AARUPADAI VEEDU INSTITUTE OF TECHNOLOGY
(An Constituent College of Vinayaka Mission's Research Foundation)

VINAYAKA MISSION'S RESEARCH FOUNDATION
(Deemed to be University under section 3 of the UGC Act 1956)

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

MEASUREMENTS AND INSTRUMENTATION LAB

EEE & SAE

REGULATION-2017

PREPARED BY

Mr. N.P. GOPINATH, M.Tech, (Ph.D)

AP.GR-II / EEE

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GUIDELINES FOR LABORATORY NOTEBOOK

The laboratory notebook is a record of all work pertaining to the experiment. This record should be sufficiently complete so that you or anyone else of similar technical background can duplicate the experiment and data by simply following your laboratory notebook. Record everything directly into the notebook during the experiment. Do not use scratch paper for recording data. Do not trust your memory to fill in the details at a later time.

Organization in your notebook is important. Descriptive headings should be used to separate and identify the various parts of the experiment. Record data in chronological order. A neat, organized and complete record of an experiment is just as important as the experimental work.

1. Heading:

The experiment identification (number) should be at the top of each page.

2. Objective:

A brief but complete statement of what you intend to find out or verify in the experiment should be at the beginning of each experiment

3. Diagram:

A circuit diagram should be drawn and labeled so that the actual experiment circuitry could be easily duplicated at any time in the future. Be especially careful to record all circuit changes made during the experiment.

4. Equipment List:

List those items of equipment which have a direct effect on the accuracy of the data. It may be necessary later to locate specific items of equipment for rechecks if discrepancies develop in the results.

5. Procedure:

In general, lengthy explanations of procedures are unnecessary. Be brief. Short commentaries alongside the corresponding data may be used. Keep in mind the fact that the experiment must be reproducible from the information given in your notebook.

6. Data:

Think carefully about what data is required and prepare suitable data tables. Record instrument readings directly. Do not use calculated results in place of direct data; however, calculated results may be recorded in the same table with the direct data. Data tables should be clearly identified and each data column labeled and headed by the proper units of measure.

7. Calculations:

Not always necessary but equations and sample calculations are often given to illustrate the treatment of the experimental data in obtaining the results.

8. Graphs:

Graphs are used to present large amounts of data in a concise visual form. Data to be presented in graphical form should be plotted in the laboratory so that any questionable data points can be checked while the experiment is still set up. The grid lines in the notebook can be used for most graphs. If special graph paper is required, affix the graph permanently into the notebook. Give all graphs a short descriptive title. Label and scale the axes. Use units of measure. Label each curve if more than one on a graph sheet.

9. Results:

The results should be presented in a form which makes the interpretation easy. Large amounts of numerical results are generally presented in graphical form. Tables are generally used for small amounts of results. Theoretical and experimental results should be on the same graph or arrange in the same table in a way for easy correlation of these results.

10. Conclusion:

This is your interpretation of the results of the experiment as an engineer. Be brief and specific. Give reasons for important discrepancies.

LABORATORY SAFETY INFORMATION

Introduction

The danger of injury or death from electrical shock, fire, or explosion is present while conducting experiments in this laboratory. To work safely, it is important that you understand the prudent practices necessary to minimize the risks and what to do if there is an accident.

Electrical Shock

Avoid contact with conductors in energized electrical circuits. Electrocution has been reported at dc voltages as low as 42 volts. Just 100ma of current passing through the chest is usually fatal. Muscle contractions can prevent the person from moving away while being electrocuted. Do not touch someone who is being shocked while still in contact with the electrical conductor or you may also be electrocuted. Instead, press the Emergency Disconnect . This shuts off all power, except the lights.
Make sure your hands are dry. The resistance of dry, unbroken skin is relatively high and thus reduces the risk of shock. Skin that is broken, wet or damp with sweat has a low resistance.

When working with an energized circuit, work with only your right hand, keeping your left hand away from all conductive material. This reduces the likelihood of an accident that results in current passing through your heart.

Be cautious of rings, watches, and necklaces. Skin beneath a ring or watch is damp, lowering the skin resistance. Shoes covering the feet are much safer than sandals.

If the victim isn't breathing, find someone certified in CPR. Be quick! If the victim is unconscious or needs an ambulance, contact the Department Office for help.

Fire

Transistors and other components can become extremely hot and cause severe burns if touched. If resistors or other components on your proto-board catch fire, turn off the power supply and notify the instructor. If electronic instruments catch fire, disconnect the power supply immediately. These small electrical fires extinguish quickly after the power is shut off. Avoid using fire extinguishers on electronic instruments.

Explosion

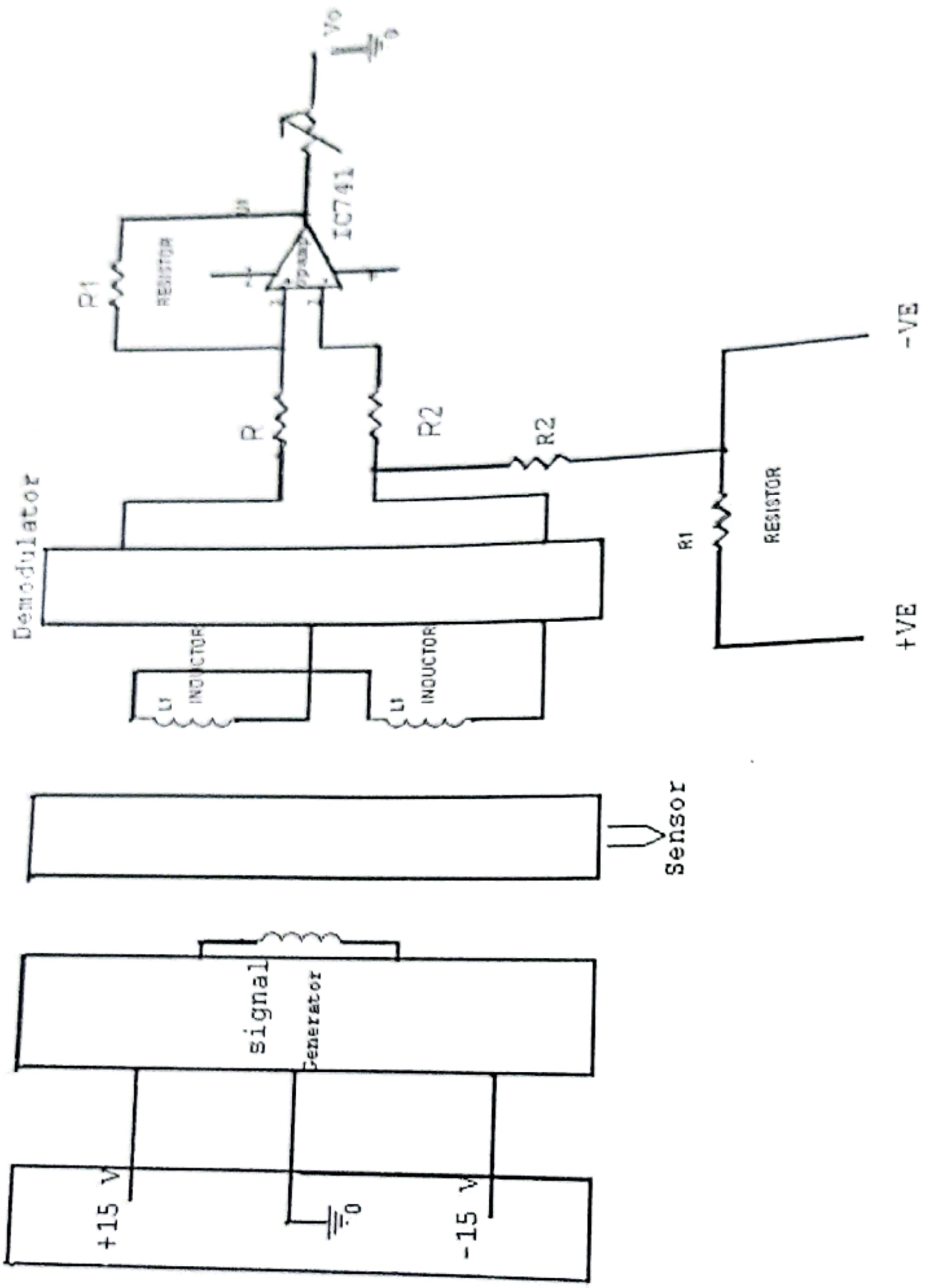
When using electrolytic capacitors, be careful to observe proper polarity and do not exceed the voltage rating. Electrolytic capacitors can explode and cause injury. A first aid kit is located on the wall near the door. Proceed to Student Health Services, if needed.

LIST OF EXPERIMENTS

SL.NO	NAME OF THE EXPERIMENT
1	STUDY OF DISPLACEMENT AND PRESSURE TRANSDUCER – LVDT
2	MEASUREMENT OF WATER LEVEL USING CAPACITIVE TRANSDUCER
3	MEASUREMENT OF STRAIN USING STRAIN GAUGE
4	MEASUREMENT OF TEMPERATURE USING THERMO COUPLE
5	AC BRIDGES
6	DC BRIDGES
7	INSTRUMENTATION AMPLIFIER
8	A/D AND D/A CONVERTERS
9	CALIBRATION OF CURRENT TRANSFORMER
10	CALIBRATION OF SINGLE PHASE ENERGY METER
11	CALIBRATION OF THREE PHASE ENERGY METER
12	MEASUREMENT OF 3 PHASE POWER AND POWER FACTOR

HOD/EEE
Dr. L. Chitra

CIRCUIT DIAGRAM FOR LVDT:



EXP NO: 1

STUDY OF DISPLACEMENT TRANSDUCER - LVDT

AIM

To study the operation of Linear Variable Differential Transformer

EQUIPMENT

S.No	Apparatus	Quantity
1	LVDT kit	1
2	Multimeter	1

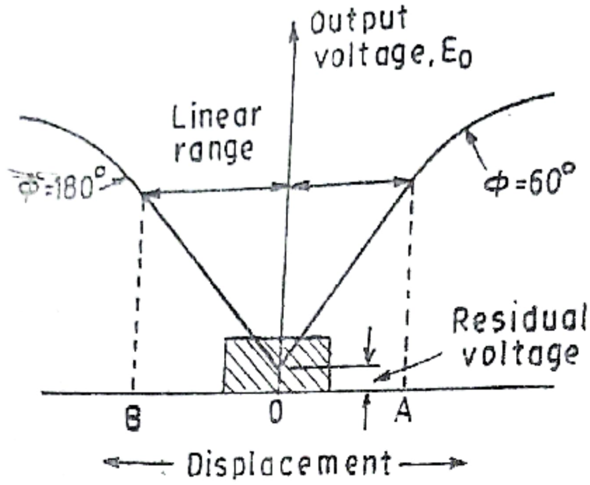
THEORY:

The most widely used inductive transducer to translate the linear motion into electrical signals is the linear variable differential transformer (LVDT).The transformer consists of a single primary winding 'P' and secondary winding 'S' wound on a cylindrical transformer. The primary winding is connected to an alternating current source. A movable soft iron core is placed inside the former. The displacement to be measured is applied to the arm attached to the soft iron core.

