I

CALIBRATION AND TESTING OF SINGLE PHASE ENERGY METER

Date:

1. CALIBRATION OF SINGLE PHASE ENERGY METER

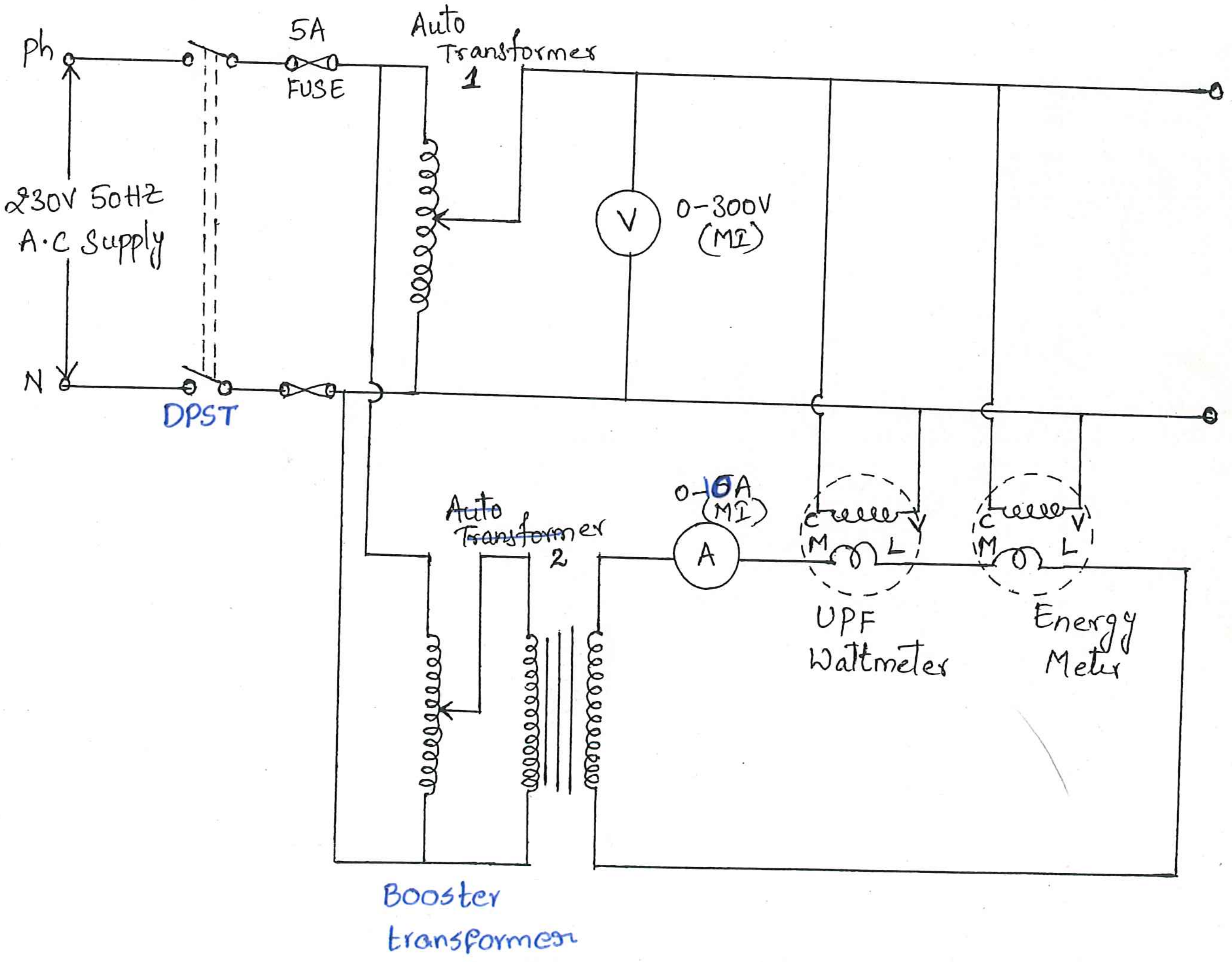
Aim: To Calibrate Energy meter by phantom loading method.

Apparatus: 1-Φ Energy Meter -------------- 230V,5-10A
UPF wattmeter
Voltmeter ------------------------ 0-300V M.I
Ammeter ------------------------ 0-10A M.I
Stop Watch
Booster Transformer ------------ 230V/0-50V, 15A
Dimmer stat ---------------------- 230V,5A

Name plate Details:

Volts:
Current:
Energy meter constant:

Circuit Diagram:



Procedure:

1. Make the connections as shown in figure.
2. Keep both the Dimmer stats at zero output position.
3. Set the Dimmer stat D_1, such that voltmeter reads 240V.
4. Now vary the booster transformer in such a way that ammeter reads 1A.
5. Now observe that the energy meter rotates in forward direction.
6. note down the time for completing 25 revolutions of the disc.
7. Repeat the same for 2A, 3A, 4A&5A.
8. Tabulate the results.

Observation Table:

S no.	V (volts)	Time (T) Sec For 25 Rev	W (watts)	$E_2=W \times T$ (Watt-sec)	% Error

Calculations:

1. Actual energy consumed (E_2):

E_2 = Wattmeter Reading x Time for 25 rev. Watt-sec

2. Reading from energy meter can be computed as:

600 rev corresponds to 1KW Hr

1 rev corresponds to 1/600 KW Hr

25 rev corresponds to 25/600 KW Hr

E_1 =........................ Watt-sec

$$\text{Error} = \frac{\text{Instrument reading - True Reading}}{\text{Instrument Reading}}$$

$$= \frac{E1-E_2}{E_1} \times 100$$

Graph: Draw graph of % error Vs current I.

Note :

1. Write down constructional details of energy meter
2. Write a short note on errors and compensation in energy meter.

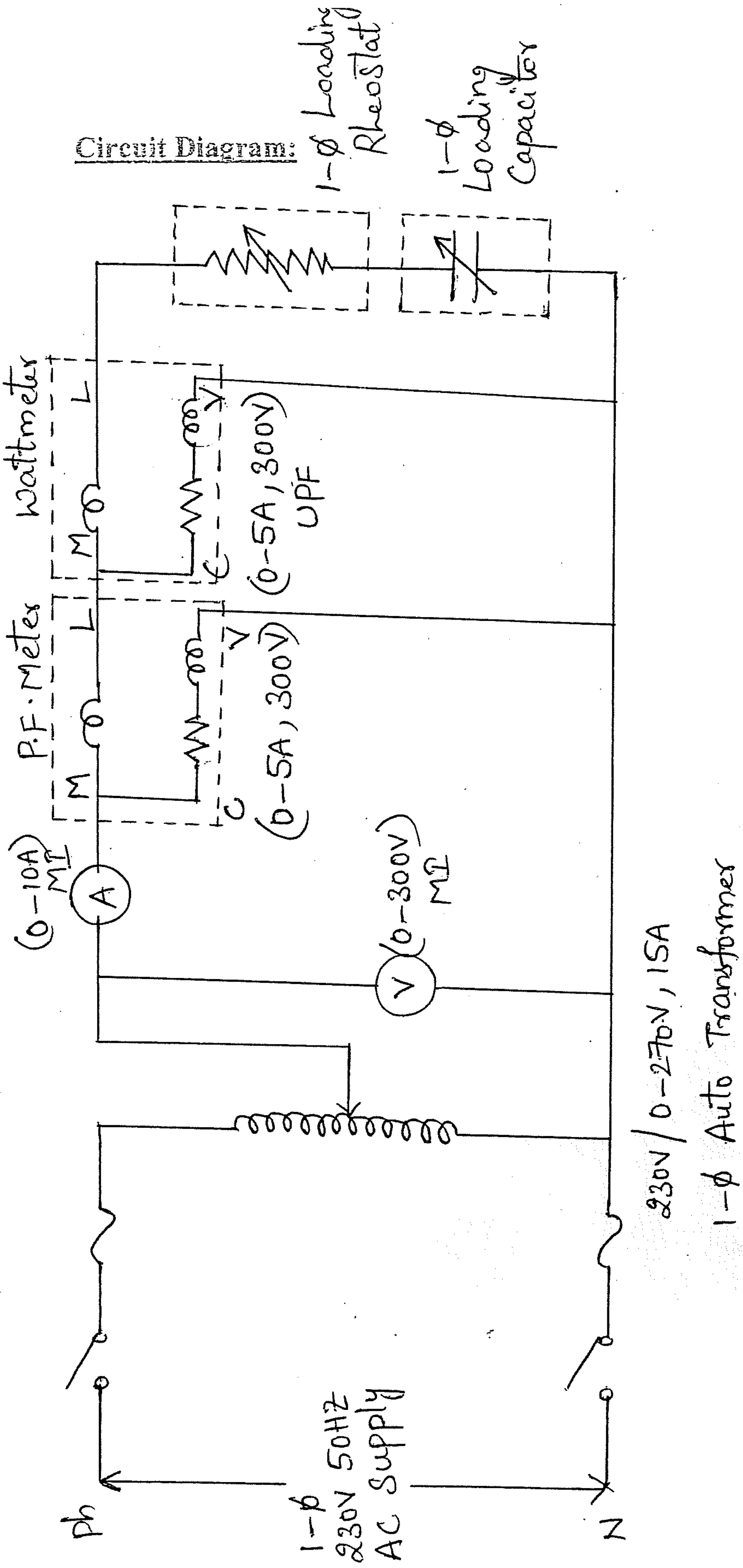
Result:

II

CALIBRATION OF DYNAMOMETER POWER FACTOR METER

24 dia.

Circuit Diagram:



Result:

CALIBRATION OF 1- PHASE DYNAMOMETER POWER FACTOR METER

Aim: To calibrate dynamometer type 1Φ Power factor meter

Apparatus:-

1) Ammeter	(0-10A)	MI	1
2) Voltmeter	(0-300v)	MI	1
3) 1 Φ Auto transformer	230/0-270v/5A		1
4) Power factor meter	0-5 A, 300v		1
5) Wattmeter	0-5A,300v		1
6) 1 Φ loading Rheostat			1
7) 1 Φ loading capacitor or Inductor			1
8) Connecting wires			

Theory:

On Measuring the current, voltage and power in an AC circuit, its power factor can be calculated from the relation ship cos Φ= P/VI ,

Power factor meter like a wattmeter have current circuit and pressure circuit. Current circuit carries the current in the circuit whose power factor to be measured the pressure coil is connected whose power factor is to be measured and is usually split up into two parallel paths one inductive and the other one non inductive. The deflection of the instrument depending upon the phase difference between the main current and currents in the two paths of pressure coil circuits(Phase angle or power factor of the circuits). The deflection indicated by a pointer.

The moving system of power factor meter is perfectly balanced at equilibrium by two opposing forces and there is no need for controlling force. Hence when a power factor meter is disconnected in the circuit the pointer remains at the position which it occupied at the instant of disconnection there are two types of power factor meters Electrodynamometer type and Moving iron type

Single Phase Electrodynamometer Type Power Factor Meter: It consisting of a fixed coil which acts as a current coil this coil split up into two parts and carries the current of the circuit and the test there fore the magnetic field produced by this coil is proportional to the main current two identical pressure coils a and b pivoted and spindle constitute moving system pressure coil A has a non inductive resistance are connected in series with it and coil B has a highly inductive choke coil L connected in series with bit the two coils connected across the voltage of a circuit the values of R and L are so adjusted that the two coils carries the same values of current at normal frequency

The torque produced by coil A $Ta = KVIM_{max} \cos\Phi \sin\theta$

θ is angular deflection from the plain reference

M_{max} is Maximum value of mutual inductance between the two coils this torque acting in the clock wise direction

Deflecting torque acting on coil B $Tb = KVIM_{max} \sin\Phi \cos\theta$

Hence at equilibrium $Ta = Tb$ so $\theta = \Phi$ there fore the deflection of instrument is a measure phase angle of the circuit. The scale of the instrument can be calibrated indirectly in terms of power factor

Procedure:-

1. Make the connection as per the circuit diagram.
2. Keep the auto transformer in minimum position. Resistance load and capacitance or inductive load also in minimum position.
3. Apply rated voltage with the help of auto transformer.
4. switch on the capacitive load or Inductive load and by vary the loads in steps
5. Note down the readings of Voltmeter, Ammeter, Wattmeter and P.F Meter.
6. Bring all the loads to minimum position.
7. Bring the auto transformer to zero position.
8. Calculate % error
9. Plot graph between load current and % error

Result:-

Calibration of Dynamometer type single phase power factor meter is performed and error is determined and Characteristics are verified.

