DIELECTRIC
&
IMPEDANCE
SPECTROSCOPY
LCR METER

SAMPLE PREPARATION & MEASUREMENTS

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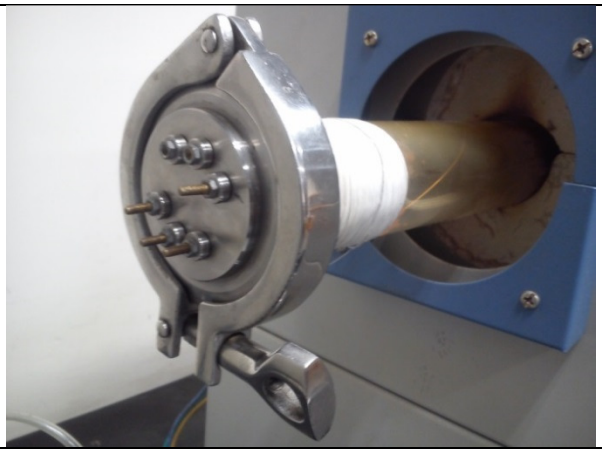
Sample Preparation

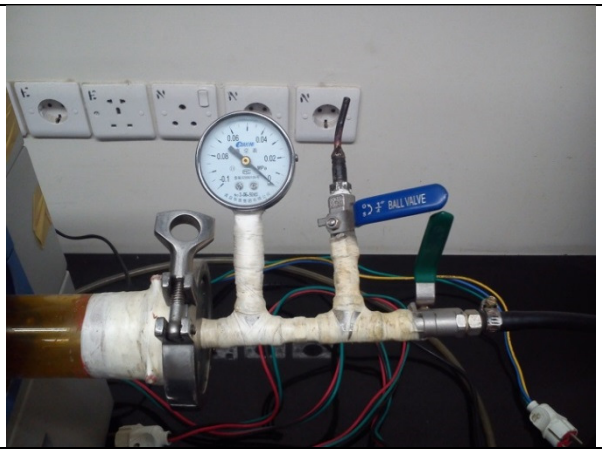
1. Polish the pellet using sand paper form both sides.
2. Clean the pellet with acetone/isopropanol.
3. Measure the diameter and thickness of the pellet.
4. Employ silver paint (thin layer) on both sides of the pellet. (First employ the silver paint on one side and wait till it dries and then apply to the other side)
5. Take two pieces of enameled copper wires of length 24 to 30 inches.
6. Remove the enamel coating from both ends of these wires.
7. Fix one wire on one side of pellet and second wire on the second side of the pellet.
8. Employ the high temperature tape on the Cu wire to strengthen the contact.

Sample loading in the Furnace

Tube furnace XD-1200NT used to heat the sample. Furnace is shown in the picture below. One end of the tube is connected to vacuum pump and the other end to the feed through.

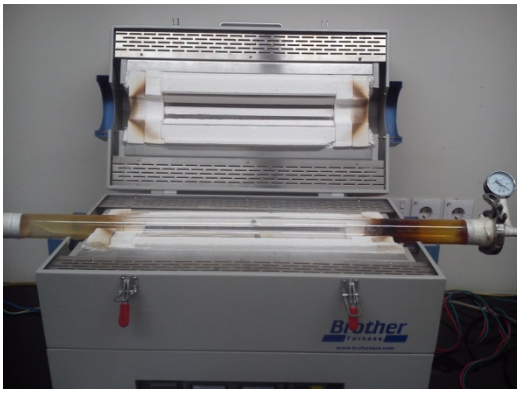


Feed Through at the end of the Tube



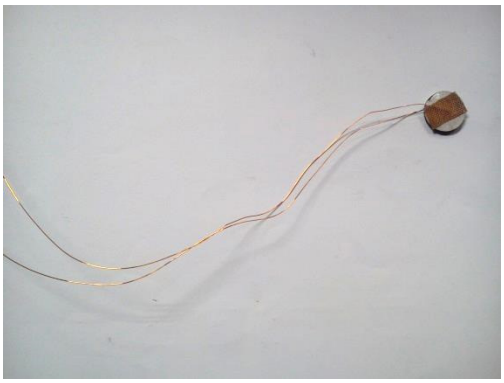
Vacuum pump side of the Tube.

Open the furnace carefully, by removing the clamps in front.



Remove the clamp on the feed through, by holding the feed through, and remove it from the tube end.

Place the feed through on the table, and connect the wires coming from the samples to the pins with two nut arrangement. Make sure that one wire passes through the high temperature sleeve.

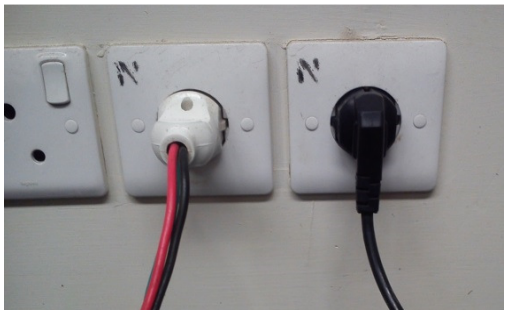


Insert the sample along with the high temperature sleeve in the tube, the position of the sample is shown in the figure below. (The sample should be placed close to the thermocouple of the furnace). Close the end with the feed through by clamp. Close the furnace.

Connection to the LCR Meter

The LCR meter has four lead, and are used in combination of two in this experiment. Connect a pair of wires to one pin of the feed through (pictured below).

Power on Procedure

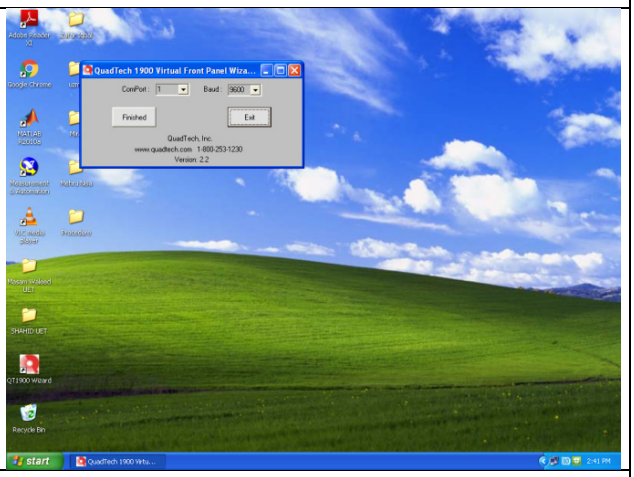
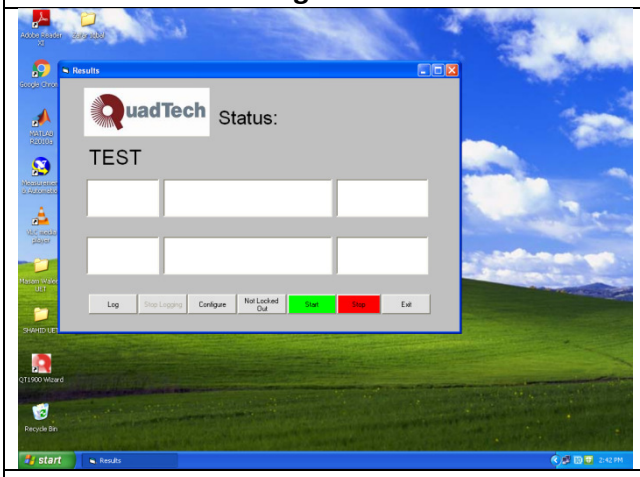
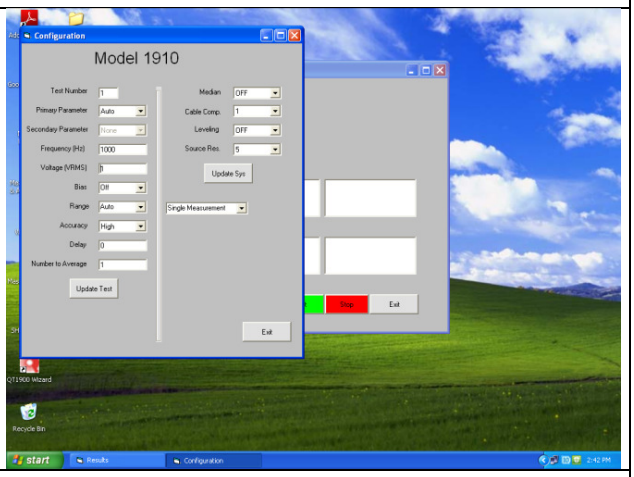
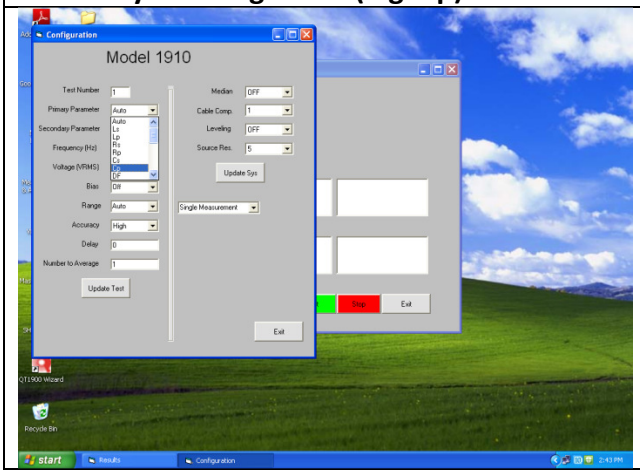
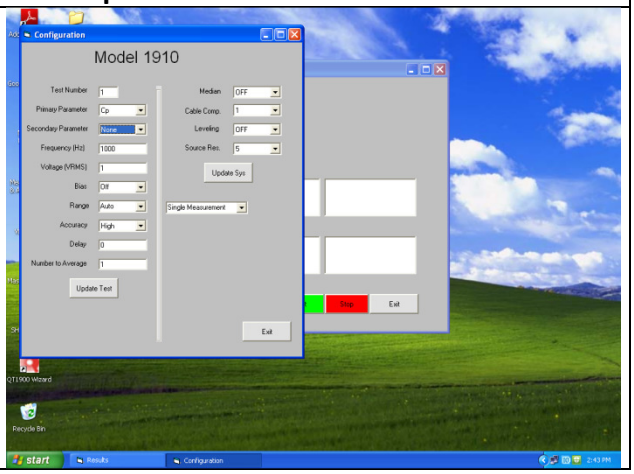