The output voltage of secondary S_1 is ES_1 and that of secondary S_2 is ES_2.To convert the output from S_1 and S_2 into a single voltage signal, the two secondary S_1 and S_2 are converted into series.

When the core is at normal (NULL) position the flux linking with both the secondary windings is equal and hence the equal emf is induced. Now the core is moved in the left of the NULL position, more flux links with winding S_1 and less with S_2.The output voltage of an LVDT is a linear function of core displacement within a limited range of motion.

MODEL GRAPH:



TABULATION:

S.NO	Core position	Voltage(in milli volt)	
		Bellow null	Above null

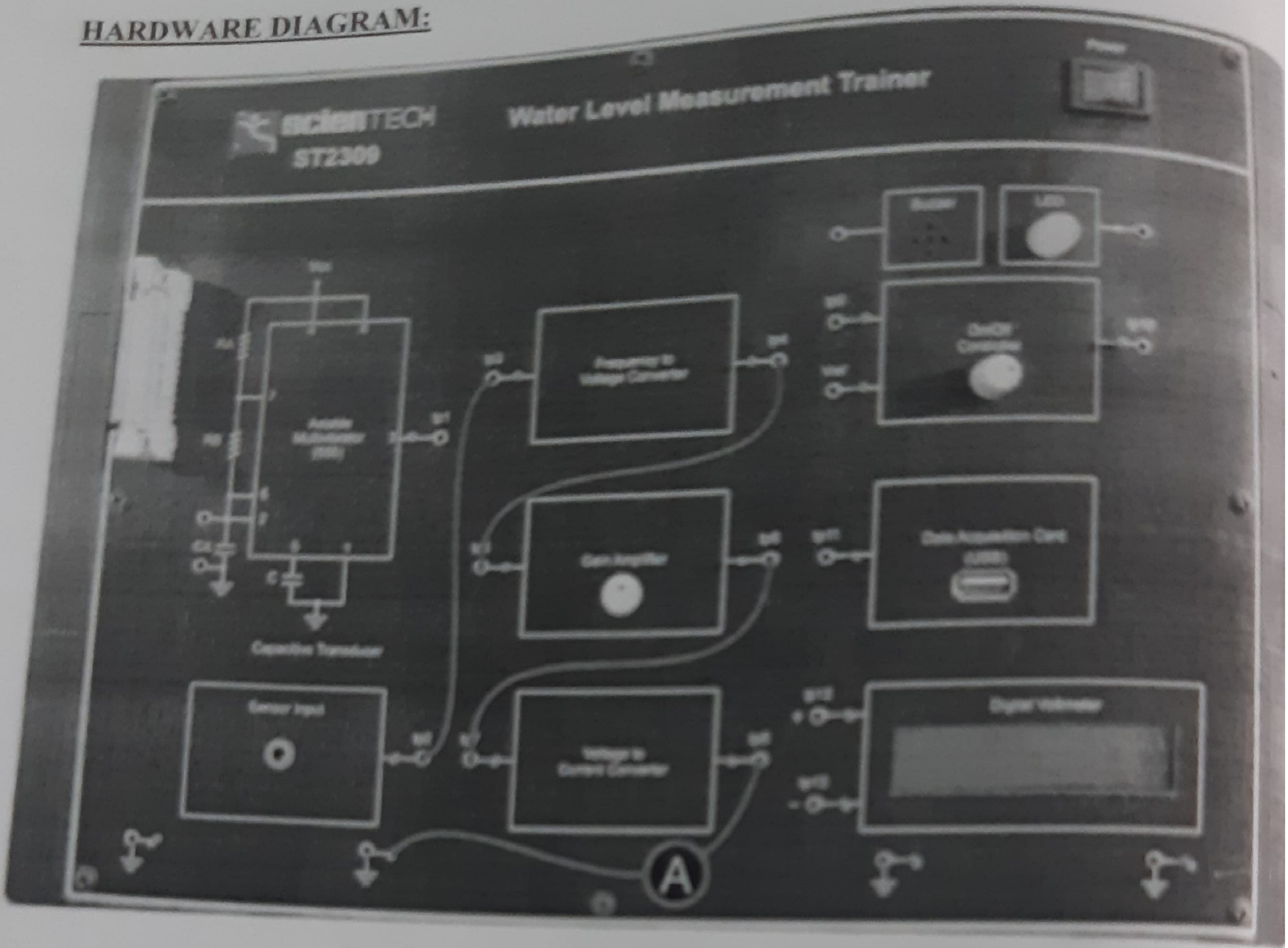
PROCEDURE:

1. Adjust the micrometer to read 200m. This position is called as end of transducer position.
2. Adjust the span adjustment pot to read 10mm.
3. Now adjust the micrometer. This position is called negative end of transducer position.
4. No need to adjust any further for this as the displacement automatically
   reads -10.
5. Repeat steps 3 and 4 repeatedly till we get the absolute value.

RESULT:

Thus the operation of LVDT was studied.

HARDWARE DIAGRAM:



OBSERVATION TABLE:

Sr. No.	Water Level (ml)	Voltage (Volts)
1.		
2.		
3.		
4.		
5.		
6.		

EXP NO: 2

MEASUREMENT OF WATER LEVEL USING CAPACITIVE TRANSDUCER

AIM:

Study of water level measurement using capacitive transducer

APPARATUS REQUIRED:

ST2309 with power supply cord, Water Level Sensor, Measuring Tank, Ammeter, 2mm Patch Cords (5Nos).

THEORY:

Capacitance pressure transducers were originally developed for use in low vacuum research. This capacitance change results from the movement of a diaphragm element. The diaphragm is usually metal or metal-coated quartz and is exposed to the process pressure on one side and to the reference pressure on the othere principle of "Strain Gauge" i.e when any pressure (force) is exerted on the strain gauge, there is corresponding change in its resistance. This change in resistance will produce an electrical output in the range of millivolts that is proportional to the applied pressure. Depending on the type of pressure, the capacitive transducer can either be an absolute, gauge.

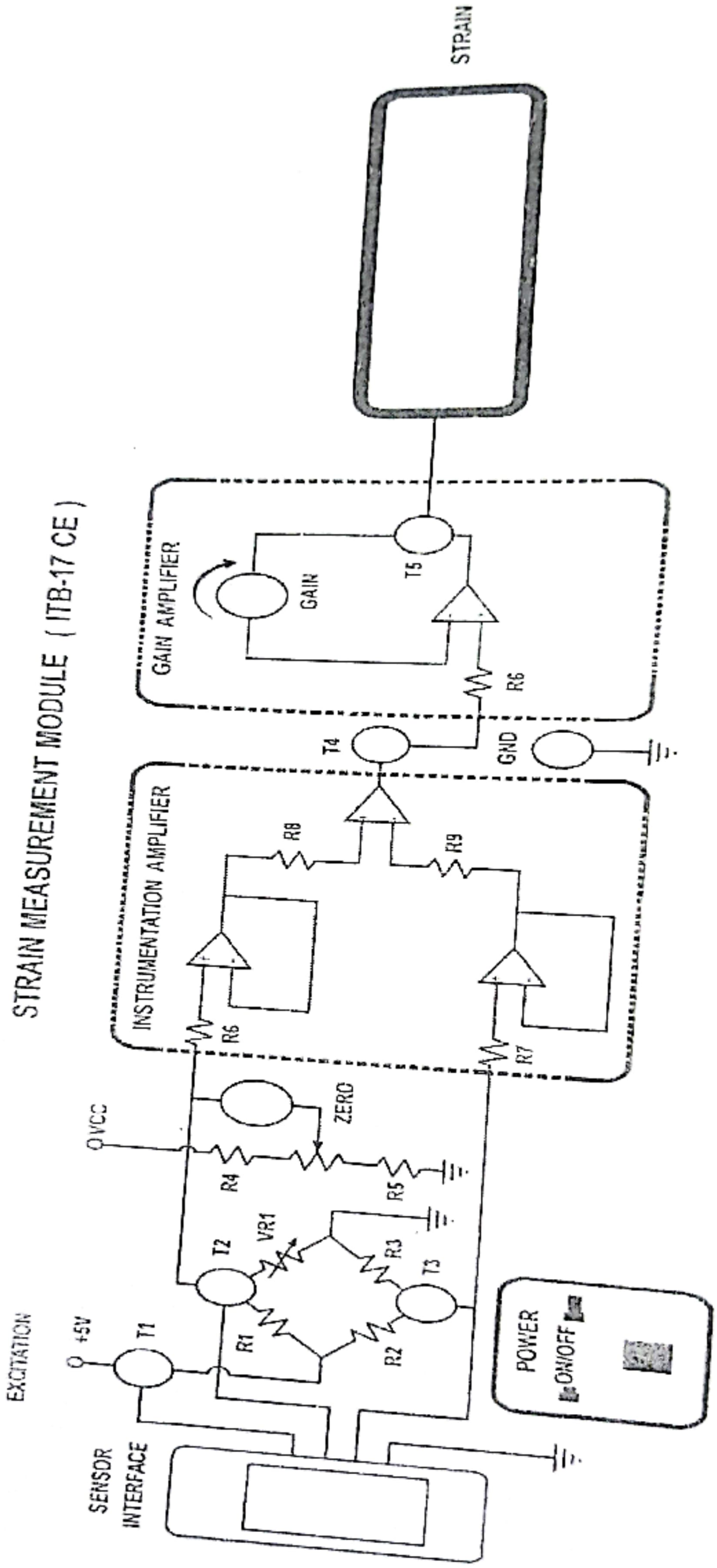
PROCEDURE:

1. Connect a Water Level sensor across the Sensor Input provided on the Trainer
2. Make the connection in the trainer as shown in the *figure.*
3. Connect the output of Voltage to Current Converter to the positive terminal of an Ammeter.
4. Ground the negative terminal of the Ammeter.
5. Switch 'On' the power supply.
6. Gradually add water to the Measuring Tank.
7. Note the change in Current after every 100ml rise in water level in the measuring tank.
8. Note the Current Readings and corresponding Water Level change in the observation table.
9. Shift the Gain amplifier to least, middle & maximum position & repeat the above Procedure to get different readings.
10. Sketch a graph between voltage & water Level.