Tabular Column:

S. No	Voltage V(Volts)	Current I(Amps)	Power factor	Wattmeter W(Watts)	Cosθ = W/VI	% Error

III

KELVIN DOUBLE BRIDGE

Date:

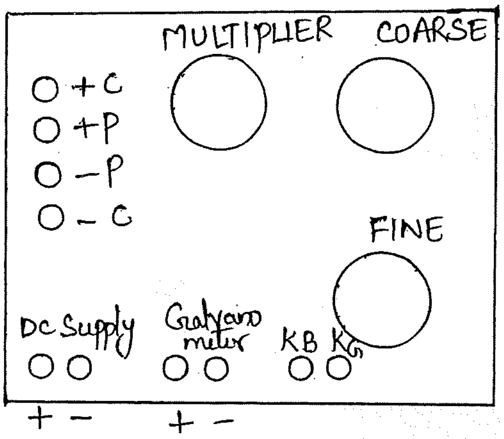
Kelvin's Double Bridge

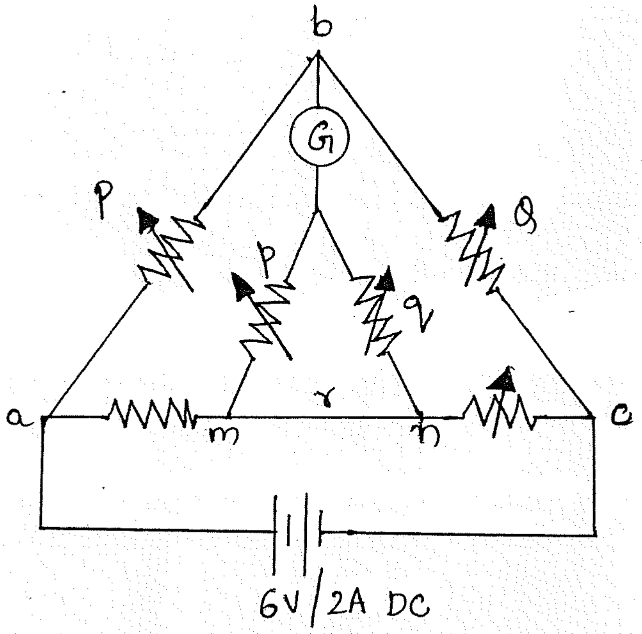
Aim: To Measure unknown low resistance value accurately.

Apparatus:

1. Precision Kelvin's double bridge circuit
2. DC Power supply 6V/2A
3. Galvanometer
4. Standard resistance 0.01Ω/10A
5. Ammeter (Whose resistance to be measured)
6. Connecting wires

Circuit Diagram:





Procedure:

1. Make the connections as shown in the figure.
2. Make sure that multiplier, coarse and fine dials are kept at minimum position.
3. Connect std resistance to the four terminals provided on the kit.
4. Press battery key K_B and then galvanometer key K_G and adjust the multiplier, coarse and fine dials to get null deflection in the galvanometer.
5. Note down the readings.
6. In case resistance to be measured is a two terminal device, then it has to be connected to P+ and P- provided on the kit.
7. Repeat point 4.
8. Note down the readings.

Tabular Column:

S No	Device	Multiplier Reading(P/Q)Ω	Coarse dial reading(Ω)	Fine dial reading(mΩ)	Unknown resistance

Calculations:

Unknown resistance = multiplier (coarse + dial)

$$R_x = \frac{P}{Q}(R) \qquad \frac{P}{Q} \text{ ---------- Multiplier.}$$

Result:

IV

5.DIELECTRIC OIL TESTING USING H.T. TESTING KIT.

5.0 Objectives:

1) To test the dielectric strength or breakdown potential of the insulating oil.
2) To test the acidity of the transformer oil.

5.1 Resources:

1. Dielectric oil testing kit – 1No.
2. Dielectric oil

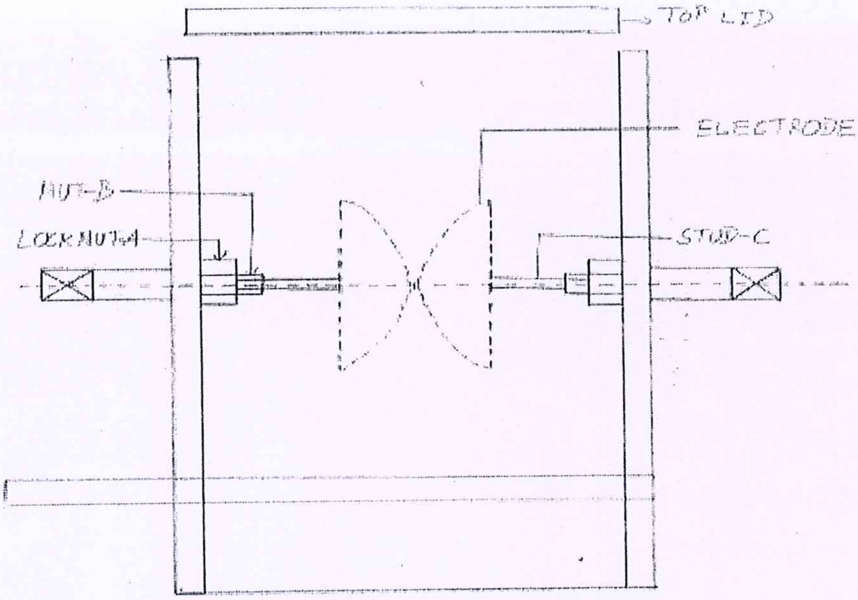
5.2 Precautions:

1.The lid of the HT testing kit should be closed properly.

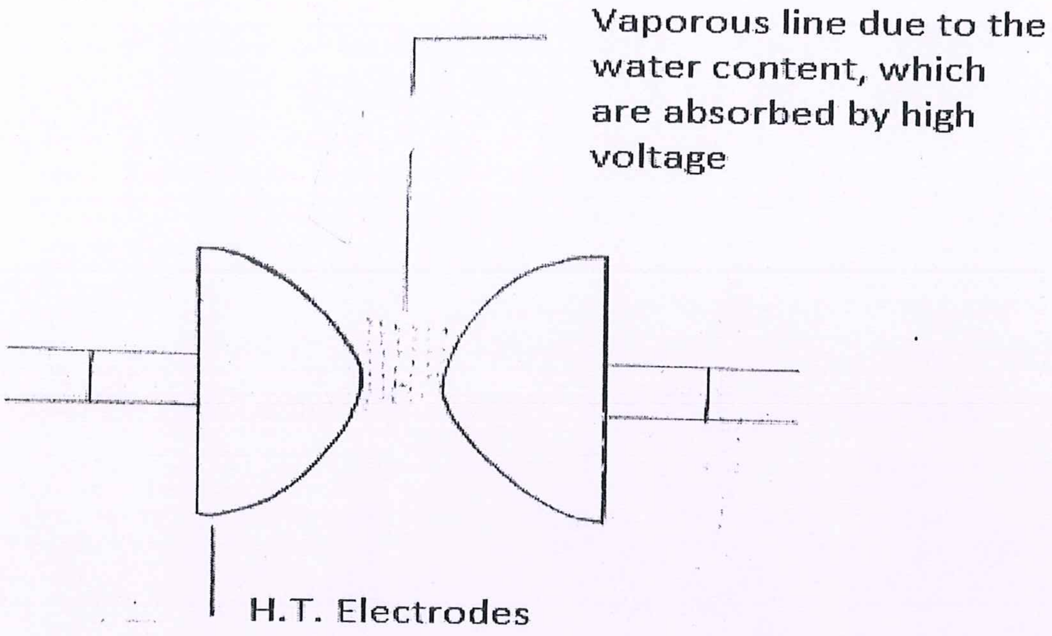
2. The variac should be kept in minimum position initially.

3. Oil cup must be kept on the HT testing horns properly.

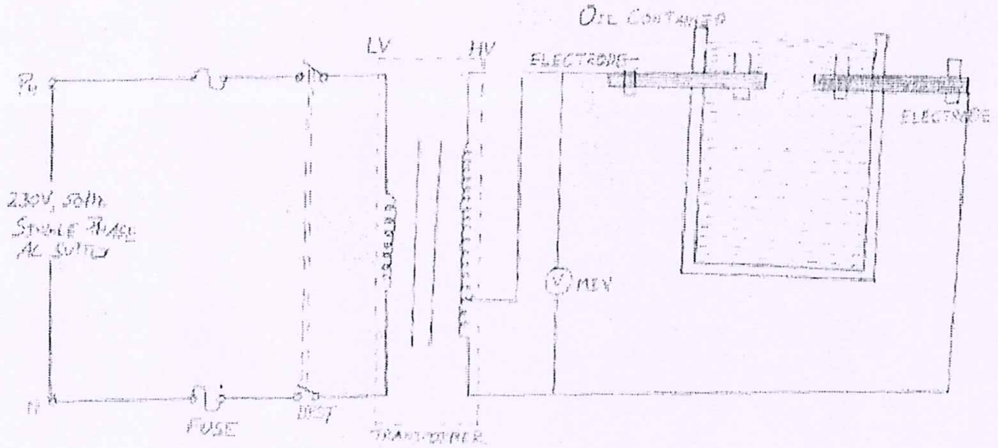
5.3 Electrode Adjusting:



5.3.1Vaporous lines due to water and impurities in oil:



CIRCUIT DIAGRAM:-



5.4 Procedure:

1. Take the oil cup and adjust the gap between the electrodes with the help of gauge.
2. Fill up oil test cup with oil to be tested, close it with the lid and place it on the HT horns under the hinged acrylic cover and close the acrylic cover properly.
3. Keep the variac in minimum position.

4. Connect the mains lead to the 220V, single phase AC 50Hz supply.
5. Switch ON the power supply by operating the toggle switch, then yellow neon bulb glows indicating that the HT kit is switched off.
6. Press the HT 'ON push' switch. The red Neon lamp will start glowing and the HT transformer circuit will be energized, the green neon bulb start glowing.
7. In case the red indication does not glow, check up the hinged acrylic cover is properly closed and the variac knob is fully rotated in the anticlockwise direction for '0' start.
8. Now start rotating the variac knob slowly in the clockwise direction till the flash over occurs across electrodes in the oil test cup. The speed of ratio should be such that the voltage rises at the rate of 2 kv/sec.
9. As soon as flash over occurs, the supply of the high voltage transformers, will be cut off and the voltage pointer will also stop indications the flash over level.

Note down the reading of voltmeter and distance between the electrodes.

10. To repeat test on the sample, switch OFF the mains supply and stir the test pot with the help of a clean rod and let it cool for sometime and close the acrylic cover properly.
11. Repeat the steps 2 to 10.
12. Switch OFF the mains supply after the tests are over.

5.5 Result:

The break over voltage of the dielectric oil is determined by using HT testing kit

V

MEASUREMENT OF THREE PHASE REACTIVE POWER WITH 1 PHASE WATTMETER

Measurement of 3–Phase Reactive Power using Single Phase Wattmeter

Aim: To Measure Reactive power in a Three Phase Circuit using Single Phase Wattmeter.

Apparatus:

Voltmeter (0 – 600 V) M.I	1
Ammeter (0 – 10A) M.I	1
Wattmeter 1 – Φ, 600V, 10A, LPF	1
3 Phase Auto transformer	1
3 Phase Loading Inductor	1

Theory:

Incase of the balanced Three Phase circuits. It is simple to use a single wattmeter to read the reactive power. The reactive power in a circuit is $Q = VI \sin\theta$ it is often convenient and even essential that the reactive power to be measured for example, in load monitoring such a measurement gives the operator or load dispatcher information connecting the nature of the load. Also the reactive power serves as a check on power factor measurements since ratio of reactive power and active power is $\tan\theta = Q/P$

Where Q and P are respectively the reactive and active powers.