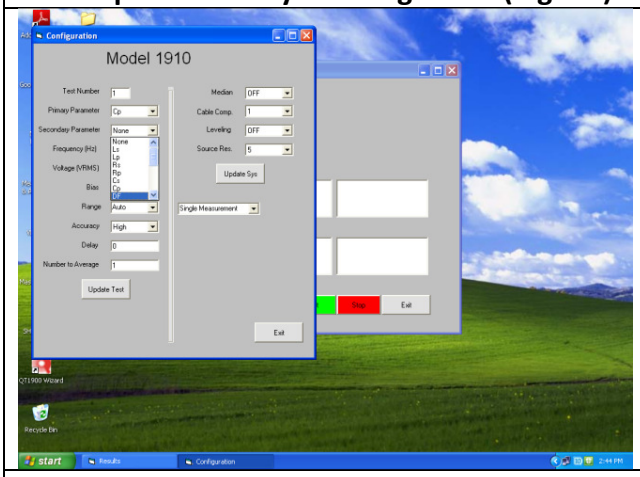
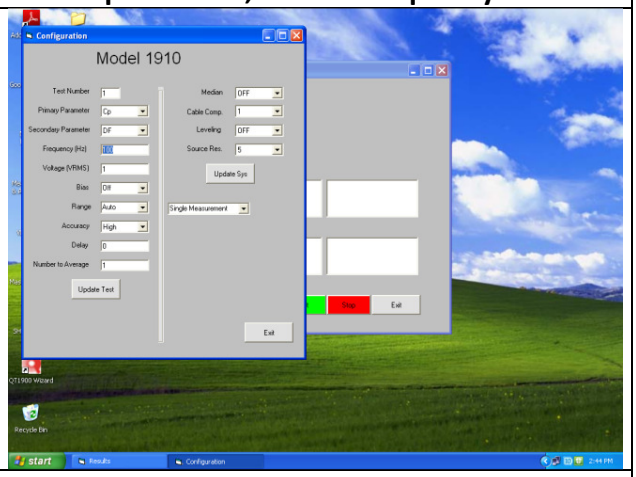
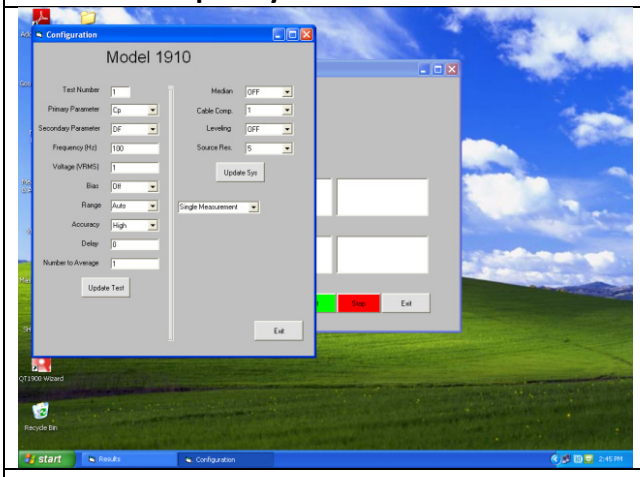
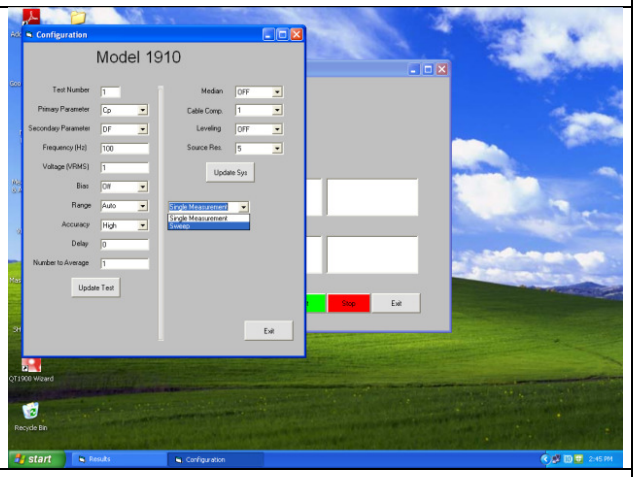
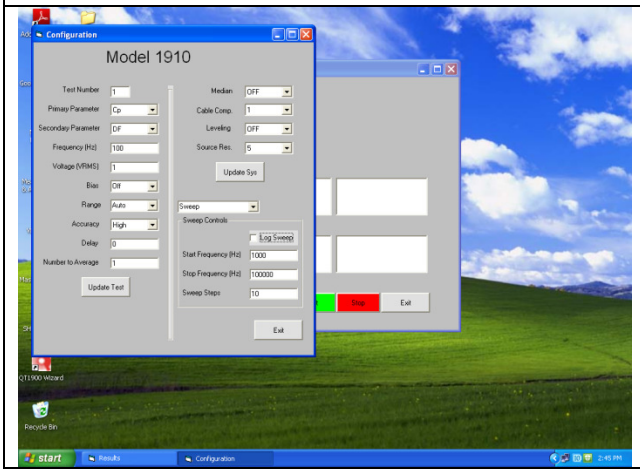
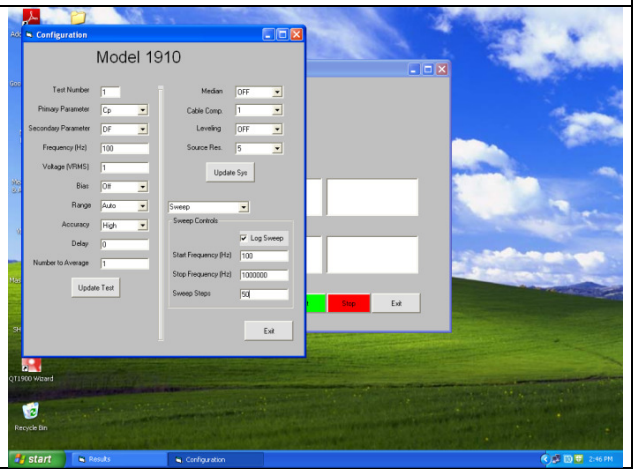
1. Switch on the vacuum pump by plugging in power cable into power board, and furnace by plugging in furnace power cable and from the front panel of the Furnace

