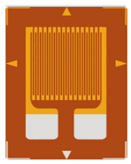
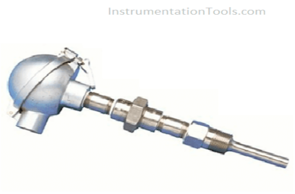
LABORATORY MANUAL
Transducers Lab


Pressure Transducer


E/P Transducer


Strain Gauge



Thermocouple

Department of Instrumentation Engineering
JORHAT ENGINEERING COLLEGE
Assam-785007

DOs

1. Log of the system properly before switching off
2. Be punctual, maintain discipline & silence
3. Leave your shoes in the rack outside
4. Handel the equipment's carefully
5. save all yours file properly
6. Report any problem to the equipment's with the person in charge.

Don'ts

1. Avoid unnecessary chat or walk
2. Avoid stepping on electrical wires or any other cables.
3. Avoid using cell phones unless absolutely necessary
4. Do not insert metal objects such as clips, pins and needles into the computer casings. They may cause fire.
5. Do not insert personal pen drive don't remove anything from the computer laboratory without permission.
6. Do not touch, connect or disconnect any plug or cable without your lecturer/laboratory technician's permission.
7. Avoid late submission of laboratory report

IN	**Transducer Lab**	**Semester-III**	**L-T-P**	**CREDIT**

Experiment No	Title of the experiments	Objective of the experiments
1	To determine strain using full bridge and half bridge	To study linearity characteristics of 1. Strain gauge Vs displacement 2. Determination of Gauge factor 3. Micro Strain Indicator
2	Study of LDR (Light dependent Resistor)	To determine the working of LDR (Light dependent Resistor) and also plot the graph of their property against lamp power(intensity).
3	Study of RTD (PT-100)	To determine the working of the RTD (PTI00) temperature transducer and also plot the graph of characteristic property against temperature.
4	Photovoltaic cell /solar cell .	At the completion of this unit you will be able to understand the working of photovoltaic cell as power source under illumination and also plot the graph of I-V and P-V to determine the parameter of solar cell. i.
5	Study of bimetallic Relay	At the completion of this unit you will be able to understand the working of Bimetallic Relay as a temperature dependent control device.
6	Study of LVDT	a) Study of LVDT as displacement transducer. b) Observe displacement versus output voltage characteristics.
7	Study of Inductive Transducer	To compare inductance transducer with other displacement transducers.
8	To study about Photodiode & Phototransistor	At the completion of this unit you will be able to understand the working of photo diode & photo transistor and also plot the graph of their property against lamp power (intensity).

9	To study about Infrared LED	To observe biasing effect on infrared LED
10	To study hall effect sensor	On completion of this unit, you will be able to understand the Hall effect and its use for motor speed measurement.
11	Study of Inductive Sensor	To study and test motor speed measurement using inductance
12	Study of thermistor temperature transducer. .	To understand the working of the Thermistor temperature transducer and also plot the graph of characteristic property against temperature.
13	To study Thermocouple of J and K type	To understand the working of the Thermocouple temperature of this unit to understand the transducer and also plot the graph of characteristic property against temperature.

EXPERIMENT NO:- 01

AIM OF THE EXPERIMENT: To determine strain using full bridge and half bridge

OBJECTIVE: To study linearity characteristics of

4. Strain gauge Vs displacement
5. Determination of Gauge factor
6. Micro Strain Indicator
7.

THEORY: Strain gauge is a passive electrical transducer. It gives variation in electrical resistance between its two terminals as effect of strain on sensor (gauge) on application of external force.

A metal conductor if stretched or compressed, a change in its resistance occurs due to change in its diameter and length. A change in its resistivity can be observed if subjected to strain, this property is called as piezo resistive effect. Thus, resistive strain gauge is also known as piezo resistive gauge. Resistance of a conductor is directly proportional to its length and inversely proportional to its area of cross section. The resistance of gauge increases with positive strain.

Strain causes change in resistance and length of sensor.

Gauge factor (GF) can be found by

Ratio of GF = $\frac{\Delta R/R}{\Delta L/L}$ -------- ΔR is change in Resistance

ΔL is change in Length

Resistive strain gauges are normally connected in full bridge or half bridge form and a constant voltage or constant current source drives it. The difference voltage available from bridge circuit is required to be amplified to measure it easily.

PROCEUDRE:

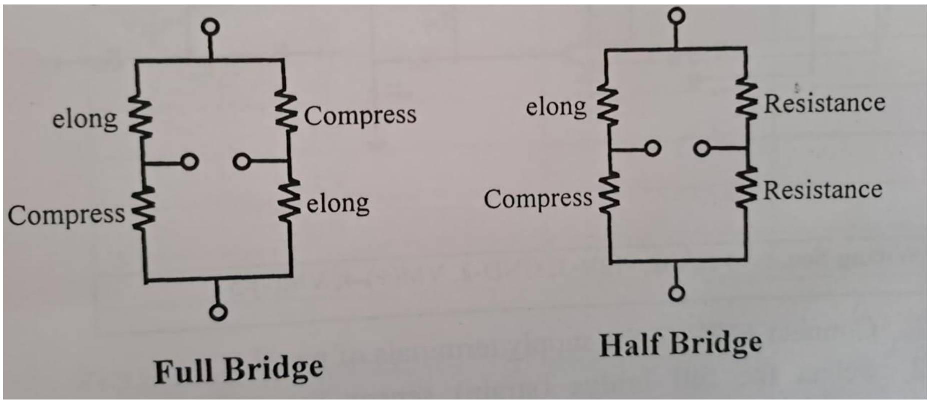
1. **Strain gauge as displacement sensor**

Panel provides strain gauge mounted on a spring steel strip. This strip is fixed at one end and another end is kept free to move. Movement or displacement of

free end strip is connected to a micrometer. Strain gauges are connected to the strip from both the surfaces, two from each side. Thus, on application of force,

strip bends and offers elongation on one side and compression from other side. Thus, gauges are connected in full bridge and half bridge as shown in fig.

Fig:- Full bridge & Half bridge



Full bridge and half bridge circuits are driven by a constant voltage source of around 1.3V. The difference signal output from bridge is amplified by an instrumentation amplifier with variable gain. Gain (Span) is required to be adjusted during experiment. A zero-adjustment potentiometer is provided in final amplifier and is to be adjusted from zero input condition.

Wiring seq:+12V-1, -12V-3, GND-2, VM(+)-4, VM(-) – 5

a) **For strain full bridge**

1. Connect $\pm 12V$ to the supply terminals of panel.
2. Select the full bridge (strain) sensor by setting rotary 6 position switch at correct location [1st] as shown.
3. Connect voltmeter (Digital preferred) at DC output terminals. Adjust micrometer to the marking of 25mm (zero strain) & adjust the output voltage to zero with the help of zero adjust pot. Now adjust

   micrometer to zero(0mm) marks (full strain) and adjust output voltage to 2.5V with the help of span adjust pot. This adjustment is necessary for range adjustment of strain gauge.

b) **For strain half bridge**

1. Select the sensor by setting rotary 6 position switch at correct location [2nd] as shown.
2. Now check the Span Zero adjustment. If not, then apply same procedure as stated above.

3. Now set the micrometer positions as in table no.1.2.1 and note down the corresponding output voltage.

Observation table

Displacement Micrometer reading mm	**Output DC volts**	
	Full	**Half**
0	2	2
5		
10		
15		
20		
25	0	0

EXPERIMENT NO:-02

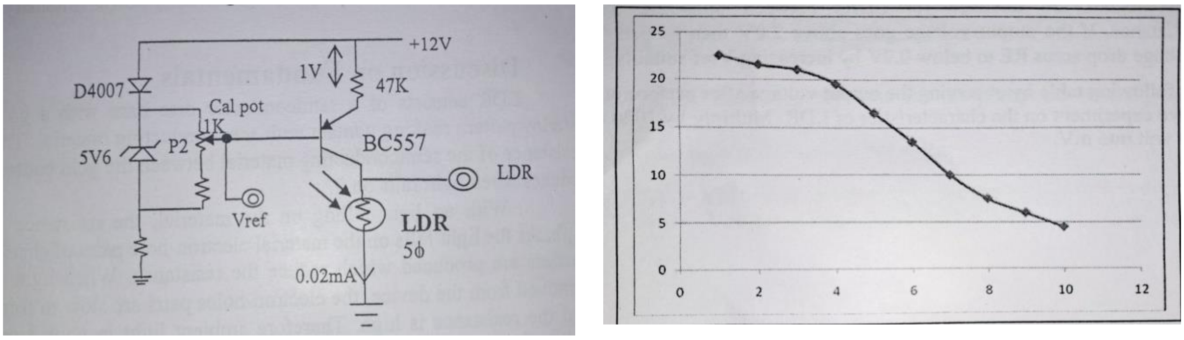
AIM OF THE EXPERIMENTS: - Study of LDR (Light dependent Resistor)

OBJECTIVES:-To determine the working of LDR (Light dependent Resistor) and also plot the graph of their property against lamp power(intensity).

