42	40.26	29	1

Figure 5.3 Page 3 of the Import Data File

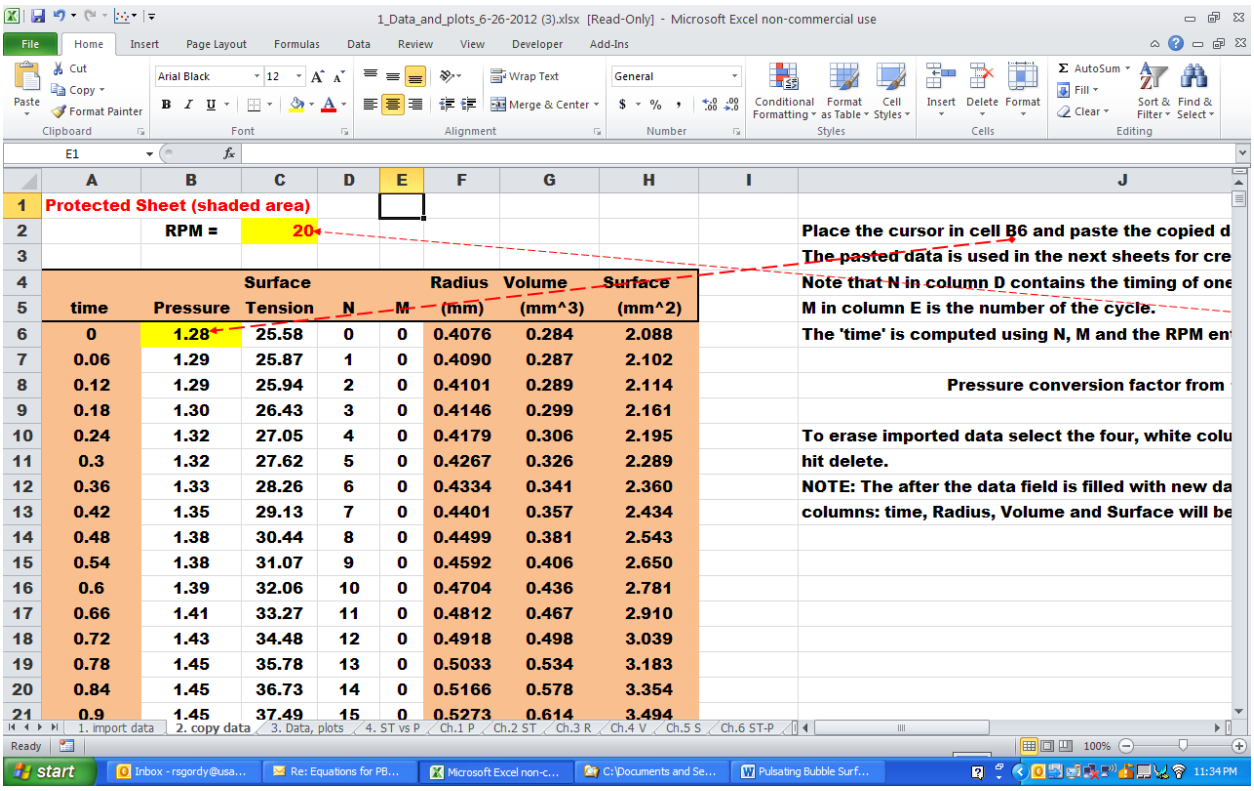


	B	C	D
64	32.81	10	1
65	31.91	11	1
66	33.61	12	1
67	34.66	13	1
68	35.74	14	1
69	36.7	15	1
70	37.75	16	1
71	38.92	17	1
72	39.82	18	1
73	40.29	19	1
74	40.66	20	1
75	41.25	21	1
76	41.62	22	1
77	41.75	23	1
78	41.93	24	1
79	41.98	25	1
80	41.43	26	1
81	41.15	27	1
82	40.88	28	1
83	40.26	29	1
84	39.65	30	1
85	38.48	31	1
86	37.53	32	1
87	36.64	33	1
88	35.46	34	1
89	34.56	35	1
90	33.48	36	1
91	32.34	37	1
92	31.26	38	1
93	29.5	39	1
94	29.07	40	1

Figure 5.4 Page 4 or the Import Data File

5.2 Copy Data Page

The purpose of the Copy Data Page is to calculate the time for each measurement and the radius and volume of the bubble for each measurement of the selected data that will be used to make plots. To prepare for the transport of the data from the Import Data File, highlight the columns BCDE in the Copy Data Page and delete the data. Do not delete the titles at the top of the columns and do not delete the time, radius, volume column that are in red. The time column is a file that solves the time equation in each cell. Then highlight the data that is needed from the Import Data File page. When highlighting all 4 columns should be highlighted. Then copy the file by clicking simultaneously control and C (copy). Then go to the Copy Page and click on cell B6 and click on control V simultaneously (Paste). This will paste the data on the Copy Data Page and it will calculate the time and the radius and volume for each cell automatically. The RPM must be entered by the user from the 'Import Data Page', this is needed to calculate the time for each cell.