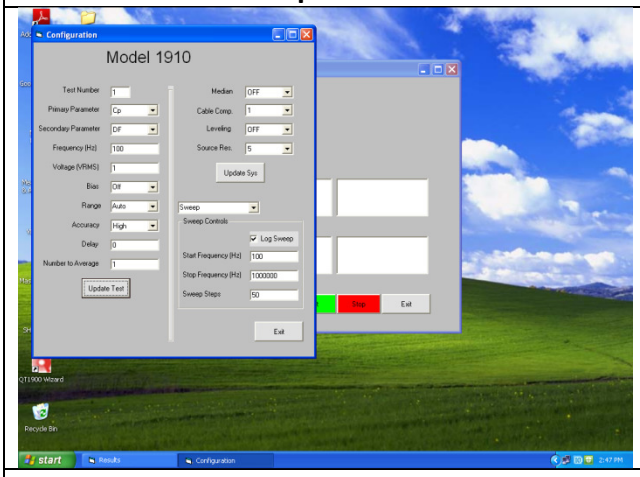
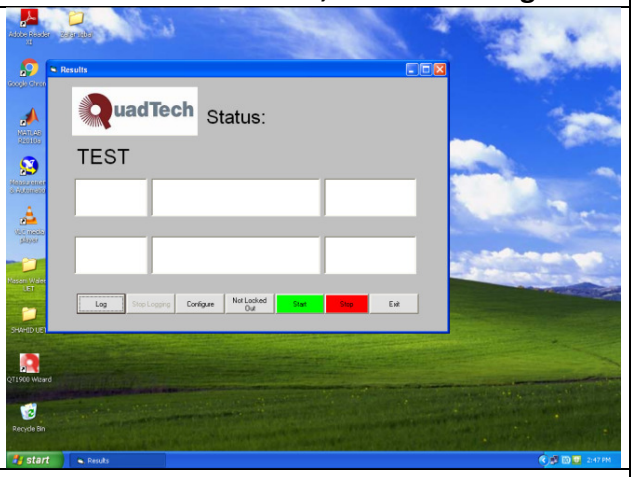
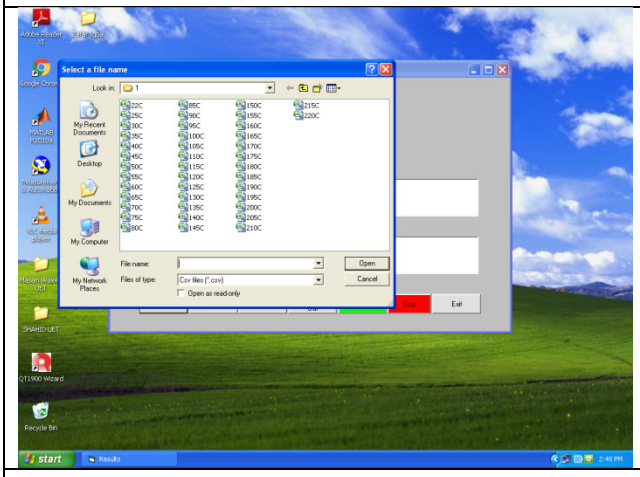
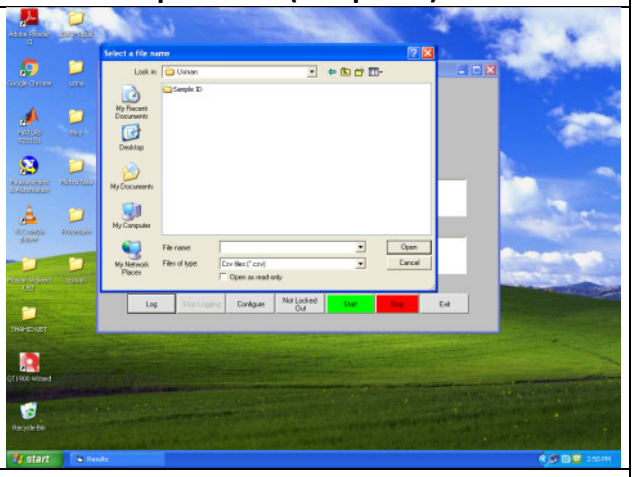
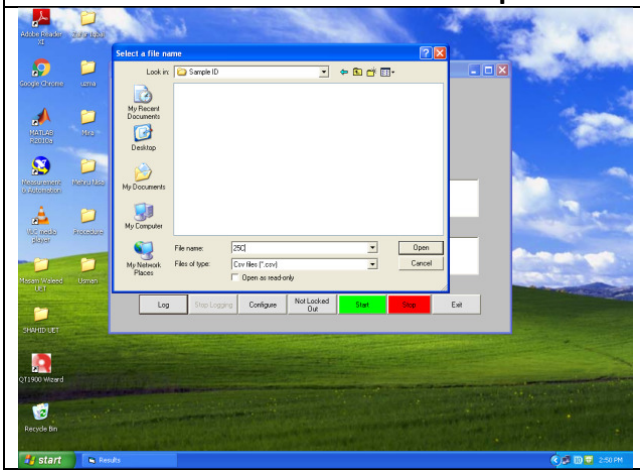
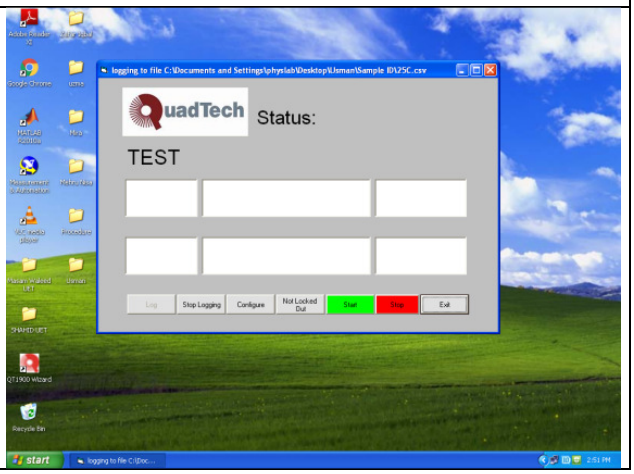
a. Rotate the lock button to the Right.
b. Press the Green color push button.
c. Run the furnace program, by holding the Run/Hold button on the Protherm.
*(You may postpone b and c steps)

2. Open the valve (with green handle) at the end of the tube.
3. Switch on the LCR meter from the front panel (power button)
4. Switch on the computer.
5. For ***physlab*** user name use the password ***Lums12345***.