RESULT:

Thus the water level measurement was done using capacitive transducer.

HARDWARE DIAGRAM:



EXP NO: 3

MEASUREMENT OF STRAIN USING STRAIN GAUGE

AIM:

To study the characteristics between strain applied to the cantilever beam strain sensor and the bridge voltage.

APPARATUS REQUIERD:

1. ITB – 17 – CE trainer kit
2. multimeter (in V)
3. cantilever beam strain sensor setup
4. weight (100g * 10 no's)
5. power chord

FORMULA USED:

Theoretical strain

$$= \frac{6PL}{Bt^2Y} = \frac{6 * 1 * 21.58}{2.8 * 0.25^2 * 2 * 10^6} = 370\mu\, strain$$

Where,

Applied load to the beam (p) = 1 Kg

Thickness of the beam (t) = 0.25 cm

Breath of the beam (B) = 2.8 cm

Length of the beam (L) = 21.58 cm

Young's modulus (Y) of the beam = 2*10^6 Kg /cm²

$$\%error = \frac{actual\ strain - theoritical\ strain}{theoritical\ strain} * 100$$

THEORY:

The change in the value of resistance by resistance by straining the guage may be partly explained by the normal dimensional behavior of elastic material.if a strip of elastic material is subjected to tension or in other words positively strained, its longitudinal dimension will increase while there will be a reduction in the lateral dimension. So when a guage is subjected to a positive strain, its length increases while its area of cross-section decreases.

Since the resistance of a conductor is proportional to its length and inversely proportional to its area of cross-section , the resistance of the gauge increases with positive strain. The change in the value resistance due to dimensional changes.the extra change in the value of resistance is

EXP NO: 3

MEASUREMENT OF STRAIN USING STRAIN GAUGE

AIM:

To study the characteristics between strain applied to the cantilever beam strain sensor and the bridge voltage.

APPARATUS REQUIERD:

1. ITB – 17 – CE trainer kit
2. multimeter (in V)
3. cantilever beam strain sensor setup
4. weight (100g * 10 no's)
5. power chord

FORMULA USED:

Theoretical strain

$$= \frac{6PL}{Bt^2Y} = \frac{6 * 1 * 21.58}{2.8 * 0.25^2 * 2 * 10^6} = 370\mu\, strain$$

Where,

Applied load to the beam (p) = 1 Kg

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Since the resistance of a conductor is proportional to its length and inversely proportional to its area of cross-section , the resistance of the gauge increases with positive strain. The change in the value resistance due to dimensional changes.the extra change in the value of resistance is

TABULATION:

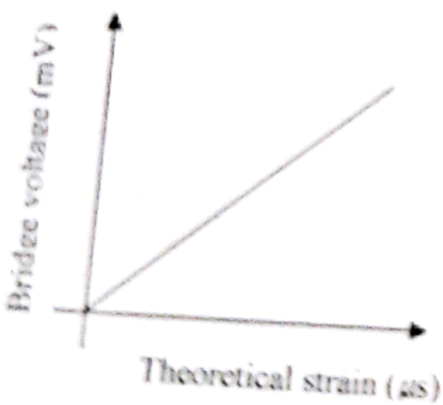
APLLIED STRAIN VERSUS BRIDGE VOLTAGE:

APPLIED LOAD(GRAM)	THEORETICALSTRAIN (μs)	BRIDGE VOLYAGE(mV)

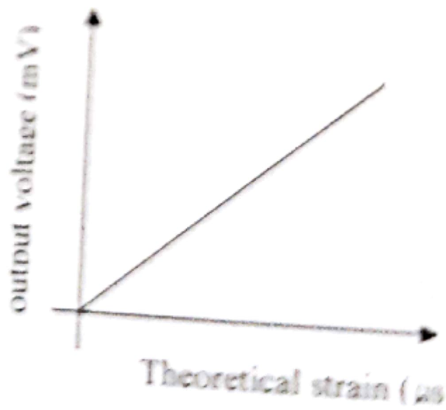
APPLIED STRAIN VERSUS THE SIGNAL CONDITIONED SENSOR OUTPUT VOLTAGE:

Theoretical strain(μs)	Signal conditioned sensor output voltage(V)	Actual strain (μs)	%error

MODEL GRAPH:



Theoretical strain versus bridge voltage



Theoretical strain versus signal conditioned sensor output voltage attributed to a change in the value of resistivity of a conductor when strained. This property is known as piezo-resistive effect. Let us consider a strain gauge made of circular wire as shown fig1. The wire has the dimensions L=length, A=area,D=diameter before being strained.the material of the wire has a resistivity ρ.Let a tensile stresss s be applied to the wire. This produces a positive strain causing the length to increase and area to decrease as shown.thus when the wire is strained there are changes in its dimensions. Let ΔL=change in length, ΔA=change in area, ΔD=change in diameter and ΔR=change in resistance.

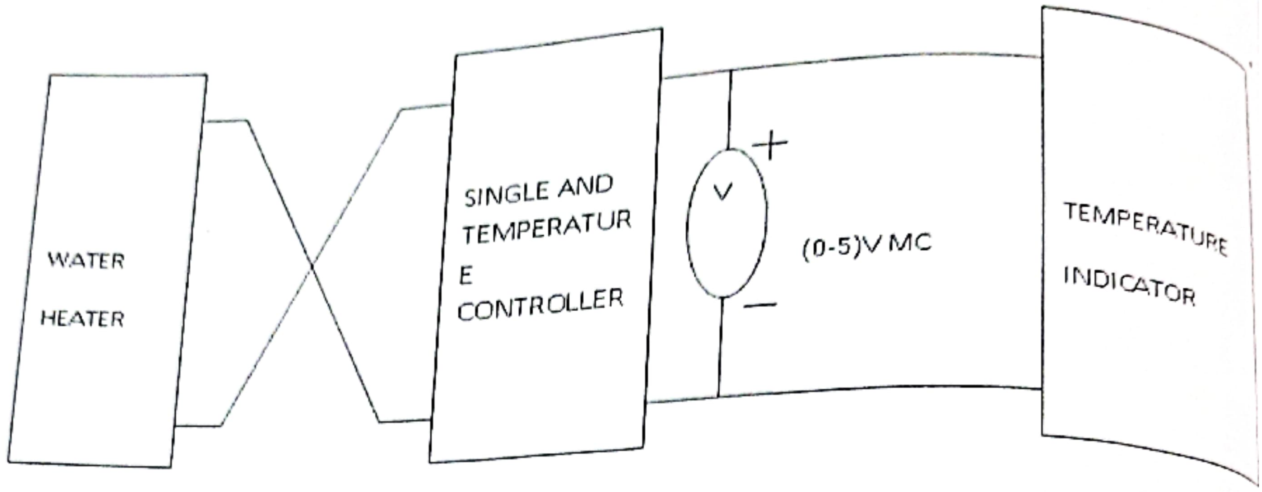
PROCEDURE:

1. Install the cantilever strain sensor setup and interface the 9 pin D connector with ITB- 17 – CE kit.
2. Connect the multimeter in mill volts mode across T2 and T3 for bridge voltmeter measurement.
3. Switch ON the module.
4. Initially, unload the beam and nullify the bridge voltage by using zero adjustment POT.
5. Now apply the load to the beam, strain will develop applied on the beam and measure the bridge voltage (mV) across T2 and T3.
6. Gradually increase the load on the beam and note down applied load and the bridge voltage (mV).
7. Tabulate the values of applied load, theoretical strain and the bridge voltage (mV).
8. Plot a graph between theoretical strain versus bridge voltmeter (mV).
9. Install the cantilever strain sensor setup and interface the 9 pin D connector with ITB- 17 – CE kit.
10. Connect the multimeter in mill volts mode across T2 and T3 for bridge voltmeter measurement.
11. Switch ON the module.
12. Initially, unload the beam and nullify the bridge voltage by using zero adjustment POT.
13. Now apply the load to the beam, strain will develop applied on the beam and measure the bridge voltage (mV) across T2 and T3.
14. Gradually increase the load on the beam and note down applied load and the bridge voltage (mV).
15. Tabulate the values of applied load, theoretical strain and the bridge voltage (mV).
16. Plot a graph between theoretical strain versus bridge voltmeter (mV).

RESULT:

Thus the characteristics between strain applied to the cantilever strain sensor and the bridge voltage was studied and graph was plotted.

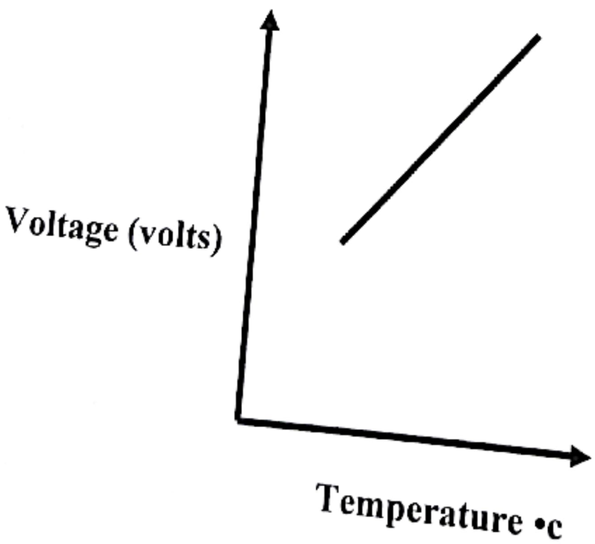
CIRCUIT DIAGRAM:



TABULATION:

S.No	TEMPEERATURE in C	VOLTAGE in Volt

MODEL GRAPH:



EXP NO: 4

MEASUREMENT OF TEMPERATURE USING THERMO COUPLE

AIM:

To find the temperature using Y-type thermo couple.