time	Pressure	Surface Tension	N	M	Radius (mm)	Volume (mm^3)	Surface (mm^2)
0	1.28	25.58	0	0	0.4076	0.284	2.088
0.06	1.29	25.87	1	0	0.4090	0.287	2.102
0.12	1.29	25.94	2	0	0.4101	0.289	2.114
0.18	1.30	26.43	3	0	0.4146	0.299	2.161
0.24	1.32	27.05	4	0	0.4179	0.306	2.195
0.3	1.32	27.62	5	0	0.4267	0.326	2.289
0.36	1.33	28.26	6	0	0.4334	0.341	2.360
0.42	1.35	29.13	7	0	0.4401	0.357	2.434
0.48	1.38	30.44	8	0	0.4499	0.381	2.543
0.54	1.38	31.07	9	0	0.4592	0.406	2.650
0.6	1.39	32.06	10	0	0.4704	0.436	2.781
0.66	1.41	33.27	11	0	0.4812	0.467	2.910
0.72	1.43	34.48	12	0	0.4918	0.498	3.039
0.78	1.45	35.78	13	0	0.5033	0.534	3.183
0.84	1.45	36.73	14	0	0.5166	0.578	3.354
0.9	1.45	37.49	15	0	0.5273	0.614	3.494

Figure 5.5 Copy Data Page

5.3 Data Plot

The Data Plot is a plot of the Surface Tension vs Time, Difference Pressure vs Time, Bubble Radius vs Time, and Bubble Volume vs Time. The paper tape printer prints the Difference

Pressure and the Surface Tension. Unlike the paper tape printer that operates at a speed that in independent of real time, the Data Plot calculates the time axis from the N and M parameters and the pulsation rate in revolutions per minute. The following screen prints from the EXCEL Plot program show the descriptions of the directions to select data and generate the plots. These plots can be highlighted and copied and pasted on a Word Document or a Power Point Presentation. Additional pages with just the plots are provided for the users convenience to copy and paste in reports or presentations.