Also the apparent power $S = VI$ which determines the line and Generator capacity may be determined from the measurements of active and reactive power.

Apparent power $S = \sqrt{P^2 + Q^2}$

The Current coil of the wattmeter is connected in one line and pressure coil is connected across the other two lines.

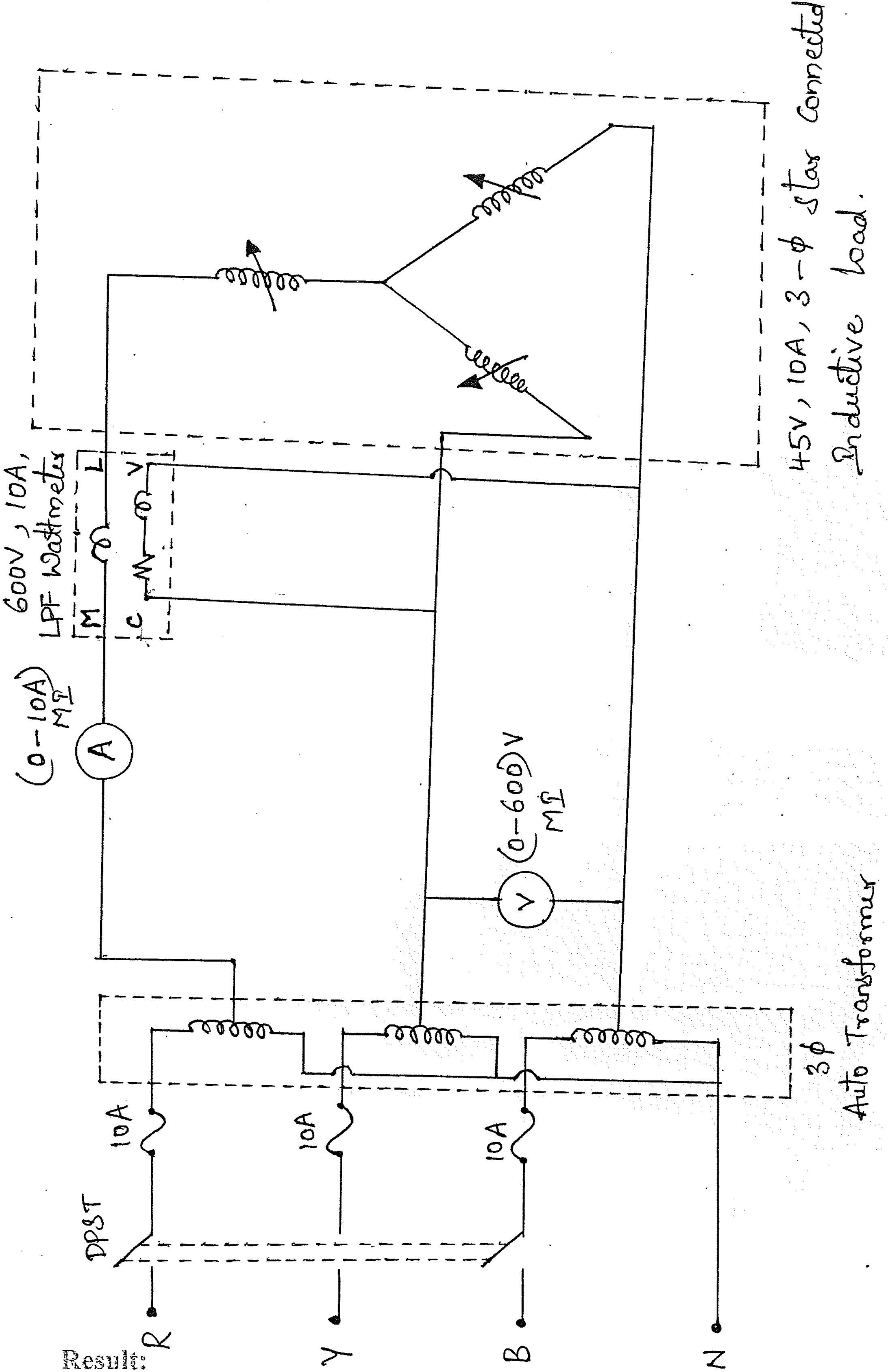
$$\text{The reading of the Wattmeter} = 3\,V\,I\cos(90 + \theta)$$
$$= 3\,V\,I\sin\theta$$

Total Reactive Power of The Circuit

$$Q = \sqrt{3}\,V\,I\sin\theta = (\sqrt{3})\ X \text{ reading of the wattmeter}$$

$$\text{Phase angle } \theta = \tan^{-1}(Q/P)$$

Circuit Diagram:



Result:

Procedure:-

(1) Connect the circuit as per the Circuit Diagram.

(2) Keep the Auto transformer in Minimum Position.

(3) Close the TPST Switch and vary the Auto transformer slowly and apply rated Voltage.

(4) Vary the load gradually and at Different loads note down the readings of Ammeter, Voltmeter and Wattmeter.

(5) Calculate the total Reactive Power and Percentage Error

Tabular Column:

S. No	**Voltage**	**Current**	**Wattmeter**	**True Power** W=VICOSφ	**% Error**

$$\% \text{ Error} = \frac{\text{Wattmeter Reading} - \text{True power reading}}{\text{True Power reading}} \times 100$$

Result: - Experiment is performed and Percentage error For Different loads determined

VI

CROMPTON DC POTENTIOMETER

Date:

. CROMPTON DC POTENTIOMETER

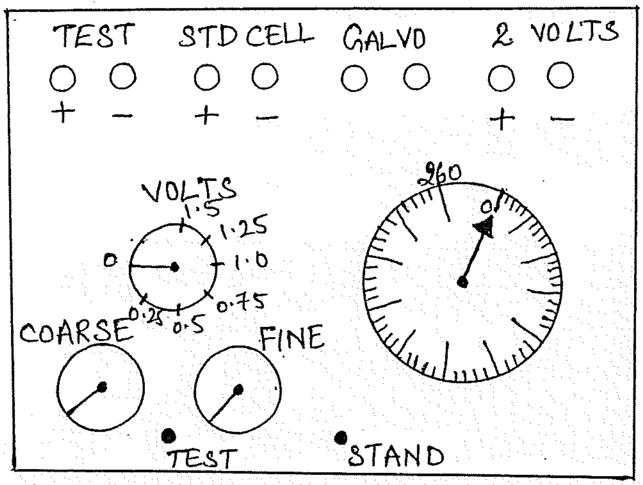
Aim: Calibration of ammeter and voltmeter by using Crompton DC potentiometer.

Apparatus:

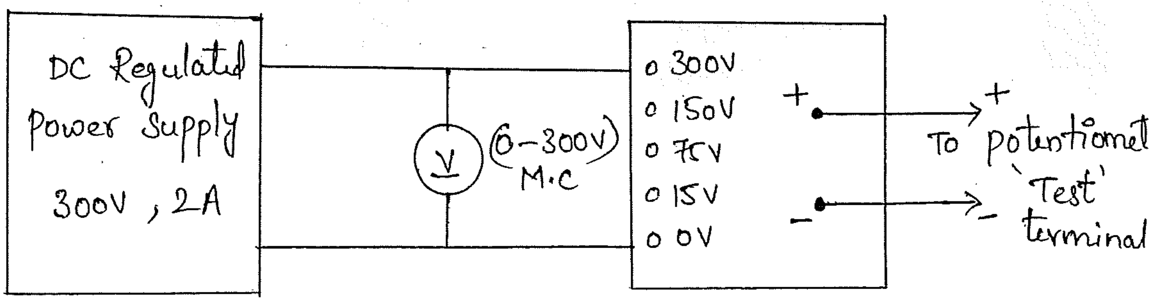
- DC Potentiometer
- Super sensitive galvanometer
- Standard cell
- Volt- ratio Box
- Potentiometer shunt(0.1Ω)
- Voltmeter- 75V, 150V, 300V(MC)
- Ammeter - 5A, 10A(MC)

Circuit Diagram:

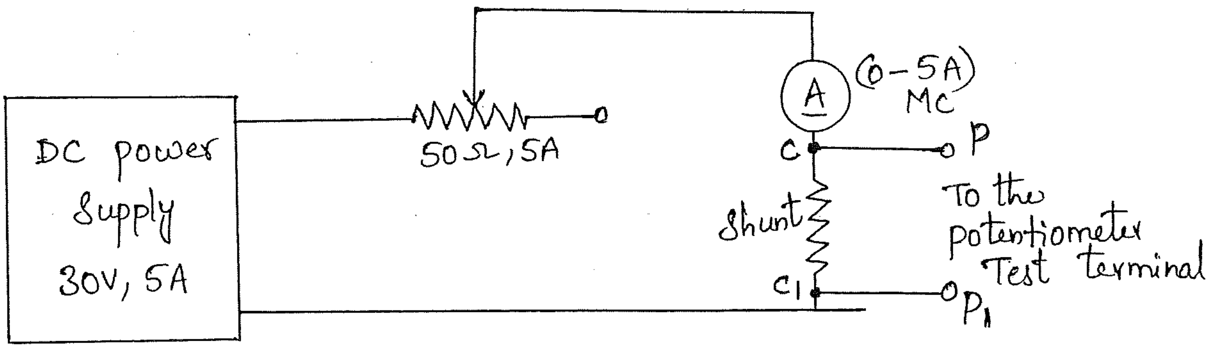
(a) Schematic Diagram



(b) Calibration of Voltmeter



(c) Calibration of Ammeter:



Procedure:

(a) Standardizing the Potentiometer:

1. Connect the galvanometer, standard cell, battery to their appropriate terminals of the potentiometer with correct polarity.
2. Set the potential dials to exact voltage of the standard cell(i.e. 1.0186v).
3. Press the 'STANDARDISE' key and see whether galvanometer is showing null deflection.
4. If not then rotate the two battery Rheostats (course and fine) to get the null deflection.
5. Now this potentiometer is said to be standardized for the calibration purpose.
6. Once it is standardized , battery rheostats should not be disturbed.

(b) Calibration of Voltmeter:

1. Connect DC voltmeter (which has to be calibrated) to the potentiometer 'TEST' terminals directly.
2. If rating of voltmeter is more than 2V, then we use volt ratio box with proper rating.
3. Give some supply such that , voltmeter shows some reading (rated) & note down that reading.
4. Press galvanometer key, adjust potential dial to get null deflection in galvanometer.
5. Note down the potential dial reading & find out the true value of voltage & percentage error.
6. Repeat the same procedure for different values of voltages.

(c) Calibration of Ammeter:

1. Make the connection as shown in figure(3).
2. Connect P-P terminals of current shunt to the test terminals of potentiometer.
3. Adjust the potential dials to get null deflection in galvanometer and measure the unknown potential across the shunt potential terminals.
4. True value of current flowing is then found by dividing measured potential in volts by resistance of shunt in ohms.
5. Repeat the same procedure for different current values and calculate the % error.