EQUIPMENT:

S.No	Apparatus	Range	Quantity
1	Y- type thermo couple	-	1
2	ON/OFF controller	-	1
3	Water heater	-	1
4	Multimeter	-	1
5	Voltmeter	(0-5)V	1

THEORY:

When two different metals having different work functions are placed together, a voltage is generated at a junction which is nearly proportional to temperature. This temperature junction is called a thermocouple. This principle is used to convert heat energy into electrical energy at the junction of two conductors.

The heat at the junction is produced by the electrical current flowing in the heater element while the thermocouple produces an emf at its output terminals which can be measured with the help of PMMC instrument .The emf produced is proportional to the temperature and hence to the rms value of the current. Therefore the scale of the PMMC instrument can be calibrated to read the current passing through the heater. The thermocouple type of instruments can be used for both DC and AC appliances.

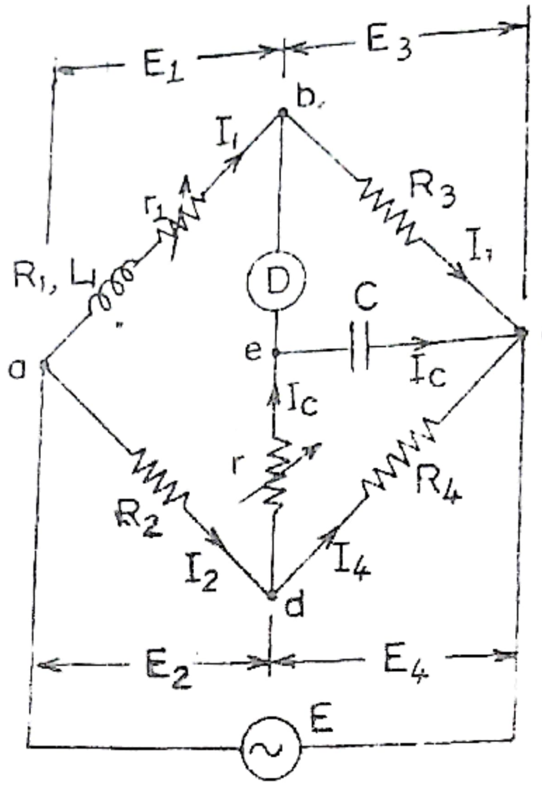
PROCEDURE:

1) Connections are made as per the circuit diagram
2) After controlling the temperature for various values of temperature increases the voltages equivalent values are noted.
3) The graph is plotted between the voltage and temperature.

RESULT:

Thus the temperature was found using Y type thermo couple.

CIRCUIT DIAGRAM FOR ANDERSONS BRIDGE:



TABULATION:

Sl. No	R(Ω)	r_1(Ω)	R_2(Ω)	R_3 (Ω)	R_4(Ω)	R_1(Ω)	$Q = \frac{\omega L_1}{R_1}$	L_1(mH)		%Error
								True	Measured	

EXP NO: 5

AC BRIDGES

1. MEASUREMENT OF SELF INDUCTANCE USING ANDERSON'S BRIDGE

AIM:

To find the unknown self inductance of the coil using Anderson's Bridge.

APPARATUS REQUIRED:

SL.No	Apparatus	Quantity
1.	Anderson's Trainer kit	1
2.	CRO	1
3.	Decade Inductance Box	1
4.	Connecting wires	As required

THEORY:

In the Anderson's bridge trainer, the value of the resistance R_2, R_3 & R_4 are 300 ohms each. For these values of resistance the range of inductance that can be measured is 150 mH to 350 mH. To measure any other value of inductance the resistance r & r_1 have to be correspondingly changed either by increasing or decreasing the resistance. The resistance in any of the arms of the bridge is increased by externally connecting some resistance in series or decreased by connecting in parallel for which the provision has been given in the trainer. The bridge consists of a built in power supply, 1 kHz oscillator & a detector.

Balance equations:

Let

L_1=self-inductance to be measured

R_1=resistance of self-inductor

r_1=resistance connected in series with self-inductor

R, R_2. R_3, R_4 = known non-inductive resistances

C=fixed standard capacitor

At balance $I_1=I_3$ and $I_2=I_c+I_4$

CALCULATIONS:

% Error = ((True value-Measured value)/True value)*100

$$I_1 R_3 = Ic \times \frac{1}{j\omega C} \quad \therefore \; Ic = I_1 j\omega C R_3$$

Writing the other balance equations

$$I_1(r_1 + R_1 + j\omega L_1) = I_2 R_2 + Ic.r \quad and \quad Ic\left(r + \frac{1}{j\omega C}\right) = (I_2 - Ic)\, R_4$$

Substituting the value of Ic in the above equations, we have

$$I_1\left(r_1 + R_1 + jL\omega_1\right) = I_2 R_2 + I_1 j\omega C R_3 .r \;\; or \;\; I_1\left(r_1 + R_1 + jL\omega_1 - j\omega C R_3\right) = I_2 R_2 \; ----- (1)$$

$$and \;\; j\omega C R_3\, I_1\left(r + \frac{1}{j\omega C}\right) = \left(I_2 - I_1 j\omega C R_3\right) R_4 \;\; or \;\; I_1\left(j\omega C R_3 r + j\omega R_3 R_4 + R_3\right) = I_2 R_2 \; ----- (2)$$

From equations (1) and (2), we obtain

$$I_1\left(r_1 + R_1 + j\omega L_1 - j\omega C R_3 r\right) = I_1\left(\frac{R_2 R_3}{R_4} + \frac{j\omega C R_2 R_3 r}{R_4} + j\omega C R_3 R_2\right)$$

Equating the real and imaginary parts

$$R_1 = \frac{R_2 R_3}{R_4} - r_1 \quad ----------------------- (3)$$

$$and \quad L_1 = C\frac{R_3}{R_4}\left[r\left(R_4 + R_2\right) + R_2 R_4\right] \; ----------- (4)$$

Procedure:

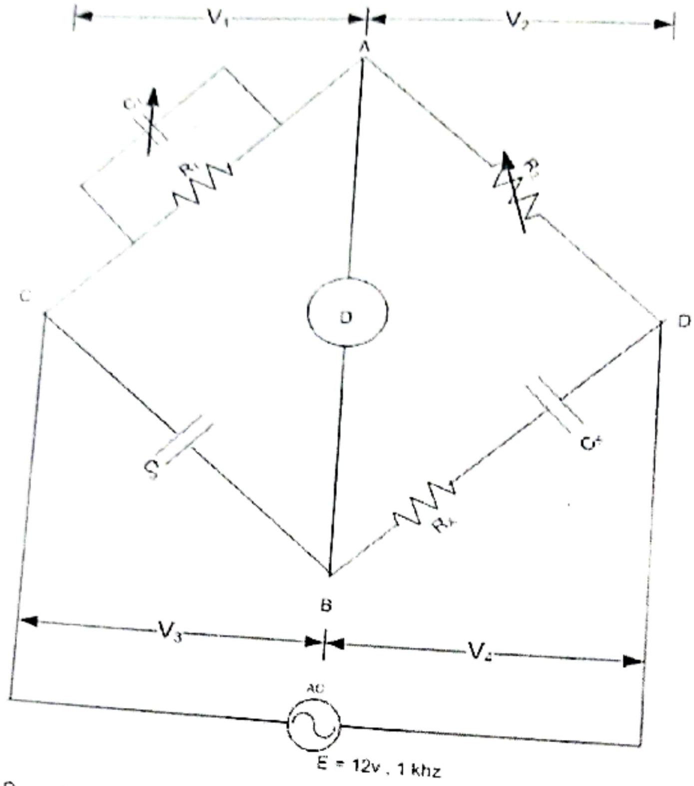
1. Switch on the trainer & connect the unknown inductance in the arm marked R_1.
2. Observe the sine wave at the secondary of the isolation transformer by using CRO.
3. Vary the resistance R from minimum position in a clockwise direction.
4. Connect the CRO between the ground & the output point and check for the balance condition.
5. For further fine balance vary the resistance r_1 which will compensate for the resistive component of the inductor.
6. Remove the wiring and measure the values of R and r_1 using DMM.
7. The above steps are repeated for different values of unknown inductance.

Result:

Thus the unknown inductance has been found using Andersons Bridge.

CIRCUIT DIAGRAM FOR SCHERINGS BRIDGE:

Capacitance measurement by Schering's Bridge



- D => Detector
- C_x => Capacitance to be determined
- R_x => Series resistance
- C_1 => Standard capacitance
- C_4 => Variable capacitance
- R_4 => Non-Inductive resistance
- R_2 => Variable Non-Inductive resistance

2. MEASUREMENT OF CAPACITANCE USING SCHERING BRIDGE

AIM:

To find the unknown capacitance value using Schering Bridge kit.

EQUIPMENT:

S.No	Apparatus	Range	Quantity
1	Schering Bridge kit	-	1
2	Multimeter	-	1
3	Unknown capacitance	-	1
4	Connecting wires	-	As required
5	CRO(cathode ray oscilloscope)	-	1
6	Function generator	-	1
7.	DCB(Decade capacitance box)	-	1
8.	Resistance	(470 Ω ,10 Ω)	Each 1 no.

THEORY:

It is an A.C. bridge used for measurement of unknown capacitance of a capacitor. Here one ratio arm has R1 parallel to G, the other ratio arm has variable resistor R2. In the third arm we have pure capacitor, has a very stable value and very small electric field for insulation measurement. This bridge is used to measure the quality of capacitor. The storage factor is defined as the ratio of power stored in element to the power dissipated.

TABULATION:

Resistance R_1 (kΩ)	Resistance R_2 (kΩ)	Given Capacitance C_x(μF)	Given Capacitance C_1 (μF)	Obtained Capacitance C_x (μF)	Quality Factor X 10^{-9}

PROCEDURE:

1. Connections as per the circuit diagram.
2. Set the value of given capacitance.
3. Set the fixed resistance R2.
4. Vary the resistance value or R1.
5. Switch off the kit removes the terminals from R1 & measure R1.
6. Calculate capacitance and quality factor.