THEORY: - LDR consists of a semiconductor disc base with a gold overlay pattern contact with semiconducting material. The resistance of the semiconducting material between the gold contact reduces when light falls on it.

With no light falling on the material, the resistance is high. As the lught falls on the material electron-hole pairs of charge carriers are produced which reudce the resistance. When light is removed from the device, the electron-holes paris are slow to form and the resistance is high. Therefore ambient light in your room will influence the observation taken e.g. If you are working under a tube light on then you will get different set of readings for a particular setting of ref. Pot. However what we are typically interested is in a general characteristics curve and not exact set of readings as enumerated in IG tables

Fig:- LDR



WIRING SEQUENCE: +12V-1,-12V-3, GND-2,4-5,6-7, VM(+)-9, VM(-)-12, VM(+)-10, VM(-)-12, VM(+)-TP36, VM(-)-35, VM(+)-TP37, VM(-)-35

You set the current every time for the particular sensor you are working with

Iconstant = $[V_{12} – V_{Ref} – 0.7V] \div R_E$

V_{12} = Voltage at power supply banana

V_{Ref} = Voltage at V_{Ref} tag & 0.7V = V_{BE}

The R_E values are chosen so that enough voltage is dropped across the LDR in question to be ale tomesure on 2V DMM or throgh CIA ADC (0-2V) range.

Procedure:-

1. Connect the test set up as above.
2. Switch on the power supply.
3. First calibrate the LDR by adjusting 1K pot(P2) such that voltage drop across corresponding(R_E) resistance should be 1V.
4. This could be done by connecting a DMM in 2V range between respective V_{Ref} and banana shocket 12(i.e. GND). V_{Ref} should be set to 10.3V(approx) to get necessary constant current.Do not forget to subtract V_{BE} drop as shwon in equation.
5. The calibration pot position should result in 0.02mA current for LDR. However adjust V_{Ref} everytime case power supply in a higher voltage(12.8V etc).Once calibrated measure voltage across output tag and GND tag by using DMM on 2V range. The current flowing through the LDR is set as above. Hence the resistance in Kohms can be calculated by dividing by 0.02(Resistance KΩ = voltage in (V) ÷ 0.02).
6. LDRs display lot of variation in its dark resistance. Typically from a few of K ohms to above 100K ohms.
7. Best results are obtained for LDRs between 50K-75k dark resistance. If the output voltage goes above 2.0V then reduce the voltage drop across R_E to below 0.9V by increasing V_{Ref} suitably.

VL(Volts)	IL(mA)	PL	O/P Voltage(V)	LDR resistance (KΩ)=op in V / 0.2
1				
2				
3				

Conclusion:

The characteristics curve of LDR Vs lamp power shows that as intensity of lamp increases resistance of LDR decreases. LDRs display lot variation in its dark resistance hence O/P voltage will also vary in that respect.

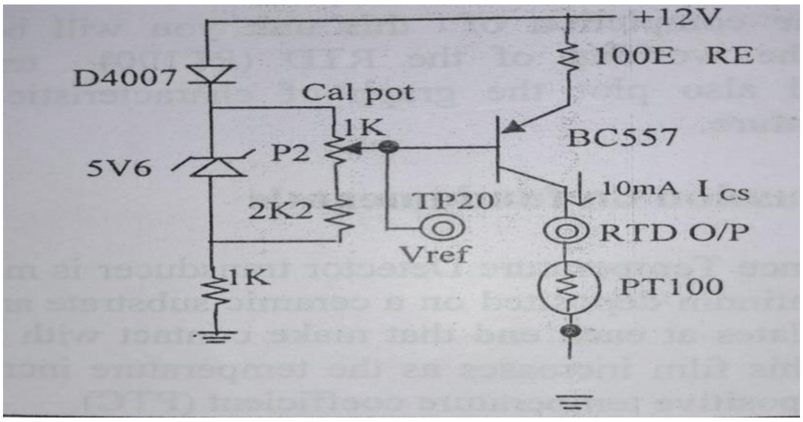
EXPERIMENT NO:-03

AIM OF THE EXPERIMENT: Study of RTD (PT-100)

OBJECTIVE: - To determine the working of the RTD (PTI00) temperature transducer and also plot the graph of characteristic property against temperature.

THEORY:- Resistance Temperature Detector transducer is made up of thin film of platinum deposited on a ceramic substrate and having gold contact plates at each end that make contact with film. The resistance of this film increases as the temperature increases i.e. the sensor has positive temperature coefficient(PTC).
The increase in resistance is linear with temperature and the relationship between the change in resistance with temperature rise is given as 0.385Ω/°C.

Rt=Ro+0.385T
Where, Rt=resistance at temperature T°C
Ro=resistance at 0℃(100Ω).



Wiring seq.: + 12V-1,-12Y-3,GND-2,VM(+)-5,VM(-)-

You set the current everytime for the particular sensor you are working with.
constant=[V12-VRef-0.7V]+RE--------------------------------(I)

Vl2 =Voltage at power supply banana VRef = Voltage at VRef tag
0.7V=VBE diode drop
The RE values are chosen so that enough voltage is dropped across the sensor in question to able to measure on 2V DMM or through CIA ADC (0-2Vrange).

Connect the test set up as above. Switch on the power supply.
First calibrate the RTD(PTI00) by adjusting IK pot(P2) such that voltage drop across corresponding (RE)resistance should be IV. This could be done by connecting a DMM in 2V range between respective Vref and +12V banana.

Using the equation, R(t)=100+tX0.39ohms/°C.----------------------------(2)
Calculate the theoretical resistance value for various temperature and note down in table. You therefore must set the pot P2 such that O/P reads mV as much as 1O times resistance value of RTD in Ohms at your room temperature using DMM(1100Ω=1100mV). You could also measure voltage at Vref w.r.t. gnd. Vref should be set to 10.3V(approx.) to get necessary constant current. Don't forget to subtract VBE drop as shown in equation(1).
The calibration pot position should result in 1OmA constant current for PTI00. However adjust Vref everytime you begin experiment in case, say, power supply is at higher voltage(I2.8Vetc.). Once calibrated measure voltage across 0/P tag & GND tag by using DMM on 2V range. The current flowing through the RTD is set as above. Hence the resistance in ohms can be calculated by dividing by 10(ResistanceΩ = voltage in mV+ 10).Here divided by 10 factor will remain same throughout the experiment as it is constant current (10mA) flowing through the RTD. Refer fig.no. 6.3.1. Hence while calculating resistance of RTD at that particular temp. use the formula,

Voltage(mV)
Resistance, R = -----------------
Current(mA

Following the same procedure calculate the resistance of RTD at different values of temperature set by selector switch switches for the oven. Plot the graph between the resistance and for both RTD and Thermistor. Fill the following table by observing resistance of RTD after performing the experiments on characteristics of RTD.

Switc position.	Temp (°C)	O/P in mV	Resistance of RTD(ohm)	
			Using equation(2)	Voltage mV/10
Posn 1	*55*			
Posn.2	*65*			
Posn.3	75			
Posn.4	85			
Posn.5	*95*			

Procedure:

1. Make the wiring connections as given in wiring schedule.
2. Before making "ON" 'the MIT-6 panel ensure that pot P5 (CAL for ON/OFF Controller) & P2(CAL for RTD or TH) are at CCW (minimum)position.
3. Put on the power supply to MIT – 6 panel.

Adjust Vref = 10.3V at tag no.20 using pot P2.

Observation table:-

Switch position	Temperature(C)	O/P in mV	Resistance of RTD(ohm)	
			Using equation(2)	Voltage mV/10
Position 1	55			
Position 2	65			
Position 3	75			
Position 4	85			
Position 5	95			

Conclusion:

As the temperature increases resistance of PT100 increases proportionally.

