The University of Jordan
School of Engineering
Mechatronics Engineering department

Transducers and sensors lab Manual (0908473)

By: Eng. Nadeen Habash

Table of Contents

Background:

In this lab students learns how to measure, use of measurement tools and how to deal with errors. They learn about different sensor types and how to design a transducer. They design signal conditioning and signal processing circuit and finally find the characteristics of the transducers.

In this lab students write full technical report.

Laboratory Safety Symbols and Rules:
Emergency Response

1. It is your responsibility to read safety and fire alarm posters and follow the instructions during an emergency.
2. Know the location of the fire extinguisher in your lab and know how to use them.
3. Know the location and function of all laboratory safety equipment.
4. Notify your instructor immediately after any injury, fire or explosion, or spill.
5. Know the building evacuation procedures.

General Safety Rules

1. Read all directions for an experiment and follow the directions exactly as they are written.
   If in doubt, ask the teacher.
2. Always obtain permission before experimenting on your own.
3. Never handle any equipment unless you have specific permission.
4. Report any accident or injury, no matter how small, to your teacher immediately.
5. Dispose of all material according to the teacher's instructions.
6. Never eat, drink, or smoke while working in the laboratory.
7. You have long hair or loose clothes, make sure it is tied back or confined.
Electrical Safety

1. Obtain permission before operating any high voltage equipment.
2. Make sure electronic equipment is OFF when plugging or unplugging from an outlet.

3. Make sure the work area for electrical equipment is clean and dry.

4. Do not "daisy-chain" electrical power cords.

5. Maintain an unobstructed access to all electrical panels.

6. Avoid using extension cords whenever possible. If you must use one, obtain a heavy- duty one that is electrically grounded, with its own fuse, and install it safely. Extension cords should not go under doors, across aisles, be hung from the ceiling, or plugged into other extension cords.

7. Never, ever modify, attach or otherwise change any high voltage equipment.

8. Always make sure all capacitors are discharged (using a grounded cable with an insulating handle) before touching high voltage leads or the "inside" of any equipment even after it has been turned off. Capacitors can hold charge for many hours after the equipment has been turned off.

End of Laboratory activity rules

1. Clean all laboratory equipment and return to their locations
2. Unplug and store properly any electrical device.
3. Wash your hands after every experiment.
4. Clean up your work area before leaving. .

Report guidelines:

The lab report Reflects your understanding of what you have done from theory to the experimental results which you can discuss and verify its correctness. In Lab report you introduce briefly the objectives of the experiment, how it was done (The methodology) and finally you show the results and discuss it.

Your report should be clear, interconnected and understood

Using past tense. As a rule of thumb, past tense is used to describe work you did over the course of the report timeline.

Using present tense. As a rule of thumb, present tense is used to describe Knowledge and facts that were known before you started.

Lab Report should include:

- Table of contents.
- List of figures
- List of tables
- Abstract
- Introduction

- Methodology
- Results
- Discussion
- References

1.Abstract:should briefly describe the work you have don and the result you got.

2.Introduction: in this part you describe the sensor its technology (resistive, capacitive....etc)

what is it used for, some

applications. and the theory behind.

3.Methodology: here you write the details about:

      a)The signal conditioning circuit design.

      b)Procedure you follow in measurement.

      c)The accuracy of devices you used.

4.Results include data collected, tables ....

5.Discussion includes:

      a)Explaining the results and finding the characteristics of the transducers

      b)Explanation of Errors

      c)You may add conclusion or summary

      d)Future Work what can be done to improve results

- **Font** should be Times new roman size 12 except headings size14.

- **Title of the figures** should be at the bottom of the figure and figures should be at the middle

- **Title of tables** should be above the table and on the right

Data analysis and regression:

To find the characteristics and calibration curve use cftool in matlab for regression and note the following:

Don't connect the experimental data with solid line
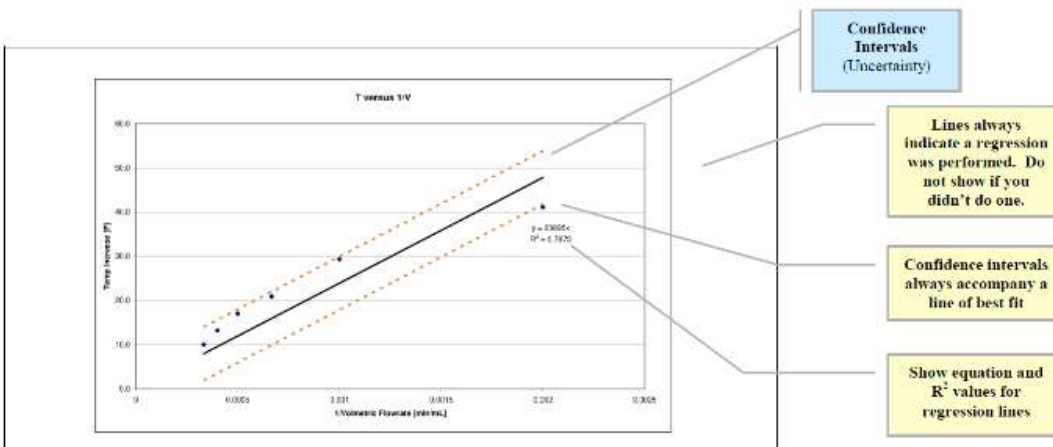
The University of Jordan
School of Engineering
Mechatronics Engineering Department

Experiment #: Title

By
Student name

Transducers and sensors lab. (0908352)

Instructor's Name

Date

Objectives:

1. To determine the density of a cuboid by measuring its dimensions and its mass using different measuring devices.
2. Measuring resistance in a circuit and learn how to deal with errors (aggregation of errors).
3. Find the uncertainty in measurement.

Pre-Lab.: Please review chapter7 (Random errors) and chapter 8 (Dealing with errors) in the measurement material**.**

Lab Theory:

1. Dealing with errors:
Sometimes we measure a value of a variable as a function of other variables. In this case the variable tolerance (limiting error) depends on the tolerance of the other measured variables. It is unlikely that errors in measurements are at maximum possible values or minimum possible values another representation of errors is also used which is the probable error. The probable error is the square root of the sum of the squares of the individual errors. This can be applied to the four mathematical operations as in the table below.

Table-1: Summery of limiting errors and Probable in the four mathematical operations

Operation	Maximum possible error (limiting error)	Probable Value (for uncorrelated errors in the variables)
Addition	$w + v \pm (v \cdot m + w \cdot n)$	$w + v \pm \left(\sqrt{(v \cdot m)^2 + (w \cdot n)^2} \right)$
Subtraction	$w - v \pm (v \cdot m + w \cdot n)$	$w - v \pm \left(\sqrt{(v \cdot m)^2 + (w \cdot n)^2} \right)$
Multiplication	$w \cdot v \cdot (1 \pm (m + n))$	$w \cdot v \cdot \left(1 \pm \left(\sqrt{m^2 + n^2} \right) \right)$
Division	$\dfrac{w}{v} \cdot (1 \pm (m + n))$	$\dfrac{w}{v} \cdot \left(1 \pm \left(\sqrt{m^2 + n^2} \right) \right)$
General	$\Delta u = \sum_{i=1}^{n} \Delta v_i \cdot \dfrac{\partial f}{\partial v_i}$	$\Delta u = \sqrt{\sum_{i=1}^{n} \left(\Delta v_i \cdot \dfrac{\partial f}{\partial v_i} \right)^2}$

It should be noted that the variables used to find the desired variable are uncorrelated.

1.1 Accuracy:

If you read different datasheets you will find that accuracy is expressed in many different ways. The following table shows the accuracy for three devices used to measure voltage and the results given by each device:

Device No.	Accuracy	Reading
1	1% rdg (reading).	10 V
2	1% f.s.(full scale)	10.01 V
3	1% reading ±2 digits.	10.4 V

For the first device 1% of reading means the error equals to the accuracy multiplied by the reading value 0.01×10=0.1 V

The true value is between 10.1 V and 9.9 V.

For the second device 1% f.s means the error equals to the accuracy multiplied by the full scale reading if for example the full scale range of this device is 20 V then the error equals 0.01×20 =0.2 V.

The true value is between 10.3 V and 9.9 V

For the third device 1% reading ±2 digits means that the error equals to 0.01×reading+2×Resolution

So error= 0.01×10.4+2×0.1=0.304 V

The true value will be between 10.096 V and 10.704

2. Dealing with random errors:

Dealing with the random errors can be done by taking a number of sample *n* of the measured value, *q(t)* and averaging over *n*. In order to quantify the confidence level in the result you need to understand how dispersed the readings (sample values) are from the mean. This first done by following the following procedure:
First Find the mean value and the standard deviation

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \sigma = \sqrt{\frac{\sum_{i=1}^{n}(\bar{x} - x_i)^2}{n}}$$

To be able to express our answers with levels of confidence we need to use the Gaussian distribution. The Gaussian distribution is shown below. The probability of a certain variable being smaller than z is equal to the area *F(z)* (i.e., the area under the curve from –∞ to the value of *z*).
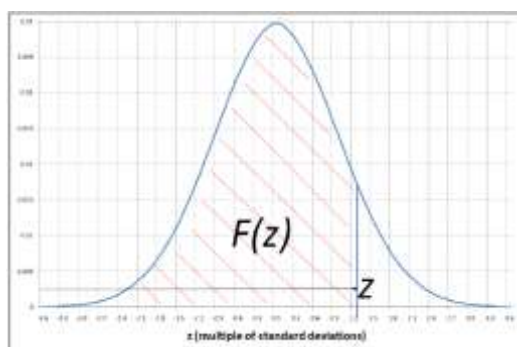
Figure 1.1: Probability density function

The function *F(z)* cannot be evaluated from a function and is tabulated. The table is given at the end of this Experiment.

Equipments:

Cuboid	Resistance 1 k,2 k
Ruler	Power supply
Vernier caliper	digital multimeter

Part 1:

In this part you will measure the dimensions of a rectangular cuboid made of beech wood and then take its weight value to find the density using the following equation:

$$density = \frac{mass}{volum}$$

Density in $kg.m^{-3}$, mass in kg and volume in m^{-3}.

Density of Beech wood=750 $kg \cdot m^3$

Measure the length using a ruler.

Measure the Width and height using the vernier caliper

Note: you should write the result with the right number of significant figures.

Length	Width	Height

Density:_____.

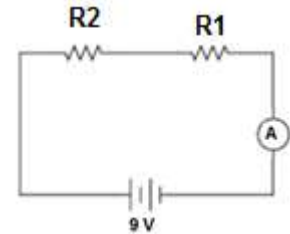Write the sources of errors in this experiment

Part 2:

In this part you will connect the following circuit. You need to measure the resistors value using the multimeter then measure the current value to calculate the voltage drop across R1. using ohms law V=I×R. See the data sheet for the multimeter.

R1=_____.

R2=_____.

I= _____.

V_{R1}=_____ .

Measure the voltage V_{R1} using the digital multimeter.

V_{R1}=_____.

Are the calculated and the measured value are the same? why?

Part 3:

You are given a sample of 20 resistors, measure these resistors values and find the following:
You will reject all resistors that are outside the +/- 1% tolerance of the nominal value.
a) How many resistors will you reject?
b) Find the mean and standard deviation.
c) Express the final answer for the resistance measured as a confidence interval with a confidence level of 99.72%.

Standard Gaussian Distribution Table (F(z))

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7703	0.7734	0.7764	0.7793	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8906	0.8925	0.8943	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9648	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9924	0.9926	0.9928	0.9930	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9986	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990
3.1	0.9990	0.9991	0.9991	0.9991	0.9992	0.9992	0.9992	0.9992	0.9993	0.9993
3.2	0.9993	0.9993	0.9994	0.9994	0.9994	0.9994	0.9994	0.9995	0.9995	0.9995
3.3	0.9995	0.9995	0.9995	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996	0.9996
3.4	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9997	0.9998
3.5	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998	0.9998
3.6	0.9998.	0.9998	0.9998	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999	0.9999

The University of Jordan
School of Engineering
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Transducers and sensors lab. (0908473)
Experiment 2: Calibration
IR sensor characteristics

Objectives:

4. Calibrate a voltmeter using source and measure function.
5. Find the static characteristics for IR sensor.

Lab Theory:

Calibration refers to the process of determining the relation between the output (or response) of a measuring instrument and the value of the input quantity or attribute, a measurement standard. However, it has become customary to use the word 'calibration' to include the process of adjusting the output or indication on a measurement instrument to agree with value of the applied standard, within a specified accuracy.

- This procedure is carried out for a range of inputs covering the whole measurement range of the instrument or sensor.

Calibration ensures that the measuring accuracy of all instruments and sensors used in a measurement system is known over the whole measurement range, provided that the calibrated instruments and sensors are used in environmental conditions that are the same as those under which they were calibrated. The Standard:

The term standard is used in the context of calibration to refer to any reference device that is used to calibrate another device. So a multi-function calibrator will be referred to as a standard when used to calibrate an ohmmeter.