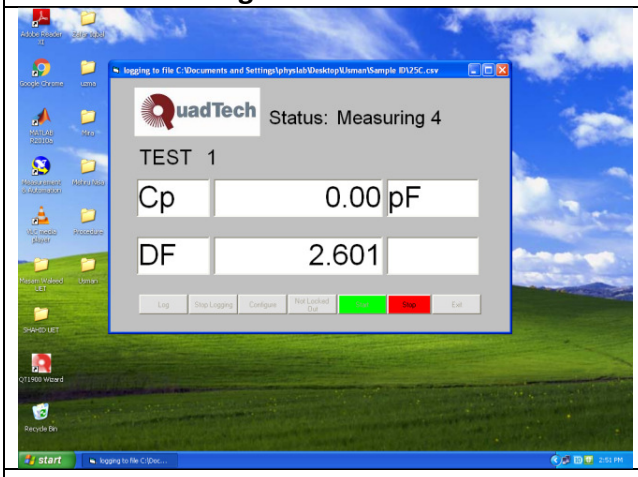
Data Acquisition Procedure for Dielectric Measurements

1. Double click on 1900QT Wizard	2. Click on Finished
	
3. Click on Configure	**4. Model 1910 window**
	
5. Select the desired primary parameter by scrolling down (e.g. Cp).	**6. Cp appears in front of primary parameter**
	

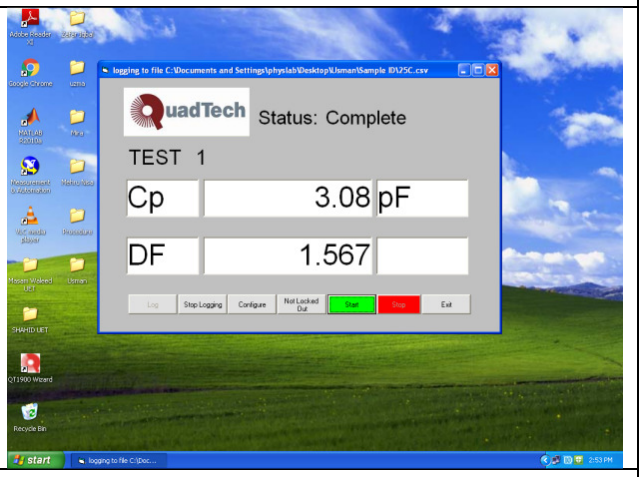
7. Select the desired secondary parameter by scrolling down (e.g. DF).	**8. DF appears in front of primary parameter, Set the frequency 100 Hz.**
	
9. Set frequency 100 Hz appear in front of frequency	**10. Select the sweep instead of single measurements**
	
11. Few other parameters appears	**12. Check the box of Log sweep, Change the start frequency to 100 and Stop Frequency to 1000,000. Sweep steps to 50**
	

13. Click on the Update test	14. To save the data, click on the log
	
15. Last selected path will appear	**16. Select the path to save the data, or you can make a new folder with sample name (sample ID)**
	
17. In the folder with sample name, give the file name. Say 25 °C for the data measured at 25 °C. Click on open	**18. Click on start.**
	

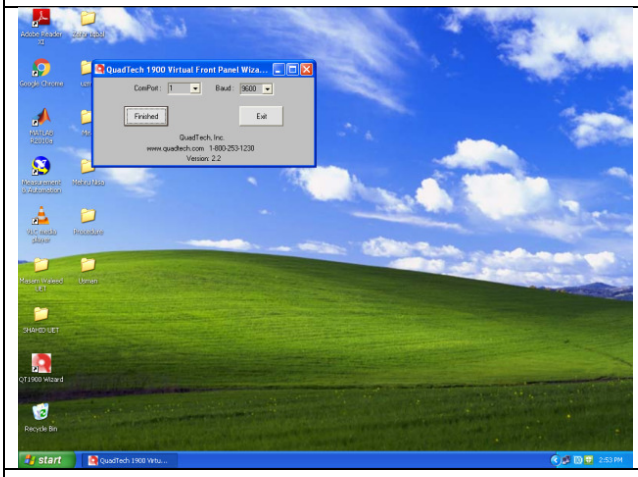
19. LCR meter will take 1-2 min to record the data. The status appearing is measuring.



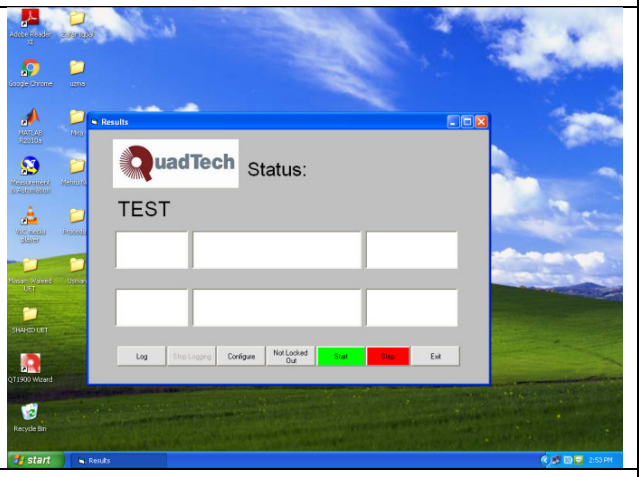
20. LCR measurement complete at 25 ^{o}C. Click on Exit.



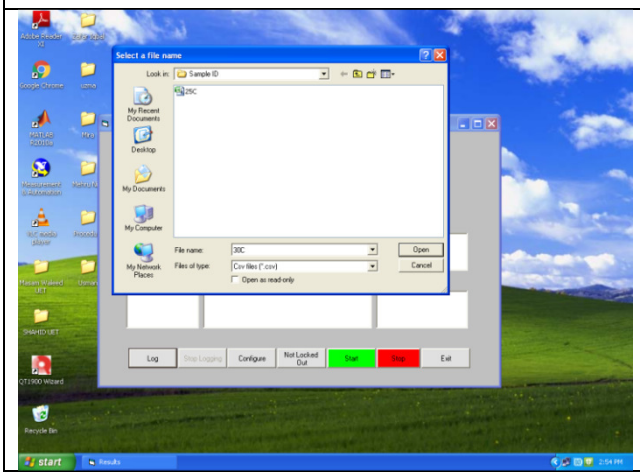
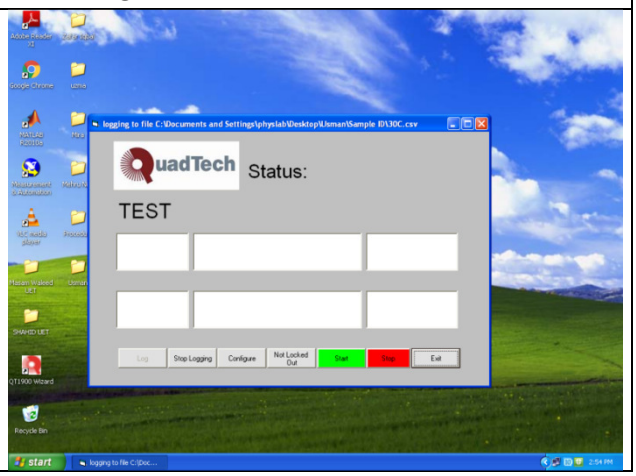
21. To record the same measurement at different temperature (say 30 ^{o}C), click on Finished.



22. Click on Log to save the data.



23. Run the program in the furnace to attain the desired temperature.
    a. Press the green push button on the front panel of the furnace.
    b. To run the program, press and hold the Run/hold button on the Protherm of the furnace so that the run is appears on the display.