EXPERIMENT NO:-04

AIM OF THE EXPERIMENTS: Photovoltaic cell /solar cell

OBJECTIVES: At the completion of this unit you will be able to understand the working of photovoltaic cell as power source under illumination and also plot the graph of I-V and P-V to determine the parameter of solar cell.

THEORY:

A) i) When a voltage is applied to a photodiode in the dark state, the current V/S diode characteristics observed is similar the curve of a conventional rectifier diode. A photodiode is a type of photodetector capable of converting light into either current or voltage, depending upon the mode of operation.

ii) Using the below equivalent circuit, the output current I is given as follows

$I= I_L-I_D-Ish = I_L-I_S\ [\exp V_D/nKT-1]\ –Ish$-----------------------(1)

q= electron charge ($1.6x10^{-19}$)

K=Boltzmann's constant ($1.38x10^{-23}$ J/K)

T= absolute temperature of the photodiode in Kelvin

n= diode ideality factor (typically between 1&2)

However since Rs is several ohms quite small while Rsh is 10^7 to 10^{11} ohms, this term of Ish becomes negligible over quite a wide range and can be ignored.

Therefore,

$I=I_L-I_D=I_L-I_S\ [\exp V_D/nKT-1]$

1) When you short circuit across o/p of diode then, output voltage

$V=V_D=0$

$e^0=1$ then ID term disappears

$I= I_{sc}$ (short circuit current) $=I_L$ ------------------ (2)

Thus short circuit current Iscdoes not depend strongly on the temperature.

2) When O/P left open circuit i.e. no load then I=0= IL-ID & V_D= V for all practical purposes, then

$I_L=I_D=Is\ [eqVD/nKT-1]$

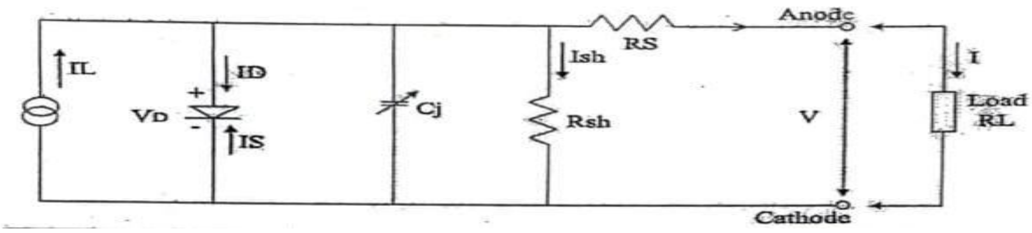
$eqV/nKT = [I_L/I_S+1]$

Taking log on both sides

$qV/Nkt= In\ [I_L/I_S +1]$

$Voc= [nKT/q]\ In\ [I_L/I_S -1]$ ------------------(3)

Since Is increases exponentially with respect to ambient temperature, Voc is inversely proportional to the ambient temperature and proportional to the log of IL. However, this relationship does not hold for very low light levels. Fig. 1.1 PN junction equivalent circuit.

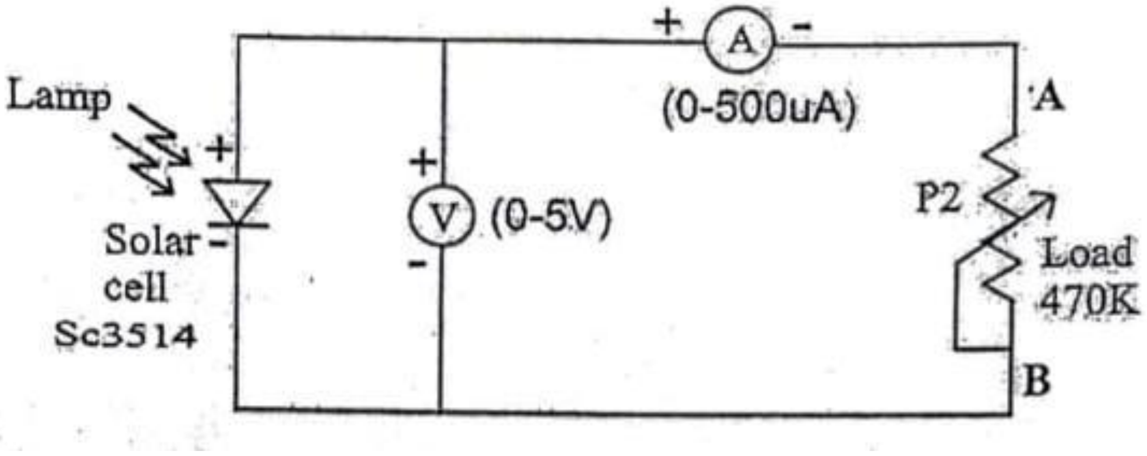


SN	Terms used	Definitions	Range
1	I_L	Current generated by the incident light (proportional to the amount of light)	
2	I_P	Diode current	
3	C_J	Junction capacitance	
4	Rsh	Shunt resistance	10_7 to 10_{11} ohms
5	R_S	Series resistance	Several ohms
6	Ish	Shunt resistance current	
7	I	Output current	
8	V	Output voltage	
9	V_D	Diode voltage which is same as V assuming Rs negligible V_{D}	
10	I_S	Reverse saturation current/dark current	

Procedure

Following fig. shows the circuit arragement for the photo-voltaic cell.

Fig. 5.4.1 Photo-voltaic cell/ Solar cell



Wiring Sequence: +121,-12V-3, GND→2, Short 4-5, 6-7,
Voltmeter (+)→8, Voltmeter (-) →12, Ammeter (+)→8,
Ammeter (-) →Loading pot terminal (A), Loading pot terminal
(B) →12 (Use external Loading pot of 470E, however optionally)

1. Turn on the Lamp. Keep the intensity of lamp in mid position.
2. Use lab DMM to measure voltage and current and connect it to respective position. Keep loading Pot to the min position (fully anticlockwise)
3. Keep loading Pot to the min position (fully anticlockwise)
4. Vary the pot slightly clockwise and note down voltage and current as R is varied & fill in the table and calculate power P=Vx I
5. Keep the lamp intensity full position, repeat the steps 2, 3, 4 again and fill the table as below.
6. Plot the I-V and P-V plots for both power levels and determine open circuit voltage (Voc), short

circuit current (Isc), maximum power (P_m) by graph.

7.From the graph we can measure the following parameters of solar cell.

Table 5.4.1 i-v characteristics of solar cell [model- sc3514) by varying load [470k]

Lamp intensity full			Lamp intensity half		
Voltage (mV)	Current (uA)	Power (mW)	Voltage (mV)	Current (uA)	Power (mW)

EXPERIMENTS NO:-05

AIM OF THE EXPERMINENT:- Study of bimetallic Relay

Objectives:- At the completion of this unit you will be able to understand the working of Bimetallic Relay as a temperature dependent control device.

THEORY:

Bimetallic Relay is an automatically resetting thermal switch having SPST contact.

1. NC (Normally closed)
2. NO (Normally Open)

The NC type of relay opens when temperature rise and NO type relay closes when the temperature falls to the rest level.

The panel is provided with NC type of relay. At about 30˚± 3˚C temperature. The contact between the two leads of the relay is opens. Various NC type of relays with higher temperature are also available. There are various with different temperature set points.

As the relay is auto resting type the contact will close when the surface will be the cool to room temperature.

PROCEDURE:

Use multi-meter on a diode range for measurement. Put the DMM probes in the sockets provided on the panel. The meter will show continuity between the two measuring ends.

Now increase the temp. of the relay by holding the 50W solder gun on the surface of the relay through the given slot. At about 30˚± 3˚C temperature. The contact between the two ends will open. Use lab thermometer to measure the temperature. Measure the resistance at that particular temperature.

Conclusion:

By increasing the temperature of the bimetallic relay the contact between the two leads becomes open. At the room temperature are normally closed.

Equipments required:

1. DMM
2. Solder iron- 25W
3. Lab thermometer
4. Panel No.- MIT6

EXPERIMENTS NO:-06

AIM OF EXPERIMENT- Study of LVDT

OBJECTIVES :

c) Study of LVDT as displacement transducer.
d) Observe displacement versus output voltage characterstics.

THEORY:

Linear variable differential transformer LVDT is a transducer. Basically it is passive inductive transformer similar to a potential transformer.