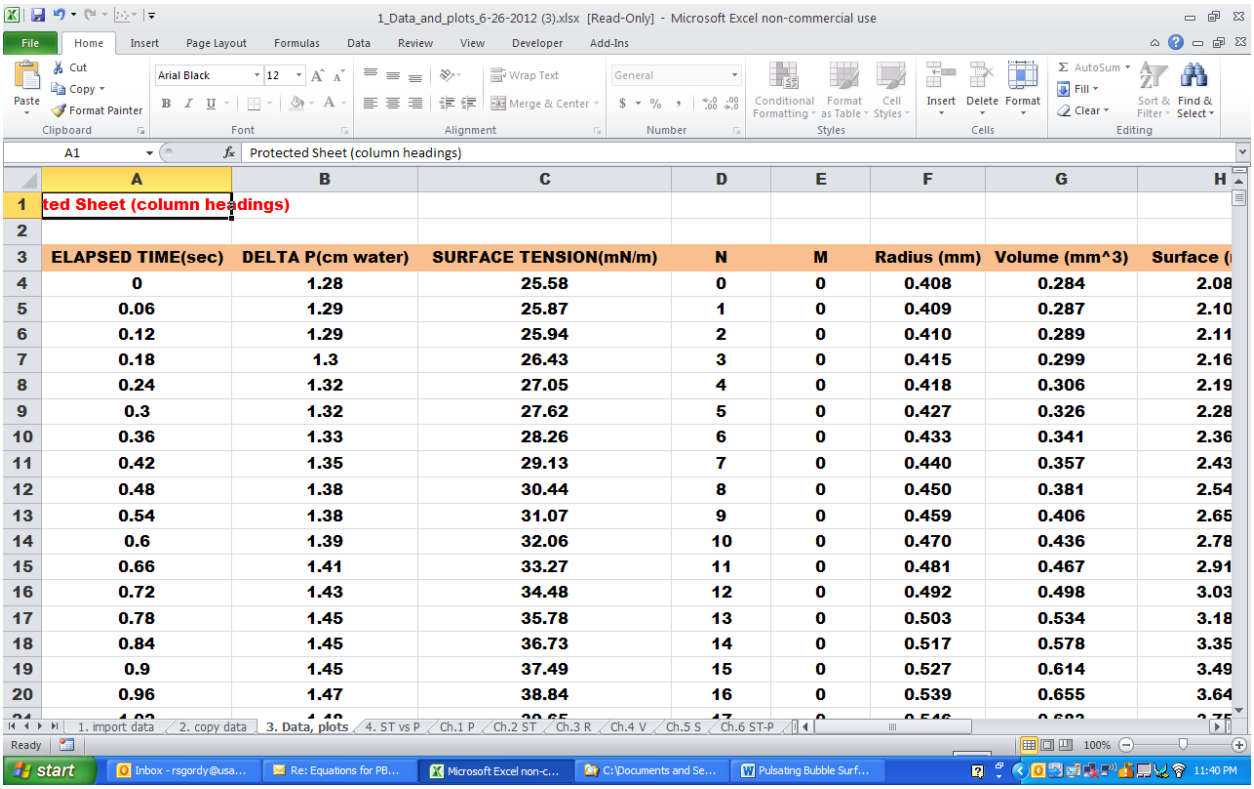


Figure 5.6 Data Plot Page Showing the Columns of Data and Calculated data

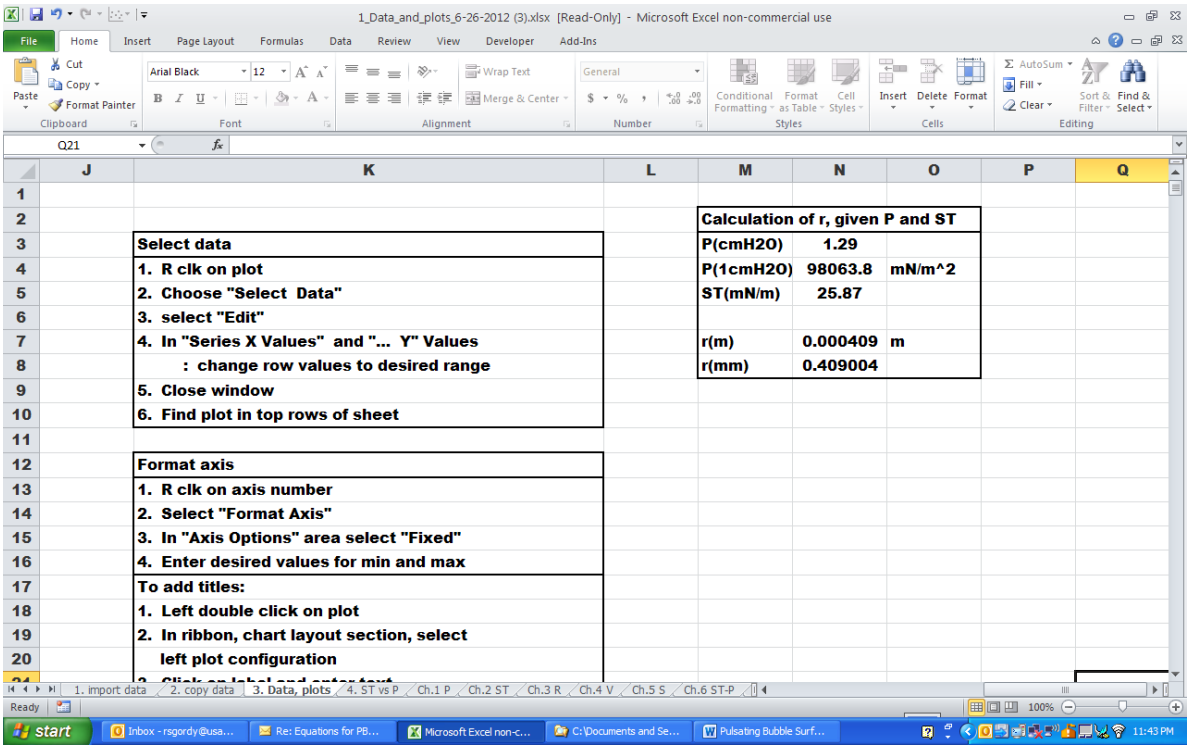