Source and Measure Functions

When buying a calibration device, there are two possible options: Source and Measure function

A _source function_ will provide the user carrying out the calibration process with a source of a known variable (e.g., a standard voltage source of 1.2 volts) that can be used to calibrate the device.
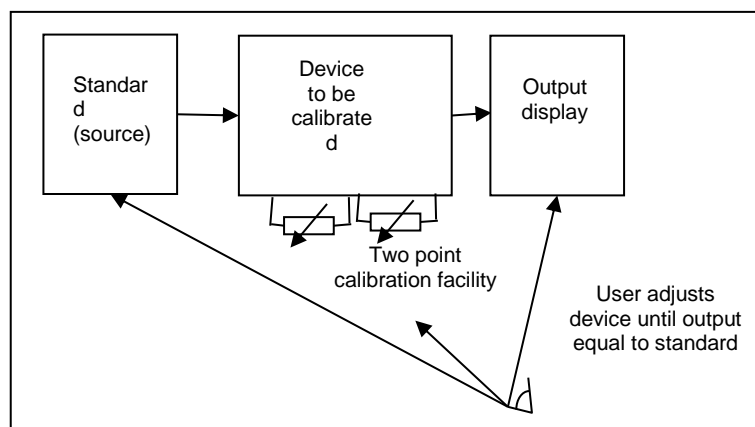
Figure 2.1: Source function calibration

A *measure function* is the use of the calibration device as a parallel measuring system to the device that is to be calibrated. The reading of the device to be calibrated can be compared to the calibration device and adjusted until identical.
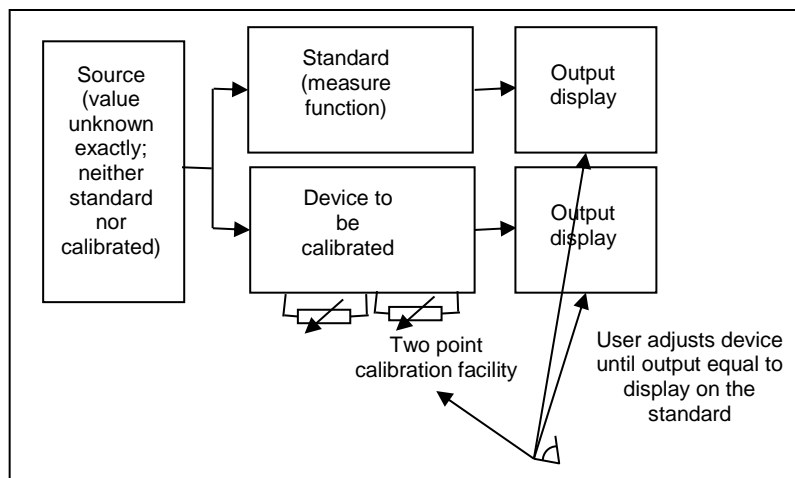

Figure 2.1: Measure function calibration

Q1: Calibrate the voltmeter you have on the bench using the voltage source (Standard) plot the data and find the zero drift and sensitivity drift.

Open the voltmeter and notice the calibration point (potentiometer) and try to fix it and plot the new result to be sure that the results are within the accepted accuracy of the device.

Part 2: Characteristics of IR sensor.

You have an IR sensor on the bench as in figure 2.3. this sensor measures distance of an object in front of the sensor. It has three wires the red and black wires are for DC excitation 10 V. the yellow one gives analogue output voltage dependent on the distance of the object. Put the object in different distances from 1 cm to 15 cm 0.5 cm each time and record the output voltage.

Figure 2.3: IR sensor

From the data collected find the range of the sensor, dead zone, sensitivity and non-linearity if the curve is linear if not find the equation of the curve using least square regression on cftool using MATLAB.

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Objectives

1. Know what is meant by the linearity and range of a mutual inductive type transformer.
2. To build LVDT Transducer and find the static characteristics of the transducer.

Introduction

The linear variable differential transformer (LVDT) is a type of electrical transformer used for measuring linear displacement. The transformer has three solenoidal coils placed end-to-end around a tube. The center coil is the primary, and the two outer coils are the secondaries. A cylindrical ferromagnetic core, attached to the object whose position is to be measured, slides along the axis of the tube. On our position measurement LVDTs, the two transducer secondaries are connected in opposition.

As the core moves, these mutual inductances change, causing the voltages induced in the secondaries to change. The coils are connected in reverse series, so that the output voltage is the difference (hence "differential") between the two secondary voltages. When the core is in its central position, equal but opposite voltages are induced in these two coils, so the output voltage is zero.

When the core is displaced in one direction, the voltage in one coil increases as the other decreases, causing the output voltage to increase from zero to a maximum. This voltage is in phase with the primary voltage. When the core moves in the other direction, the output voltage also increases from zero to a maximum, but its phase is opposite to that of the primary. The magnitude of the output voltage is proportional to the distance moved by the core (up to its limit of travel), which is why the device is described as "linear". The phase of the voltage indicates the direction of the displacement.
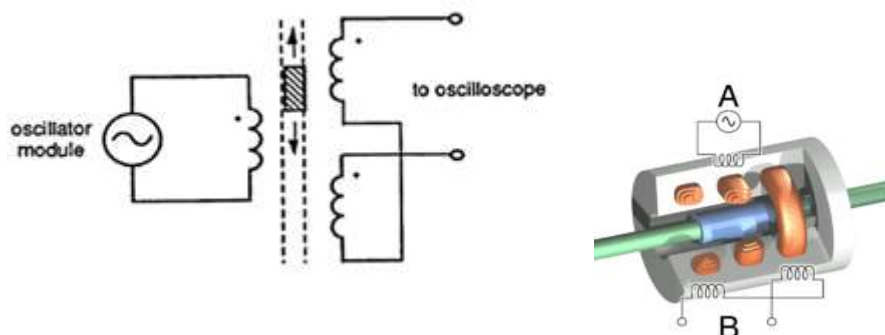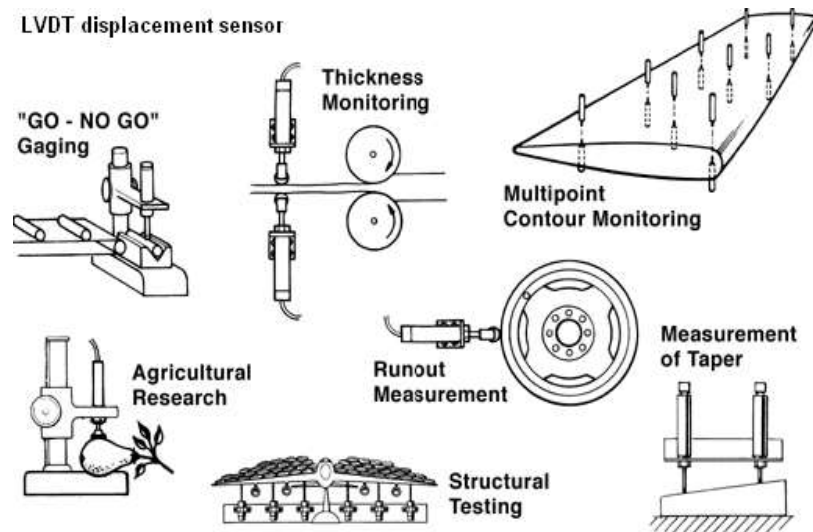

Figure: 3.1 LVDT setup and wiring

Figure 3.2: Some LVDT applications.

Part1: LVDT AC output

Connect up the circuit of fig.3.3 as shown in fig.3.1 carefully check that the terminals of the transducer are wired up correctly
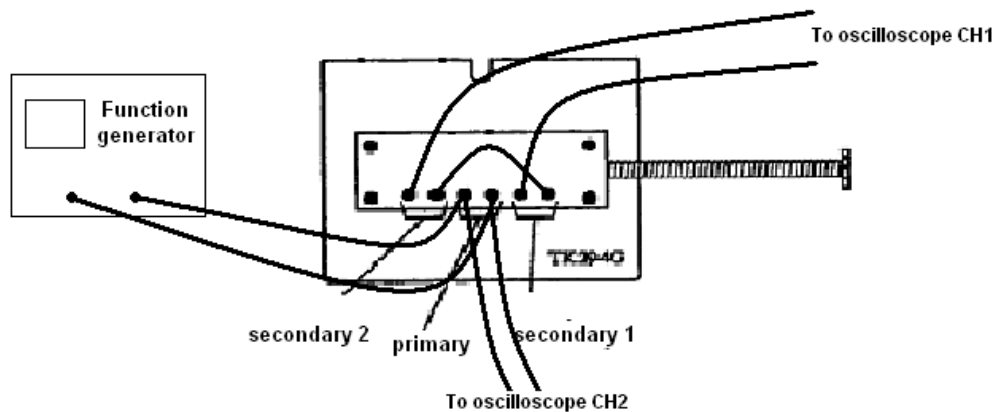

Figure 3.3: LVDT connections

Adjust the function generator to give output of 6 kHz and 1V pk-pk. By pressing the rod against the return spring, move the ferrite core through the body of the transducer. Observe the secondary output waveform on the oscilloscope, it should go through a maximum shifting phase and then a second maximum, reduce almost to zero, change phase and go through two further maximums again shifting phase. Observe particularly the phase change at the zero position. it should be 180°.

Using the micrometer move the core through the coils in 3mm steps, recording the output at each step, to fill table 3.1.

Record your readings in table ignore the third column .when the output passes through the null position, as you have noted ,there was an 180° phase change. Record the position where this happens, and all subsequent readings as negative.

Using your results, plot a graph of the output against position for the whole range of movement.

Table 3.1: displacement and output voltage reading.

Position(mm)	Output ac (volts pk-pk)	Output (dc volts)

Q1: Draw in what you consider to be the best straight line approximation to the central section . it will most likely pass through the zero null point.

Q2: Find linearity and sensitivity of the sensor.

Q3: Would a dc voltage output be more convenient?

What basic components do we need to convert the ac voltage in to a dc voltage?

Q4: How can we take account of the change in phase as the output voltage passes through zero?

Part 2: LVDT DC output

Switch off the power supply and connect up the circuit of fig 3.3. Carefully checks that the terminals on the transducer are wired up correctly.
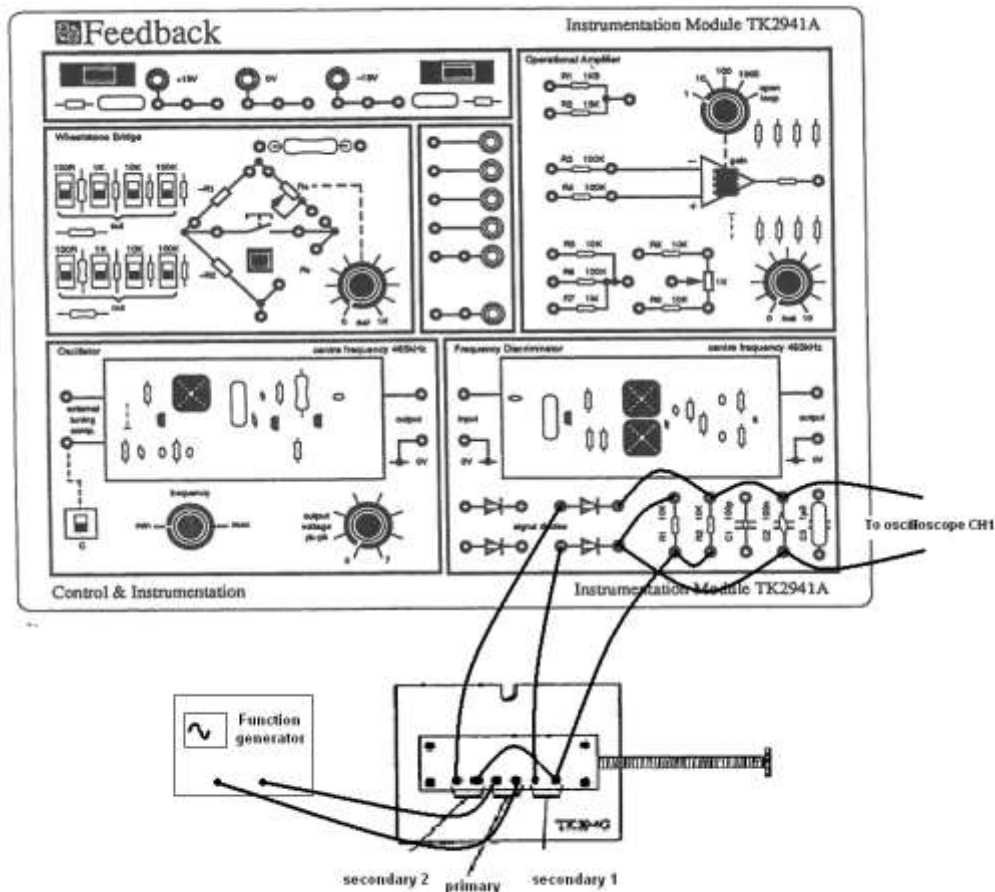
Figure 3.3: LVDT with rectifire

Connect your oscilloscope across the rectifier output terminals,. Temporarily remove the two connections from each of the two 100Nf ,C2, sockets while still keeping the patching leads joined together i.e. remove the capacitor from the circuit. Note the rectification provided by the diodes alone.