LVDT consists of three windings , one primary and two secondaries of equal turns. Primary is wound centrally between two secondaries. All three windings are wound on a hollow tubular former through which magnetic core slides. Normal position of core causes equal induced voltage in both the secondaries . Hence the total difference voltage of both the secondaries becomes zero.

When Es1= Es2 (core at null position or central position)

Ediff=0

When core is moved left

Es1>Es2 &

Ediff (Es1-Es2) is in phase with Es1

When core is moved right Es1<Es2

Ediff(Es1-Es2) is in phase with Es2.

Amount of Ediff is produced to the displacement of the core. Phase angle of the output voltage decides the direction of core from its normal null position.Electronic circuit can be used to recover appreciable difference signal from LVDT.

CIRCUIT DIAGRAMS :

Fig 2.2.1 Construction of LVDT

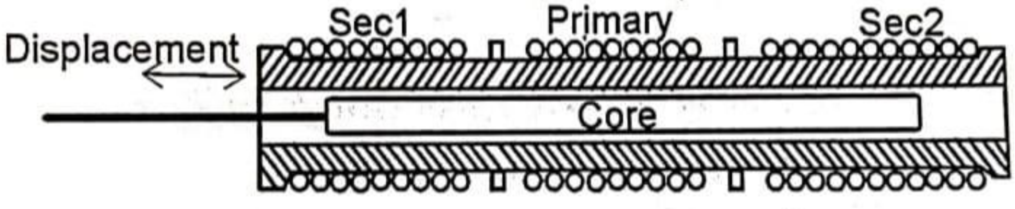


Fig. 2.2.2 Antiseries Secondaries

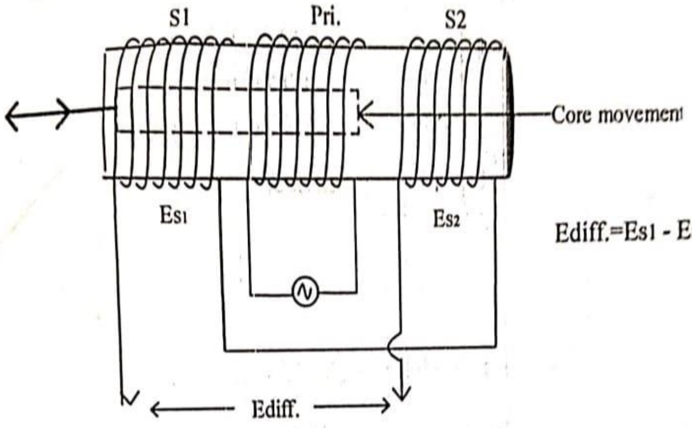
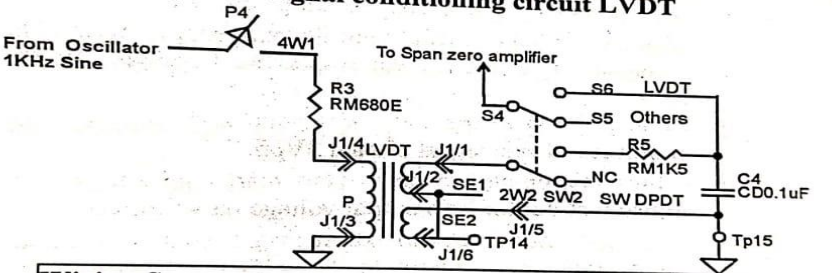


Fig. 2.2.3 Signal conditioning circuit LVDT



PROCEDURE:

WIRING SEQUENCE : +12V – 1, -12V-3, GND-2, VM(+)-6, VM(-)-7

LVDT primary winding is driven by sinusoidal signal of about 1 Khz at 2 Vpp. Basic oscillator is constructed around U1 in wein bridge configuration. The sine wave is further fed to the primary of LVDT.

1. Select the required sensor using rotary 6 position switch keeping at correct location (1st& DPDT switch SW2 on LVDT)
2. Identify all adjustment controls and supply terminals. Connect ± 12v DC to the respective terminals on the panel.
3. Connect CRO to the TP11 test point and observe the amplitude of sine signal around 2Vpp.
4. Adjust micrometer to near zero mark and adjust zero adjustment pot for zero output voltage on voltmeter.
5. Now move micrometer to extreme right position i.e. near 20mm and adjust output to 2V with the help of span adjustment potentiometer.
6. Move the micrometer towards left as given in table & and note down the output voltage on voltmeter .

CHARACTERSTICS AND CALCULATION:

OBSERVATION TABLE:

Micrometer reading Distance in mm	Output voltage [× 10 = displacement (mm)]

Plot a graph of distance versus output voltage.
Displacement in mm = O/P volt × 10

CONCLUSION :

Observations and graph drawn exhibits linear relation between displacement and output voltage

EQUIPMENTS REQUIRED:

1) Voltmeter – DMM OR Center zero± 5V
2) CRO.
3) Panel- MIT2

EXPERIMENTS NO :-07

AIM OF THE EXPERIMENT: Study of Inductive Transducer

OBJECTIVE: To compare inductance transducer with other displacement transducers.

THEORY:

This Panel provides inductive transducer and its measurement circuitry on board. Inductive transducer provided is based on variation in permeability which causes change in self inductance. Inductance coil is wound on a tubular former. A sliding core inside the coil former causes change in self inductance .

L total = Lair + Liron -------------- (1) .

- When micrometer is at zero (fully out core) then Ltotal = Lair = 1mH approx
- When micrometer is at 20min (fully in core) then Ltotal = Liron = 5mH approx

Note : These are approximated values, may vary from piece to piece. Also when fully out, core may still contribute a little to the Ltotal.

From Basics we have

$L \ a \ \alpha \ NT^2$ (2)

Where NT = total no. of turns and

NT = Na + Ni &

Na = NT - Ni ------------------(3)

As Ni α displacement (D) (of core), We may state

Ni / Nt = D / 20mm ------------------ (4)

Using (4) we can rewrite (1) in general form as

$LT = Lair \ (20\text{-}D/20)^{2+} \ Li \ (D/20)^{2\text{------------------}}$ (5)

Which can be evaluated for various values of D (displacement).

Deductions : Relationship between' Displacement and Inductance is parabolic (X^2) type. Inductance therefore could be used for very small displacements (piecewise linear), unlike LVDT as overall graph won't be linear. You can calculate Ltotal using equation (4) and approximate values Of Lair & Liron as in (1)

Theoretical Inductance value

DISPLACEMENT	INDUCTANCE mH
0 5 10 15	1 0.87 15 2.5 5

This can be tallied by measuring inductance values at tp14 & tp15 after selecting NC position at selector switch and power off only.

NOTE : Obviously above calculations are based on approximation of Lair - 1mH & Liron = 5mH which itself can vary by as much as 20%. Hence should be referred only for comparison and to understand non linear nature of this sensor.

CIRCUIT DIAGRAMS:

Fig. 2.3.1 Construction of inductive transducer

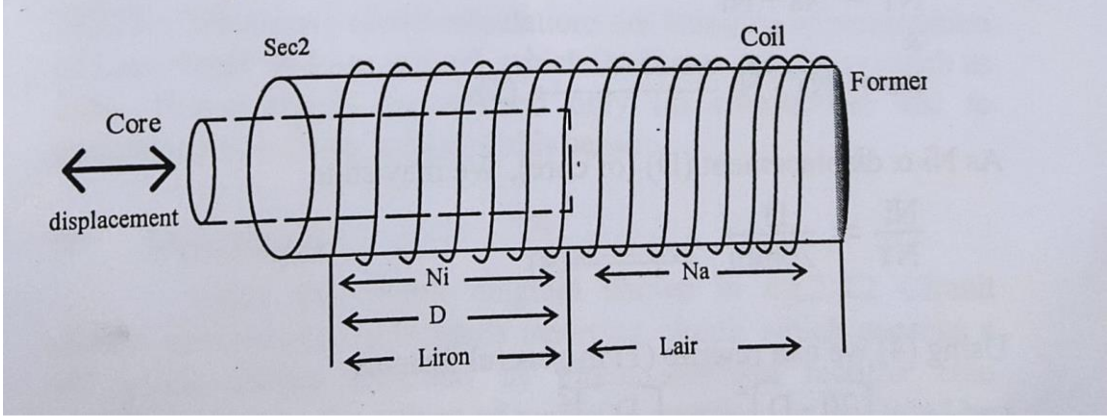
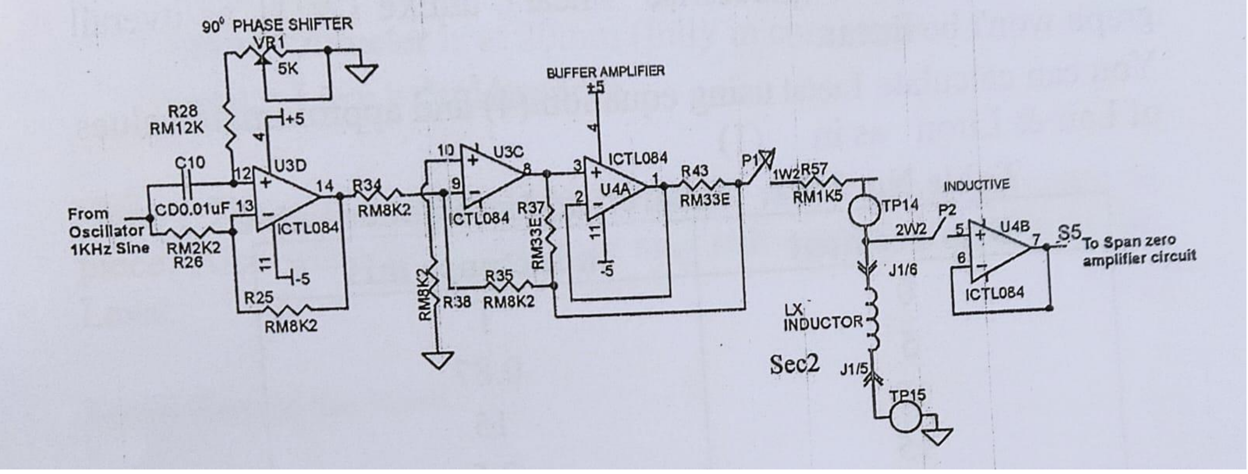


Fig. 2.3.2 Inductance Measurement



PROCEDURE:

Study the circuit. diagram shown .Circuit 1 shown is basically inductance metering circuit which consists a 90° phase shifter followed by phase sensitive rectifier cum amplifier. Finally the output of precision rectifier is ampiffled by final amplifier where zero adjustment and span adjustments are provided. Final DC output can be measured on voltmeter.

Wiring Sequence : +12V-1, -12V-3, GND-2, VM(+)-6, VM(-)-7

1. Connect ± 12V supply to the panel supply terminals.
2. Select the inductive sensor using rotary 6 position switch SW1 at its correct location (2nd) and DPDT switch SW2 on OTHER SENSORS.
3. Connect digital voltmeter at DC output terminals.

4. Adjust micrometer to '0' reading. Adjust output zero reading on voltmeter with the help of zero adjust pot.
5. Set micrometer to 20mm and adjust output voltage 2V with the help of span potentiometer.
6. When micrometer is at 20mm, then it is max. inductance position and hence frequency of output voltage is maximum.
7. Now set the micrometer position and note down corresponding, DC output voltage on voltmeter.

Micrometer reading (displacement) mm	**DC O/P voltage**

OBSERVATION TABLE :

Plot graph of displacement (micrometer reading) versus DC output voltage.

OP Volt (mV) = K [Displacement (mm)]^2 where K is an Empirical constant , which can be observed.

Typically K = 5

Therefore, Displacement (mm) = √OP volt(mv)/ K

CONCLUSION:

Observations of the experiment shoe that the output DC voltage is proportional to the square of displacement approximately.

EQUIPMENTS REQUIRED:

1) Power Supply: ±12 V
2) Voltmeter; DMM or DPM : 2V
3) Panel: MIT2

EXPERIMENTS NO:-08

AIM OF THE EXPERIMENT: To study about Photodiode & Phototransistor

OBJECTIVES: At the completion of this unit you will be able to understand the working of photo diode & photo transistor and also plot the graph of their property against lamp power (intensity).

THEORY: It is a NPN three-layer semiconductor device, the regions being emitter (e), base (b), and collector(c). The device differs from the normal transistor in allowing the light to fall on the base to collector region, focused there by a lens.

With no light falling on the device there will be a small leakage current flowing due to thermally generated hole-electron pairs.

When the light falls on the base collector junction region leakage current increases, with base connection open-circuited this current flows out via base-emitter junction and is amplified by normal transistor action to give a collector current. If the base to GND resistor is short then if acts on photo diode otherwise as phototransistor with variable sensitivity.

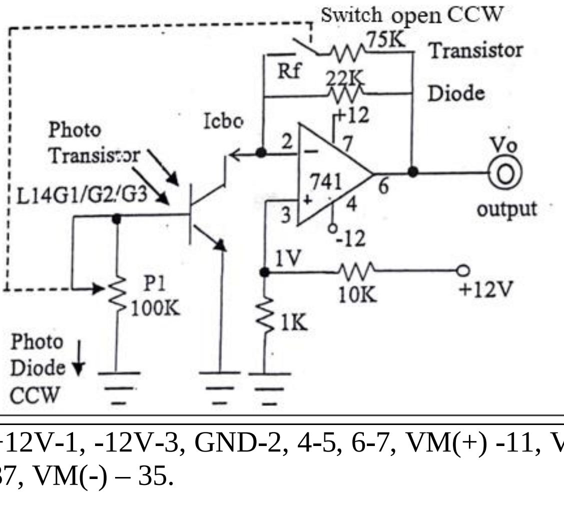
V_{out}=V- lcbo *R where V Supply voltage
Icbo Collector leakage current
R Collector load resistance

A base to emitter bypass pot resistance can determine the sensitivity or amplification(photo transistor). However if you short the base to emitter by turning pot, the device will act as photo diode with no amplification. Thus photodiode is phototransistor without transistor action.

Panel is provided with the photodiode &transistor mounted in front cf the light source provided on the panel. By varying the intensity of light following on photodiode & transistor its characteristics can be found out.

PROCEDURE: The circuit diagram for the phototransistor & diode is as shown below.

Fig. 5.2.1 Photodiode & Photo transistor I to V converter



Wiring sequence: +12V-1, -12V-3, GND-2, 4-5, 6-7, VM(+) -11, VM(-) – 12, VM(+) – TP36, VM(-) – 12, VM(+) – TP37, VM(-) – 35.

Connect the test setup as shown above. You would have observed in the circuit above that pin 2 = pin 3=1 V hence all the operation of circuit is taking place under constant VCE (IV) as a result variation in photo current due to VCE is nil. Then whatever variation in current you will observe will be solely due to light. This is also justification why 1V V_{CE} is maintained.

1. Initially keep the sensitivity pot (PI) at maximum position so that the device will act as photo-transistor.
2. Switch ON the power supply.
3. Take readings of output voltage increasing the lamp voltage by IV
4. The incident light falling on the C-B junction which is photo sensitive junction (reverse biased by IV), produces junction current which when passed through Rf produces output V_{op} = RfXIcbo
5. Now keep the sensitivity pot at medium position. Take the readings in the previous manner.

6. Turn the sensitivity pot to minimum position where switch opens so that I to V converter gain increases. It will act as photo-diode as the base is shorted to GND.
7. Take the readings adapting the same procedure.

.

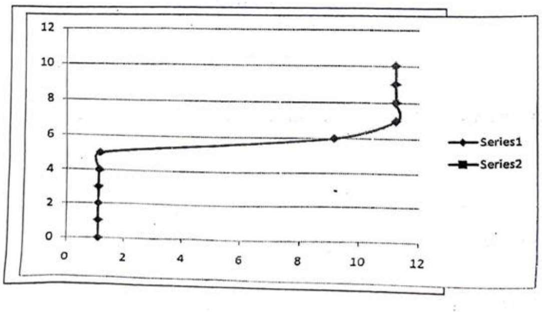
Observation Table

INPUT			**Sensor Output**	
			V_o(mV)	
V_L(Volts)	**I_L(mA)**	**P_L(w)**	**Photo diode**	**Photo Transistor**
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

Now plot the graph of output voltage against Lamp power on the same graph paper for all the three different photo-transistor sensitivity ranges.

Note: plot graph keeping VL on Y axis & Vo (for phototransistor) on X axis.

Note: Reading may vary from panelise due to components tolerance. however nature of graph will be same.



CONCLUSION: As the lamp intensity goes on increasing the voltage across photodiode & transistor increases. Photo diode generates very weak signal as compared to photo transistor, hen need amplification.