Figure 5.7 View of the Data Plots Instructions for Importing the Data

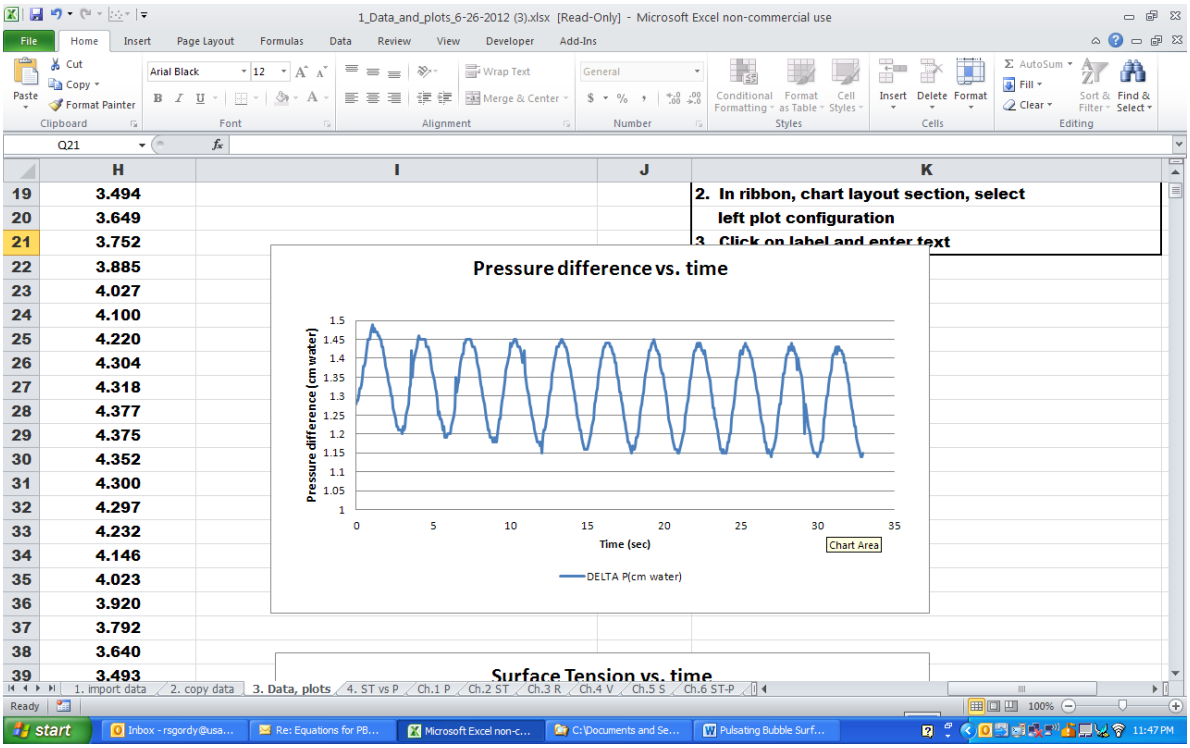
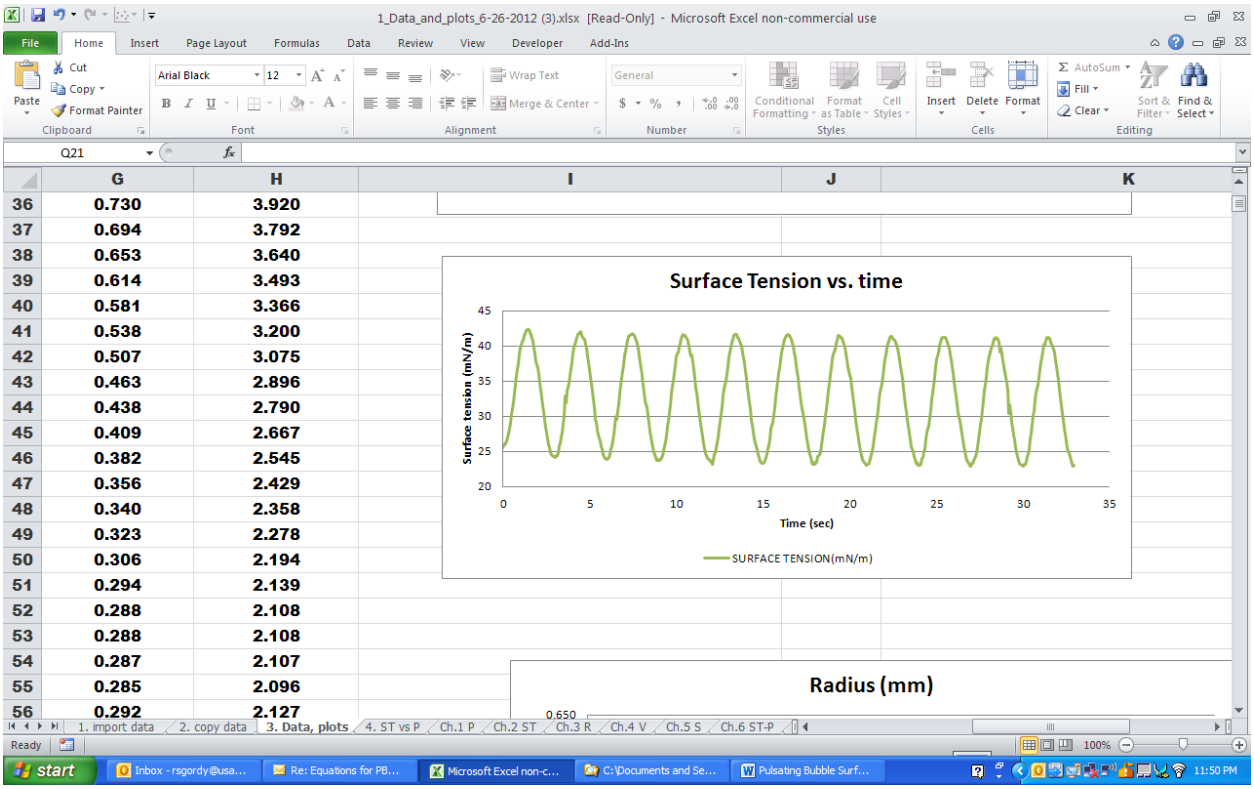