Replace the connections, this time across the 100pF capacitor, C1.Note that this value of capacitance does not provide adequate smoothing and that the dc waveform has a large ripple.

Change the connections again to place the 1μF capacitor, C3 in circuit observe the waveform whilst very rapidly moving the core.

Q5: What is the function of the capacitor.

Replace the correct 100nF Capacitor and withdraw the core from the coils. Take a set of readings of dc output voltage and position at 3mm intervals as you move the core through the two secondary coils as before.

Record your readings in the third column in your table. Record the position where the output voltage is zero.

Using your results, plot a graph of output against position for the whole range of movement. Draw it on the same graph you did the ac graph. We are going to perform the same operations on it.

Q6: What shape is your graph, especially over the central section?

Q7: Find the sensitivity linearity and range of the sensor.

Q8: Discuss the results you got in the previous two parts.

Objectives:

-Know how the change in resistance of a material, caused by a change in its physical dimension, can be used to measure the strain in the material

-To design a one and two arm bridges

-Find the characteristics of the strain gauge

Pre-lab: read about dc bridges and strain gauges.

Introduction:

The strain gauge is the most common device used in mechanical testing and measurements. The most common type is the bonded resistance strain gauge, which consists of a grid of very fine foil or wire. The electrical resistance of the grid varies linearly with the strain applied to the device. When using a strain gauge, you bond the strain gauge to the device under test, apply force, and measure the strain by detecting changes in resistance. Strain gauges are also used in sensors that detect force or other derived quantities, such as acceleration, pressure, and vibration. These sensors generally contain a pressure sensitive diaphragm with strain gauges mounted to the diaphragm.
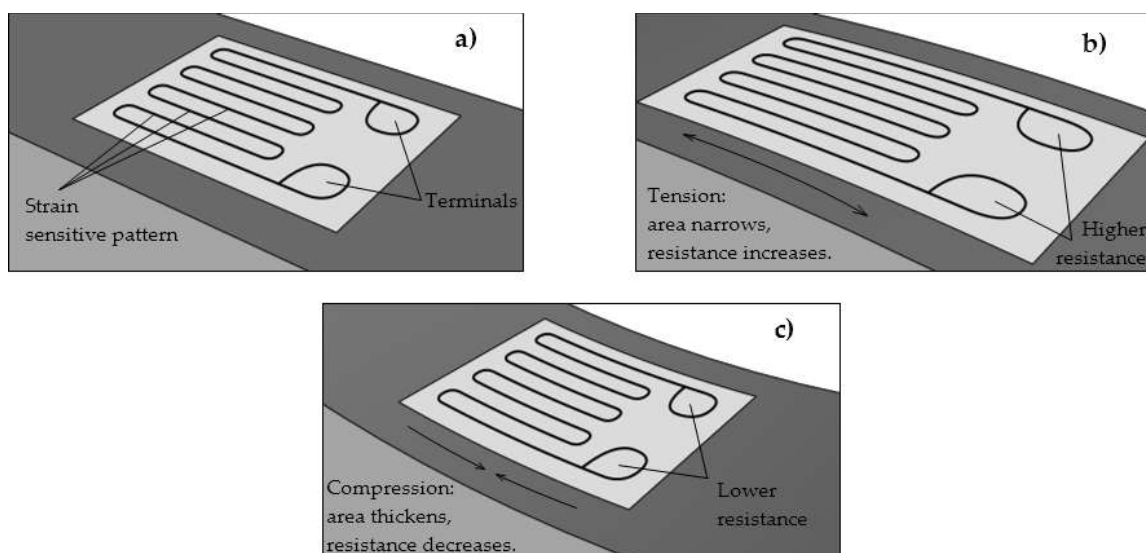
Figure 4.1: working concept behind the strain gauge on a beam under exaggerated bending.

Because strain measurement requires detecting relatively small changes in resistance, the Wheatstone bridge circuit is almost always used. The Wheatstone bridge circuit consists of four resistive elements with a voltage excitation supply applied to the ends of the bridge.

Strain gauges can occupy one, two or four arms of the bridge, with any remaining positions filled with fixed resistors. Figure 4.2shows a configuration with a half-bridge strain gauge consisting of two strain gauge elements, R_{G1} and R_{G2}, combined with two fixed resistors, R_1 and R_2.

Figure 4.2: Half-Bridge Strain Gauge Configuration

$$V_O = \left(\frac{R_{G2}}{R_{G1} + R_{G2}} - \frac{R_2}{R_1 + R_2} \right) \cdot V_{EXC}$$

When the ratio of R_{G1} to R_{G2} equals the ratio of R_1 to R_2, the measured voltage V_O is 0 V. This condition is referred to as a balanced bridge. As strain is applied to the gauge, their resistance values change, causing a change in the voltage at V_O. Full-bridge and half bridge strain gauges are designed to maximize sensitivity by arranging the strain gauge elements in opposing   directions.

For example, the half-bridge strain gauge in Figure 5 includes an element R_{G1}, which is installed so that its resistance increases with positive strain, and an element R_{G2}, whose resistance decreases with positive strain. The resulting V_O responds with sensitivity that is twice   that   of   a   quarter-bridge   configuration.

Some signal conditioning products have voltage excitation sources, as well as provisions for bridge-completion resistors. Bridge completion resistors should be very precise and stable. Because strain-gauge bridges are rarely perfectly balanced, some signal conditioning systems also perform nulling. Nulling is a process in which you adjust the resistance ratio of the unstrained bridge to balance the bridge and remove any initial DC offset voltage. Alternatively, you can measure this initial offset voltage and use this measurement in your conversion routines to compensate for unbalanced initial condition.

Part1: Basic Strain Gauge

Procedure:

- Design a one arm bridge using the setup in the lab. You have two strain gauges fixed on cantilever beam.
- You need to specify R1, R2 and R3in the bridge so that you initially balance the bridge as no force is applied to the beam. You need to apply series balancing after specifying the resistance values, use potentiometer for this purpose. The nominal value of the strain gauge resistance is 120 Ω check it. The maximum current that is allowed to pass through the gauge is 50 mA.
- After designing the bridge use AD620 instrumentation amplifier see the data sheet. You need to specify the value of R_G depending on the maximum output voltage of the bridge, see figure 4.3.
- Use the micrometer to deflect the cantilever beam .5 mm each time and record the data in table 4.1.
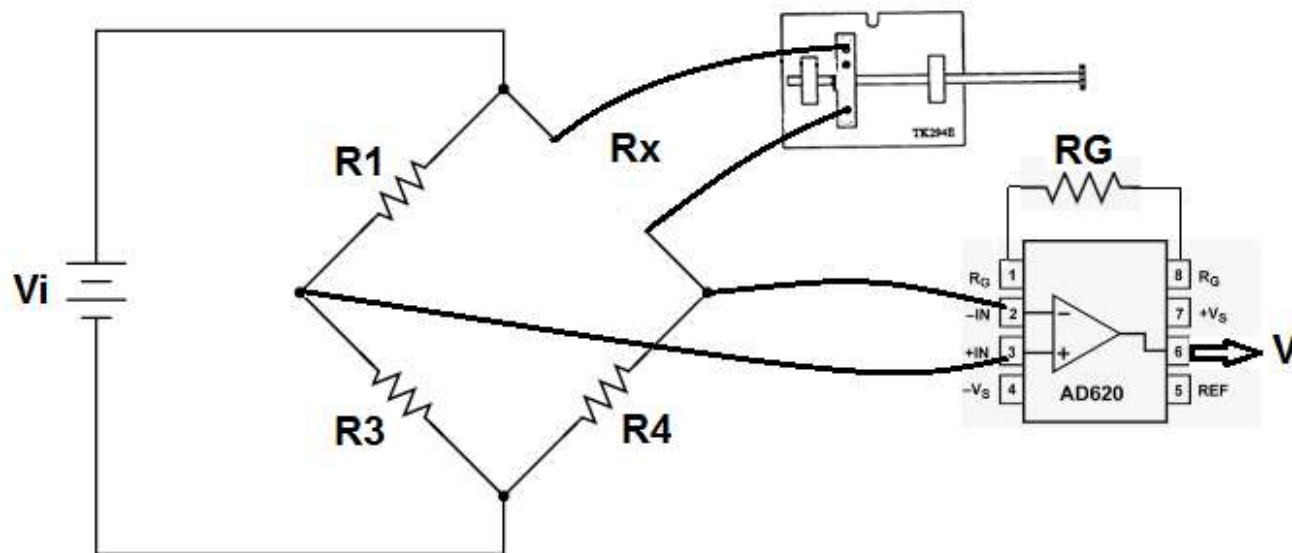
Figure 4.3: Strain Gauge circuit.

Q1: What are the advantages of using the Wheatstone bridge?

The second step is amplifying

Q2: why do we need this step?

Then you can read the output voltage from the signal

Q3: If we want to improve the output signal what type of conditioning can we add to the circuit, for pc processing as an example?

Table 4.1

Micrometer setting (mm)	Output Voltage(mV)
0	
0.5	
1	
1.5	
2	
2.5	

3	
3.5	
4	
3.5	
3	
2.5	
2	
1.5	
1	
0	

Plot your results of micrometer settings against output voltage.

Q5: Find the maximum hysteresis, non-linearity and the sensitivity as a percentage of f.s.d?

Part2: Dual Gauge System

Connect up the circuit of figure 4.4. Although the tow gauges are nominally of equal resistance there could still be a small unbalance remaining so the offset potentiometer is used.
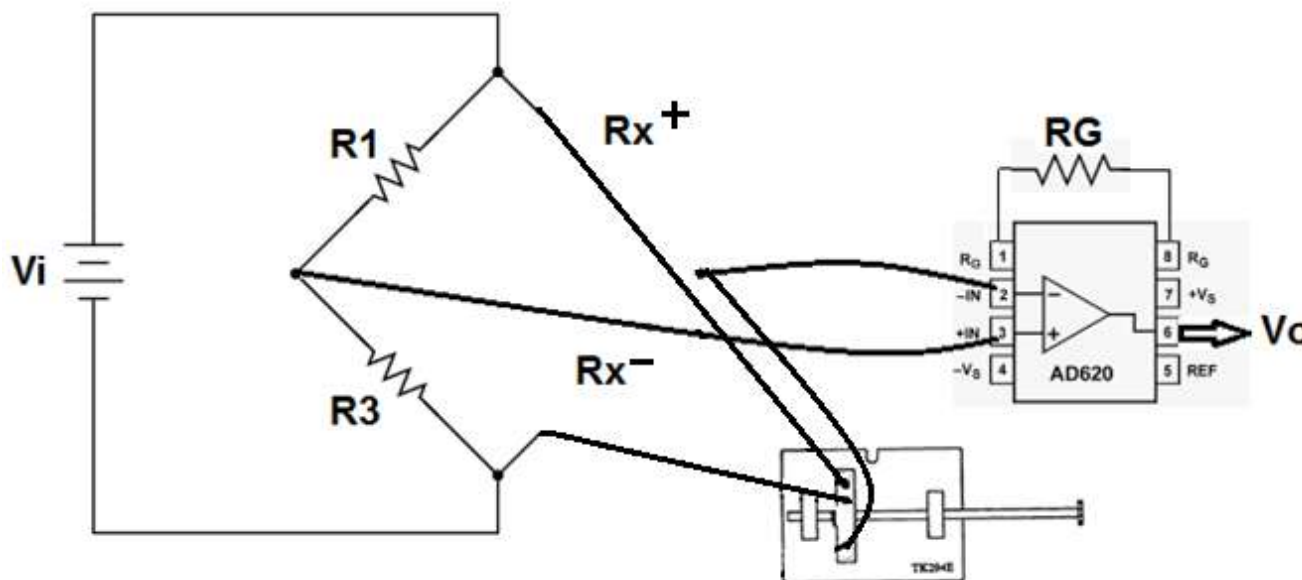

Figure4.4: Dual Strain Gauge circuit.

On the Wheatstone bridge set R1=R2=1 kΩ, Set the operating rod to the same mid-position as was used in part1 and then adjust R49 to give an exact zero as before. Now take a set of readings of output voltage against micrometer setting as before (0 up to 4 and back up to 10.0 mm) and record them in the following table.

Plot your results of micrometer settings against output voltage.

Q6: Are the new results free from thermal effects, explain?

Q8: Find the maximum hysteresis, non-linearity and the sensitivity as a percentage of f.s.d?

Part 3: Load cell 4-arm bridge

In this part you have a load cell and 10 loads of 50 g each see the circuit on the load cell that shows how to connect the four output terminals then add the loads on the load cell 50 g each time and record the output voltage in table 4.2

Plot your results of micrometer settings against output voltage.

Q6: Are the new results free from thermal effects, explain?