EXPERIMENT NO: 09

AIM OF THE EXPERIMENT: To study about Infrared LED

OBJECTIVES: To observe biasing effect on infrared LED.

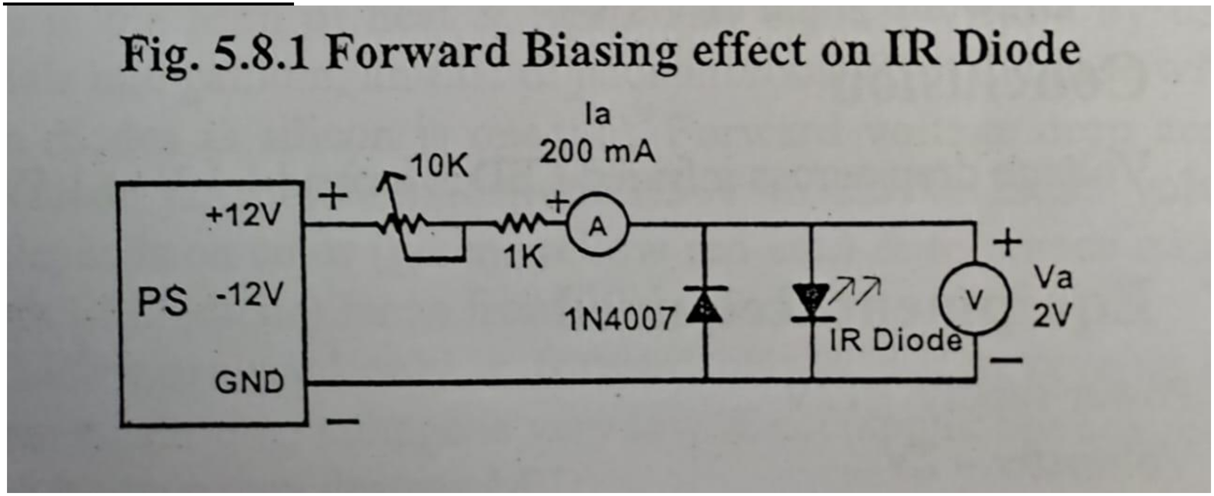
THEORY: The light emitted by LED is visible to the human eye. However light emitted by infrared LEDs is invisible to the human eye, but its properties are very similar to that emitted by visible LEDs. These are widely used in optical communication & detection systems.

PROCEDURE:

1) Identify infrared LED on panel & make connections as shown in fig. 5.8.1
2) Switch on the power supply.
3) Vary the anode current by adjusting input voltage using 10K pot as in table 5.8.1.
4) Monitor voltage drop Va across LED.

Fig. 5.8.1 Forward Biasing effect on IR Diode

CIRCUIT DIAGRAM:



WIRE SEQUENCE: +12V-1, -12V-3, GND-2, 4-5, 6-13, 14-AM(+), AM(-)-15, 16-19, 12-28, VM(+)-25, VM(-)-26

OBSERVATION TABLE:

SL NO.	Ia Ma	Va volts
	0	
	2	
	3	
	4	
	5	
	6	

Draw the graph Ia V/s Va

EXPERIMENTS NO:-10

Aim of the experiment- To study hall effect sensor

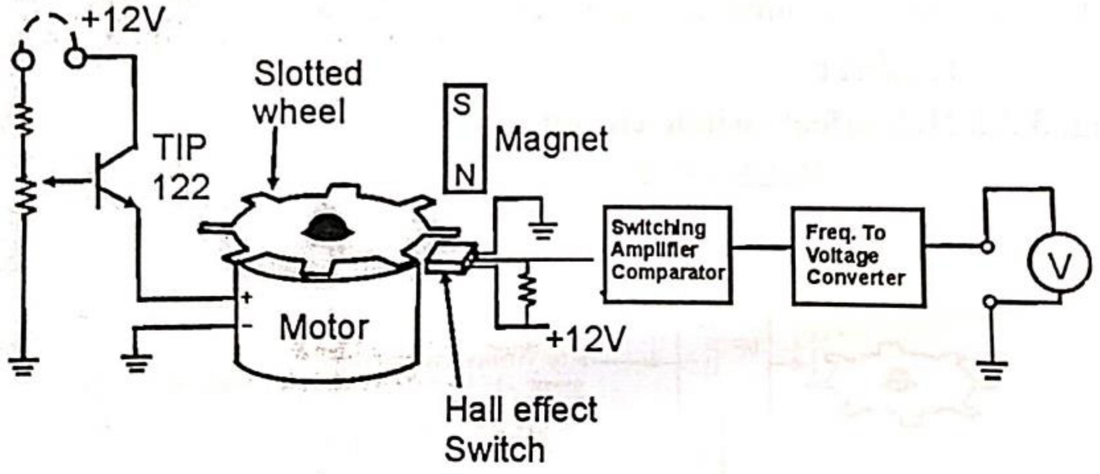
Unit Objective:- On completion of this unit, you will be able to understand the Hall effect and its use for motor speed measurement.

Discussion of fundamentals

Hall effect switch is a semiconductor switch and activates on presence of Magnetism around it and deactivates on removal of magnetic field. This property of hall effect switch is useful for motor speed measurement fig. below shows typical arrangement for motor speed measurement using Hall effect switch.

Figure of Hall effect switch for Speed measurement

Fig. 3.3.1 Hall effect switch for Speed measurement

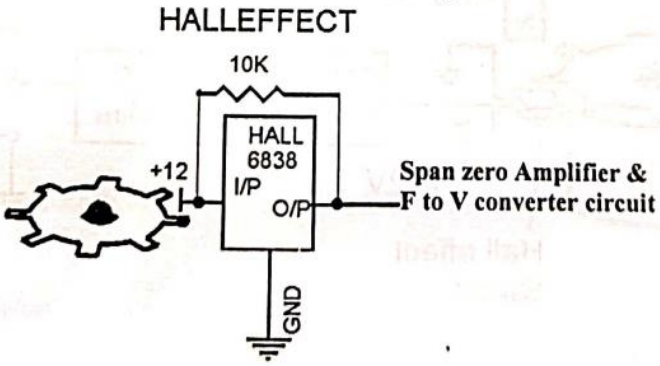


Panel is provided with a 12V motor. Speed of motor can be controlled by varying the potentiometer on panel. (connected to base of TIP122). a slotted wheel fitted on motor shaft rotate and hall effect switch is placed just below the teeth of wheel. A permanent magnet is mounted jus above the wheel height. Permanent Magnet produces permanent Magnetic field around Hall effect switch and open collector output of it switches to zero. On rotation of motor slotted wheel rotates. When tooth of wheel appears in between magnet and Hall switch Magnetic field weakens and Hall effect switch output changes its state (becomes high). Thus, hall effect gives one pulse per tooth of wheel. Hence you need to divide by 8 to arrive at shaft rotation frequency.

These pulses are amplified and converted into sharp pulses by comparator. Further theses pulses are converted into DC voltage by frequency to voltage converter. Output of F to V converter after amplification is made available is made available at output terminals for measurement. Complete circuit diagram is shown in figure.

Procedure:
Hall effect switch circuit

Fig. 3.3.2 Hall effect switch circuit



Wiring Sequence : +12V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

Wiring Sequence: +12V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

1. Connect ±12V from the power supply to the panel.
2. Select the hall effect sensor by setting rotary 6 position switch at correct location [2nd] as shown.
3. Vary the motor speed by speed control pot.
4. Keep it at zero speed (motor stand still). Measure the voltage across output.
5. Adjust if not zero volt, using zero adj. Pot.
6. Now, set motor voltage to 3V using motor speed control pot & adjust output voltage at tag no. 6 & 7 to 0.33V using zero pot.
7. Now set the motor speed to full and adjust output voltage to 2V using span adj. pot.

12V DC motor available in market may have different speeds for the same voltage applied. Hence obviously the frequency will change resulting in to change in output voltage. Hence at the time of calibration it is recommended that apply full voltage to motor and measure frequency on oscilloscope. So, output voltage to be set will be,

$$V = \frac{[\text{freq.} / 8] \times 60}{2000} \text{ Volts.}$$

8. Repeat the span zero adjustment procedure twice to ensure the 0-2V measurement range. Thus, display in Volts x 2000 will represent RPM.
9. Now measure the output voltage for each position of potentiometer (motor voltage).