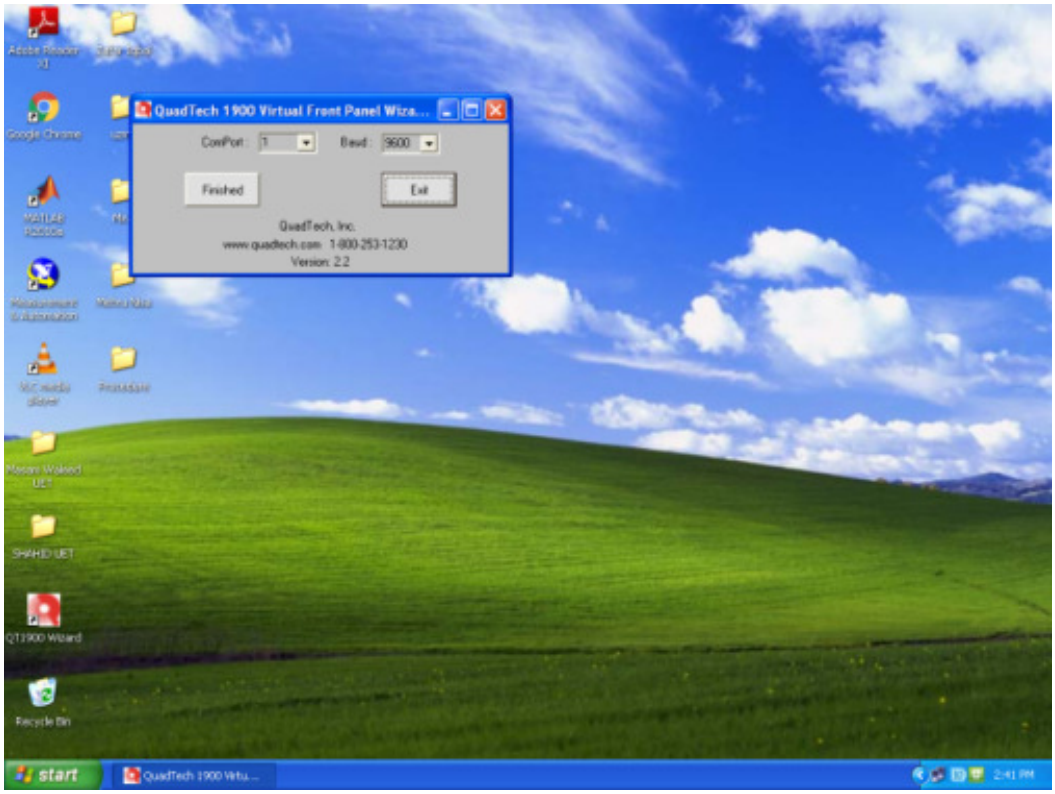
24. Change the file name to 30 °C and click on open.	25. Click on start, to record the data, when furnace temperature reaches 29 °C.
	

Note:

Repeat the steps 20-24 (except 23) for the desired range of the temperature.

Power off Procedure:

1. Close the program by clicking on Exit after step 20.



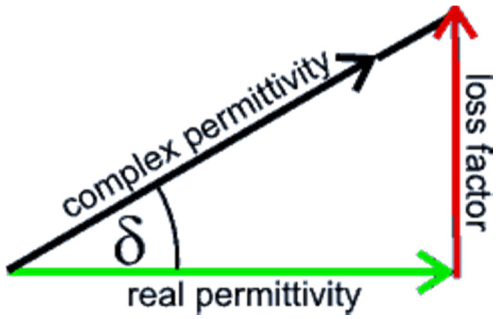
2. Stop the furnace program, by holding the stop button on the Protherm.

3. Press the red color push button.
4. Rotate the lock button to left.
5. Closed the valve (with green handle) at the end of the tube.
6. Switch off the Vacuum pump by unplugging in the black plug from the power board, and furnace by unplugging the furnace power cable from the power board.
7. Switch off the LCR meter from the front panel (power button)
8. Shut down the computer.

Data conversion Formulae

Dielectric constant ε is a complex quantity,

$$\varepsilon = \varepsilon' + i\varepsilon''$$



We measure the Capacitance (C) and dissipation factor (DF=tanδ) in this experiment.

Real part of ε is

$$\varepsilon' = \frac{Cd}{\varepsilon_o A}$$

Where,

C: the capacitance (F)

d: thickness of the sample (m)

A: Area of the sample (m^2)

ε_o: Permittivity of free space 8.85×10^{-12} F/m

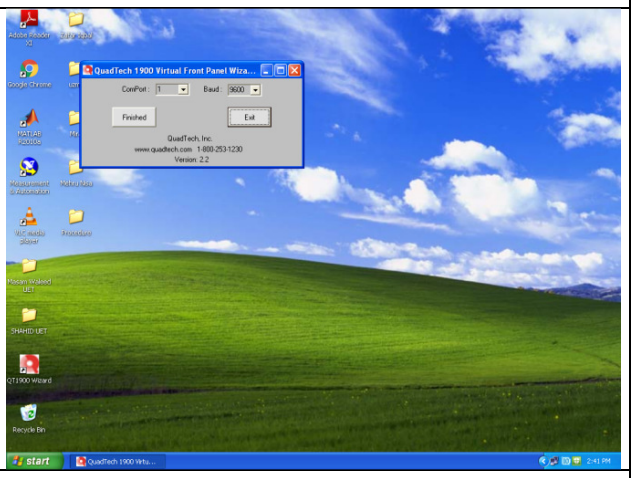
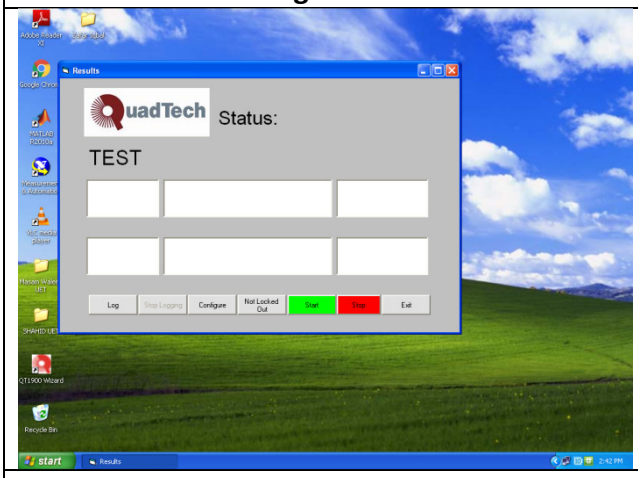
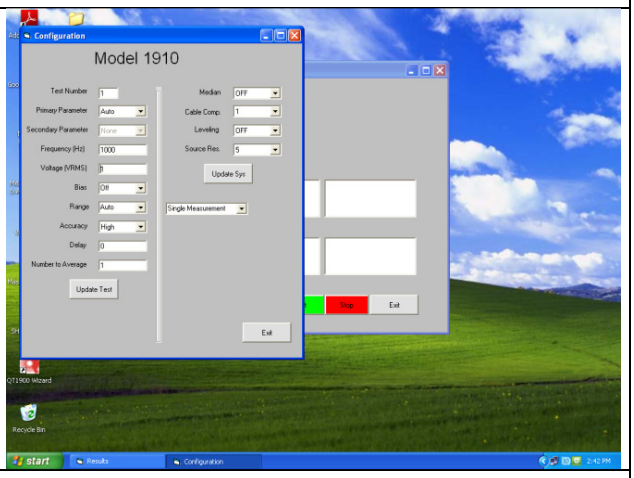
The imaginary part of ε is

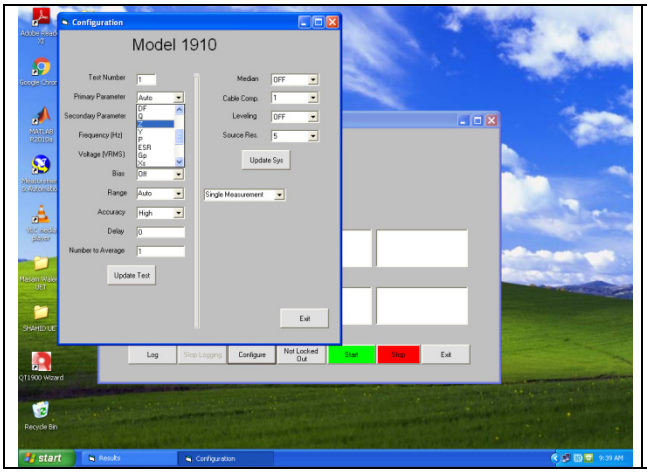
$$\varepsilon'' = \varepsilon' \tan\delta$$

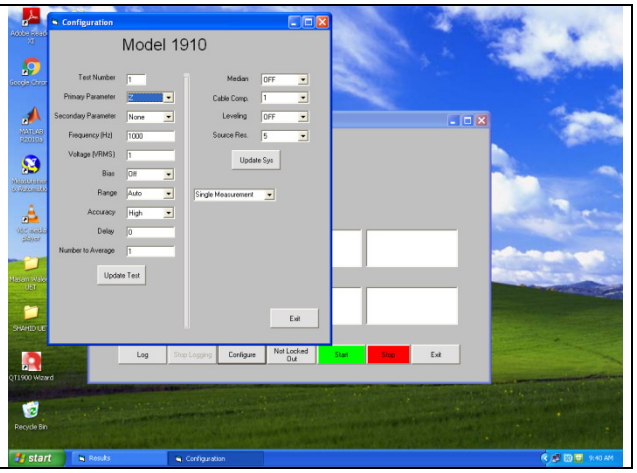
The ac conductivity σ

$$\sigma = \omega\varepsilon' \tan\delta = 2\pi f\varepsilon' \tan\delta = 2\pi f\varepsilon''$$