Tabular Forms:

(a) Calibration of Voltmeter:

S No.	E	Voltmeter Reading(V)	Potentiometer Reading(e)	True voltmeter value(v)	% error

(b) Calibration of Ammeter:

S No.	Ammeter Reading(A)	Potentiometer Reading	True Current value(A)	% error

Graphs:

Draw the calibration curve
% error Vs measured current
% error Vs measured voltage

Calculations:

(a) Calibration of Voltmeter:

Volt ratio box rating used E = ... Volts
Potentiometer reading e = ... Volts
True voltmeter value = (E/1.5) x e (Volts)

$$\text{Error} = \frac{\text{Measured value - true value}}{\text{Measured value}} \times 100$$

(b) Calibration of Ammeter:

Potentiometer reading e = ... Volts
Shunt Rating = 0.1Ω
True current = e/0.1 .... A

$$\text{Error} = \frac{\text{Measured value - true value}}{\text{Measured value}} \times 100$$

Result:

VII

Experiment – 1: SCHERING BRIDGE AND ANDERSON'S BRIDGE

1.1 OBJECTIVE

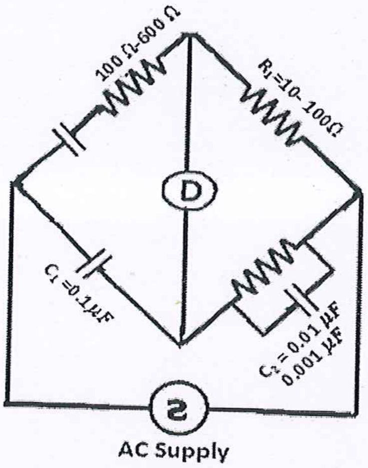
To find the Capacitance of a capacitor using Schering bridge and find the self inductance of a given inductor in terms of standard capacitors.

1.2 RESOURCES

S. No.	Name of the Equipment
1.	Educational trainer kit of Schering bridge and Anderson's bridge
2.	Galvanometer
3.	Patch chords
4.	Detector Head Phones

1.3 CIRCUIT DIAGRAM

SCHERING BRIDGE



1.4 PROCEDURE

1. AC supply is connections to terminals marked.
2. The headphones are connected as detectors.
3. All dials are kept at zero positions.
4. Keeping R = 100ohm and unknown capacitance is connected to unknown terminals.
5. Switch ON the power and adjust R_1 and R_2 to minimize sound.
6. Note down R_1, R_2 and C_1.
7. Repeat the above step for 3 other unknown capacitances.

1.5 TABULAR COLUMN

S. No.	R_1 (Ω)	R_2 (Ω)	C_1 (μF)	R (Ω)	Unknown Capacitance
1.					
2.					
3.					

1.6 MODEL CALCULATIONS

Schering Bridge

Non Inductive resistance R_1 =

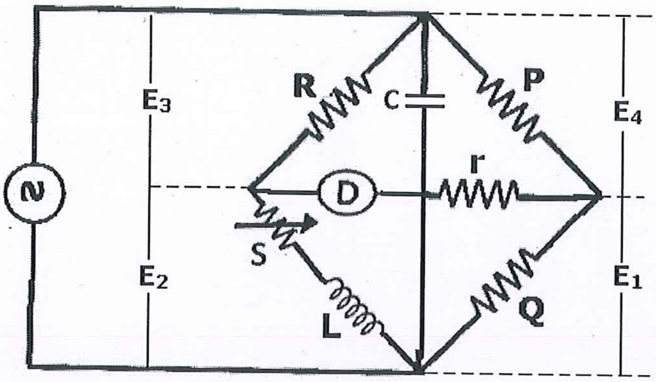
Variable Non Inductive resistance R_2 =

Variable Capacitor C_1 =

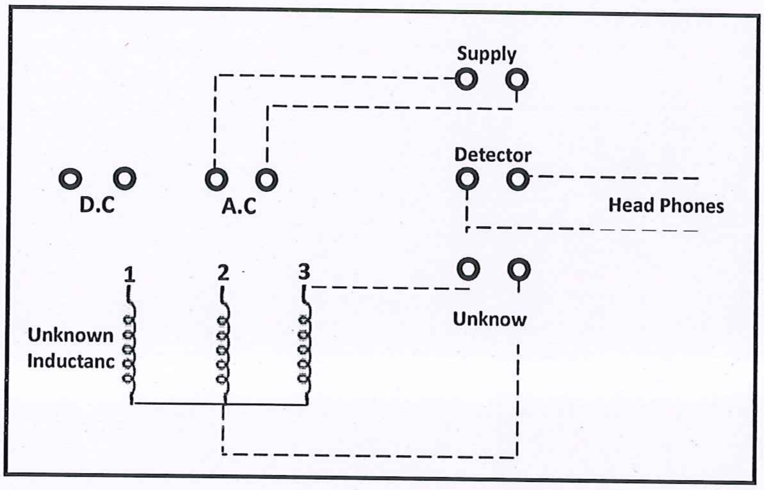
Unknown Capacitance $C = C_1 \times R_1/R_2$

1.7 CIRCUIT DIAGRAM

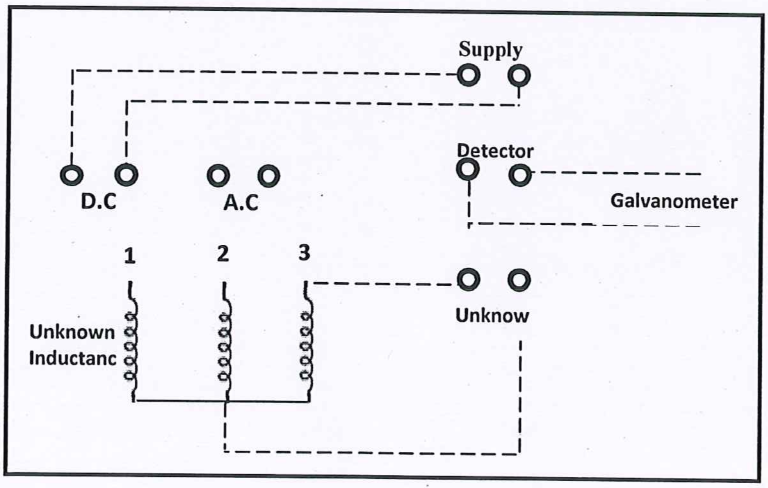
ANDERSON'S BRIDGE



AC Circuit



DC Circuit



1.8 PROCEDURE

1. Connections are mode as per the circuit diagram.
2. The unknown inductance is connected to terminals marked ‘L’
3. K_c/s oscillator is connected to terminals marked oscillator and headphones to respective terminals.
4. A fixed value of capacitance C= 0.01μF is selected.
5. A minimum of sound is obtained from headphones (or) constant line on CRO by varing ‘S’ and ‘m’ respectively.
6. The value of ‘L’ is calculated using the formula
   $$L = C \times \frac{R}{p}[r(P+Q)+PQ] \text{Henry.}$$
7. The experiment is repeated for different values of C.
8. The value of inductance is verified using P = Q = R = 1000ohm.

1.9 TABULAR COLUMN

S. No.	DC Supply			AC Supply		
	r (Ω)	R (Ω)	S (Ω)	r (Ω)	R (Ω)	S (Ω)
1.						
2.						
3.						

S. No.	DC Supply	AC Supply
	L(H)	L(H)
1.		
2.		
3.		

1.10 MODEL CALCULATIONS:

Anderson’s Bridge:

Value of Capacitor	C =
Standard resistance	P = Q =1000ohm
Variable resistance	r =
Value of fixed capacitor	S =
Value of inductor	$L = C \times \frac{R}{p}[r(P+Q)+PQ]$ mH

P = 1000Ω; Q = 1000Ω; R = 1000Ω;

S = Resistance of the unknown inductor

1.11 RESULT

Hence self capacitance and inductance are measured using Schering bridge and Anderson's bridge

1.12 PRE-LAB QUESTIONS

1. What is the purpose of schering bridge?
2. What is the purpose of Anderson bridge
3. What is the dissipation factor of a capacitor?
4. What is the condition for balance in any dc bridge?
5. What is the condition for balance in any ac bridge?
6. Anderson bridge is modification of which bridge?
7. What is the formula for dissipation factor?
8. Why there are two conditions of balance in ac bridges ?
9. What are the different bridges used to measure capacitance?
10. What are the different bridges used to measure inductance?

1.13 LAB ASSIGNMENT

1. Perform Schering bridge experiment with tune able amplifier detector?
2. Perform Anderson bridge experiment with tune able amplifier detector?

1.14 POST-LAB QUESTIONS

1. Why is Schering bridge particularly suitable for measurement at high voltage?
2. What is the limitation of Anderson bridge?
3. What is the balanced condition for DC bridges?
4. What is the balanced condition for AC bridges
5. What type of bridge is used for measurement of capacitance?
6. What type of bridge is used for measurement of inductance?

VIII

LVDT
CHARACTERISTICS AND CALIBRATION

CONTENTS

****

INTRODUCTION

The primary object of the INSTRUMENTATION TRAINER is to introduce and to educate electronic instrumentation systems in a manner sufficiently complete that the students will acquire proper knowledge and the idea about the transducers and their applications to measure mechanical and terminal quantities. The mechanical quantities include strain, force, pressure, torque, displacement, acceleration; frequency etc.The terminal quantities include temperature and heat flux.

It is understood that the students will have a conceptual understanding of these quantities through exposure of mechanics or physics courses, such as static's, dynamics, strength of materials or thermodynamics. The student's experience in actually measuring these quantities by conducting experiments, however, will usually be quit limited. It is an objective of this tutor to introduce methods commonly employed in such measurements and the usage of such electrical components such as capacitance, resistance, inductance, intensity, etc.

Emphasis in the instrumentation trainer will be directed toward electronic instrumentation systems rather than mechanical systems. In most cases electronic systems provide better data more accurately and completely characterize the design or process being experimentally evaluated. Also, the electronic system provides an electrical out put signal that can be used for automatic data reduction or for the control of the process. These advantage of the electronic measurement system over the mechanical measurement system have initiated and sustained trend in instrumentation toward electronic methods.

An attempt is made through these "Instrumentation trainer" to make as easy as possible for the students to learn about the electronic instrumentation system and various transducers used for the measurement of mechanical component. The instrumentation tutor panels are design in such a way that the block diagrams of the stages of electronic instrumentation system are clearly pictured on them. This makes the instrumentation tutor self explanatory and also the best teaching aid for Engineering students.

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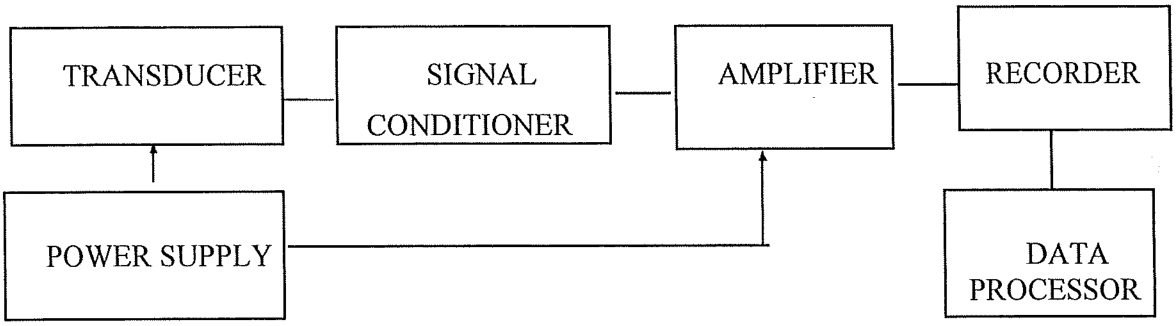
Since the instrumentation tutors are not instrument as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutor are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

THE ELECTRONIC INSTRUMENTATION SYSTEM.

The complete electronic instrumentation system usually contains six sub systems or elements.

The **TRANSDUCER** is a devise that convert a change in the mechanical or thermal quantity being measured into a change of an electrical quantity. Example strain gauges bonded in to an specimen, gives out electrical out put by changing its resistance when material is strained.



The **POWER SUPPLY** provides the energy to drive the Transducers, example differential transformer, which is a transducer used to measure displacement requires an AC voltage supply to excite the coil.

SIGNAL CONDITIONERS are electronic circuits that convert, compensate, or manipulate the out put from in to a more usable electronic quantity. Example the whetstone bridge used in the strain transducer converts the change in resistance R to a change in the resistance E

AMPLIFIERS are required in the system when the voltage out put from the transducer signal conditioner combination is small. Amplifiers with gains of 10 to 1000 are used to increase their signals to levels where they are compatible with the voltage - measuring devices.

........3

RECORDERS are voltage measuring devices that are used to display the measurement in a form that can be read and interpreted. Digital/Analog voltmeters are often used to measure static voltages.