Observe waveforms at Tp13 (f) as shown in the table.
Verify O/P volt = [(f/80 x 60] /2000

Observation table

[To maximum rpm of motor / 2]

Motor Volt	Freq. at Tp13 f (Hz)	RPM Using (f/8 x 60) formula	Output Voltage	Speed RPM = o/p voltage x (To maximum rpm of motor/2)
0 3 : : : 10.9	: : : : : :	: : : : : :	0 :0.33 : : : 2	

Conclusion:

Hall effect switch is found to be useful for speed measurement of motor with the help of magnetic, mechanical arrangement of set up. Hall effect switch responds each time of magnetic field interruption by teeth of wheel.

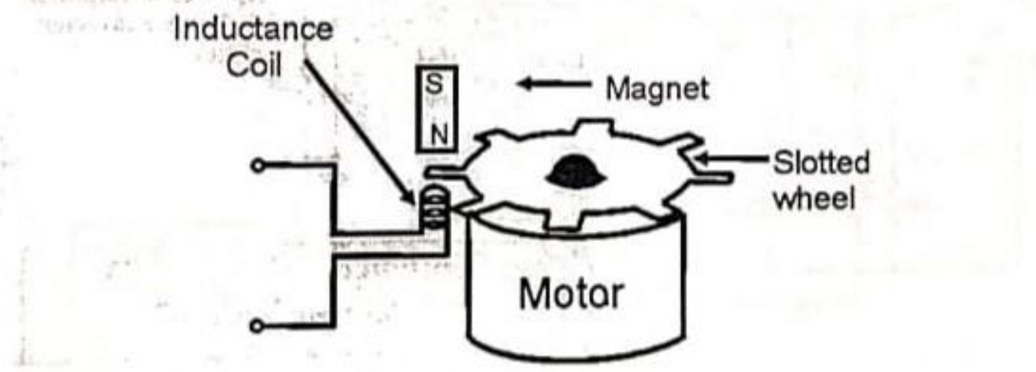
EXPERIMENTS NO:-11

AIM OF THE EXPERIMENTS: Study of Inductive Sensor

OBJECTIVE: To study and test motor speed measurement using inductance.

Discussion of fundamentals :
Value of inductance (effectively inductive reactance) if kept in Magnetic field changes when magnetic field is disturbed. This property is used for Motor speed measurement Fig. 1 Shows arrangement of Inductance kept in Magnetic field and motor for speed measurement.

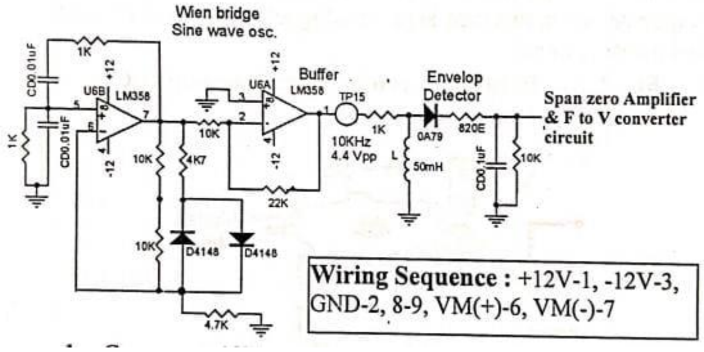
Fig. 3.4.1 Inductance coil for Speed measurement



Permanent Magnet establishes a magnetic field around Inductance coil. It offers certain reactance to a sine wave signal applied and drops some output voltage across it. When motor rotates, a slotted wheel connected to motor shaft also rotates and disturbs magnetic field by its each tooth. This causes change in value of inductive reactance. Hence voltage across coil changes

each time as magnetic field disturbed. This voltage change can be converted into pulses for speed measurement of motor. Thus you need to divide by 8 to arrive at motor shaft rotation frequency. Obviously at RPM 600 (motor voltage 3V) you can have weak rate of change as in magnetic pickup and hence difficulties in measurement.

Procedure :
Figure shows electronic circuit used to measure speed of motor using inductance as a sensor.



Wiring Sequence : +12V-1, -12V-3, GND-2, 8-9, VM(+)-6, VM(-)-7

1. Connect +12V power supply to the panel. Select the inductive sensor by setting rotary 6 position switch at correct location [3rd] as shown.
2. Vary the motor speed by speed control pot. Keep it at zero speed.
3. Measure the voltage across output.
4. Adjust if not zero volt using zero adjustment pot.
5. Now set motor voltage to 3v using motor speed control pot & adjust output voltage at tag no. 6 & 7 to 0.33v using zero pot.
6. Now set the motor to full speed and adjust output voltage to 2V using span adjustment pot. 12V DC motor available in market may have different speeds for the same voltage applied. Hence obviously the frequency will change resulting in to change in output voltage. Hence at the time of calibration it is recommended that apply full voltage to motor and measure frequency on oscilloscope. So output voltage to be set will be,
V=[freq/8]x60/2000 volts
7. Repeat the span zero adjustment procedure twice to ensure the 0-2V measurement range. Thus O/p voltage in mV represents speed in rpm directly.
8. Now measure the output voltage at various motor speeds

Observation table
[To maximum rpm of motor/2]

Motor volt	Freq.at Tp13 F{hz}	RPM using [f/8x60] formula	Output voltage	Speed RPM =O/P voltage X[maximum rpm of motor/2]
0			0	
3			0.33	
10.9			2	

Verify that O/P voltage = [(f/8) x 60]/2000

Conclusion:

Inductance placed in changing magnetic field can be used for the measurement of speed.

Equipments Required

EXPERIMENTS NO:- 12

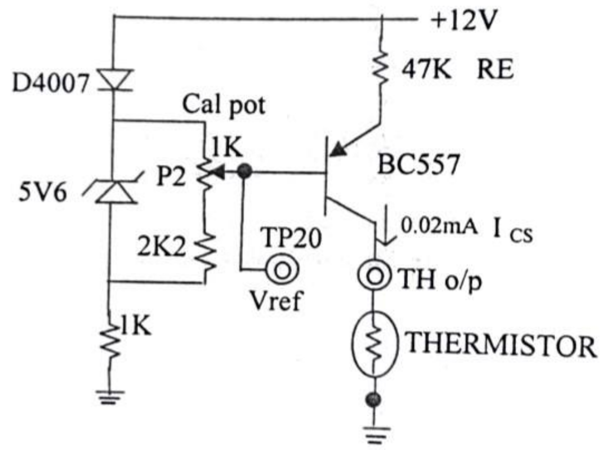
AIM OF THE EXPERIMENT:- Study of thermistor temperature transducer.

OBJECTIVE:-To understand the working of the Thermistor temperature transducer and also plot the graph of characteristic property against temperature.

THEORY:

The resistance of the thermistor changes with change in temperature. In the given panel the thermistor used is of NTC type that is its resistance decreases with increase the temperature. The thermistor is placed close to the oven, so as the temperature of oven rise the resistance of thermistor decreases. This will lead to a non-linear characteristics curve to be plotted between the resistance and temperature for the sensor.

CIRCUIT:



The circuit shows a constant current source made of single PNP transistor. Connect the test set up as shown below.

Wiring sequence: +12V-1, -12V-3, GND-2, VM (+)-5, VM (-)-6, VM(+)-15, VM(-)-17.

Connect the test set up as shown above. Switch on the power supply.

The value of the constant current has to be set by plot P2and observing voltage of Vref on DMM. You set the current every time for the particular sensor you are working with.

Iconstant = [V12-Vref-0.7] ÷Re

V12= voltage at power supply banana

Vref= voltage at Vref tag

0.7= Vbe diode drop

The Re value are chosen so that enough voltage is dropped across the sensor in question to able to measure on 2V DMM or through CIA ADC (0-2V range).

First calibrate the sensor by adjusting 1k pot (p2) such that voltage drop across corresponding Re resistance should be 1V. This could be done by connecting a DMM in 2V range between respective Vref and +12 banana. Being nonlinear device its resistance when plotted against temperature looks like graph of 1/x. Therefore, the aim of experiment is to understand 1/x graph of thermistor and not necessarily it actual resistance (K ohm). You therefore must set the plot P2 such that O/P reads mV as much as 20 times the resistance value in k ohm for your room temperature using DMM (50kohm=3000mv). You could also measure voltage at Vref. Vref should be set to 10.3 v.