Q8: Find the maximum hysteresis, non-linearity and the sensitivity as a percentage of f.s.d?

Q9: Discuss the results you obtained in part one and two.

Plot your results of micrometer settings against output voltage.

Q6: Are the new results free from thermal effects, explain?

Q8: Find the maximum hysteresis, non-linearity and the sensitivity as a percentage of f.s.d?

Q9: Discuss the results you obtained in part 1, 2 and 3.

Objectives

In this experiment you will:

- Calibrate J-type thermocouple

- You will measure the time constant of the thermocouple in air and in water.

- You will design a transducer that measures temperature and display it on LCD.

Introduction

A thermocouple transducer is formed by a junction of two dissimilar metals. The junction, when heated, will produce a small voltage and associated current flow.

The voltage developed is directly proportional to the temperature of the junction.

Background

Thermocouple Type:

-Type J (Iron-Constantan)– cheap because one wire is iron; high sensitivity but also high uncertainty (iron impurities cause inaccuracy)

-Type K (chromel{90 percent nickel and 10 percent chromium}–alumel)(Alumel consisting of 95% nickel, 2% manganese, 2% aluminium and 1% silicon) popular type since it has decent accuracy and a wide temperature range; some instability (drift) over time If the thermocouple is connecting direct to a voltmeter as shown in figure 5.1, problems will occur:

-The measured voltage depends not only upon the unknown temperature but room temperature as well. This is undesirable because room temperature can fluctuate, causing apparent fluctuations in the measured temperature.

-The second problem is that the contacts between metal Cu and the voltmeter and metal C and the voltmeter will both set up small "contact" voltages which will be different from each other because metals Cu and C are different. The differences between these two voltages set up an additional voltage that gives rise to error in the measurement.
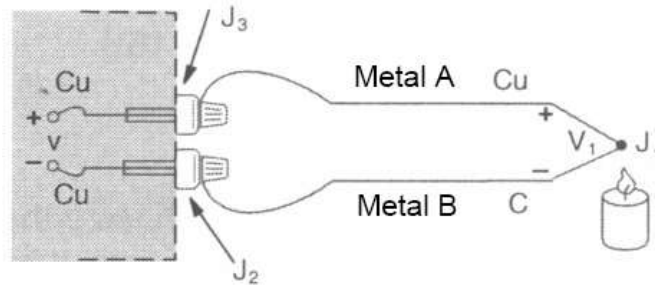
Figure 5.1: Thermocouple

This as created another junction! Displayed voltage will be proportional to the difference between J1 and J2 (and hence T1 and T2).see figure 5.2

A solution is to put J2 in an ice-bath; then you know T2, and your output voltage will be proportional to T1-T2.
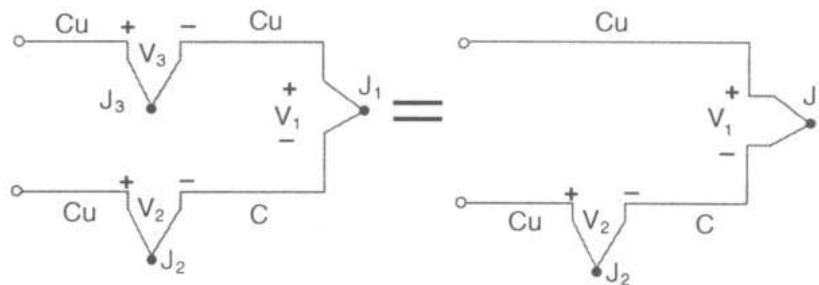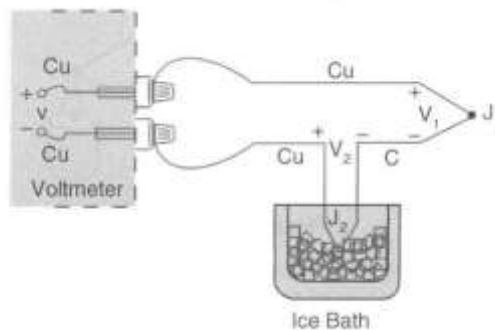

Figure 5.2: Equivalent circuit

Figure 5.3: Solution circuit

Law of Intermediate Materials

This law states that when a third metal is connected between the two dissimilar metals this will not affect the output voltage as the two junction at the same temperature.
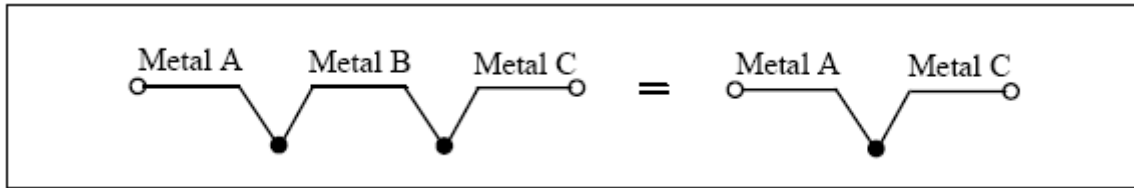
Figure 5.4:law of intermediate metals

When a thermocouple is heated, it is required a certain period of time for the output voltage of the junction to be follow temperature change. The difference between the temperature change and the output voltage is referred to as the time constant (tc) of the devise. The time constant (tc) is defined as the time required for the output to reach 63.2% of its final output voltage value at the new temperature, in response to a step function change in temperature. As shown in figure 5.5.
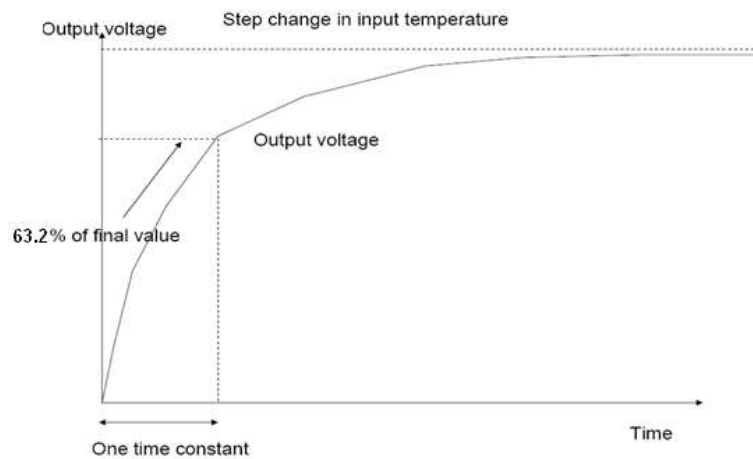
Figure5.5: Time constant

Procedure

Part 1: Calibrating the Thermocouple

Connect the circuit shown in figure 5.6 ,switch on the power supply and place the probe near to the amplifier input so that all points are at the same temperature. To avoid possible 'pick up' of signal, due to the proximity of the thermocouple lead to the TK2941A oscillator, the positive input to the operational amplifier is decoupled to 0with a 100 µF capacitor. Read the room temperature near the amplifier .this will be the cold junction temperature and should ideally be constant during the experiment. Switch the gain of the operational amplifier to 1000, disconnect the prope, note the meter reading in table 5.1and place it and a thermometer in the water tank and clip this on the heat bar at notch 20.
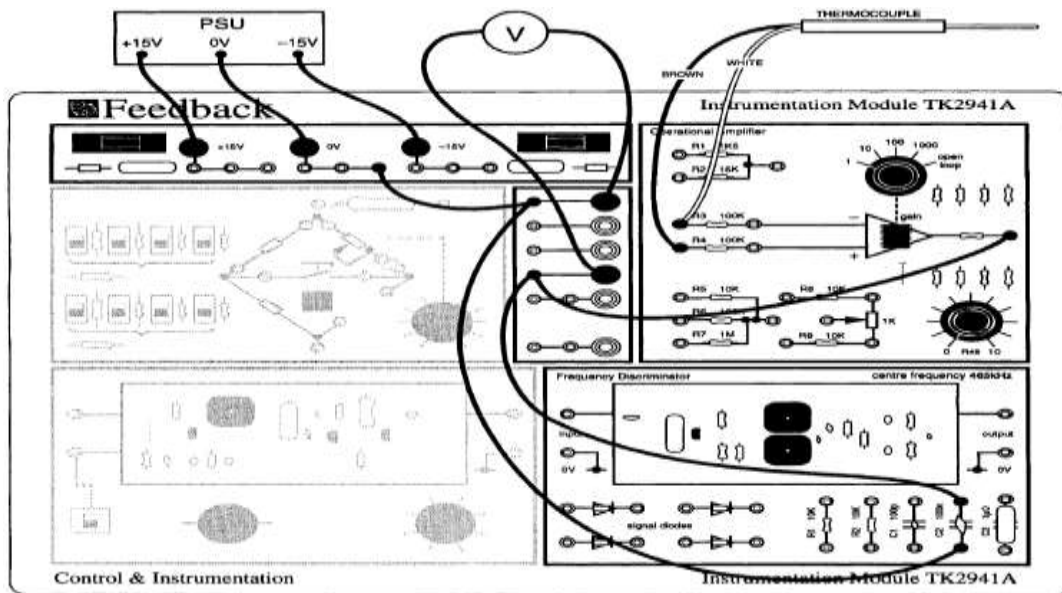
Figure 5.6: Thermocouple circuit.

When the temperature is steady (about 15 minutes) note the thermometer reading and the meter reading. Repeat for notches 18,16,..etc every 2 minutes up to the point $100^{o}C$ is reached. Fill the following table.

Table 5.1: Thermocouple reading and corresponding temperature values

Notch no.	Room temp. (^{o}C)	Tank temp.(^{o}C) (thermometer)	Meter (V)	Thermocouple emf (mV)	Temperature From J type reference table
20					
18					
16					
14					
12					
10					
8					
6					
4					
2					

Calculate the temperature difference and the thermocouple emf,which will be the meter reading divided by 1000 expressed in mV.

Plot the emf against temperature difference.

Q1: Find the sensitivity in $\mu V/^{o}C$?

Q3: What source of error could contribute to uncertainty about this figure?

Part 2: Measuring time constants

i. Time constant for J-type thermocouple in water:

1) Place the thermocouple in the cold water. Record the final voltage value at which it settles.

2) Remove the thermocouple and place it in the hot water mug and keep it. Record the voltage that it shows.

3) The difference between the two voltages will be the step function it is exposed to when moving from one to the other. The time constant will be the time takes it to drop to the 37% of the difference between the two values.

4) Prepare a stopwatch to measure the time.

5) At the same time, start the stopwatch and move the thermocouple from the hot water to the cold water.

6) Note when the voltage drops to 37% of the difference and check the time.

7) This is the time constant for the thermocouple in water.

ii. Time constant for J-type thermocouple in air:

1) Place the thermocouple in air. Wait long enough for it to settle.

2) Record the final voltage value at which it settles.

3) Remove the thermocouple and place it in the hot water mug and keep it. Record the voltage that it shows.

4) The difference between the two voltages will be the step function it is exposed to when moving from one to the other. The time constant will be the time takes it to drop to the 37% of the difference between the two values.

5) Prepare a stopwatch to measure the time.

6) At the same time, start the stopwatch and move the thermocouple from the hot water to the air. Note when the voltage drops to 37% of the difference and check the time. This is the time constant for the thermocouple in air.

Part 3: Thermocouple temperature full transducer design:

5) Now design a transducer that use thermocouple to measure temperature and display the results on LCD. You need to compensate for the error (cold junction)

You will be given ARDUINO, temperature sensor LM35 and AD620**.**

Discussion:

- Discuss the main problems with this experiment and how you can improve it.

- Comment on the accuracy of the method, the number of point obtained and the number of significant figures you are getting from the multimeter.

This experiment was prepared by Prof. Lutfi Al-Sharif edited by : Eng. Nadeen Habash

The University of Jordan
School of Engineering
Mechatronics Engineering department
Transducers and sensors lab. (0908473)
Experiment 6.1: Signal analysis and processing using labview

Objectives:

To be familiar with signal processing toolkit in labview.

Be familiar with data acquisition system.

About labview:

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a graphical programming language that uses icons instead of lines of text to create applications. In LabVIEW, you build a user interface by using a set of tools and objects. The user interface is known as the front panel. You then add code using graphical representations of functions to control the front panel objects. This graphical source code is also known as G code or block diagram code. The block diagram contains this code. In some ways, the block diagram resembles a flowchart.
What Is Data Acquisition?