Figure 5.8 Data Plot Page Showing the Difference Pressure vs Time for a Selected Segment of Data

5.4 Surface Tension vs. Time

The Surface Tension vs Time plot is given as a solitary plot. It is like the Data Plot except only addresses the Surface Tension. The instructions are given on the data plot.

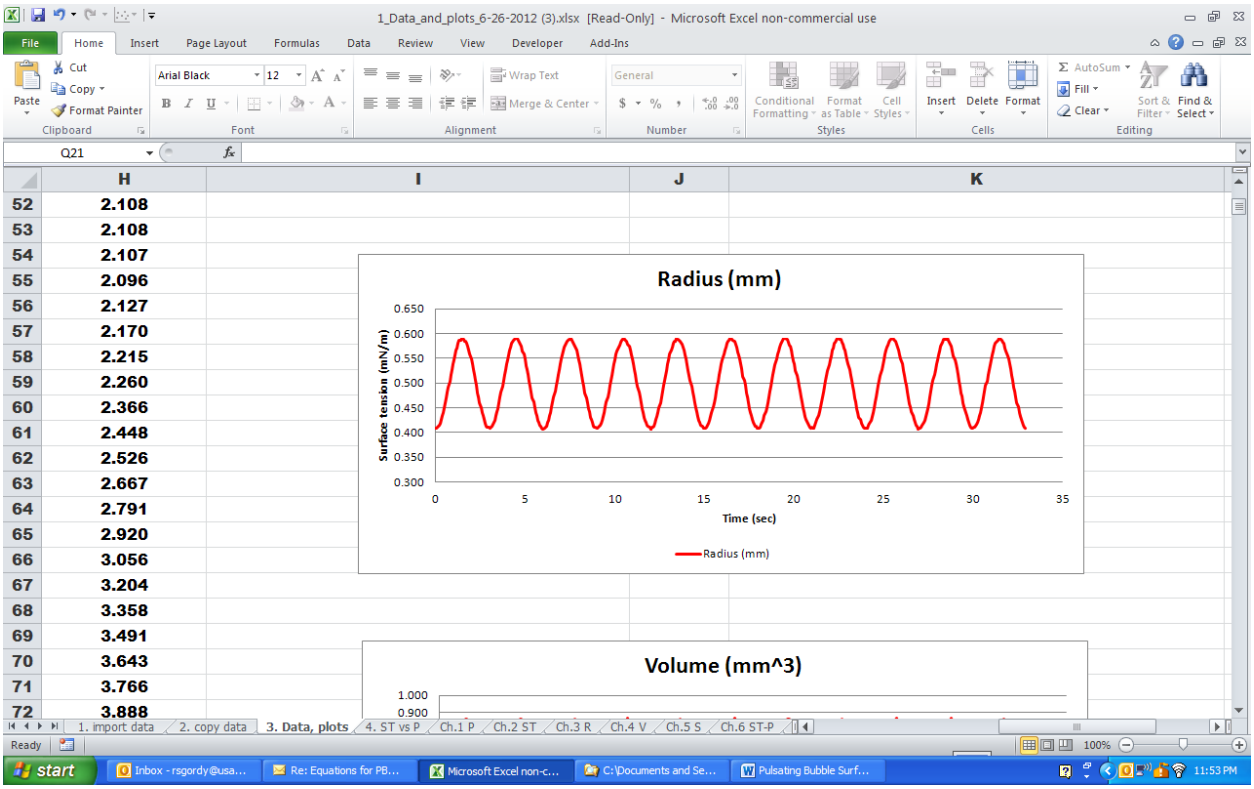


	G	H
36	0.730	3.920
37	0.694	3.792
38	0.653	3.640
39	0.614	3.493
40	0.581	3.366
41	0.538	3.200
42	0.507	3.075
43	0.463	2.896
44	0.438	2.790
45	0.409	2.667
46	0.382	2.545
47	0.356	2.429
48	0.340	2.358
49	0.323	2.278
50	0.306	2.194
51	0.294	2.139
52	0.288	2.108
53	0.288	2.108
54	0.287	2.107
55	0.285	2.096
56	0.292	2.127

Figure 5.9 Data Plot Page Showing the Surface Tension vs Time for a Selected Segment of Data

5.5 Bubble Radius vs. Time

The Bubble Radius vs Time plot is given as a solitary plot. It is like the Data Plot except only addresses the Bubble Radius. The instructions are given on the data plot.

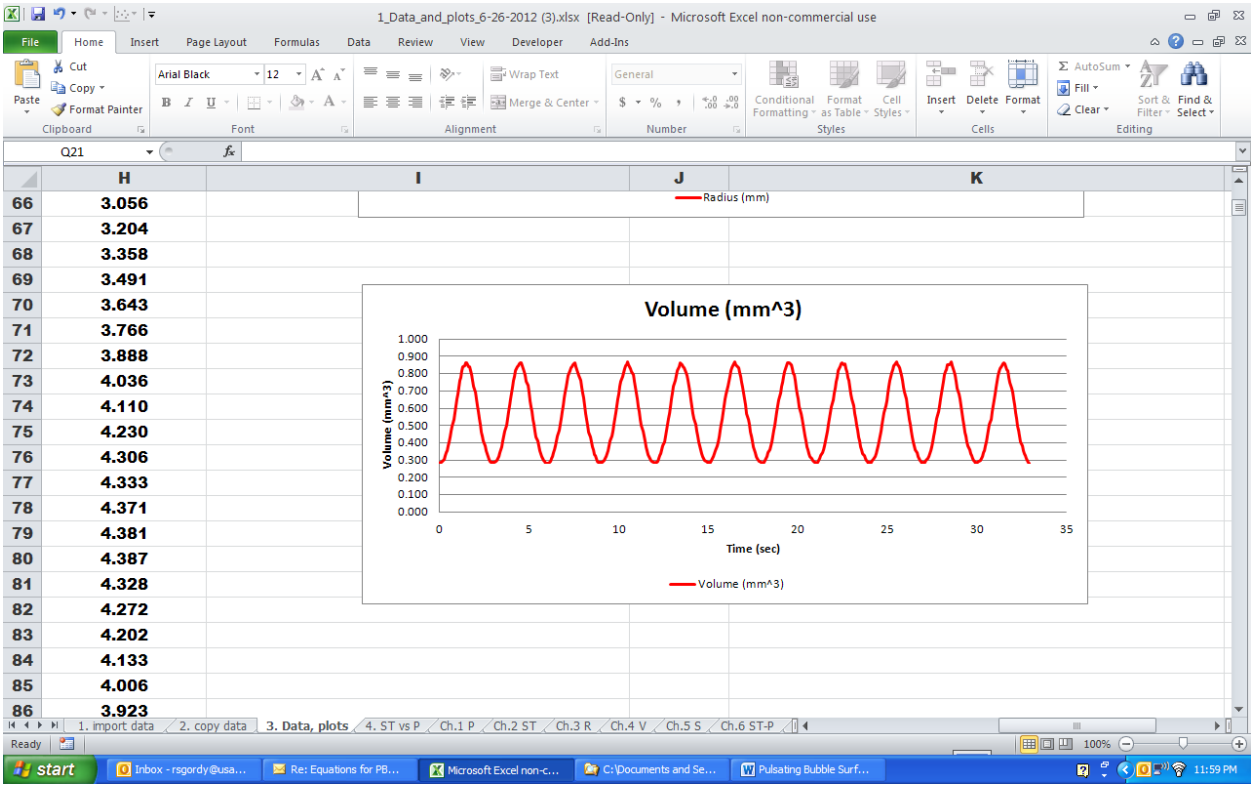


	H
52	2.108
53	2.108
54	2.107
55	2.096
56	2.127
57	2.170
58	2.215
59	2.260
60	2.366
61	2.448
62	2.526
63	2.667
64	2.791
65	2.920
66	3.056
67	3.204
68	3.358
69	3.491
70	3.643
71	3.766
72	3.888