DATA PROCESSORS are used to convert the out put signals from the instrument system into data that can be easily interpreted by the Engineer . Data processors are usually employed where large amount of data are being collected and manual reduction of these data would be too time consuming and costly.

******

THEORY

MEASUREMENT OF DISPLACEMENT

Differential transformers, based on a variable Inductance principle, are also used to measure displacement. The most popular variable-inductance transducer for linear displacement measurement is the Linear Variable Differential Transformer (LVDT). The LVDT illustrated in the fig. consists of three symmetrically spaced coils wound onto an insulated bobbin. A magnetic core, which moves through thee bobbin without contact, provides a path for magnetic flux linkage between coils. The position of the magnetic core controls the mutual between the center or primary coil and with the two outside or secondary coils.

When an AC carrier excitation is applied to the primary coil, voltages are induced in the two secondary coils that are wires in a series-opposing circuit. When the core is centered between the two secondary coils, the voltage induces between the secondary coils are equal but out of phase by 180^0. The voltage in the two coil cancels and the output voltage will be zero. When the core is moves from the center position, an imbalance in mutual inductance between the primary coil and the secondary coil occurs and an output voltage develops. The output voltage is a linear function of the core position as long as the motion of the core is within the operating range of the LVDT.

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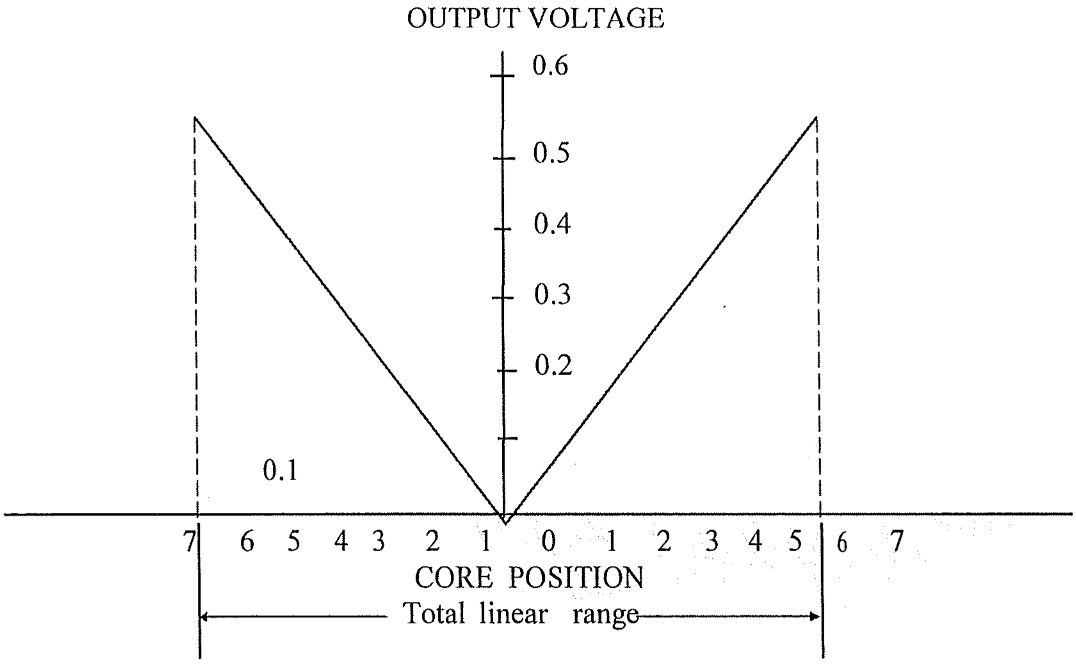

FIG. 1 Magnitude of the output Voltage as a function of LVDT core Position.

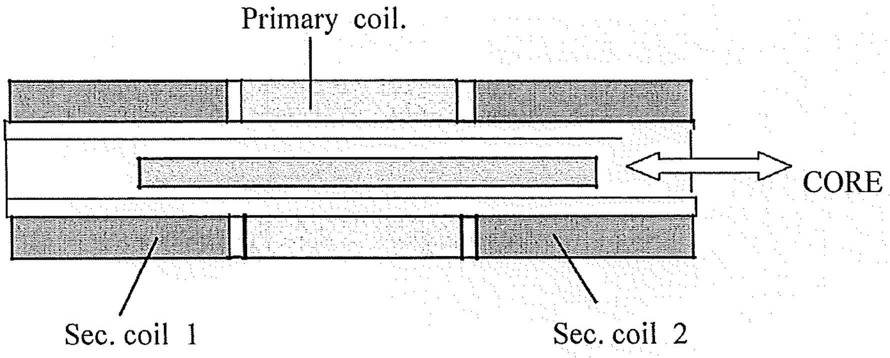

FIG. 2 Diagram to shows schematically the working of LVDT.

CIRCUIT EXPLANATION

The circuit can be divided into three parts.

1. Power supply. 2. Display. 3. Frequency generator &

3. Signal Conditioner.

1. POWER SUPPLY.

The power supply unit provides power for all the electronic device in the instrument. There are two different regulated power supply in the unit.

a) +5V, -5V 250mA too drive digital integrated circuits.

b) +5V - 0 -5V, 250mA to drive linear integrated circuits. 2.

DISPLAY

The display circuit is basically a $3^1/_2$ digit voltmeter which accepts DC of 200mV for full scale Reading. The display will be indicated through seven segment bright LED's.

3. FREQUENCY GENERATOR

The circuit is an IC based (OP AMP) used to generate excitation voltage to the LVDT primary coil. The IC's use +5 V and -5 V and produce a fine square wave of desired frequency. The Voltage can be adjusted using a trimpot. The square wave is then trimmed by FET, PnP and NpN transistor. Then the Frequency is adjusted by varying the trimpot. The voltage and frequency is adjusted to 2khz 2 V which is fed to LVDT as an excitation voltage.

4. SIGNAL CONDITIONER

The circuit which processes the output of transducers and presents a fixed DC voltage to the display constitute the Demodulator and amplifier. Demodulator is a phase sensitive detector and AC amplifier which gives out DC voltage which is amplified and fed to summing amplifiers. The output of the summing amplifier is fad to the display.

****

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SPECIFICATION

INDICATOR

* DISPLAY : $3^1/_2$ digit seven segment red LED display of range 200mV for full scale deflection. to read $^+/-$ 1999 counts.

* EXCITATION VOLTAGE : 1000 Hz at 1V

* OPERATING TEMPERATURE : $+10^0$ C to 55^0 C

* ZERO ADJUSTMENT : Front panel through Potentiometer.

* SENSITIVITY : 0.1mm

* SYSTEM INACCURACY : 1%

* REPEATABILITY : 1%

* CONNECTION : Through 6 core shielded cable with Din connector.

* FUSE : 250mA fast glow type.

* POWER : 230 V +/- 10 %, 50 Hz.

SENSOR

* RANGE : +/- 10.0 mm

* EXCITATION VOLTAGE :1 to 4 kHz at 1 to 4V

* LINEARITY : 1%

* OPERATING TEMPERATURE : $+10^0$ C to 55^0 C

* CONNECTION : Through 6 core shielded cable provided along with the sensor of 2M length.

* CALIBRATION JIG : Micrometer of 0 to 25mm length is mounted on the base.

****

........7

PANEL DETAILS

DISPLAY : $3^{1}/_{2}$ Digit LED display of 200mV FSD to read upto “$^{+}$/- 1999” counts.

ZERO : Single turn potentiometer to adjust “000” when the sensor is connected.

CAL : Single turn potentiometer to adjust the calibration point.

CIRCUITRY : Block diagram of the circuit for displacement indicator. The diagram also shows LVDT block diagram also.

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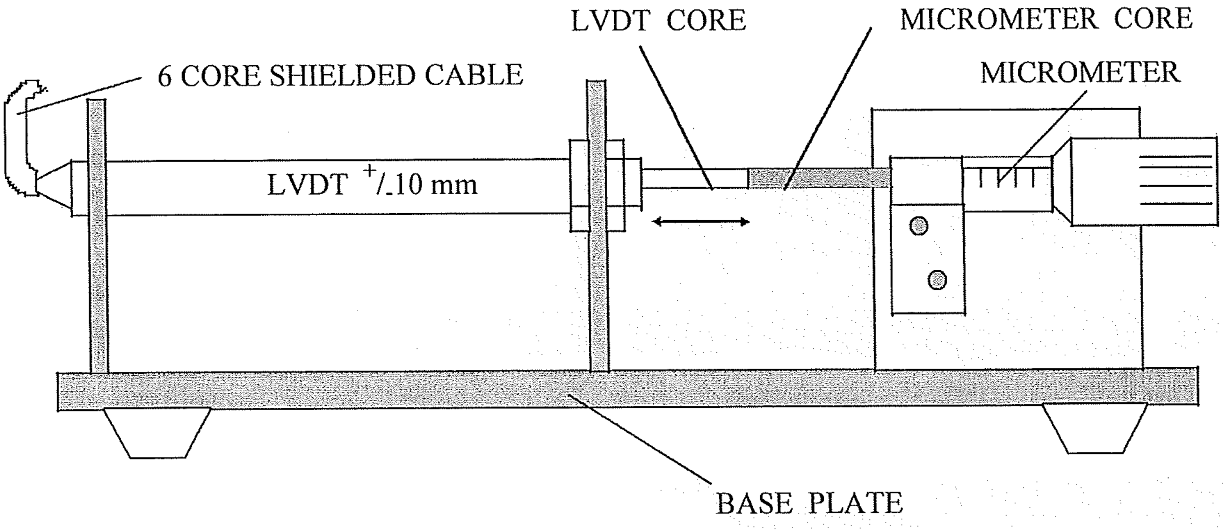
L V D T WITH CALIBRATION JIG



MOUNTING OF L V D T ON THE CALIBRATION JIG

L V D T has to be mounted perfectly on the calibration Jig. Micrometer should be moved till the micrometer reads 20.0 mm. LVDT should be mounted too the center plate by the two nuts provided. The core of the LVDT should be aligned with the core of the micrometer. Adjust the core of the LVDT till it touches the micrometer core and tighten the nut.

..........9

CONNECTION DETAILS

CONNECTING INSTRUMENT TO MAINS

3 Pin power chord is provided, attached to the instrument. Connect the 3pin plug to 230V 50Hz. socket.

Before connecting ensure that the power On switch is in OFF position.

SENSOR CONNECTION

6 core shielded cable is connected to the LVDT with male connectors of different colors are fixed to each wire. Connect the male pins to the socket matching the color correctly.

*****

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OPERATING PROCEDURE

1 Connect the power supply chord at the rear panel to the 230V 50Hz supply. Switch on the instrument by pressing down the toggle switch. The display glows to indicate the instrument is ON.

2 Allow the instrument in ON position for 10 minutes for initial warm-up.

3. Rotate the micrometer till it reads "20.0"

3 Adjust the CAL potentiometer at the front panel so that the display reads "10.0"

4 Rotate the core of micrometer till the micrometer reads "10.0" and adjust the ZERO potentiometer till the display reads "00.0"

5 Rotate back the micrometer core upto 20.0 and adjust once again CAL Potentiometer till the display read 10.0. Now the instrument is calibrated for +/-10.0mm range. As the core of LVDT moves the display reads the displacement in mm.

6. Rotate the core of the micrometer in steps of 1 or 2 mm and tabulate the readings. The micrometer will show the exact displacement given to the LVDT core the display will read the displacement sensed by the LVDT. Tabulate the readings and Plot the graph Actual V/s indicator reading.

****

EXPERIMENT & TABULAR COLUMN

Measurement of displacement through LVDT is well accepted method in process control instrumentation. In measurement Repeatability, Linearity, Accuracy are important factors. So the experiment to test the LVDT for all these factors.