The calibration pot position should result in 0.02 mA constant current for Thermistor. However, adjust Vref every time you begin experiment in case power supply is at higher voltage. Once

calibrated measure voltage across O/P tag & GND tag by using DMM on 2V range. The current flowing through the thermistor is set as above. Hence the resistance in Kohms can be calculated by dividing by 20. Here divided by 20factor will remain same throughout the experiment as it is constant current flowing through the thermistor. hence the calculatedresistance of thermistor in K ohm at that particular temperature us ethe formula,
Resistance, R (in K ohm) =Voltage(mV)/20
Following the same procedure calculate the resistance of thermistor at different values of temperature set by selector switch switches for the oven. Fill the fo9llowing table plot the graph between the resistance and the temperature for both the thermistor.

PROCEDURE:

1) Make the wiring connections as given in the wiring sequence.
2) Before making ON the MIT-6 panel ensure that pot P5 & P2 are at CCW (minimum) position.
3) Put on the power supply to MIT-6 panel.
4) Adjust Vref=10.3V at tag no 20 using pot P2.
5) Adjust pot P5 such that the oven just turns on indicated by red glowing.
6) Above setting is required to calibrate AD 590 & Thermister, RTD.
7) Now measure temp (in the form of voltage) at temp. read tag with DMM on 20 V range.
8) You will observe the voltage at temperature read tag is increasing & will reach up to the step point selected. (+-0.02 v is allowable range) that is for 55°C set point the temperature. Read tag may show 0.53V or 0.57 V. within this range of voltage the oven become off indicating set point temperature & actual oven temperature are nearly equal.
9) At this point measure voltages at O/P of different sensors that is RTD O/P, thermistor O/P, AD 590 O/P.
10) Take the above set of readings at different set points say 65°C, 75°C, 85°C, 95°C etc.

OBSERVATION TABLE

Switch posn.	Temperature(°c)	O/P in mV	Resistance of Thermistor(Kohms)=Voltage mV/20

NOTE: while shifting from one sensor to another without cooling off, may give wrong results because hot sensor will show different initial resistances.

CONCLUSION

As the temperature increases resistance of NTC decreases. The relation is 1/x type.

EQUIPMENTS REQUIRED:

1. DC power supply +- 12V
2. Voltmeter -2V
3. Panel No.- MIT6

EXPERIMENTS NO:-13

AIM OF THE EXPERIMENT:- To study Thermocouple of J and K type

OBJECTIVE:- To understand the working of the Thermocouple temperature of this unit to understand the transducer and also plot the graph of characteristic property against temperature.

THEORY:-

J-Type thermocouple:-It is made up of Iron and Constantine is used as a temperature detector. The ends of the two different materials are joined together to produce a junction. When a temperature gradient is applied across the junction a voltage will be develop. The two ends that are joined together produce ''hot' junction and the other free end is referred to as 'cold' junction. The output voltage obtained depends upon the applied temperature difference and the material used for the sensor.

K type Thermocouple:-Itis made up of Chromel and Alumel Constantine. The ends of these two materials are joined together to produce a junction. The two ends that are joined together produce 'hot' junction and the other free end is referred to as 'cold' junction. The output voltage obtained depends upon the applied temperature difference and the material used for the applied sensor.

Panel provides Thermocouples (both J & K types) fitted in a mini oven arrangement. The oven generates the required temp. when the selector switch is set for a particular temp.

In case you wish to use this panel using an external thermocouple, the same may be achieved by connecting external TC at tag 8 and 12 directly by passing on board TC.

To check whethér thermocouple junction is working or not, measure mV across their banana tags at various temp. without putting them in circuit. These readings will be less than those given in TC tables as tables are referred to cold junction at 0°C while here cold junction will be at room temp. & hence need to compensate.

Table 6.5.1 voltages across Thermocouples

Position	Temp.	J type	K type

Procedure:-

Circuit diagram for the thermocouple with instrumentation amplifier is as fig. Connect the test set up as shown below.

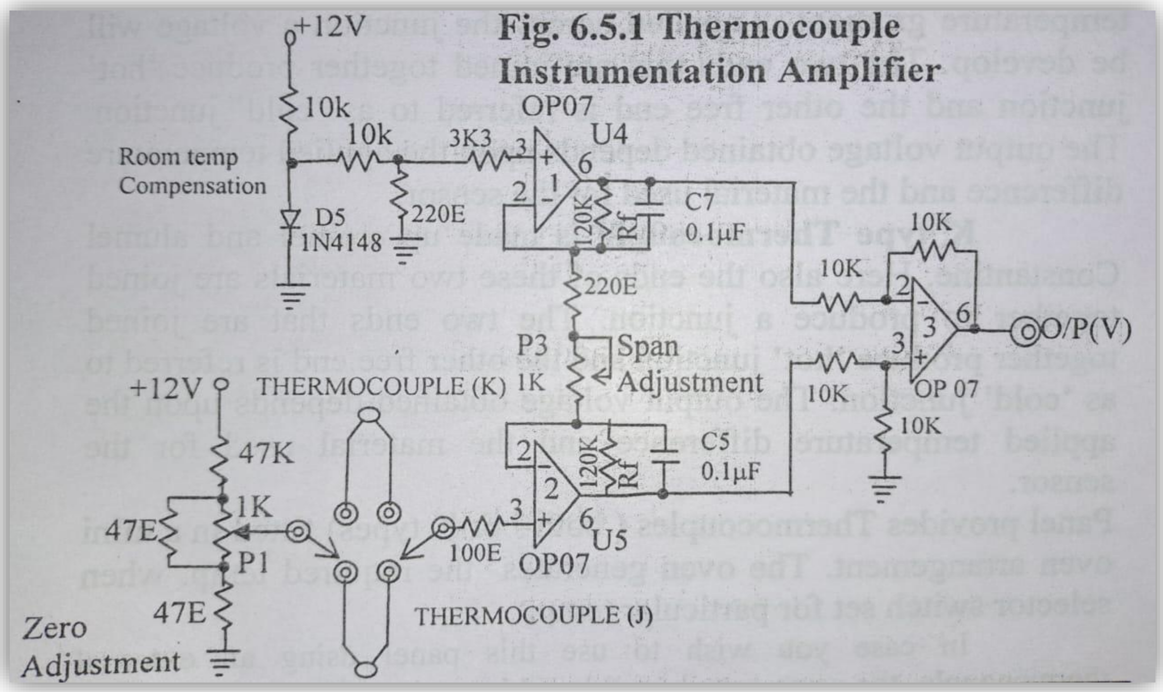


Fig. 6.5.1 Thermocouple Instrumentation Amplifier

Wiring seq:- +12V-1,-12V-3,GND-2,VM(+)-5,VM(-J-6,VM(+)-16,VM(-)-17 8-9,12-11 OR 8-10,12-13

Do the initial span zero adjustment following procedure as follows.

Span Zero Adjustment for thermocouple J type or K type

Select the J type thermocouple by shorting the respective patch cords. Keep P3 (span potentiometer) at minimum position. Using pot Pl(zero potentiometer) adjust o/p (tag no. 16) to voltage equal to room temperature in "C divided by 100 .Now select the 95 C temp. range (5" position). Allow the temp to stabilizes at that range. Set 0.95V as O/P at that temp.range using pot P3. Now again bring the temp. select switch at 1°" position i.e. 55°C, when temp. stabilizes at that range, set 0.55V at the O/P using P1.Then take readings at various temp. ranges. This is the initial span zero adjustment procedure. Repeat the same procedure for K type thermocouple also.

As temperature of the mini-oven goes on increasing the output voltage of the thermocouple goes on increasing, but only piecewise linearly. For different values of temperature, note down the output of the thermocouple. The gain of the amplifier is so set that output in volts (x100) is the same as temp. in "C. Don't forget that offset error in temperature control loop will cause here variation in output of TC. Fill down the following table by observing the output voltage of the thermocouple.

Temp= OP voltage X 100

Table 6.5.2 Observation table (J type)

Switch posn.	Temp.	O/P voltage of T/C

Repeat the same procedure for K type thermocouple. Select it by changing the patch cord connections. Remember that for measurement of K type thermocouple you will have to follow the span zero adjustment procedure again. Also let the oven to cool to room temperature before starting for K type thermocouple otherwise the results will be erroneous. Plot the graph between the temperature and the output voltage. Thermocouple may not show you big changes in reading in such a short span of 100°c.

Table 6.5.3 Observation table (K type)

Switch posn.	Temp.	O/P voltage of T/C

Conclusion:-

As the temperature increases o/p of the thermocouple increases, however only piecewise linear.