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible, and cost-effective measurement solution.
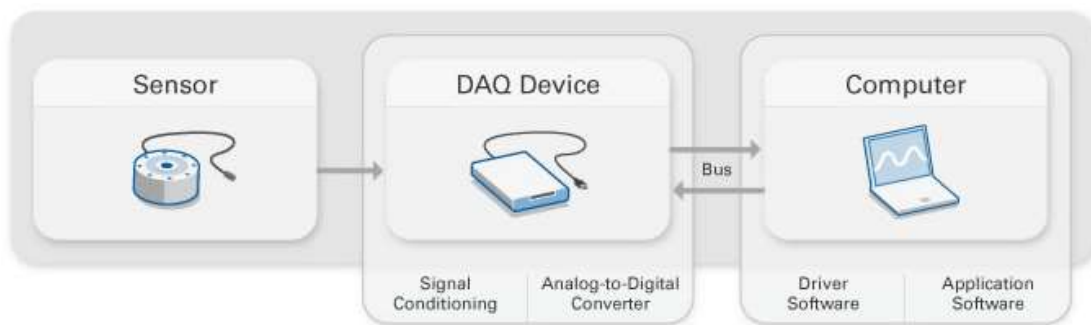
To read more see the following site:

http://www.ni.com/dataacquisition/whatis/

1. LabVIEW Fundamentals Manual, National Instruments.

   http://www.ni.com/pdf/manuals/374029a.pdf

2. Getting Started with labVIEW Manual, National Instruments.
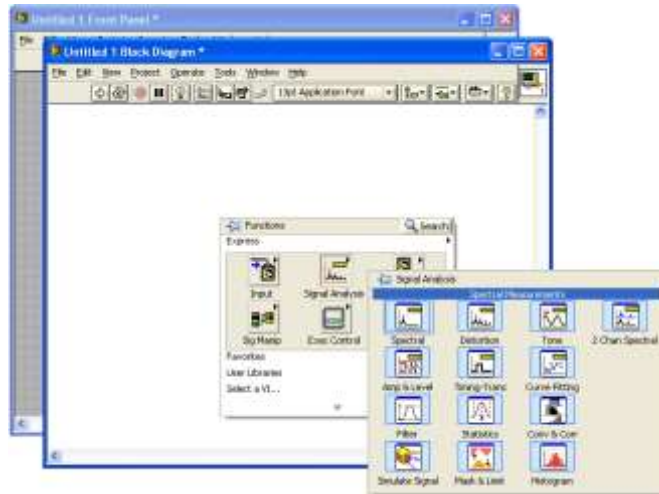
http://www.ni.com/pdf/manuals/373427c.pdf

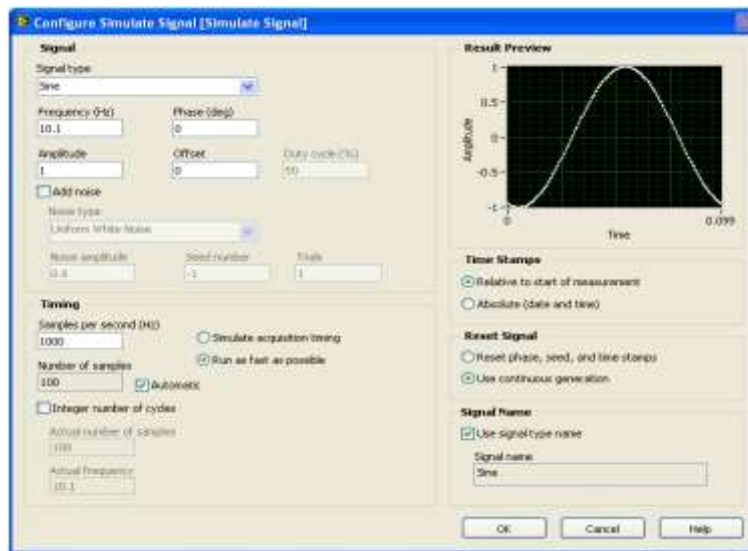Open the labview program then open a blank VI.

The following windows will be opened
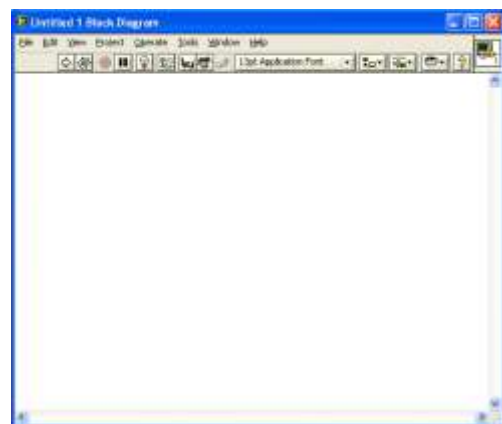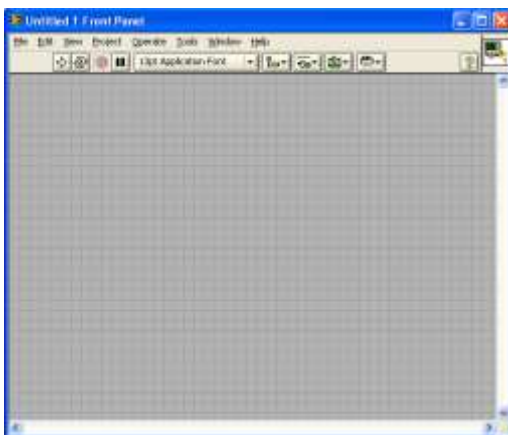
Right click in the block diagram window choose signal analysis>simulate signal.
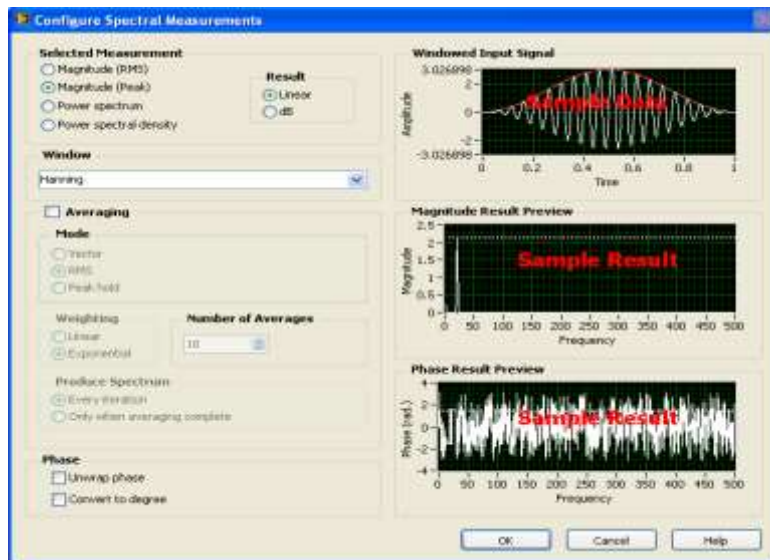
The following window will appear choose sin wave with 400 Hz and amplitude 1V

Again add another block but now let the amplitude be 2V and the frequency 50 Hz

At the same way from signal analysis choose spectral measurement block, select magnitude peak and the linear result then press ok
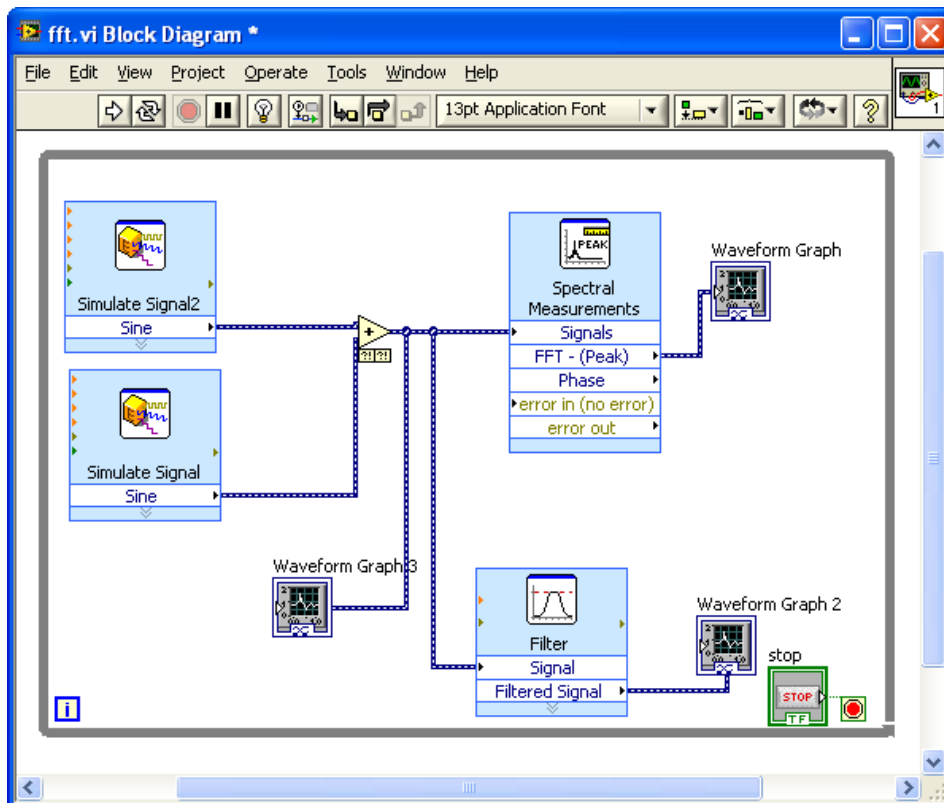
Now select filter block Use the suitable values for the filter sitting to remove the signal of 400 Hz. From arithmetic and comparison block select add.

From the front panel window right click and select graph indicators>graph, select three graphs.
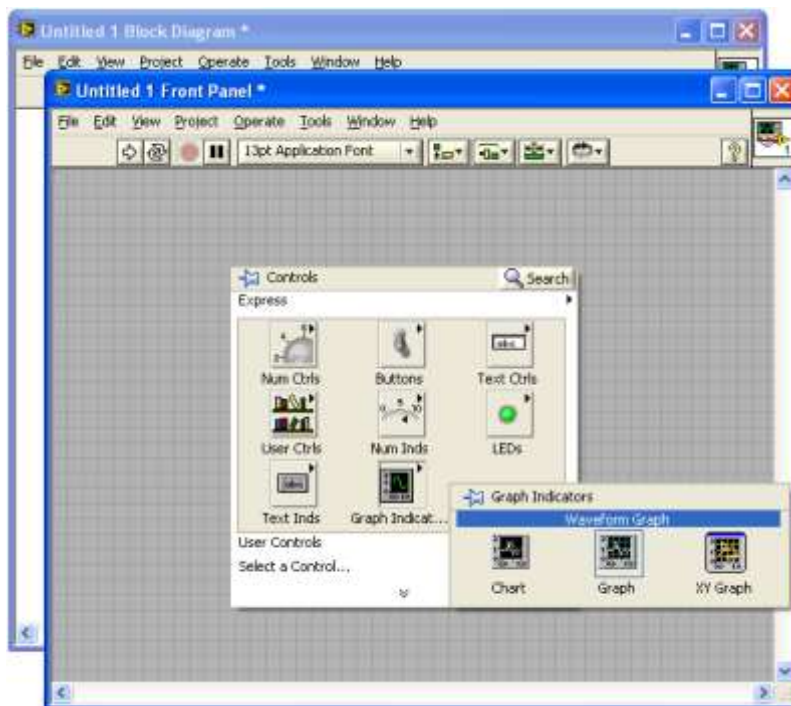
Connect the blocks as shown in the following figure and click on (run continuously button) .

Comment on the graphs.

The University of Jordan
School of Engineering
Mechatronics Engineering department
Transducers and sensors lab. (0908473)
Experiment 6.2: Illumenence measurement using Light Dependent Resistance (LDR).

Objectives:

Make a transducer that finds the illuminance depending on the vary in resistance of the LDR.

Introduction:

A photoresistor or light dependent resistor (LDR) is a resistor that decreases with increasing incident light intensity. It can also be referred to as a photoconductor or CdS device, from "cadmium sulfide," which is the material from which the device is made and that actually exhibits the variation in resistance with light level. Note that CdS is not a semiconductor in the usual sense of the word (not doped silicon). A photoresistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.
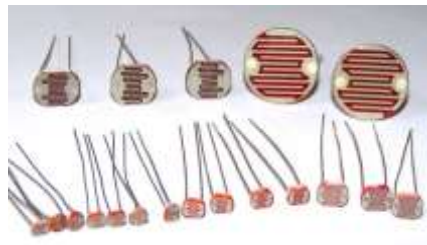
Light Level – Illuminance:

Light Level or Illuminance, is the total luminous flux incident on a surface, per unit area, Illumenance is measured in foot candles (ftcd, fc, fcd) (or lux in the metric SI system). A foot candle is actually one lumen of light density per square foot, one lux is one lumen per square meter.[1]

Procedure:

In this experiment you are going to find the illuminance using an LDR sensor and display the value of illuminance on a PC using DAQ system, the DAQ used in this experiment is usb-6008 from NI see the manual. (http://www.ni.com/pdf/manuals/371303l.pdf) notice the input and output range of the DAQ.

Now you are going to make a transducer that finds the illumenance using LDR,

to do that you need a lux meter and variable illumenance source, Vary the illumenance and measure the LDR resistance and fill the following table.

LDR resistance	Illuminance
	10
	20
	. .
	1000

Try to collect as many readings as you can so you find more accurate relation

Now find the relation between the resistance and the illumination, use any program excel for example.