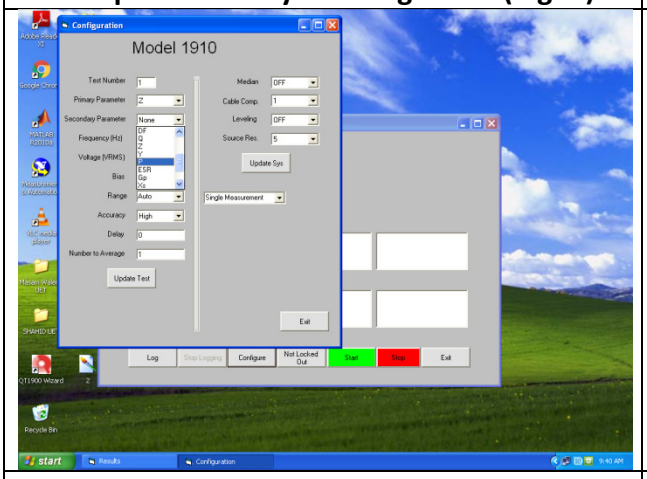
Data Acquiring Procedure for Dielectric Measurements

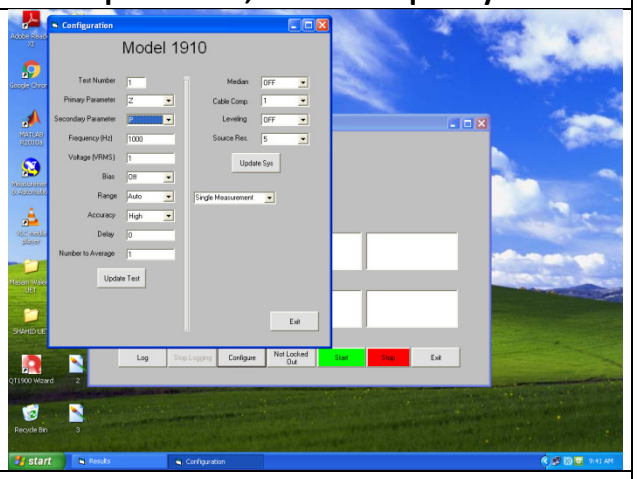
26. Double click on 1900QT Wizard	**27. Click on Finished**
	
28. Click on Configure	**29. Model 1910 window**
	
30. Select the desired primary parameter by scrolling down (e.g. Z).	**31. Z appears in front of primary parameter**



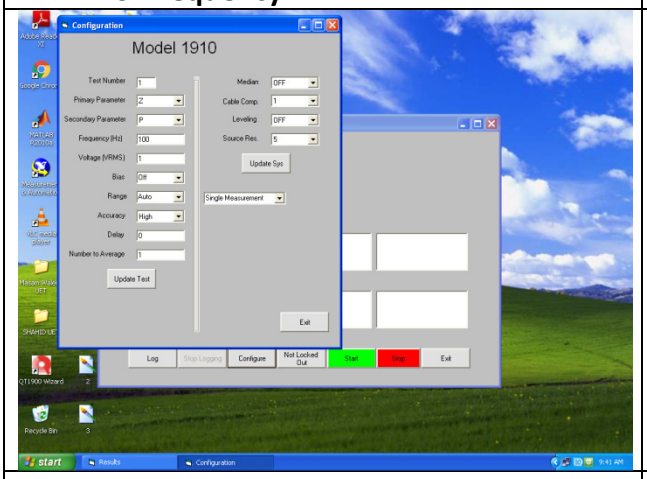


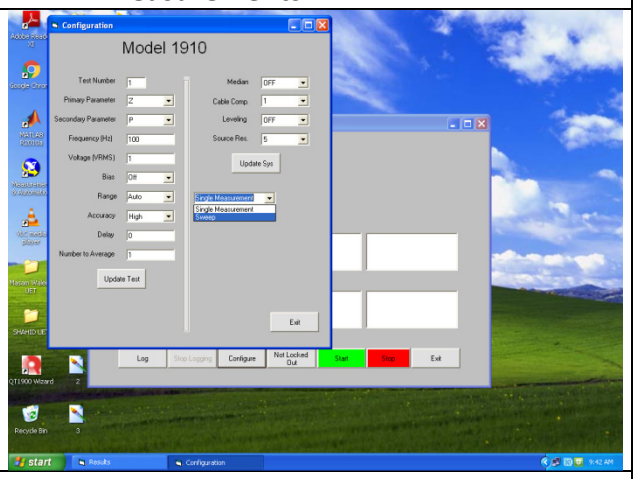
32. Select the desired secondary parameter by scrolling down (e.g. P).	33. DF appears in front of primary parameter, Set the frequency 100 Hz.



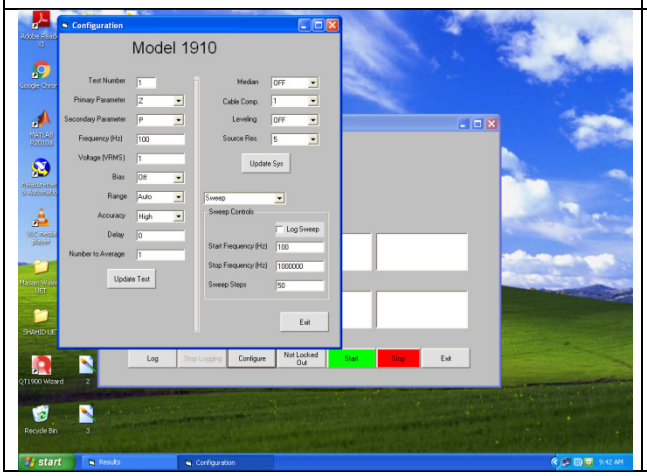
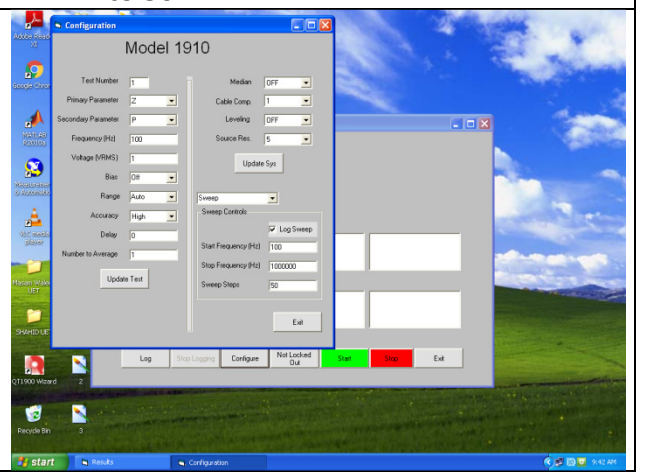