Formula Used :

$C_x = (R1 / R2)\, C_2$

Quality Factor (Q) $= 2\pi f \left(\frac{C_1}{R_1} \right)$

RESULT:

The value of unknown capacitance was found experimentally by using the Schering bridge.

Unknown Capacitance, Cx =

CIRCUIT DIAGRAM FOR WHEATSTONE BRIDGE:

TABULATION:

Resistance R_1 (kΩ)	Resistance R_2 (kΩ)	Calculated resistance $R_x = (R_1/R_2)*R_3$

Formula Used:

Unknown resistance $R_x = (R_1/R_2)*R_3$

EXP.NO: 6

DC BRIDGES

1. MEASUREMENT OF RESISTANCE USING WHEATSTONE BRIDGE

AIM:

To find the given medium resistance value by suitable bridge connections and compare with the value measured by the multimeter.

EQUIPMENT:

S.No	Apparatus	Range	Quantity
1.	Wheat stone Bridge kit	10kΩ	1
2.	Unknown resistance	-	1
3.	Multimeter	-	1
4.	Connecting Wires.	-	As required
5.	RPS	(0 – 30)v	1

THEORY:

The bridge consists of four resistive arms together with a source of emf and null detector. The galvanometer is used as a null detector. The current through the galvanometer depends on the difference point C and D. The bridge is said to be balanced when the potential across the galvanometer is zero volts. So that there is no current through the galvanometer. Hence the bridge is balanced when the potential difference between C and D is equal.

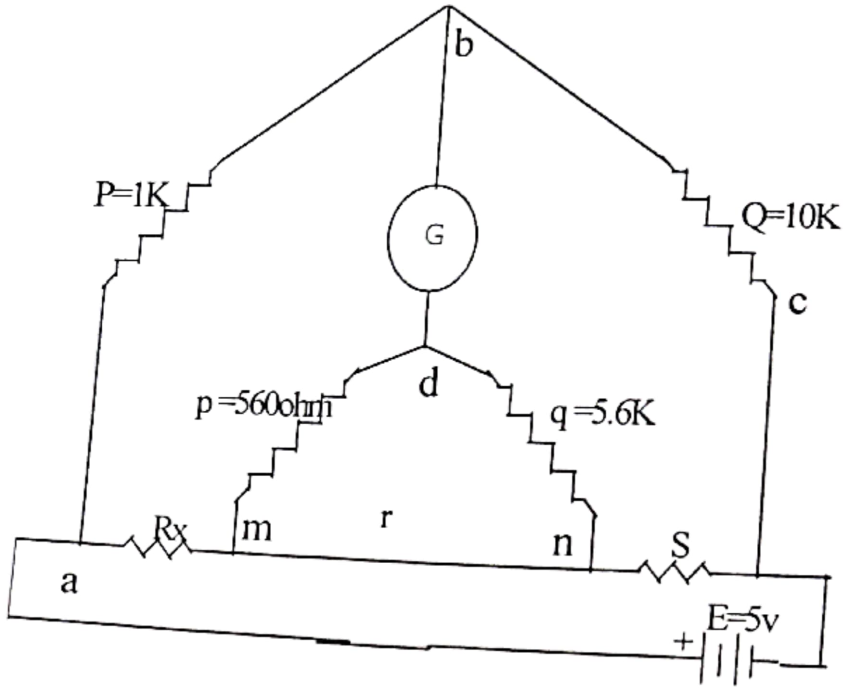
PROCEDURE:

1. Connections are given as per the circuit diagram.
2. The unknown resistance Rx is connected.
3. The variable resistance is varied to show the galvanometer zero to make the bridge under balanced condition.
4. After getting null indication, switch off the supply and find the variable resistance value using multimeter.
5. Repeat the same steps for various resistance values.

RESULT:

The value of unknown resistance using Wheat stone's bridge was, R_4 =

CIRCUIT DIAGRAM FOR KELVINS DOUBLE BRIDGE:



TABULATION:

S.No	P (Ω)	Q (Ω)	S (Ω)	Unknown Resistance Rx (Ω)		% Error
				True	Measured	

CALCULATIONS:

% Error = (True value – Measured value)/True value

2. MEASUREMENT OF RESISTANCE USING KELVIN'S DOUBLE BRIDGE

AIM:

To find the given low resistance values using Kelvin's double bridge kit.

EQUIPMENT:

S.No	Apparatus	Range	Quantity
1	Kelvin Double bridge kit	-	1
2	Unknown resistance	1kΩ,56kΩ,560Ω	1
3	Multimeter	-	1
4	Connecting wires.	-	As required
5.	RPS	(0 – 30)v	1
6.	Galvanometer	-	1

THEORY:

Kelvin's double bridge is a modification of Kelvin's bridge and provides more accuracy in measurement of low resistances It incorporates two sets of ratio arms and the use of four terminal resistors for the low resistance arms, as shown in fig .

Rx is the resistance under test and S is the resistor of the same higher current rating than one under test. Two resistances Rx and S are connected in series with a short link of as low value of resistance r as possible. P, Q, p, q are four known non inductive resistances, one pair of each (P and p, Q and q) are variable. A sensitive galvanometer G is connected across dividing points PQ and pq . The ratio P/Q is kept the same as p/q , these ratios have been varied until the galvanometer reads zero.

BALANCE EQUATION:

$$Eab = \frac{P}{P+Q} Eac \text{ and } Eac = I\left[R+S+\frac{(p+q)r}{p+q+r}\right] \text{-----------} (1)$$

$$\text{and } Eamd = I\left[R+\frac{p}{p+q}\left\{\frac{(p+q)r}{p+q+r}\right\}\right] = I\left[R+\frac{pr}{p+q+r}\right] \text{--------} (2)$$

For zero galvanometer deflection, Eab = Eamd

$$\text{or } \frac{P}{P+Q} I\left[R+S+\frac{(p+q)r}{p+q+r}\right] = I\left[R+\frac{pr}{p+q+r}\right]$$

$$\text{or } R = \frac{P}{Q}.S + \frac{qr}{p+q+r}\left[\frac{P}{Q}-\frac{p}{q}\right] \text{---------------------} (3)$$

Now, if $P/Q = p/q$ *Equation (3) becomes,* $R = \frac{P}{Q}.S$ ----------(4)

PROCEDURE:

1. Connections are given as per the circuit diagram.
2. Supply is switched on.
3. The bridge becomes unbalanced when unknown resistance R is connected.
4. The bridge is balanced by varying standard resistance.
5. Unknown resistance is calculated using balance equation.
6. The above steps are repeated for various values of unknown resistance.

FORMULA USED:

Rx = (P/Q) * S ohms

RESULT:

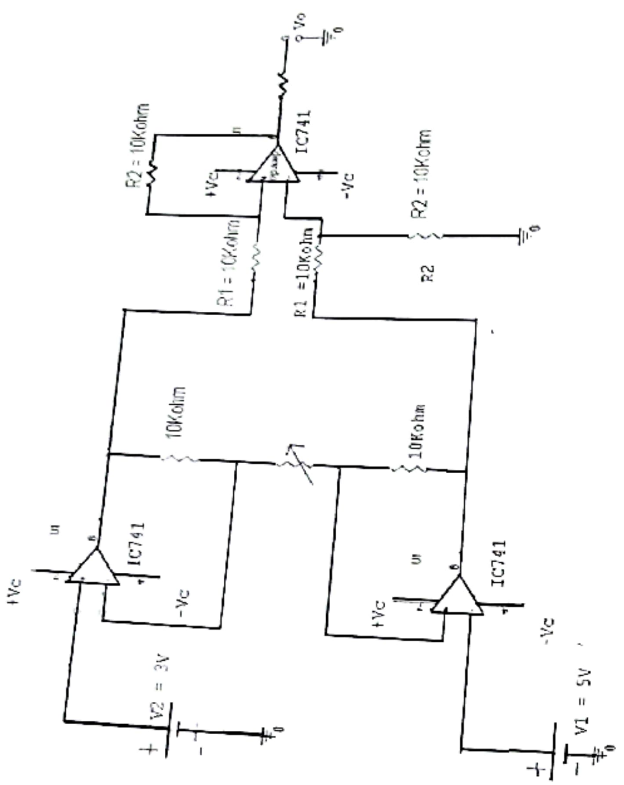
The value of unknown resistance was found experimentally.

Values measured (Rx) are,

1.

2.

CIRCUIT DIAGRAM FOR INSTRUMENTATION AMPLIFIER:



EXP NO: 7

INSTRUMENTATION AMPLIFIER.

AIM:

To construct an instrumentation amplifier using IC741 and to calculate the voltage gain.