Now connect the following circuit:
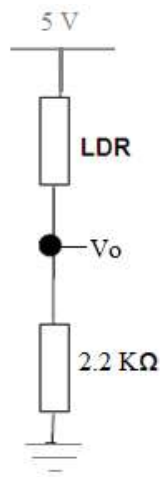
The range of the LDR resistance is 100 Ω-1MΩ

Q1: What is the maximum output voltage? Find the maximum output voltage you can get from the bridge. Is it suitable as input to the DAQ? Why?

take the output from the bridge as a differential input to the DAQ card see the manual for the DAQ, Open Labview program in the block diagram window from view menu choose functions palette>inputs> DAQ assist. in the window that appears choose Acquire signals >analog input > voltage.
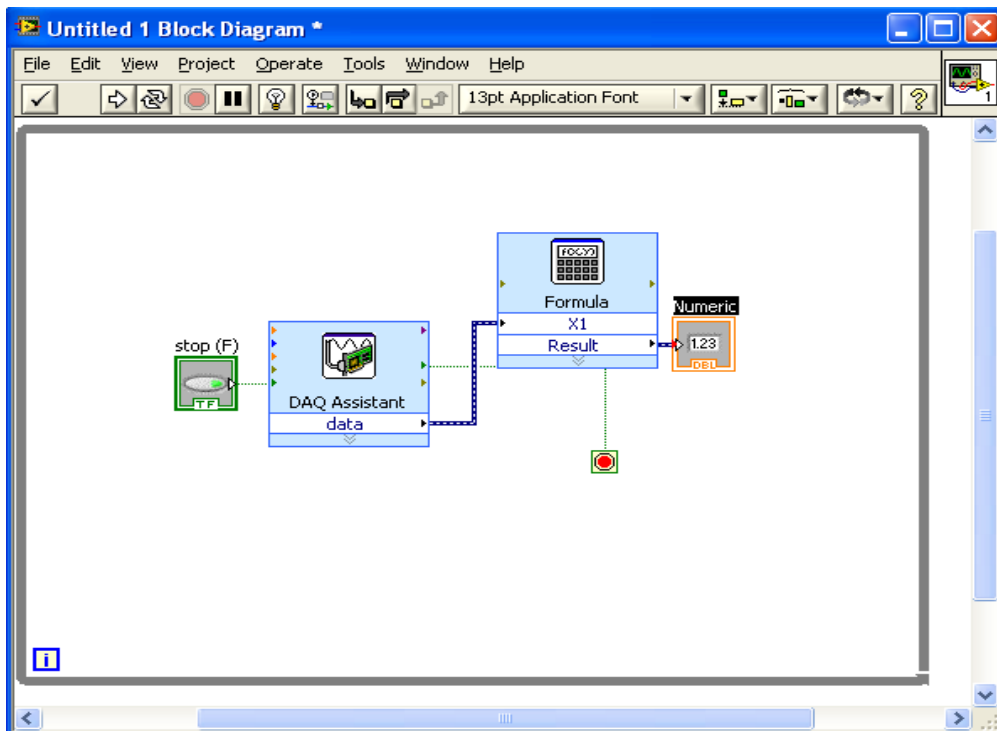
Select ai2 (analog input2) then click finish Then fill the values as in the following figure.
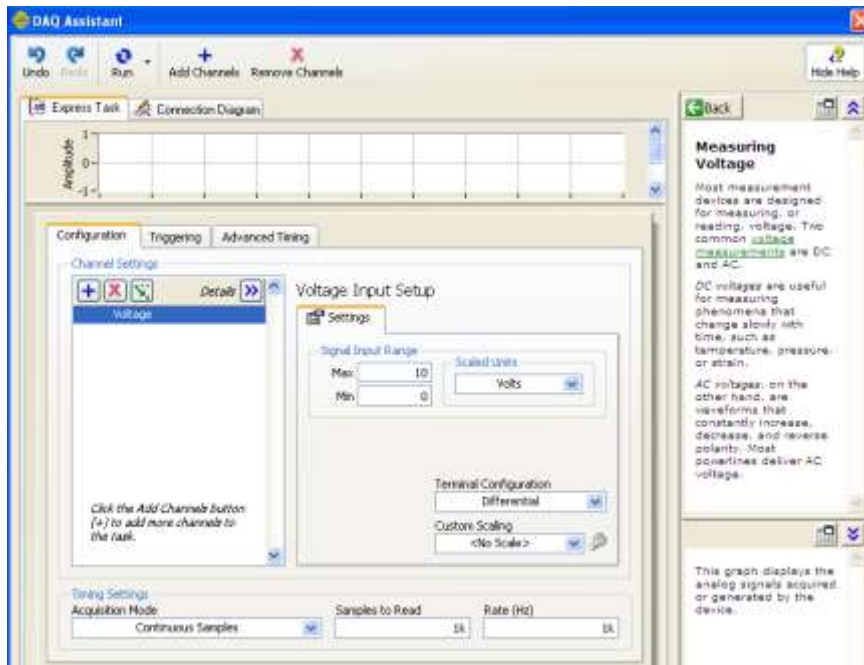
Now right click in the block diagram window select arithmetic and comparison>formula. Then right the equation then press ok.

Connect the signal out from DAQ to the input of the formula then right click on results select creat>numeric indicator as in the following figure

Right he furmula that represent the relation between the lux value and the voltage value then run the program.

Objectives:

-Know how the change in resistance of a material, caused by a change in its physical dimension, can be used to measure the strain in the material

-Find the characteristics of the strain gauge

Pre-lab: read about dc bridges and strain gauges.

Introduction:

Resistance thermometers, also called **resistance temperature detectors** (**RTDs**), are sensors used to measure temperature. Many RTD elements consist of a length of fine wire wrapped around a ceramic or glass core but other constructions are also used. The RTD wire is a pure material, typically platinum, nickel, or copper. The material has an accurate resistance/temperature relationship which is used to provide an indication of temperature. As RTD elements are fragile, they are often housed in protective probes. Platinum is the best metal for RTDs due to its very linear resistance–temperature relationship, highly repeatable over a wide temperature range. The unique properties of platinum make it the material of choice for temperature standards over the range of −272.5 °C to 961.78 °C. Platinum is chosen also because of its chemical inertness.

The significant characteristic resistive elements is the linear approximation of the resistance versus temperature relationship between 0 and 100 °C of metals used as. This temperature coefficient of resistance is denoted by α and is usually given in units of $\underline{\Omega}$/(Ω·°C):

$$\alpha = \frac{R_{100} - R_0}{100\,°C \cdot R_0}$$

where

Ro: is the resistance of the sensor at 0 °C,

R100" is the resistance of the sensor at 100 °C.

Pure platinum has α = 0.003925 Ω/(Ω·°C) in the 0 to 100 °C range and is used in the construction of laboratory-grade RTDs. Conversely, two widely recognized standards for industrial RTDs IEC 60751 and ASTM E-1137 specify α = 0.00385 Ω/(Ω·°C). Before these standards were widely adopted, several different α values were used. It is still possible to find older probes that are made with platinum that have α = 0.003916 Ω/(Ω·°C) and 0.003902 Ω/(Ω·°C).

These different α values for platinum are achieved by doping; basically, carefully introducing impurities into the platinum. The impurities introduced during doping become embedded in the lattice structure of the platinum and result in a different R vs. T curve and hence α value.

Non-linearity in Wheatstone bridge:

The Wheatstone bridge is a type of d.c. bridge that is used for precision measurement of resistance from approximately 1 ohm to the low mega-ohm range.

$$V_o = V_i \left(\frac{R_x}{R_x + R_3} - \frac{R_2}{R_2 + R_4} \right)$$

When the Wheatstone bridge is used in the deflection type mode, a non-linearity exists between the input and output. R_x is a sensor that changes in accordance with the variable that is being measured. With R_2, R_3, R_4

and the nominal value of R_x (say R_{xo} which is the value oR_{xo} when the input is zero) at equal values, this equation suffers from non-linearity between Vo and R_x. In order to reduce this non-linearity, the values of $R_3 and R_4$ have to be increased in relation to R1and Rx0.If we assume that the R3 and R4 are n times the value of R2and Rx0, and we assign δ as the percentage change in the value of Rx, then we can re-write the equation above as:
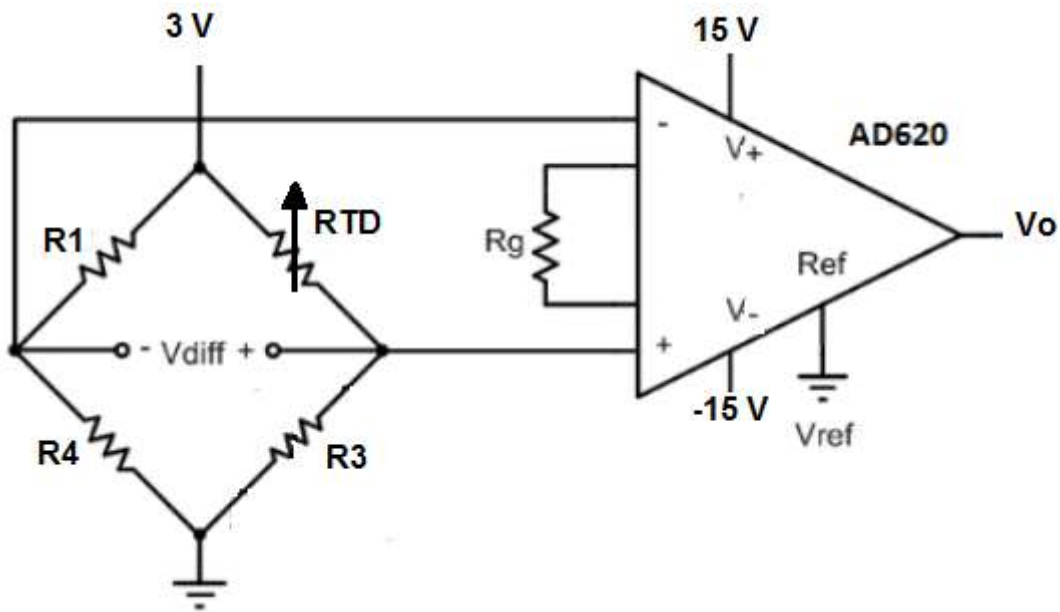
$$V_o = V_i \times \left(\frac{R_x}{R_x + R_3} - \frac{R_2}{R_4 + R_2} \right)$$

$$= V_i \times \left(\frac{R_{x0} \times (1 + \delta)}{R_{x0} \times (1 + \delta) + n \times R_{x0}} - \frac{R_2}{R_2 + n \times R_2} \right)$$

$$= V_i \times \left(\frac{(1 + \delta)}{(1 + \delta) + n} - \frac{1}{1 + n} \right)$$

This expression is independent of the values of the resistors and only dependent on δ and n. It can be shown that the non-linearity is reduced by increasing the value of n.

Part1: Basic RTD Circuit:

Procedure:

Connect the following circuit:

For initial balancing at 0 Colet R1=R2=R3=100 Ω.

Insert the thermometer and the RTD in the water tank and fill the table

below. Clip the tank to the heat bar at notch 20, wait until the temperature stabilized then record the output voltage and temperature.

Q1: Plot the voltage versus temperature

Q2: Find the sensitivity and non-linearity of the bridge.

Notch no.	Voltage	Temperature
20		
18		
16		
14		
12		
10		
8		
6		
4		
2		

Part 2: Non-linearity of Wheatstone bridge

Now let R3=R4=1k, Repeat the previous procedure and fill the following table

Notch no.	Voltage	Temperature
20		
18		
16		
14		
12		
10		
8		
6		
4		
2		

Q3: Plot Vo versus temperature on the same previous graph.

Q4: Find the sensitivity and nonlinearity

Q5: Compare the results you obtain in the two parts.

Q6:Discuss the reasons for choosing the Wheatstone bridge as a signal conditioning element.

Q7: Why do we use OP-AMP.

Q8: What is the difference between the LM741 OP-AMP and AD620?

Q9: What are the sources of errors in this experiment?

Q10: If you are going to complete the circuit and display the results on

PC what signal processing elements are needed and how can you finally display the

temperature reading?

Objectives:

-To be familiar with twin t-notch filter and low pass filter.

-To design low pass filter and twin t-notch filter with the suitable values to remove a noise signal of known frequency.

-To be familiar with signal processing toolkit in labview.