Figure 5.10 Curve of Bubble Radius vs Time

5.6 Bubble Volume vs. Time

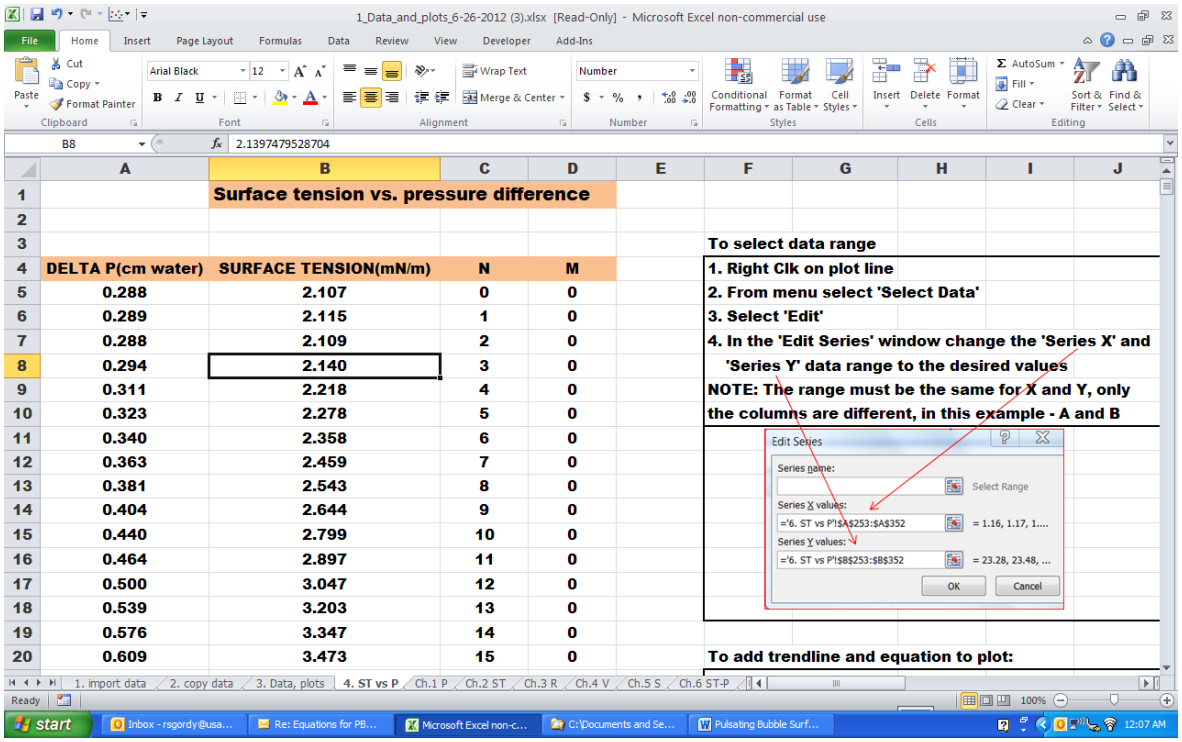
The Bubble Volume vs Time plot is given as a solitary plot. It is like the Data Plot except only addresses the Bubble Volume. The instructions are given on the data plot.



	H
66	3.056
67	3.204
68	3.358
69	3.491
70	3.643
71	3.766
72	3.888
73	4.036
74	4.110
75	4.230
76	4.306
77	4.333
78	4.371
79	4.381
80	4.387
81	4.328
82	4.272
83	4.202
84	4.133
85	4.006
86	3.923

Figure 5.11 Bubble Volume vs Time Directions

5.7 Surface Tension vs. Difference Pressure



	A	B	C	D
1		Surface tension vs. pressure difference		
2				
3				
4	DELTA P(cm water)	SURFACE TENSION(mN/m)	N	M
5	0.288	2.107	0	0
6	0.289	2.115	1	0
7	0.288	2.109	2	0
8	0.294	2.140	3	0
9	0.311	2.218	4	0
10	0.323	2.278	5	0
11	0.340	2.358	6	0
12	0.363	2.459	7	0
13	0.381	2.543	8	0
14	0.404	2.644	9	0
15	0.440	2.799	10	0
16	0.464	2.897	11	0
17	0.500	3.047	12	0
18	0.539	3.203	13	0
19	0.576	3.347	14	0
20	0.609	3.473	15	0