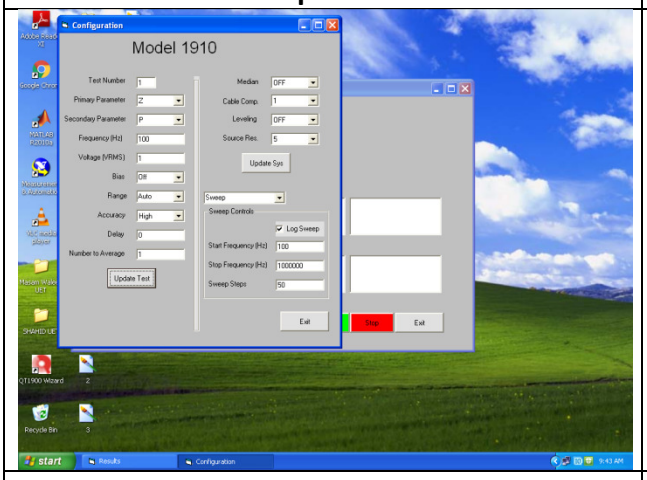
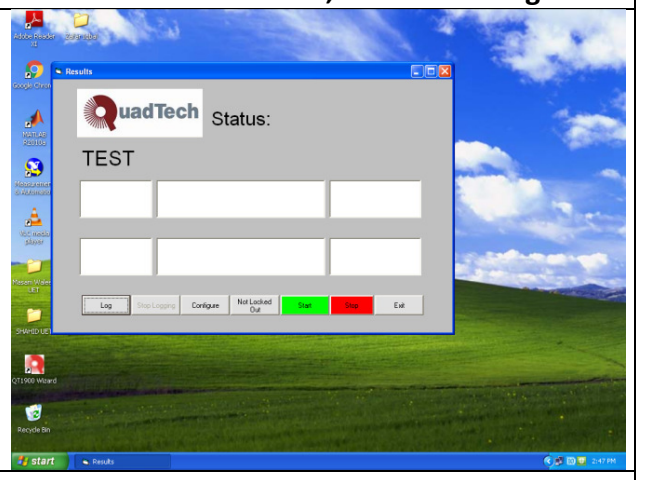
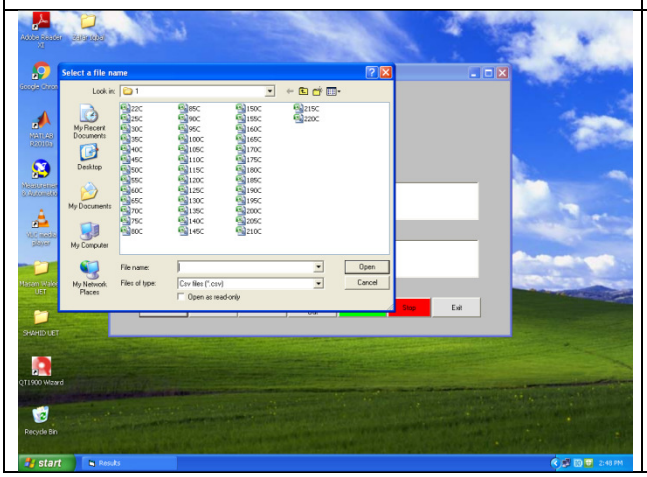
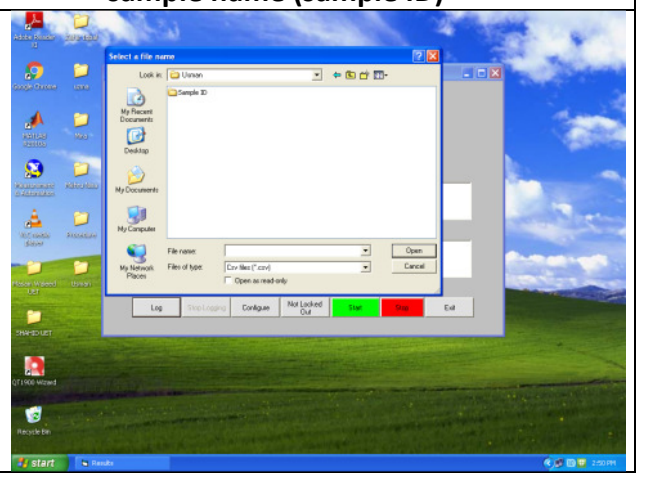
34. Set frequency 100 Hz appear in front of frequency	35. Select the sweep instead of single measurements

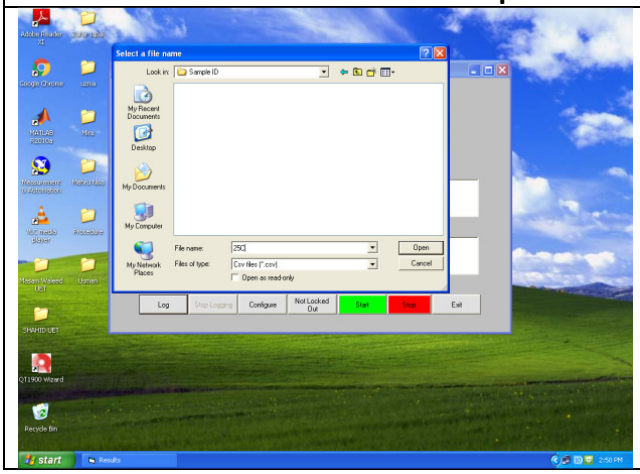
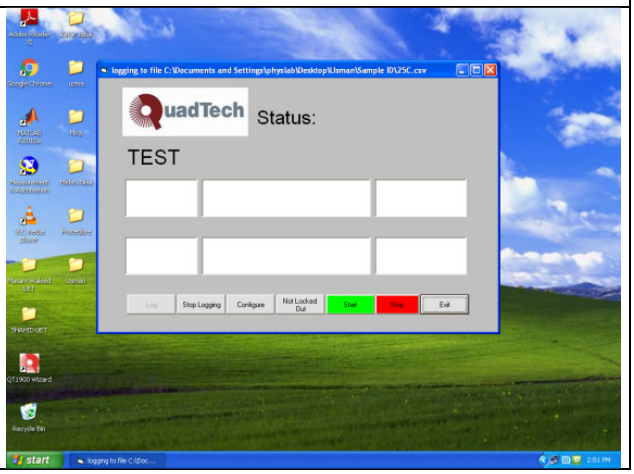


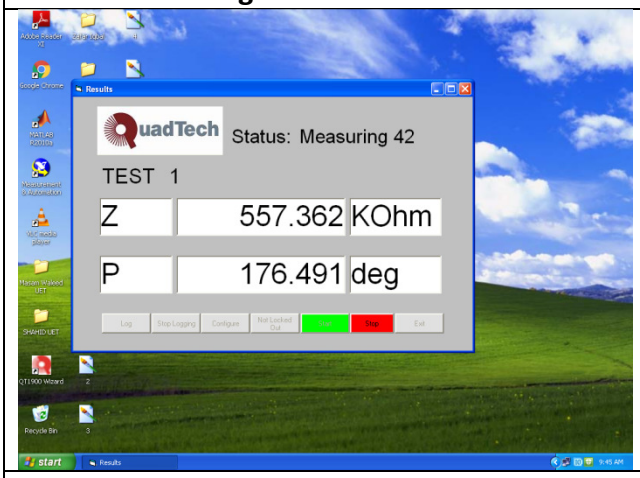
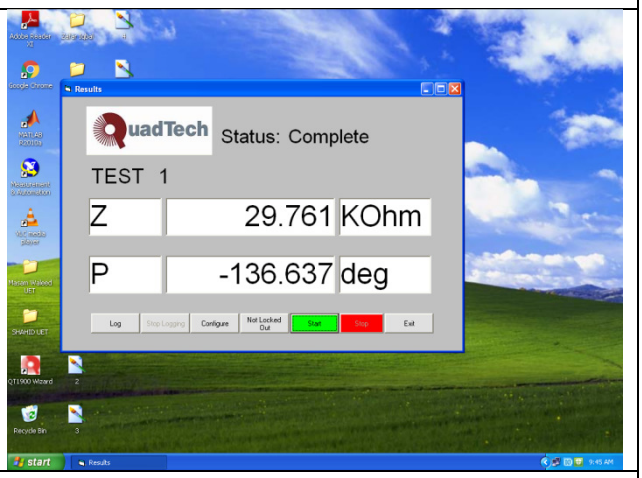