Introduction:

A filter is a device or process that removes from a signal some unwanted component or feature. A low-pass filter is a filter that passes low-frequency signals but attenuates (reduces the amplitude of) signals with frequencies higher than the cutoff frequency.
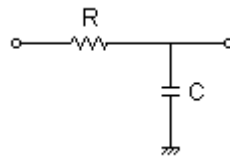
RC low pass filters

$F_O = 1/(2\pi RC)$

Active filter: is a type of analog electronic filter that uses active components such as an amplifier. Amplifiers included in a filter design can be used to improve the performance and predictability of a filter,[1] while avoiding the need for inductors (which are typically expensive compared to other components). An amplifier prevents the load impedance of the following stage from affecting the characteristics of the filter.Active Low Pass Filter with Amplification
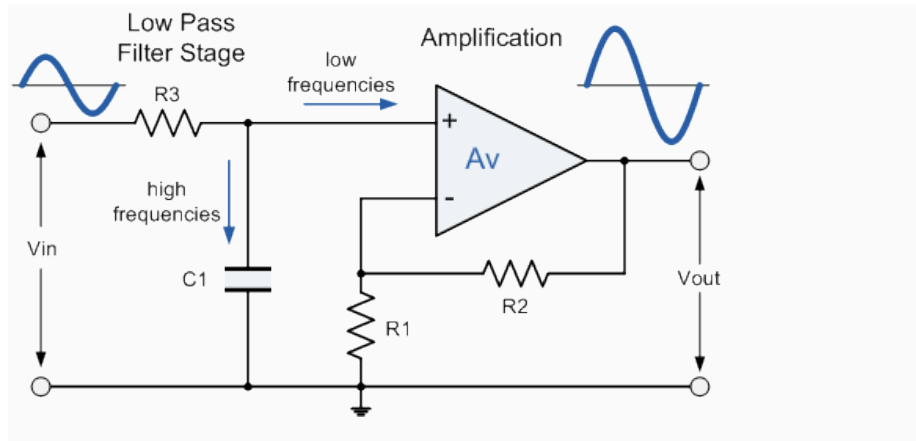
The frequency response of the circuit will be the same as that for the passive RC filter, except that the amplitude of the output is increased by the pass band gain, A_F of the amplifier. For a non-inverting amplifier circuit, the magnitude of the voltage gain for the filter is given as a function of the feedback resistor (R_2) divided by its corresponding input resistor (R_1) value and is given as:

DC gain $= (1 + \dfrac{R2}{R1})$

Therefore, the gain of an active low pass filter as a function of frequency will be:

Gain of a first-order low pass filter:

Voltage Gain $Av = \dfrac{Vout}{Vin} = \dfrac{Af}{\sqrt{1+(\frac{f}{fc})^2}}$

Where:

A_F = the pass band gain of the filter, $(1 + R2/R1)$

f = the frequency of the input signal in Hertz, (Hz)

fc = the cut-off frequency in Hertz, (Hz)

Thus, the operation of a low pass active filter can be verified from the frequency gain equation above as:

1. At very low frequencies, $f < fc$, $\dfrac{Vout}{Vin} \cong A_F$

2. At the cut-off frequency, $f = fc$, $\dfrac{Vout}{Vin} = \dfrac{A_F}{\sqrt{2}} = 0.707\,A_F$

3. At very high frequencies, $f > f_c$, $\dfrac{Vout}{Vin} < A_F$

Thus, the Active Low Pass Filter has a constant gain A_F from 0Hz to the high frequency cut-off point, f_C. At f_C the gain is $0.707A_F$, and after f_C it decreases at a constant rate as the frequency increases. That is, when the frequency is increased tenfold (one decade), the voltage gain is divided by 10. In other words, the gain decreases 20dB (= 20log 10) each time the frequency is increased by 10. When dealing with filter circuits the magnitude of the pass band gain of the circuit is generally expressed in *decibels* or *dB* as a function of the voltage gain, and this is defined as:
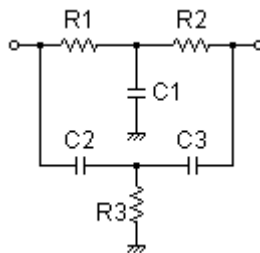
Magnitude of Voltage Gain in (dB):

Av(dB)=20log$_{10}$($\dfrac{Vout}{Vin}$)

-3dB=20log$_{10}$($\dfrac{Vout}{Vin}$)

A Twin t notch filter:

 is a filter that removes unwanted frequency signals

Twin t notch filter

Where R1=R2,R3=R1/2

C2=C3,C1=2*C2

F$_O$=1/ (2πRC), R=R1=R2, C=C2=C3

Prelab.1:

Design a twin t notch filter that attenuates (reduces the amplitude of) signals with frequency 150 Hz, let C2=C3=1µF, C1=2 µF, Find R1,R2, R3.
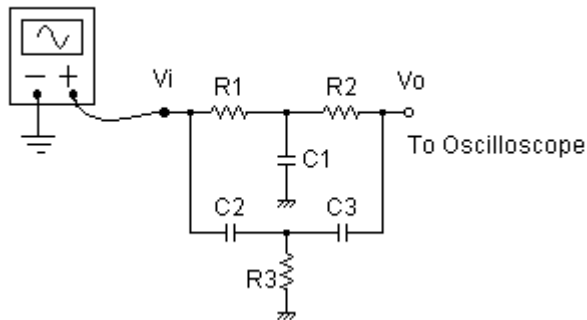
Prelab.2:

Design a non-inverting active low pass filter circuit that has a gain of two at low frequencies, a high frequency cut-off or corner frequency of 500Hz and an input impedance of 330Ω.

Part 1:

Connect the following circuit on the breadboard you have in the lab.

Vi=5V pk-pk, R1=R2=1.12 kΩ, R3=560 Ω, C2=C3=1 μF, C1=2 μF

Function Generator

Now vary the frequency starting from 10 Hz to 3KHz and complete the following table:

Frequency	Amplitude pk-pk	20Log(Vo/Vi)	Frequency	Amplitude pk-pk	20Log(Vo/Vi)
10			250		
20			300		
40			350		
60			400		
120			450		
130			500		
140			600		
150			700		
160			800		
170			1000		
180			1100		
190			1200		
200			1500		
210			2000		
220			3000		

Q1: Plot the gain magnitude versus frequency, using a *logarithmic* frequency axis
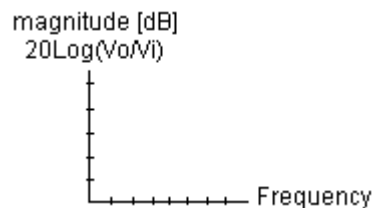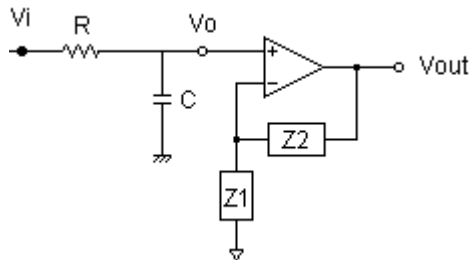

Q2: What is the center rejection frequency you got from the graph? Are the theoretical and the practical values are the same? If not, why?

Part 2:

In this part you will filter unwanted frequency using low pass filter.

Connect the following circuit with the filters element values as you found in prelab2.

Q3: Plot t he gain magnitude versus frequency, using a *logarithmic* frequency axis

Q4: Build a second order filter and repeat the previous steps.

Frequency	Amplitude pk-pk(Vout)	Vout/Vi (experimentally)	Vout/Vi (theoretically)	20Log(Vo/Vi)
50				
100				
150				
200				
250				
300				
350				
450				
500				
550				
600				
650				
700				
750				
800				
850				
900				
1000				

Objectives:

- Know that a thermistor has a negative temperature coefficient of resistance.

- Have noted the practical implications of the self-heating effect.

- Have produced a calibration curve for the thermistor.

- Recognize the term dissipation constant.

Introduction:

All electrical conductors possess resistance and in every case the resistance is to some degree dependent upon temperature.in most cases resistance increases with temperature rise and the change is usually an undesirable effect to be made as small as possible.

It is possible, however, to take advantage of this effect to enable temperature changes to be detected by it .in in this experiment, through you shall study a device called thermistor (from Thermal Resistor)which has a very large and nearly always negative temperature coefficient. The applications for such a device extend beyond simple temperature measurements and are very numerous indeed.

There are two types: PTC (positive temperature coefficient) and NTC (negative temperature coefficient).

PTC: If the resistance increases with increasing temperature, the device is called PTC thermistor. PTC thermistors can be used as heating elements in small temperature controlled ovens.

NTC: If the resistance decreases with increasing temperature, the device is called NTC thermistor. NTC thermistors are used as resistance thermometers in low temperature measurements of the order of 10 K.

Thermistors are also commonly used in modern digital thermostats and to monitor the temperature of battery packs while charging

Steinhart-Hart equation

The Steinhart-Hart equation is a widely used for accurate temperature measurements:

$$\frac{1}{T} = a + b \ln(R) + c \ln^3(R)$$

where a, b and c are called the Steinhart-Hart parameters

B parameter equation

Resistance of the thermistor can also be characterized with the exponential function of temperature

$$R = R_o e^{B\left(\frac{1}{T} - \frac{1}{T_o}\right)}$$

Or

$$R = A e^{\frac{B}{T}}$$

where **R** is the resistance of thermistor at the temperature **T** (in **k**), R_O is the resistance at given temperature and **B** is the material constant.

B parameter equation is essentially the Steinhart Hart equation with

$$a = \frac{1}{T_o} - \frac{1}{B} \ln(R_o) \, , b = \frac{1}{B}, \text{ and } c = 0.$$

If we arrange the Eq. 7.3 into a logarithmic form, we get a linear function of

$$\ln(R) = \ln(A) + \frac{B}{T}$$

The temperature dependence of the resistance of a thermistor is shown in the following Figure.

Ln(R) vs. 1/T is also given in the Figure As it is clearly seen, Ln(R) is linearly dependent on 1/T The slope of the straight line is B
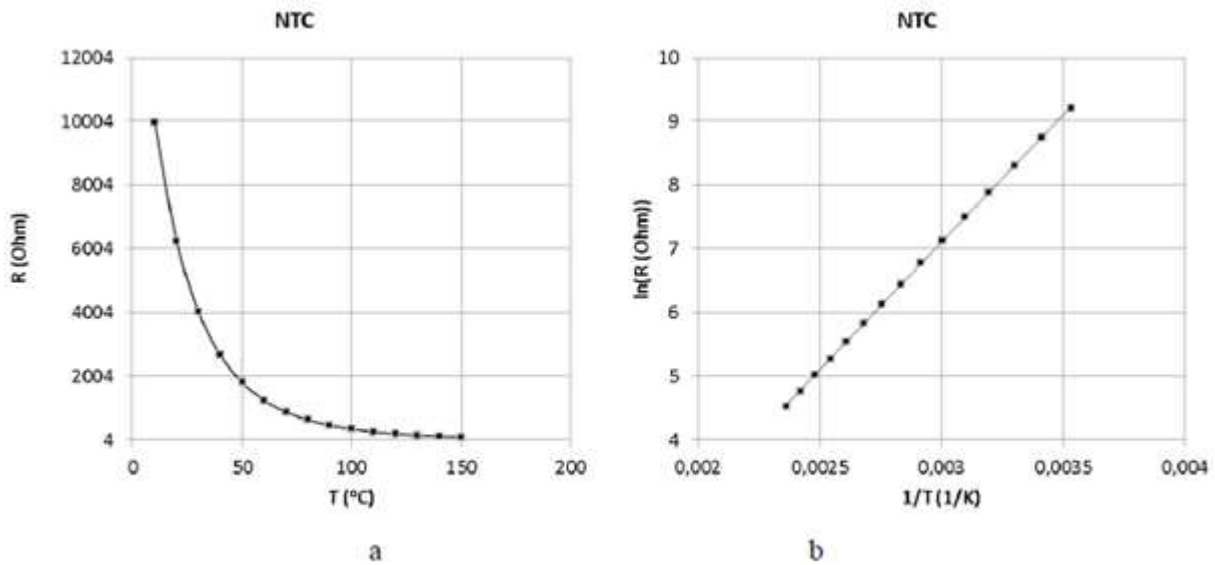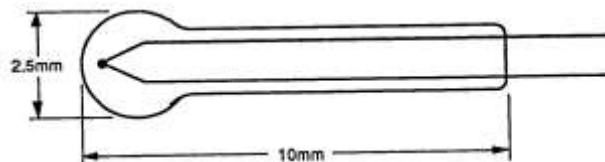
Figure 3.1 The temperature dependence of the resistance of a thermistor.

Q1: Mention some applications for the thermistor.

Thermistors are made from various metal oxide materials fired at a high temperature and appear in many different physical forms. the one used in this experiment although not visible inside its protective probe ,is a glass encapsulated bead of material supported on its connecting wires as shown in the following figure.

The resistance of a thermistor is dependent upon its temperature

The shape of the curve relating resistance to temperature is governed by an equation of the type

$$R = A_e{}^{b/T}$$

Where R : resistance in ohms

T :absolute temperatures

E:base of natural logarithms

A and b are constants

For the thermistor in this kit the value of R at 20C is about 2000 ohm and it varies with temperature as sketched in the following figure, shortly you will plot such a curve experimentally .

We must ensure that whatever measuring circuit we use does not appreciably heat up the thermistor, thus giving an artificially high temperature not representative of its surroundings. This effect is called 'self heating', in some applications it is deliberately used but in most it must be kept small. But how small? This question should be answered before calibration .so first we will determine how the resistance changes when power is dissipated in it by a current.