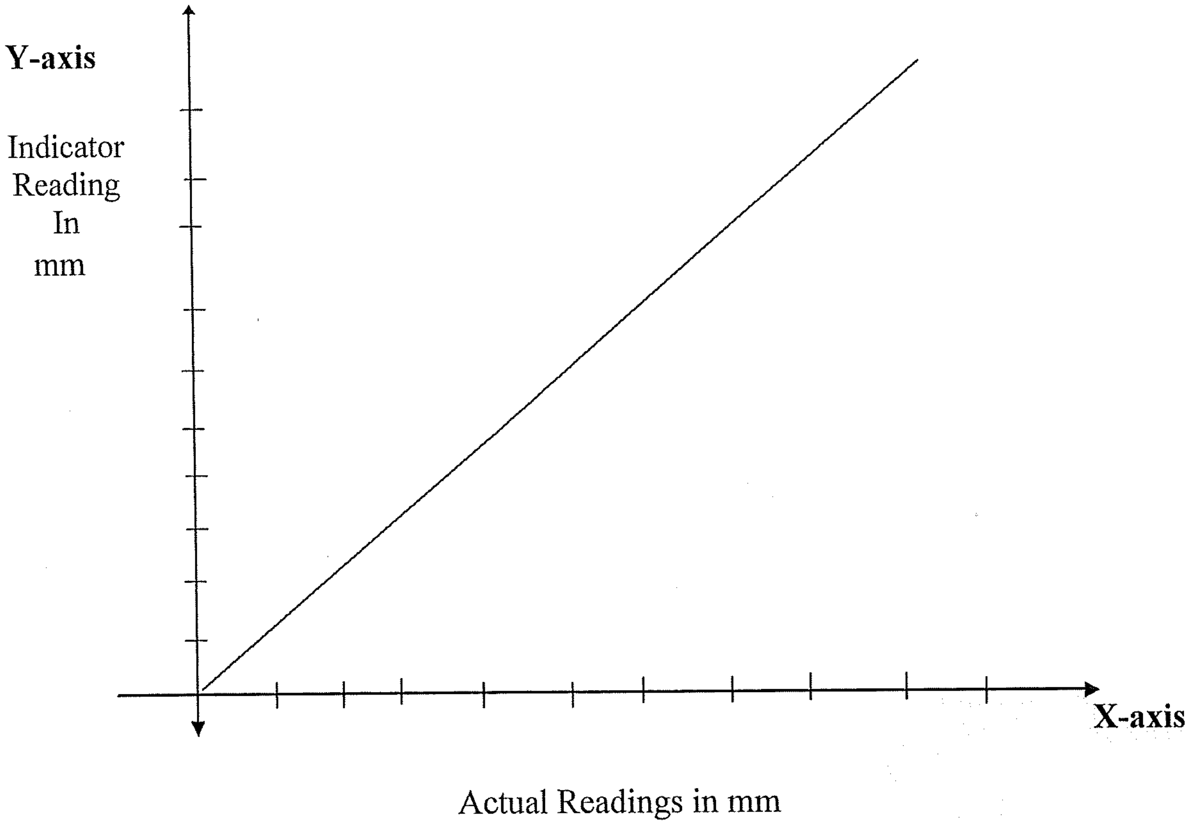
EXPERIMENT is the Known displacement is given to the LVDT core through micrometer and the displacement sensed by the micrometer can be noted down. Graph of Micrometer reading versus LVDT reading can be Plotted. Accuracy and the linearity of the LVDT can be calculated by the graphs. Repeatability can be calculated by repeating the experiment 3 to 4 times and tabulating the readings both for ascending and descending of displacement.

SAMPLE READINGS:

A SL. No.	B ACTUAL MICROMETER READINGS (MM)	C INDICATOR READINGS LVDT (MM)	D ERROR B-C	E % ERROR
01	0	-10.1	+0.01	1
02	2	-08.0	00.0	----
03	4	-06.0	00.0	----
04	6	-04.0	00.0	-----
05	8	-02.0	00.0	----
06	10	00.0	00.0	----
07	12	+02.0	00.0	----
08	14	+04.0	00.0	----
09	16	+06.0	00.0	---
10	18	+08.0	00.0	----
11	20	+10.0	00.0	---

Graph:

Graph Plotted Actual Micrometer Readings (X-axis) Vs Indicator Readings (Y-axis)



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IX

CALIBRATION OF LPF WATTMETER BY PHANTOM TESTING

CALIBRATION OF LPF WATTMETER - BY PHANTOM TESTING

Aim:

To Calibrate a given LPF Wattmeter by phantom testing Method.

Apparatus Required:

Sl. No.	Name of the Equipment	Range	Type	Quantity
01	Auto Transformer	230/(0-270)V, (0-5)A	1- Φ	02
02	L.P.F. Wattmeter	(150/300/600)V (2.5/5)A	Dynamometer Type	01
03	Voltmeter	(0-300)V	MI	01
04	Ammeter	(0-5)A	MI	01
05	Inductive Load	0-150mH, 5A	1- Φ	01
06	Connecting Wires	------	------	As required

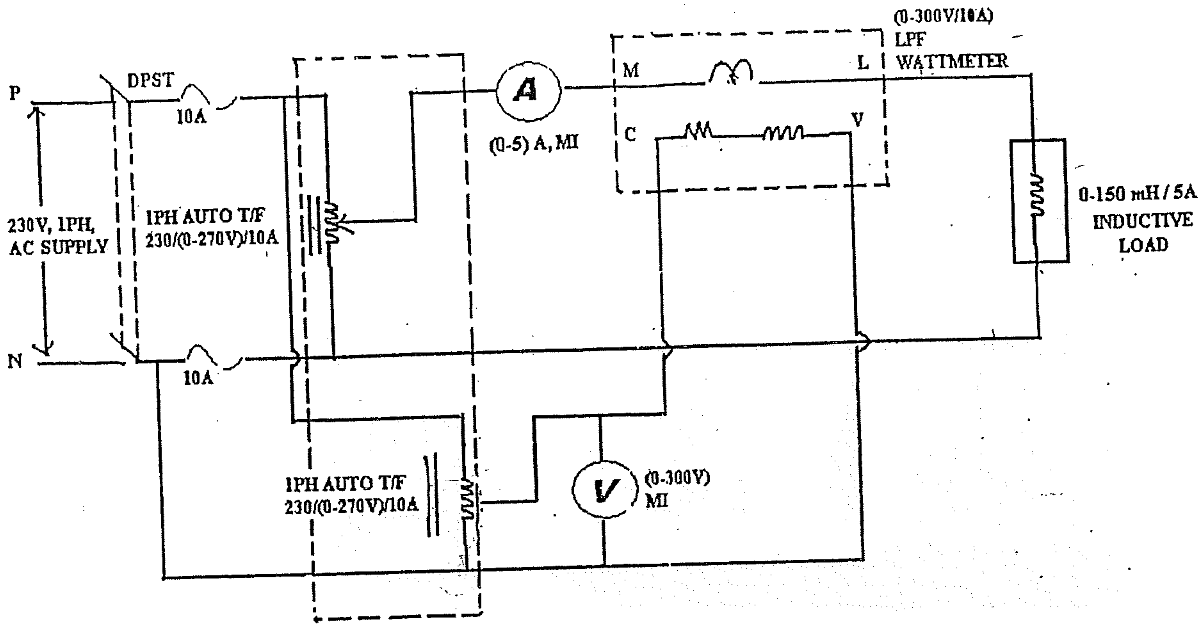
Theory:

Measurement of power in circuits having low power factor by ordinary electro dynamometer wattmeters is difficult and inaccurate because

1. The deflecting torque on the moving systems is small even when the current and pressure coils and fully excited.
2. Errors introduced because of inductance of pressure coil tend to be large at low power factors, special features are incorporated in an electro dynamometer wattmeter to make it a low power factor type of wattmeter. These features are discussed in detail below.
   (a) Compensation for pressure coil current.
   (b) Compensation for Inductance of pressure coil.
   (c) Small control torque.
   (d) Pressure coil current.

Thus from the advantages of low power factor wattmeters it is calibrated using Phantom loading.

Circuit Diagram:



Procedure:

1. Connections are made as per circuit diagram.
2. Kept the Auto Transformer (1 & 2) in minimum position.
3. The Auto Transformer 2 is varied in pressure circuit the voltmeter reading is adjusted to rated value i.e 150V.
4. Slowly the Auto Transformer 1 is varied in current coil circuit the Ammeter reading is adjusted at different valued in steps from 0-5Amps.
5. The experiment is repeated for different values of current at constant voltage.
6. After noting the values slowly decrease the auto transformers till Ammeter and Voltmeter comes to zero position and switch off the supply.

Precautions:

1. There should not be any loose connections.
2. Meter readings should not be exceeded beyond their ratings.
3. Readings of the meters must be taking without parallax error.
4. Ensure that setting of the Auto Transformer at zero output voltage during starting.

Theoretical Calculations

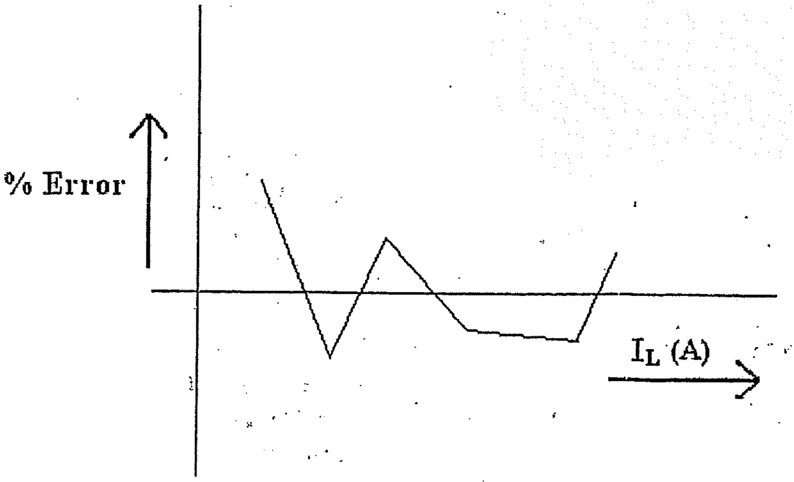
$$\% \text{ Error} = \frac{\text{Wattmeter Reading} - \text{Actual Power}}{\text{Actual Power}} \times 100$$

Observation Table;

Sl. No.	Voltage V{Volts}	Load Current I_L {Amps}	Wattmeter {Watts)	True Power (Wt) = VI Cosϕ	%Error
	150	1A	7.6		
	150	2A	11.1		
	150	3A	13.6		
	150 150	1.5A 2.5A	9.2 12.0		

Model Graph:

A graph is drawn between % Error and Load Current



X

MEASUREMENT OF 3PHASE ACTIVE POWER BY ONE WATTMETER METHOD AND 2 NO'S OF C.T

EXPERIMENT - 7

MEASUREMENT OF 3 - PHASE POWER BY USING 1-PHASE WATTMETER AND TWO CURRENT TRANSFORMERS

7.1 AIM:

To measure 3- phase power by using 1- phase wattmeter and two Current Transformers (CTs)

7.2 APPARATUS:

S. No.	Equipment	Range	Type	Quantity
1.	Wattmeter	UPF	600V,10A	1
2.	Current Transformers (CTs)	-	20/5A	2
3.	Voltmeter	0-600V	MI	1
4.	Ammeter	0-10A	MI	1
5.	Resistive Load	-	3-Ph, 415V, L load	1
6.	Connecting wires	-	-	Sufficient

7.3 CIRCUIT DIAGRAM:

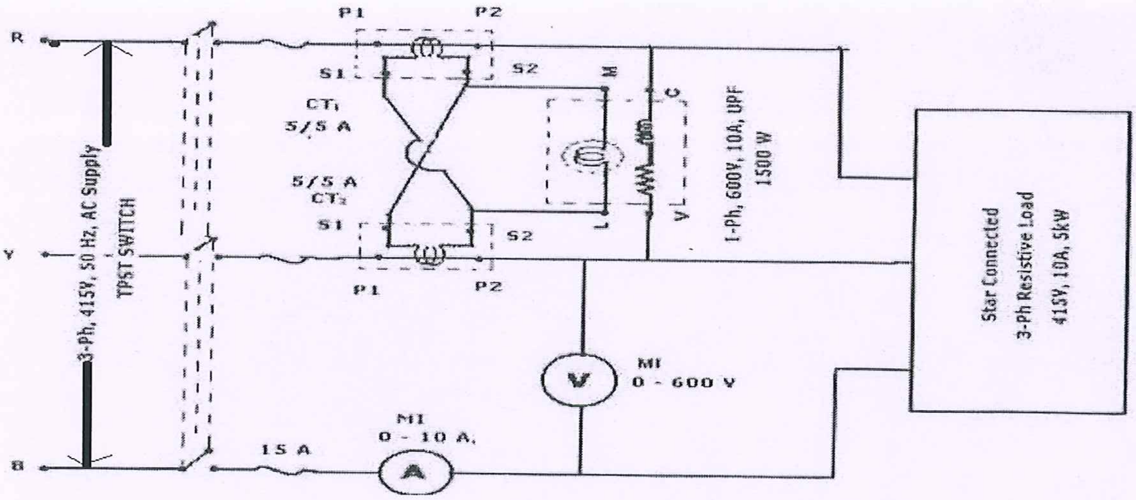


Fig - 1

7.4 PROCEDURE

1. Connections are given as per the circuit diagram.
2. Supply is switched on.
3. Apply the different inductive loads
4. The meter readings are noted as per table given.