Figure 5.12 Surface Tension vs Difference Pressure Data and Instructions

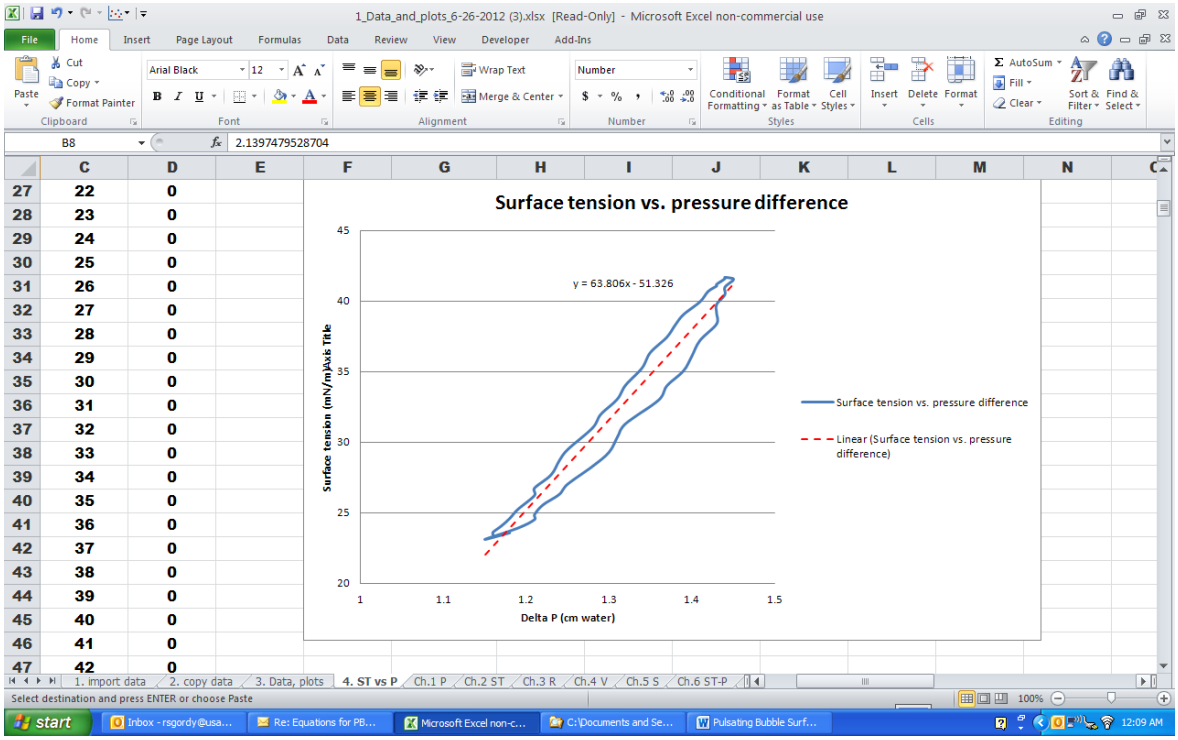


Figure 5.13 Curve of Surface Tension vs Difference Pressure

The Surface Tension vs Difference Pressure plot gives a measure of the hysteresis of the bubble. The area within this curve is a measure of the energy absorbed by the bubble over one cycle of the sinusoidal oscillation. The data used in the plots are not of surfactant and are not representative of surfactant. Most surfactants are proprietary and this data does not infringe on any valid data.

6.0 Care and Cleaning of the PBS

The PBS requires very little care. The water bath should be cleaned out each time it is used. Residual surfactant that gets into the water bath will precipitate into the sides and cloud the observation window. The PBS components are solid state and it takes very little time for the system to stabilize. Therefore it is not necessary to leave the system on when it is not in use. **All of the components making up the PBS are long life components, except the water bath light which is incandescent and has a 2000 hour life. The part number of this part is a Radion part number 53, the user should have some of the lights on hand.**

7.0 Calibration of the Analog Printed Circuit Board

The calibration of the Pressure Transducer Gain and the Temperature Gain can be done by removing the stainless steel cover and making the adjustments of the two variable resistors at the top right of Figure 7.1. The variable resistor on the right most position is the Pressure Transducer Gain, the variable resistor on the left is the Temperature Gain. The procedure for adjusting these gains is given in this section. However, this should not be done unless there is good reason to do so.

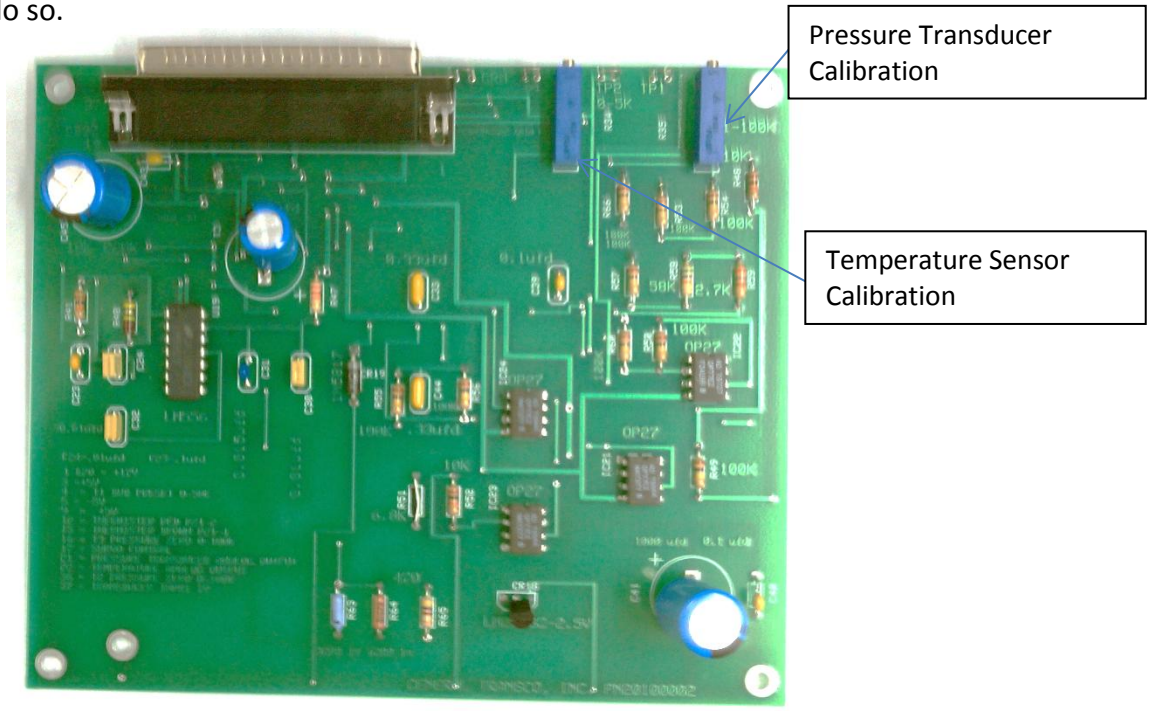


Figure 7.1 Analog Printed Circuit Board Showing Calibration Points

The gains are adjusted at the factory and it the user is not very sure of the procedure they can get the system out of calibration with no recourse but to send the system back to GTI's factory.