Part1:self heating

Connect the circuit shown in the next figure.
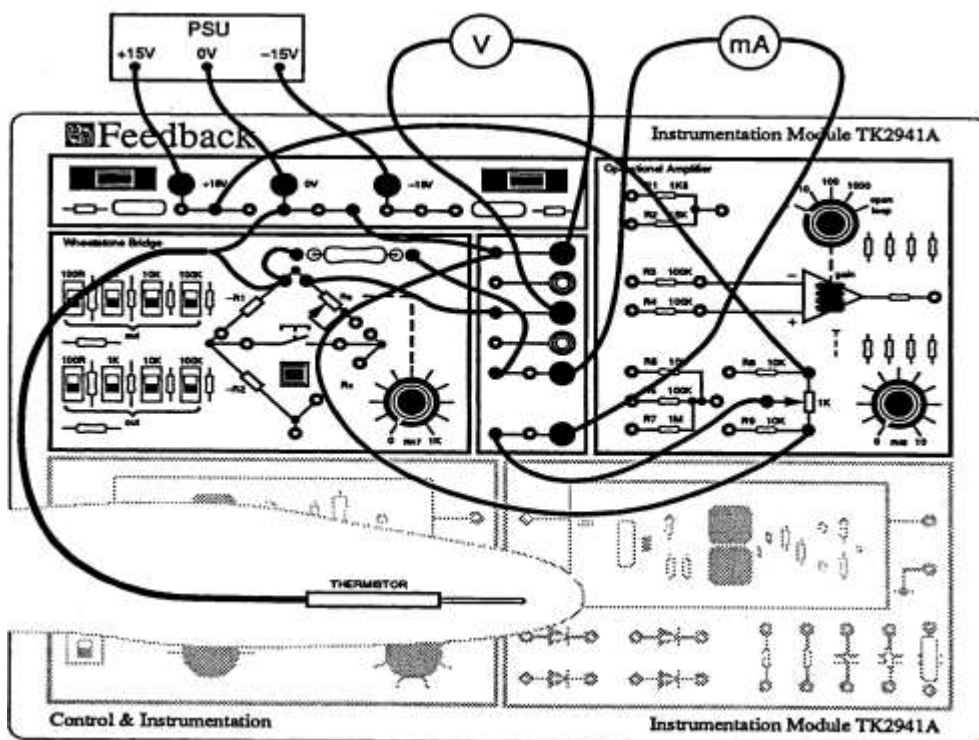
Note that the potentiometer set to zero and switch on the power supply.

Note: the current taken by the voltmeter, although small may need to be taken in to account to obtain accurate results as follows:

I: measured current

V : measured voltage

Ifs: voltmeter full scale current

Vfs: voltmeter full scale voltage

The thermistor current:

$$I' = I - \frac{V}{V_{FS}} \times I_{FS}$$

And the thermistor resistance

$$R = \frac{V}{I'}$$

The power dissipated in the thermistor is **V x I'**.

For this experiment it is referable that the ambient temperature is fairly constant over the period of the readings. Use a mercury thermometer to read room temperature.

Now increase the variable dc supply using the potentiometer to set the current to the values shown in the following table after each change of the current wait at least 1 minute before recording the voltage.you have to be careful at the higher currents because having changed the voltage the current will go on increasing for a while as the thermistor heats up and reduces in resistance.

Note: do not allow the current to exceed 20 mA.

Q2: Why the 220 ohm resistor is used in series with the probe?

I(mA)	V (V)	R=V/I (kΩ)	P=VXI
Air			
1			
2			
4			
10			
15			
20			
Water			
1			
2			
4			
10			
15			
20			

**Q3**: Plot a graph R versus P for both sets of readings .

Q4: Discuss the differences between the curves obtained for air and for water.

Q5: How many mW of power can safely be dissipated in the thermistor without lowering its resistance by more than 1% of its starting value for air and for water?

Part 2: calibration-zero power measurement

To calibrate the thermistor we wish to place it in the calibration tank with a mercury thermometer and heat the water to various temperatures, measuring the thermistor resistance

at each point by means of a Wheatstone bridge. Suppose we used an equal ratio bridge excited by about 1 V as follows:
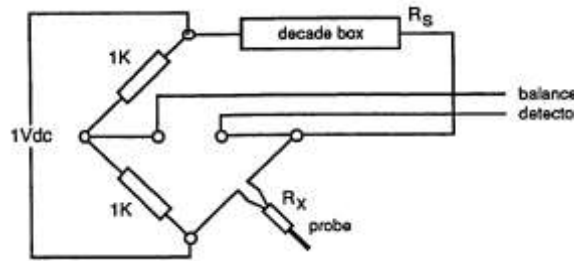
At balance the voltage across Rx will always be half the supply that is 0.5 V . if Rx should fall to say 100 ohm when heated externally the power dissipated would be 0.5^2/100=2.5 mW.

Q6: Is this more or less than your upper limit allowed in answer to Q5?

Connect the following circuit:
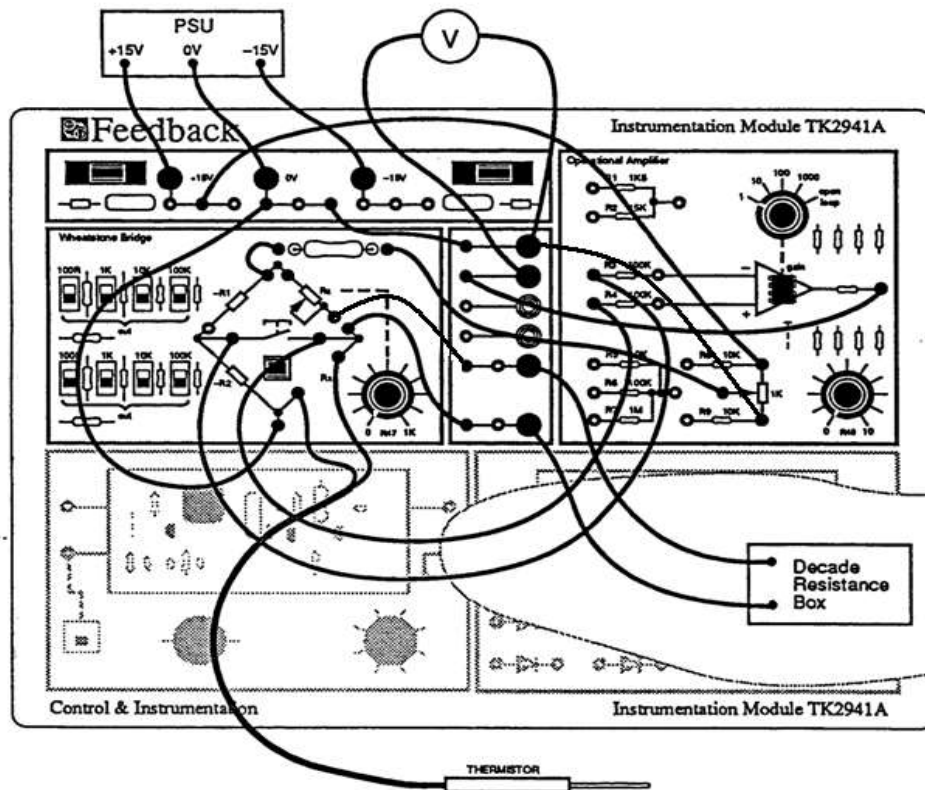
Q7: What is the maximum power is now dissipated in the thermistor at balance?

In the Wheatstone bridge set switch SW3 and SW6 'in' and all other switches 'out'.

Switch on the power supply and set the potentiometer to give 1 volt dc across the bridge circuit.

We are now in a position to make measurements of the thermistor resistance at different temperatures with negligible self-heating . this is often called zero power measurement.

Insert the thermometer and the thermistor in the water tank and and fill the following table, when the thermometer is steady at room temperature balance the bridge and note the temperature and resistance. Clip the tank to the heat bar at notch 20 ,wait until the temperature stabilized and rebalance the bridge to read the thermistor resistance.

Notch no.	Temperature C	Resistance(ohm)	Temperature(K)	1/T	Ln(R)
20					
18					
16					
14					
12					
10					
8					
6					
4					
2					

Q8: Plot a graph for R versus temperature.

Q9: Is the curve linear?

Dissipation constant

When a thermistor is to be used in a temperature measurement or control system there will be two conflicting requirements.

Greatest possible sensitivity from the detector circuit requiring as large an energizing current as possible.

Limited error, implying a limit to the self heating effect.

The dissipation constant is a parameter which helps to resolve this conflict by specifying how much power can be dissipated by the energizing current without causing more than the permitted amount of self heating.

It is defined as:

Dissipation constant= mW of power dissipation which will cause a temperature rise of 1 C.

Obviously the value of the constant will depend upon the thermal conduction characteristics of the medium in which the thermistor is situated because if this is high more power will be

needed to rise the temperature by 1 C than if it is low. That is why you obtained different curves in part 1 q4..

Those curves show how resistance varied with power dissipation whilst the curve you have just obtained in part 2 showed how resistance varied with temperature. We can thus combine the information from these two graphs to show how the thermistor temperature is affected by its power dissipation the following figure shows typical graphs
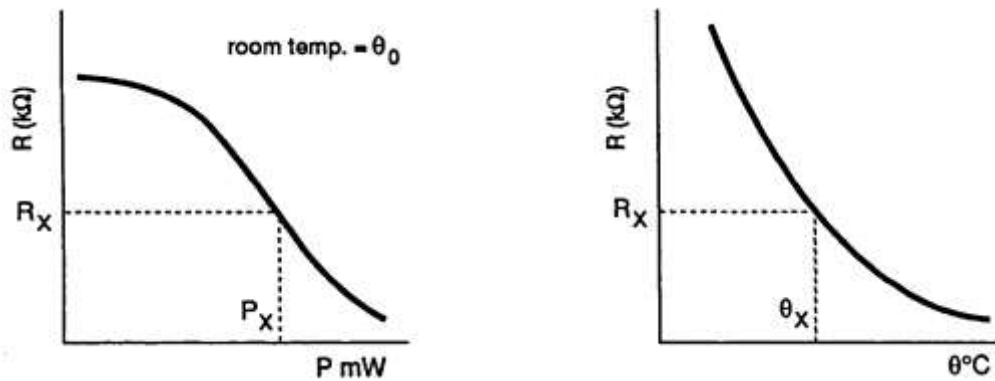
By taking a number of values of Rx at arbitrary intervals you can find corresponding values of Px and Θx

Θx is the actual temperature of the thermistor when ambient temperature is Θo and it is dissipating a power Px. Thus Px causes an increase in temperature above ambient of (Θx- Θo) C

Q9: Find Px, Θx and (Θx- Θo) for About 8 values of Rx noting in each case for each of the two graphs (in air and in water)from part 1. Now plot Px(air)and Px water against (Θx- Θo) as follows:
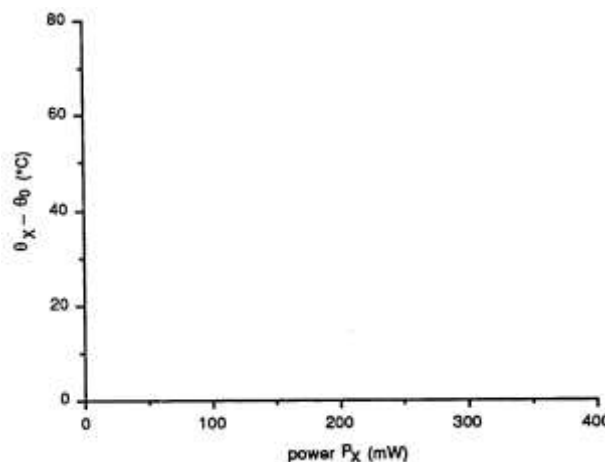
From the graph work out the slopes in terms of mW per C for air and water. These slopes are the dissipation constants for the two conditions.

The University of Jordan
School of Engineering
Mechatronics Engineering department
Transducers and sensors lab. (0908452)
Experiment 10: Variable distance capacitive sensor)

Objectives:

To design a signal conditioning circuit for a variable distance capacitive sensor.

Pre-lab:
Read about Ac bridges

Design:
In this lab you should design a circuit to measure displacement. The displacement is detected using a variable distance capacitor. The minimum value of the capacitance =40 Pf, maximum value=1 nF. Then you should find the linearity sensitivity and the range of the transducer
.

References:

- "Measurement & Instrumentation Principles", Alan S. Morris, Elsevier, 2001

- Mechanical Measurements", Thomas Beckwith, Roy Marangoni, John Lienhard, Pearson Education, Pearson International Edition, Sixth Edition.

Useful links:

- http://www.engineeringtoolbox.com/light-level-rooms-d_708.html
- http://fetweb.ju.edu.jo/staff/Mechatronics/LShareef/MandI_files/11%20DC%20Bridges/11%20DC%20%20bridges%20rev%203%2020080425.pdf
- http://www.sensorland.com/HowPage001.html
- http://www.rdpe.com/displacement/lvdt/lvdt-principles.htm