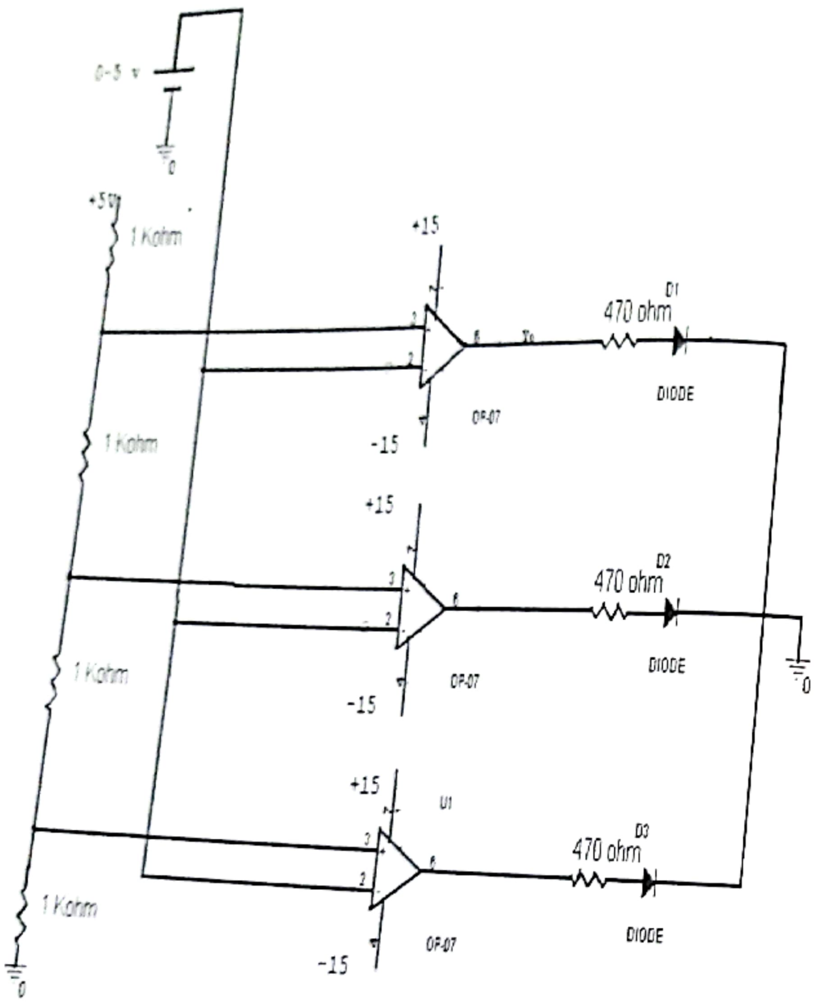
EQUIPMENT:

S.no	Apparatus	Range	Quantity
1	Operational Amplifier	IC741	3
2	Resistors	10Kohm	6
3	DRB	-	1
4	Bread board	-	1
5	Dual power supply	(15-0-15)v	1
6	Voltmeter	(0-10)V	1
7	Multimeter	-	1
8	Connecting wires.	-	As required

THEORY:

The instrumentation amplifier is a dedicated amplifier with extremely high input impedance. Its gain can be precisely set by a single internal or external resistor. The high common mode rejection makes this amplifier very useful in recovering small signals buried in large common mode offsets and noise.

Instrumentation amplifier consists of two stages .The first stage consists of very high input impedance to both input signals and allows to set the gain with a single resistor. The second stage is a differential amplifier with constant negative feedback output and ground connections are brought out.



NO: 8

EXP

A/D CONVERTER AND D/A CONVERTERS

1. ANALOG TO DIGITAL CONVERTER

AIM:

To convert the given analog input into its equivalent digital output.

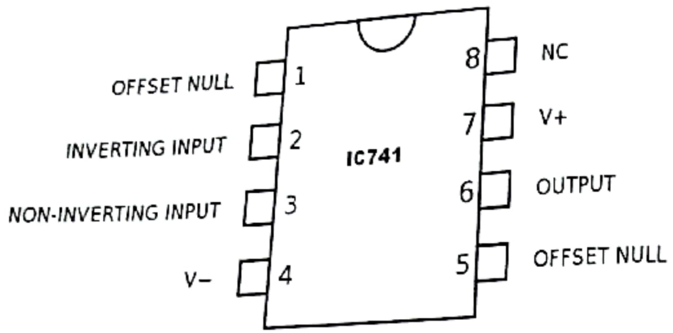
EQUIPMENT:

S.No	Apparatus	Range	Quantity
1	Op Amp	IC741	3
2	Dual power supply	(15-0-15)V	1
3	Resistors	1KΩ	4
4	LED	470Ω	3
5	RPS	(0-30)V	1
6	Bread board	-	1
7.	Connecting wires	-	As required

THEORY

Important factors in the design of an analog-to-digital converter are the speed of conversion and the number of digital bits used to represent the analog signal level. The minimum number of bits used in analog-to-digital converters is eight. The use of eight bits means that the analog signal can be represented to a resolution of 1 part in 256 if the input signal is carefully scaled to make full use of the converter range. However, it is more common to use either 10 bit or 12 bit analog-to-digital converters, which give resolutions respectively of 1 part in 1024 and 1 part in 4096. Several types of analogue-to-digital converter exist. These differ in the technique used to effect signal conversion, in operational speed, and in cost.

PIN DIAGRAM :IC741



TABULAR COLOUM:

S.No	Analog I/P	X_2	X_1	X_0

PROCEDURE:

1. The connections are made as shown in diagram
2. The voltage is increased in steps. The analog input is also given
3. The truth table is verified

RESULT:

Thus the analog to digital convertor was implemented and the truth table was verified.

CIRCUIT DIAGRAM FOR D/A CONVERTER:

TABULATION:

S.NO.	D3	D2	D1	D0	Output Voltage

2. DIGITAL TO ANALOG CONVERTER

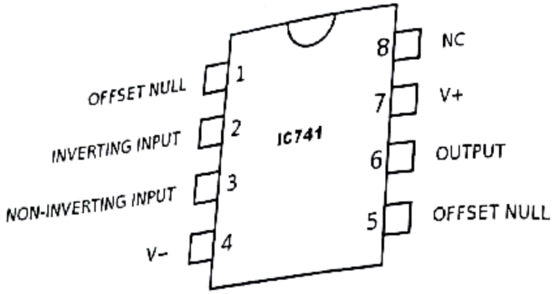
AIM:

To convert the given digital input into its equivalent analog output.

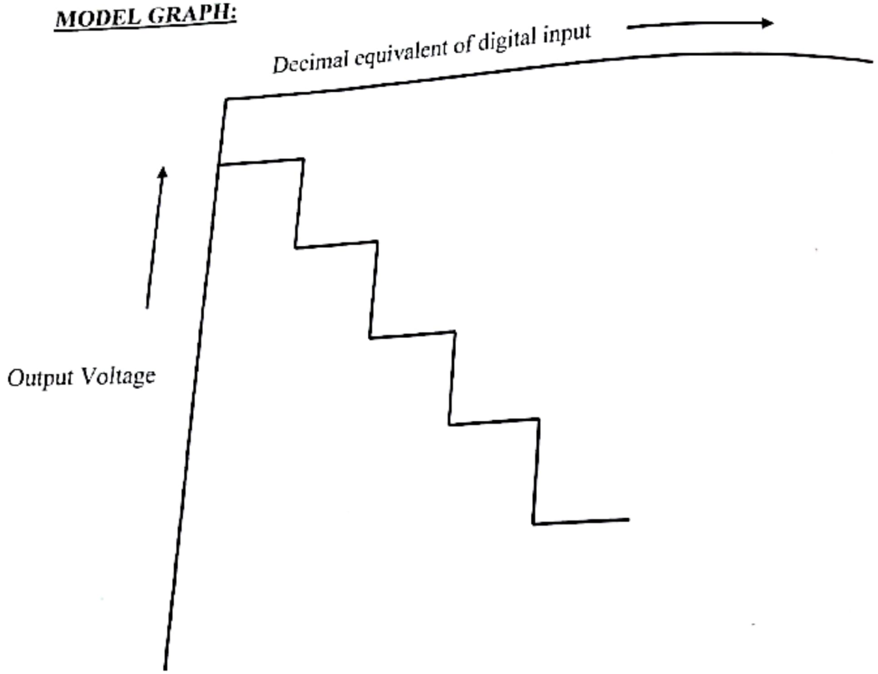
EQUIPMENT:

S.No	Apparatus	Range	Quantity
1	Op amplifier	IC741	1
2	Dual power supply	(15-0-15)V	1
3	Resistor	2.2KΩ	5
4	Resistor	1 KΩ	5
5	Voltmeter	(0-30)V	1
6	Connecting wires	-	As required
7	RPS	(0-30)V	1

PIN DIAGRAM:



MODEL GRAPH:



THEORY :

Digital-to-analog conversion is much simpler to achieve than analog-to-digital conversion and the cost of building the necessary hardware circuit is considerably less. It is required wherever a digitally processed signal has to be presented to an analogue control actuator or an analogue signal display device. A common form of digital-to-analogue converter is illustrated here. This is shown with 8 bits for simplicity of explanation, although in practice 10 and 12 bit D/A converters are used more frequently. This form of D/A converter consists of a resistor-ladder network on the input to an operational amplifier.

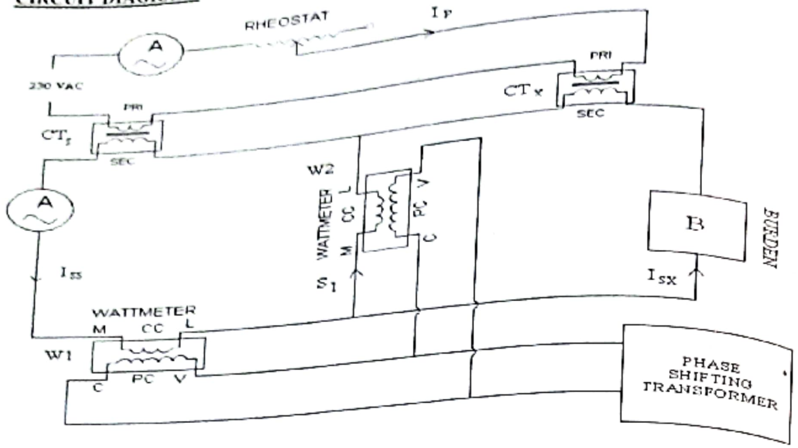
PROCEDURE:

1. Make the connections as per the circuit diagram
2. Apply the binary input by closing appropriate switches
3. Measure the analog output using a multimeter.
4. Tabulate the measured values.
5. Plot a graph between digital input Vs analog output.

RESULT:

Thus the given digital input was converted into its equivalent analog output.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S.No	Iss	Wiq	W2q	W1p	W2p	Rx	Θx

EX NO: 9

CALIBRATION OF CURRENT TRANSFORMER

AIM:

To determine the percentage ratio error and the phase angle error of the given current transformer by comparison with another current transformer whose error are known

APPARATUS:

S.No	Equipment	Range	Type	Quantity
1	Standard CT	0-5A	AC	
2	Testing CT	0-300V	AC	
3	Wattmeter		LPF	2
4	Ammeter	MI type	AC	2
5	Rheostat		AC	
6	Phase shifting transformer			

THEORY:

This is a comparison type of test employing deflect ional methods. Here the ratio and phase angle of the test transformer x are determined in terms of that of a standard transformer s having same nominal ratio.