7.5 TABULAR COLUMN

S.No.	Load (A)	Wattmeter Reading (W_L)	Ammeter Reading (I_L)	Voltmeter Reading (V_L)	Power Consumed by Load (P_L)	% Error
1						
2						
3						
4						
5						

7.6 MODEL CALCULATION

7.7 RESULT

Hence the power in 3-phase circuit is measured by using 1-phase wattmeter and two CTs and error in meter is found.

7.8 PRE LAB VIVA QUESTIONS

1. What is electrodynamometer type wattmeter?
2. What is meant by balanced load?
3. What is meant by unbalanced load?
4. What is instrument transformer?
5. Why instrument transformers are used?
6. What is meant by term "burden "of an instrument transformer?
7. What is meant by testing of instrument transformers?
8. What are the different testing methods for a current transformer?
9. Why the secondary of a CT should not be kept open?
10. Where a current transformer is standardized?

7.9 POST LAB VIVA QUESTIONS

1. What is the difference between current and potential transformers?
2. How to reduce the losses that occur in the instrumental transformers?
3. What are the precautions to be followed while doing the experiment?

XI

RESISTANCE
STRAIN GAUGE

INTRODUCTION

The primary object of the **INSTRUMENTATION TRAINER** is to introduce and to educate electronic instrumentation systems in a manner sufficiently complete that the students will acquire proper knowledge and the idea about the transducers and their applications to measure mechanical and terminal quantities. The mechanical quantities include strain, force, pressure, torque, displacement, acceleration, frequency, etc. The terminal quantities include temperature and heat flux.

It is understood that the students will have a conceptual understanding of these quantities through exposure of mechanics or physics courses, such as static's, dynamics, and strength of materials or thermodynamics. The student's experience in actually measuring these quantities by conducting experiments, however, will usually be quit limited. It is an objective of this tutor to introduce methods commonly employed in such measurements and the usage of such electrical components such as capacitance, resistance, inductance, intensity, etc.

Emphasis in the instrumentation trainer will be directed toward electronic instrumentation systems rather than mechanical systems. In most cases electronic systems provide better data more accurately and completely characterize the design or process being experimentally evaluated. Also, the electronic system provides an electrical out put signal that can be used for automatic data reduction or for the control of the process. These advantage of the electronic measurement system over the mechanical measurement system have initiated and sustained trend in instrumentation toward electronic methods.

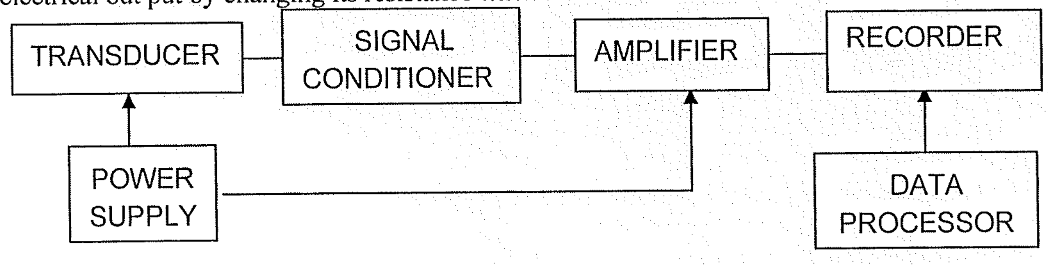
An attempt is made through these "Instrumentation trainer" to make as easy as possible for the students to learn about the electronic instrumentation system and various transducers used for the measurement of mechanical component. The instrumentation tutor panels are design in such a way that the block diagrams of the stages of electronic instrumentation system are clearly pictured on them. This makes the instrumentation tutor self-explanatory and also the best teaching aid for Engineering students.

Since the instrumentation tutors are not instruments as a whole the accuracy of the measurement cannot be claimed. It is very clear that the instrumentation tutor are only for demonstration purpose and cannot be used for any external measurement other than conducting experiments.

THE ELECTRONIC INSTRUMENTATION SYSTEM.

The complete electronic instrumentation system usually contains six sub systems or elements.

The **TRANSDUCER** is a devise that convert a change in the mechanical or thermal quantity being measured into a change of an electrical quantity. Example strain gauges bonded in to an specimen, gives out electrical out put by changing its resistance when material is strained.



The **POWER SUPPLY** provides the energy to drive the Transducers, example differential transformer, which is a transducer used to measure displacement requires an AC voltage supply to excite the coil.

SIGNAL CONDITIONERS are electronic circuits that convert, compensate, or manipulate the out put from in to a more usable electronic quantity. Example the whetstone bridge used in the strain transducer converts the change in resistance AR to a change in the resistance AE

AMPLIFIERS are required in the system when the voltage out put from the transducer signal conditioner combination is small. Amplifiers with gains of 10 to 1000 are used to increase their signals to levels where they are compatible with the voltage - measuring devices.

RECORDERS are voltage measuring devices that are used to display the measurement in a form that can be read and interpreted. Digital/Analog voltmeters are often used to measure static voltages.

DATA PROCESSORS are used to convert the out put signals from the instrument system into data that can be easily interpreted by the Engineer . Data processors are usually employed where large amount of data are being collected and manual reduction of these data would be too time consuming and costly.

THE INSTRUMENT

UNIQUE Digital Strain measuring setup comprises of Strain Indicator and Cantilever Beam setup. Strain Indicator is a strain gauge signal conditioner and amplifier used to measure strain due to load applied on the cantilever beam. The strain gauge are bonded on the cantilever beam and are connected in the form of whetstones bridge. A pan and weights upto lKg is provided to load the cantilever beam. Uniques Strain measuring setup is a complete system which can be used to conduct measurement on strain using strain gauges. The strain indicator is provided with zero balancing facility through adjustable potentiometer. Digital display will enable to take error free readings.

The digital indicator comprises of four parts.

1. Power Supply 2. Signal conditioning 3. Amplifier 4. Analog and digital converter.

The inbuilt regulated power supply used will provide sufficient power to electronic parts and also excitation voltage to the strain gauge bridge transducers. The signal conditioners Buffers the output signals of the transducers. Amplifier will amplifies the buffered output signal to the required level where it is calibrated to required unit. Analog to digital converter will convert the calibrated analog out put to digital signals and display through LED's.

THEORY BEHIND IT

When a material is subjected to any external load, there will be small change in the mechanical properties of the material. The mechanical property may be, change in the thickness of the material or change in the length depending on the nature of load applied to the material. This change in mechanical properties will remain till the load is released. The change in the property is called strain in the material or the material get strained. So the material is mechanically strained, this strain is defined as ' The ratio between change in the mechanical property to the original property'. Suppose a beam of length L is subjected to a tensile load of P Kg the material gets elongated by a length of □l So according to the definition strain S is given by

$$S = \square l / L \qquad \text{.....Eq1}$$

Since the change in the length of the material is very small it is difficult to measure □l. So the strain is always read in terms of microstrain. Since it is difficult to measure the length Resistance strain gauges are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesives. As the material get strained due to load applied, the resistance of the strain gauge changes proportional to the load applied. This change in resistance is used to convert mechanical property in to electrical signal which can be easily measured and stored for analysis.

The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge. The sensitivity of strain gauges is usually expressed in terms of a gauge factor Sg where Sg is given as

$$\Delta R / R = Sg \qquad \text{....... Eq 2}$$

Where □ is Strain in the direction of the gauge length.

The output □R / R of a strain gauge is usually converter in to voltage signal with a Whetstones bridge, If a single gauge is used in one arm of whetstones bridge and equal but fixed resistors is used in the other arms, the output voltage is

$$Eo = Ei / 4 \, (\square Rg/Rg) \qquad \text{.... Eq3}$$

Substituting Eq 2 into Eq 3 gives

$$Eo = 1/4 \, (Ei \; Sg \; \square)$$

....Eq 4

The input voltage is controlled by the gauge size (the power it can dissipate) and the initial resistance of the gauge. As a result, the output voltage Eo usually ranges between 1 to 10 □V / microunits of strain.

SPECIFICATION

DISPLAY RANGE : 31/2 digit RED LED display of 200 mV FSD to read up to +/-1999 microstrain
GAUGE FACTOR SETTING : 2.1
BALANCE : Potentiometer to set zero on the panel.
BRIDGE EXCITATION : 10VDC
BRIDGE CONFIGURATIONS : Full bridge.
MAX. LOAD : lKg.
POWER : 230 V +/- 10% at 50Hz. with perfect grounding.

All specifications nominal or typical at 23° C unless noted.

CANTILEVER BEAM SPECIFICATION

MATERIAL : Stainless Steel

BEAM THICKNESS (t) : 0.25 Cm.

BEAM WIDTH (b) : 2.8 Cms.

BEAM LENGTH (Actual) : 22 Cms.

YOUNGS MODULUS (s) : 2×10^6 Kg / cm^2

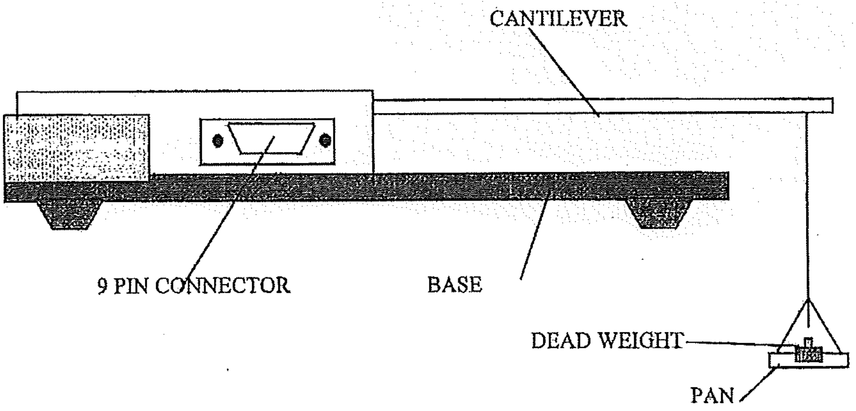
STRAIN GAUGE : Foil type gauge

GAUGE LENGTH (1) : 5 mm

GAUGE RESISTANCE (R) : 300 Ohms.