If when verifying the calibration using the Pressure Calibrator it is seen that when -4cm position on the calibrator does not give a 4.00 +/- 0.02 reading when the 0 position on the calibrator gave 0.00 to 0.01 then the pressure calibration on the analog board is required. If the measurement through the pressure settings on the Pressure Calibrator does not give linear readings in the calibration mode on the Tera Term Terminal program then the pressure transducer needs to be replaced at the GTI factory.

The procedure for calibrating the pressure on the Analog Board is to set the Pressure Calibrator to 0cm and adjust the Pressure Zero Knob on the front panel so that the reading on the Tera Term gives 0.00 to 0.01switching back and forth. Then set the Pressure Calibrator to -4cm and view the pressure reading on the Tera Term, and adjust the variable resistor on the left to give 4.00 +/- 0.02. The Pressure Transducer is now calibrated.

The procedure for calibrating the temperature sensor is to fill the water bath, insert an electronic thermometer into the water bath. Set the temperature higher than ambient and depress the yellow button on the front panel on the PBS. Observe the temperature on the Tera Term. The Tera Term will be displaying the temperature that is being read by the system. Compare the temperature read by the system with the temperature output form the thermometer. Adjust the variable resistor on the right until both temperature readings are the same. The temperature should read at the Tera Term within +/-2 degrees.

These adjustments are not necessary unless the pressure or the temperature gets out of adjustment.

8.0 List of items Delivered with each PBS

1. Pulsating Bubble Surfactometer
2. Pressure Calibrator
3. One Set (Water Bag)
4. One bag of 100 sample chambers
5. One internet cable
6. One RS232 serial 9 pin cable
7. One USB to RS232 Adapter with installation disk
8. One CD with operators manual, Tera Term program, Quick Operators Guide, EXCEL plot program
9. Two large pipet
10. Two small pipet
11. Two sample chamber gaskets
12. Two spare light bulbs
13. One sample chamber tweezers

Appendix A
Hypo-phase Exchange System

An accessory known as the Hypo-phase Exchange System is available as an accessory to the PBS. This system uses a different sample chamber that has two stainless steel tubes enabling the exchange of a control fluid thus introducing control agents into the surfactant while the bubble is oscillating and the measurement is underway see Figure A-2. This is accomplished without disturbing the bubble size or oscillation. This is accomplished by introducing the same amount of fluid that is extracted. This is accomplished using a balanced peristaltic pump. The surface of the bubble is not disturbed except for the effect of the control contaminant.

This system is use full for surfactant research to study the effects of aerosols and contaminants such as smoke and many other contaminants that can be put into solution. The Hypo-phase Exchange System is shown in Figure A-1.

This system is made to order and 3 months should be expected after the order, unless there is a build in process. Delivery and price will be quoted on request.

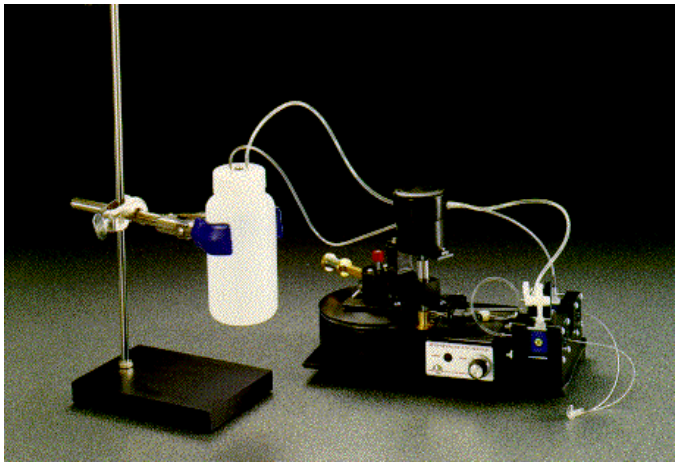


Figure A-1 Hypo-phase Exchange System mounts on top of the PBS.

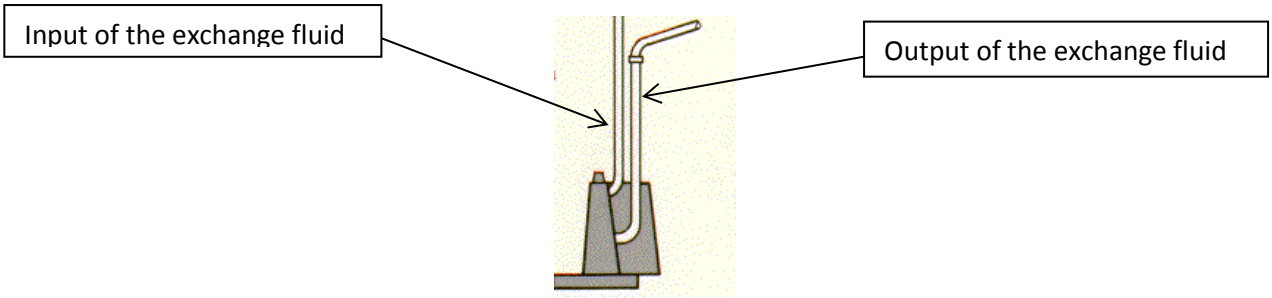


Figure A-2 Hypo-Phase Exchange System Sample Chamber

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