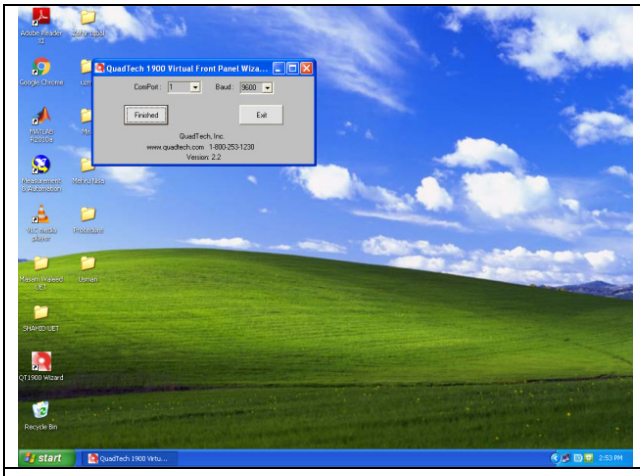
36. Few other parameters appears	37. Check the box of Log sweep, Change

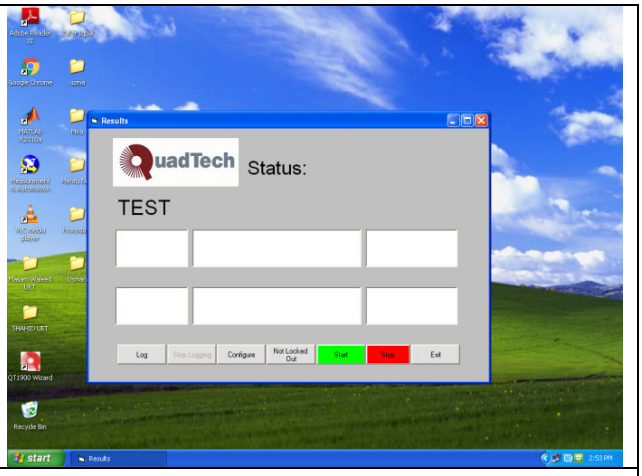
	the start frequency to 100 and Stop Frequency to 1000,000. Sweep steps to 50
	

38. Click on the Update test	**39. To save the data, click on the log**
	
40. Last selected path will appear	**41. Select the path to save the data, or you can make a new folder with sample name (sample ID)**
	

42. In the folder with sample name, give the file name. Say 25 °C for the data measured at 25 °C. Click on open	43. Click on the start.
	

44. LCR meter will take 1-2 min to record the data. The status appearing is measuring.	45. LCR measurement complete at 25 °C. Click on Exit.
	
46. To record the same measurement at different temperature (say 30 °C), click on Finished.	47. Click on Log to save the data.





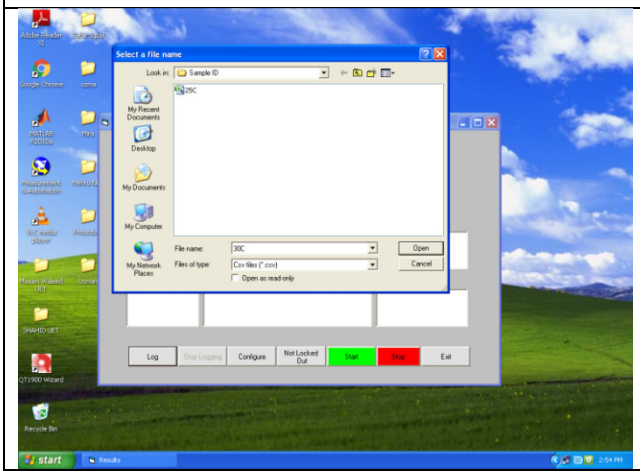
If not done before.

48. Run the program in the furnace to attain the desired temperature.

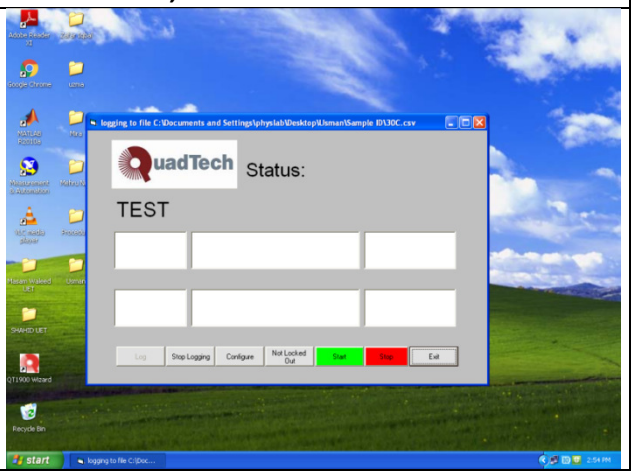
c. Press the green push button on the front panel of the furnace.

d. To run the program, press and hold the Run/hold button on the Protherm of the furnace so that the run is appears on the display.

49. Change the file name to 30 ^{o}C and click on open.



50. Click on start, to record the data, when furnace temperature reach to 29 ^{o}C,

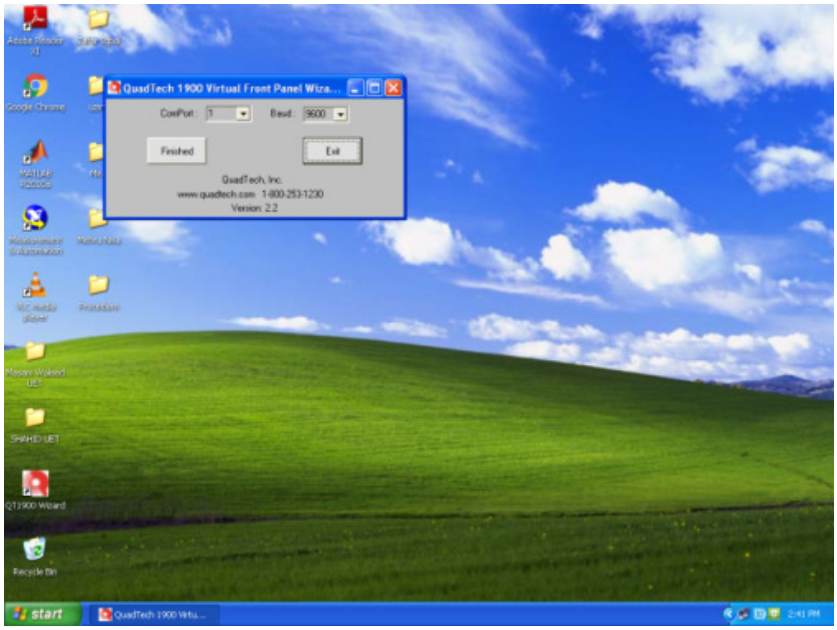


Note:

Repeat the step 20-24 (except 23) for the desired range of the temperature.

Power off Procedure:

9. Closed the program but clicking on Exit.

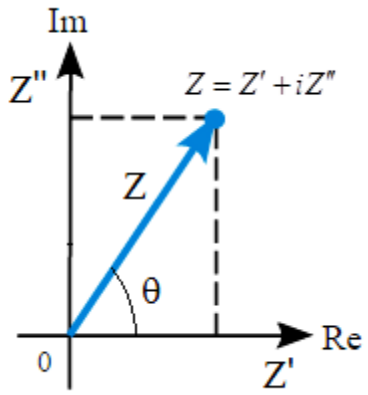


10. Stop the furnace program, by holding the stop button on the Protherm.
11. Press the red color push button.
12. Rotate the lock button to left.
13. Closed the valve (with green handle) at the end of the tube.
14. Switch off the Vacuum pump by unplugging in the black plug from the power board, and furnace by unplugging the furnace power cable from the power board.
15. Switch off the LCR meter from the front panel (power button)
16. Shut down the computer.

Data conversion Formulae

Impedance Z is a complex quantity,

$$Z = Z' + iZ''$$



We measure the Impedance (Z) and Phase (P = θ) in this experiment.

$$Z = |Z|e^{i\theta} = |Z|\cos\theta + i|Z|\sin\theta$$

Real Part of Z is

$$Z' = |Z|\cos\theta$$

$$Z'' = |Z|\sin\theta$$

Note: For converting the data on Excel/origin: θ should be in radian.

The degree to radian conversion is $\theta\,(\text{in degree}) \times \frac{\pi}{180}$ or $\theta\,(\text{in degree}) \times \frac{3.14159}{180}$