The errors are as follows say:

CT Error	Ratio Error	Phase Angle Error
S	RS =	θs =
X	RX =	θX =

The primaries of the two CTs are connected in series and the current through them is say IP. The pressure coils of two wattmeters are supplied with constant voltage V from a phase shifting transformer.

The current coil of wattmeter W1 is connected to S through an ammeter. The current coil of wattmeter W2 is connected as shown in fig and carriers a current SI.

SI = Iss - Isx (Victorian difference)

Where in is the current in the current coil of W1 and Isx is the current flowing through the burden. The phase shifting transformer is adjusted so that the wattmeter W1 reads zero.

W 1q =

VpcqIss cos

90 = θ W2q =

Vpcq SI cos

(θX – θs)

= V Isx sin (θX – θs)

Where Vpcq is the voltage from the phase shifting transformer, which is in quadrature with the Iss in is current coil of W1.

Then the phase of the voltage from to phase shifting transformer is shifted through 90°. Therefore, now V is in phase with the current Iss.

W1p = V Iss

W2p = VSI sin (θX – θs)

= V [Iss – isx cos (θX – θs)

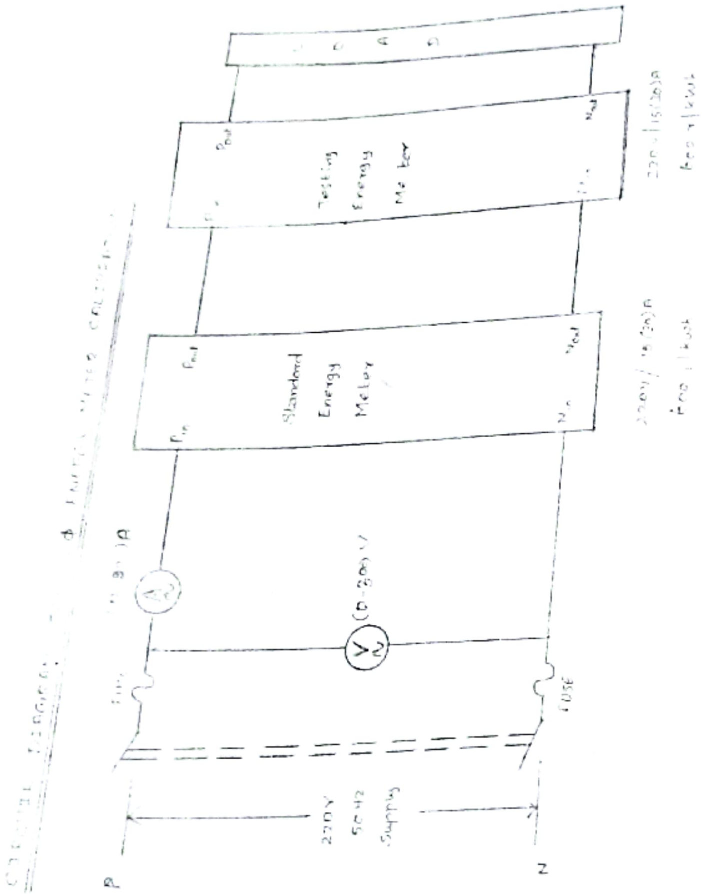
Therefore VIsx = W1p – W2p

PROCEDURE:

1. The connections are made as per the circuit diagram. The burden is adjusted to have a suitable current In. the phase angle is adjusted using the phase shifting transformer will wattmeter W1 reads zero. Reading of the other wattmeter (W2q) is noted.
2. A phase shift of 90 is obtained by the phase sulfating transformer. The two wattmeter readings W Ip and W 2p are then observed
3. The ratio error is calculated using the formula Rx = Rs
4. The phase angle error is calculated using the formula
5. The experiment is repeated by varying the burden and setting different values for Iss.
6. The average values of Rs and are then obtained.

RESULT:

Thus the Current Transformer was calibrated.



EX NO: 10

CALIBRATION OF 1∅ ENERGYMETER

AIM:

To calibrate the given single phase energy meter at unity and other power factors

EQUIPMENT:

S.No	Apparatus	Range	Quantity
1.	Energy meter		1
2.	Wattmeter	300V/10A UPF	1
3.	Stop watch		1
4.	Ammeter	(0-10)A	1
5.	Voltmeter	(0-300)V	1

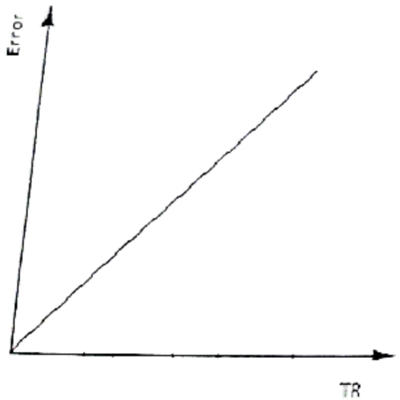
THEORY:

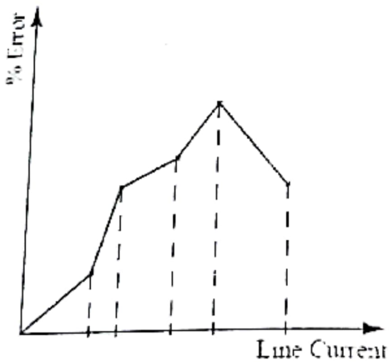
Energy meter is an integrating instrument which measures quantity of electricity. It works on the principle of induction i.e. on the production of eddy currents in the moving System by the alternating flux. These alternating currents induced in the moving system , interact With each other to produce a driving torque due to which disc rotates to record energy. In energy meter there is no controlling torque and thus due to driving torque only a continuous rotation of the disc is produced. To have constant speed of rotation braking magnet is provided. There are four main parts of operating mechanism of single phase energy meter. (i) Driving system, (ii) Moving system, (iii) Braking system, (iv) Registering system. Every energy meter has its own characteristic constant specified by the manufacturer which the energy relates the energy measured in joules and the number of revolutions of the disc.

TABULATION:

SL.NO	Voltage(V)	Current(A)	Num of revolutions of standard energy meter	Num of revolutions of testing energy meter	Error

MODEL GRAPH:



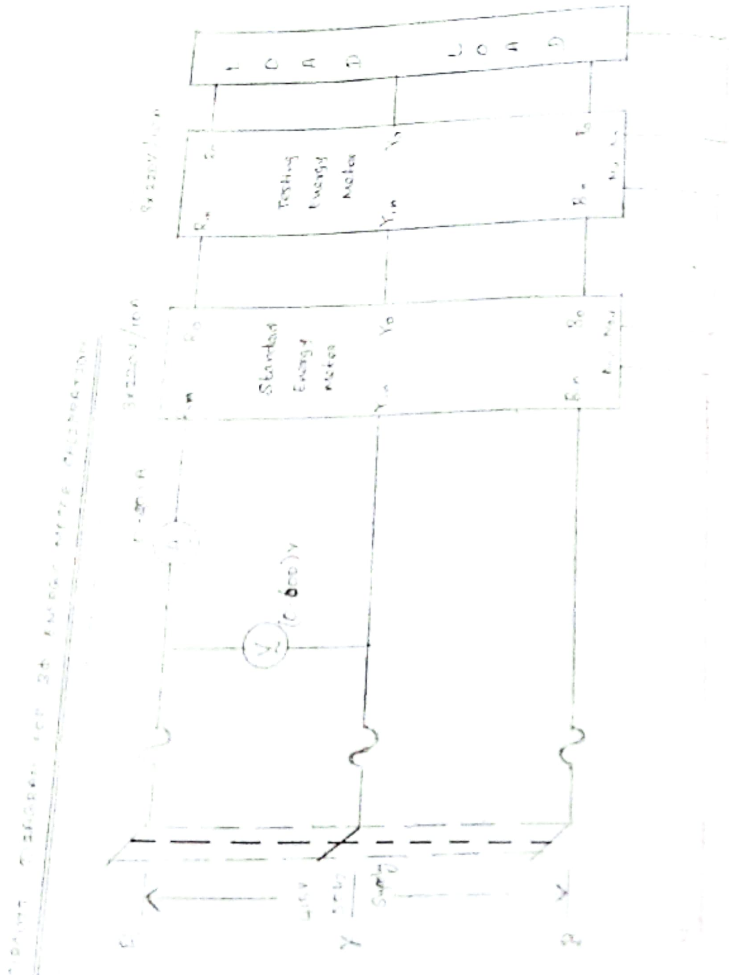


PROCEDURE:

1. Connections are given as shown in the circuit diagram.
2. Supply is given by closing the DPSTS switch.
3. The num of revolutions of standard and testing energy meters are noted for 5 minutes.
4. The above step is repeated for various loads and the error is noted.

RESULT:

Thus the single phase energy meter was calibrated.



EX NO: 11

CALIBRATION OF THREE PHASE ENERGY METER

AIM:

To calibrate 3 phase energy meter using standard 3 phase wattmeter.

EQUIPMENT:

SL.NO	NAME OF APPARATUS	TYPE	RANGE	QTY
1.	3φ variac	-	440/(0-440)V	1
2.	Ammeter	MI	(0-10)A	1
3.	Voltmeter	MI	(0-600)V	1
4.	3-φ energy meter	600rev/hr	30A,3*240V	1
5.	Wattmeter	UPF	10A, 600V	1
6.	Rheostat Load	-	-	1
7.	Connecting Wires	-	-	As req

THEORY:

In a three phase four wire system, the measurement of energy is to be carried out by a three phase energy meter. For three phase three wire system, the energy measurement can be carried out by two element energy meter, the connections of which are similar to the connections of two wattmeter for power measurement in a three phase, three wire system, classified as:

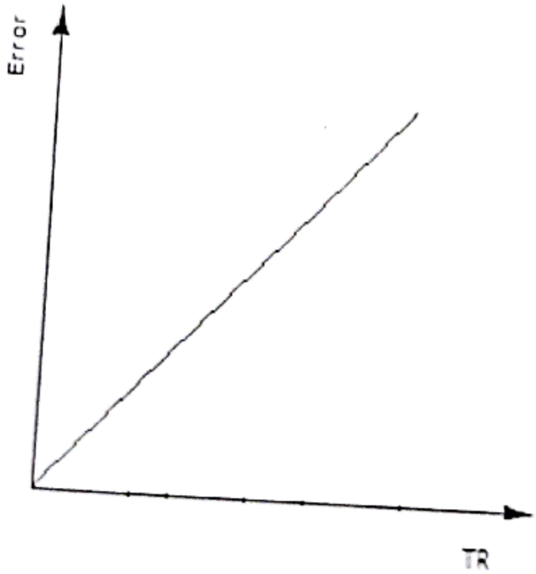
1) Three element energy meter.
2) Two element energy meter.

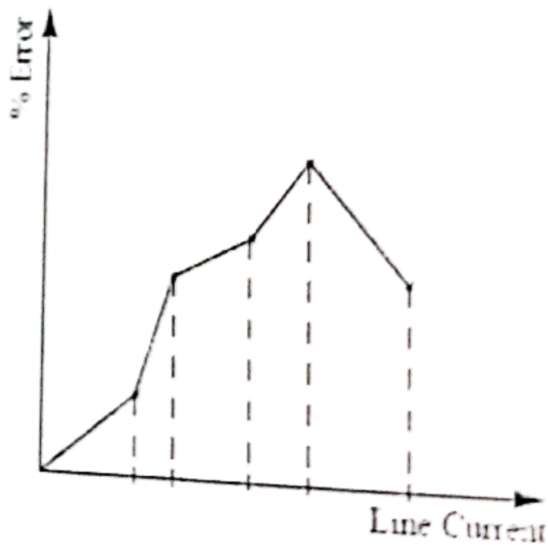
This meter consists of three elements. Pressure coils are denoted by P_1, P_2, P_3 and current coils as C_1, C_2, C_3.

TABULATION:

SL.NO	Voltage(V)	Current(A)	Num of revolutions of standard energy meter	Num of revolutions of testing energy meter	Error

MODEL GRAPH:





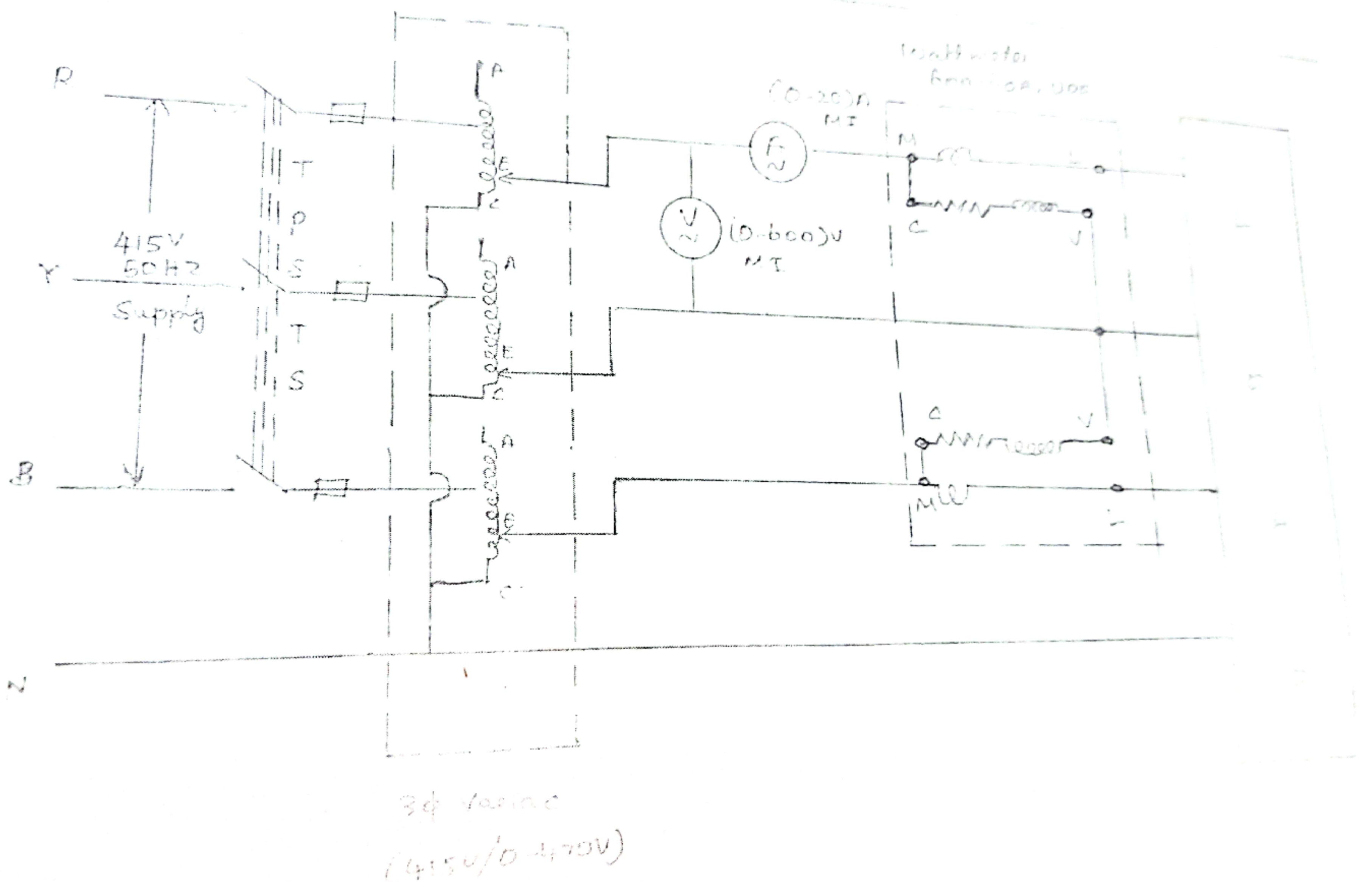
PROCEDURE:

1. Connections are given as shown in the circuit diagram.
2. Supply is given by closing the DPSTS switch.
3. The num of revolutions of standard and testing energy meters are noted for 5 minutes.
4. The above step is repeated for various loads and the error is noted.

RESULT:

Thus the three phase energy meter was calibrated.

CIRCUIT DIAGRAM :- 3 PHASE POWER AND POWER FACTOR



EX NO: 12

MEASUREMENT OF 3 PHASE POWER AND POWER FACTOR

AIM:

To find three phase power and power factor using two wattmeter method.

EQUIPMENT:

S.No	Apparatus	Range	Type	Quantity
1.	Ammeter	(0-10)A	MI	1
2.	Voltmeter	(0-600)V	MI	1
3.	Wattmeter	600V,20A	UPF	1
4.	3-Φ resistive load	-	-	1
5.	3-Φ Auto transformer	415/0-470V	MI	1
6.	Connecting wire	-	-	As req

THEORY:

Watt meters generally used to measure power in the circuits. A watt meter principally consists of two coil one coil is called the current coil, and other the pressure and voltage coil. The load voltage is impressed the pressure coil. The terminal M denotes main side, L denotes load side, common denotes common point current coil and pressure coil, and V denotes the second terminal of the pressure coil. When the current flow through the two coils, they set up magnetic fields in space. An electromagnetic torque is produced by interaction of the two magnetic fields. Under the influence of the torque, one of the coil moves on the calibrated scale against the action of the spring. The instantaneous torque produced by electromagnetic action is proportional to the product of the instantaneous values of the currents in the two coils. The small current in the pressure coil is equal to the input voltage divided by the impedance of the pressure coil. The inertia of the moving system does not permit it to flow the instantaneous fluctuations in torque. The wattmeter deflection is therefore, proportional to the average power delivered to the circuit.

TABULAR COLUMN:

S.NO	Current I in (Amps)	Watt meter reading W1 (Watts)	Watt meter reading W2 (Watts)	POWER P Watts	P.F COSØ

FORMULA USED:

1. Total power P = W1+W2 (W)
2. ∅ = Tan-1 √3[W1-W2/W1+W2]
3. P.F = Cos∅.

Variations in wattmeter readings:

We know that $W_1 = E_L I_L \text{Cos}(30-\varphi)$

$W_2 = E_L I_L \text{Cos}(30+\varphi)$

From the above it is evident that individual readings of the wattmeters not only depends on the load but also upon its power factor.Let us take up the following cases:

(i) When $\varphi=0$

i.e, power factor is unity (load is resistive)

Then, $W_1 = W_2 = E_L I_L \text{Cos } 30$

The reading of each wattmeter will be equal.

(ii) When $\varphi=0$

i.e, power factor is 0.5(lag)

Then, $W_2 = E_L I_L \text{Cos}(30+60) = 0$

Hence, the power measured by W_1 only.

(iii) When $90>\varphi>60$

i.e, 0.5>p.f>0

Then W_1 is still positive but reading of W_2 is reversed. For a leading power factor conditions are just opposite of this. In that case ,W_1 will read negative because the phase angle between current and voltage is more than 90.For getting the total power ,the reading of W_2 is to be subtracted from that of W_1.Under this condition, W_2 will read downscale i.e, backwards. Hence to obtain a reading on W_2, it is necessary to reverse either its pressure coil or current coil, usually the former. All readings taken after reversal of pressure coil are to be taken as negative.

(iv)When $\varphi = 90$

i.e., power factor is 0(load is pure inductive or capacitive)

Then, $W_1 = E_L I_L \text{Cos}(30-90) = E_L I_L \sin 30$

$W_2 = E_L I_L \text{Cos}(30+90) = -E_L I_L \sin 30$

Those two readings are equal in magnitude but opposite in sign

$$W_1+W_2 = 0$$

So far we have considered lagging angles (taken as positive). Now let us discuss how the readings of Wattmeters change when the power factor is leading one.

For $\varphi = +60$ (lag); $W_2 = 0$

$\Phi = -60$ (lead); $W_1 = 0$

Thus we find that for angles of lead the readings of the two Wattmeters are interchanged hence when the power is leading

$$W_1 = E_L I_L \cos(30+\varphi)$$

$$W_2 = E_L I_L \cos(30-\varphi)$$

PROCEDURE:

1. Connections are made as per the circuit diagram, keeping the resistive load in the initial position.
2. Supply switch is closed and reading of ammeter and wattmeter are noted .If one of the wattmeter reads negative, then its potential coils (C and V) are interchanged and readings are taken in negative.
3. The above procedure is repeated for different values of load.

RESULT:

Thus the power and power factor was measured by using two Wattmeters.