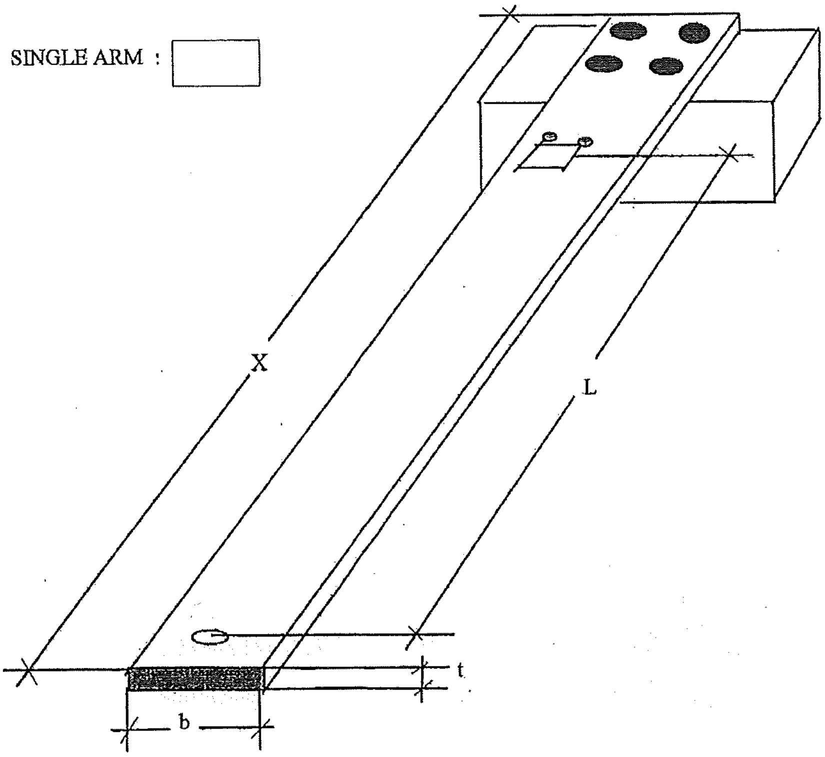
GAUGE FACTOR (g) : 2.01

CANTILEVER BEAM SETUP



PHYSICAL DIMENSION OF THE CANTILEVER BEAM

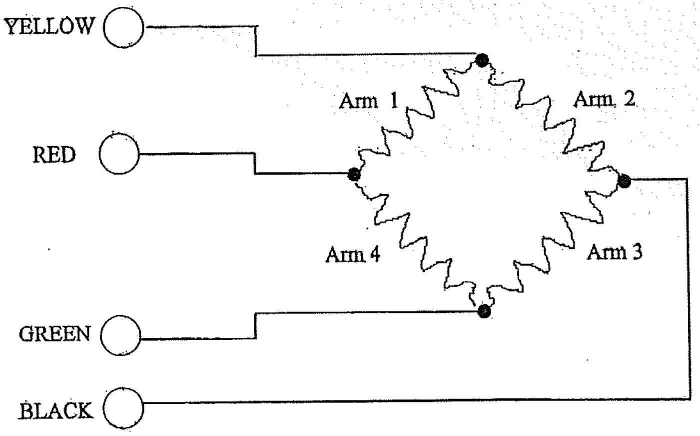
A. SINGLE ARM : ☐



PHYSICAL DIMENSIONS

Over all BEAM Length (X) : 300 mm
Actual Length (L) : 220.0 mm (Middle of the Strain Gauge Grid to loading point)
Width of the Beam (b) : 28.0 mm
Thickness of the Beam (t) : 2.5 mm

CONNECTION DETAILS



OPERATING PROCEDURE

- Check connection made and Switch ON the instrument by toggle switch at the back of the box. The display glows to indicate the instrument is ON.
- Allow the instrument in ON Position for 10 minuets for initial warm-up.
- Adjust the ZERO Potentiometer on the panel till the display reads '000'.
- Apply 1 Kg load on the cantilever beam and adjust the CAL potentiometer till the display reads 377 micro strain, (as per calculations given below) Remove the weights the display should come to ZERO incase of any variation adjust the ZERO pot again and repeat the procedure again. Now the Instrument is calibrated to read micro-strain.
- Apply load on the sensor using the loading arrangement provided in steps of 100g upto 1Kg.
- The instrument displays exact microstrain strained by the cantilever beam
- Note down the readings in the tabular column. Percentage error in the readings, Hysteresis and Accuracy of the instrument can be calculated by comparing with the theoretical values.

Specimen calculation for cantilever beam

$$\boxed{S = (6\ P\ L) / BT^2E}$$

P = Load applied in Kg. (1 Kg)
L = Effective length of the beam in Cms. (22 Cms)
B = Width of the beam (2.8 Cms)
T = Thickness of the beam (0.25Cm)
E = Youngs modulus ($2 \text{ X } 10^6$)
S = Microstrain

hen the microstrain for the above can be calculated as fallows

$$S = \frac{6 \text{ X } 1 \text{X} 22}{2.8 \text{ X } 0.25^2 \text{ X } (2 \text{ X } 10^6)}$$

$$S = 3.77 \text{ X } 10^{''4}$$

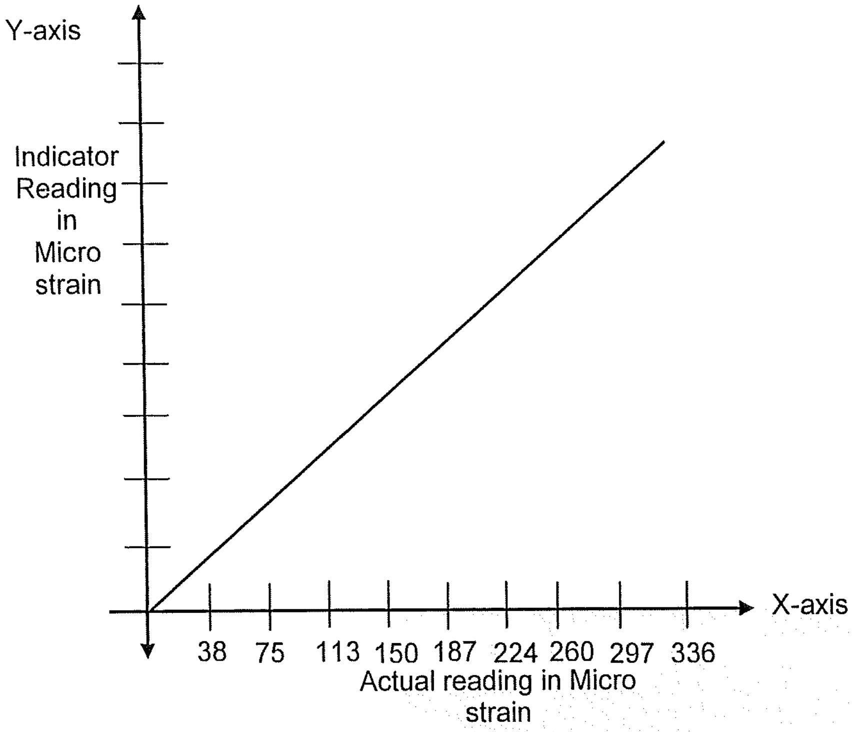
S = 377 microstrain.

Sample Readings:

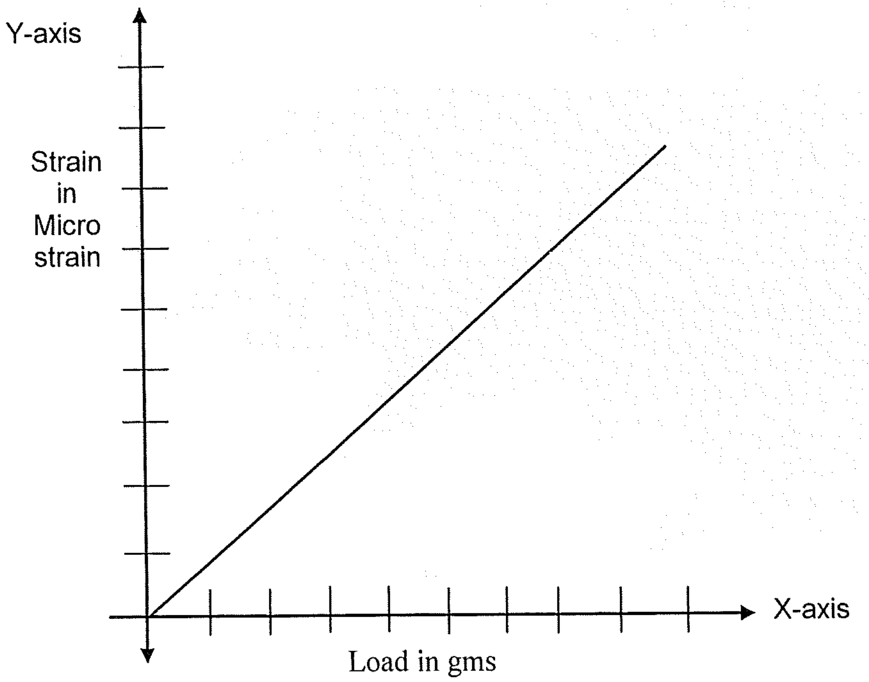
A SL. No.	B Weight (inGrams)	c Actual readings (using formulae) $S = (6\ P\ L) / BT^2E$(in micro strains)	D Indicator readings (in micro strains)	E ERROR in 0/ /o
01	100			
02	200			
03	300			
04	400			
05	500			
06	600			
07	700			
08	800			
09	900			
10	1000			

$$\% \text{ ERROR} = \frac{[(\text{Actual Reading (C) - Indicator Readings f (D)}] \text{ x } 100}{\text{Max. Weight in gms}}$$

Graph : **Graph Plotted Actual Readings (X-axis) Vs Indicator Readings (Y-axis)**



Load Vs Strain



XII

MEASUREMENT OF PARAMETERS OF A CHOKE COIL USING 3 VOLTMETERS AND 3 AMMETERS

Date:

Measurement of parameters of Chokecoil

Aim: To measure resistance and inductance of a given choke coil using

(i) 3 Ammeters method

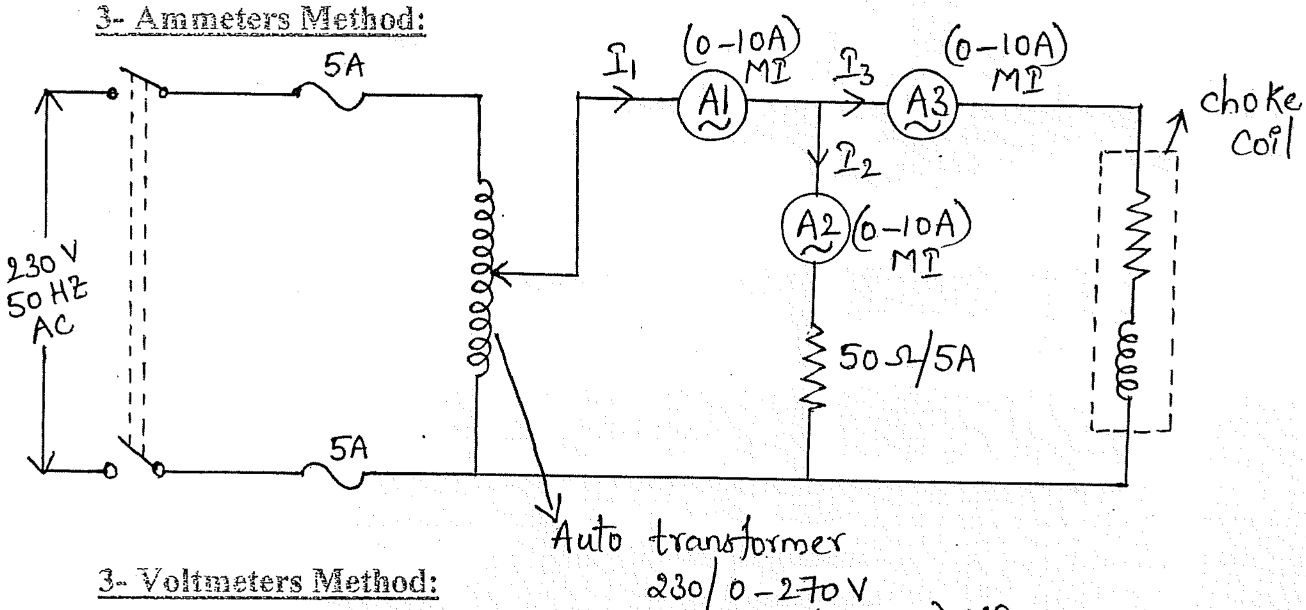
(ii) 3 Voltmeters method

Apparatus:

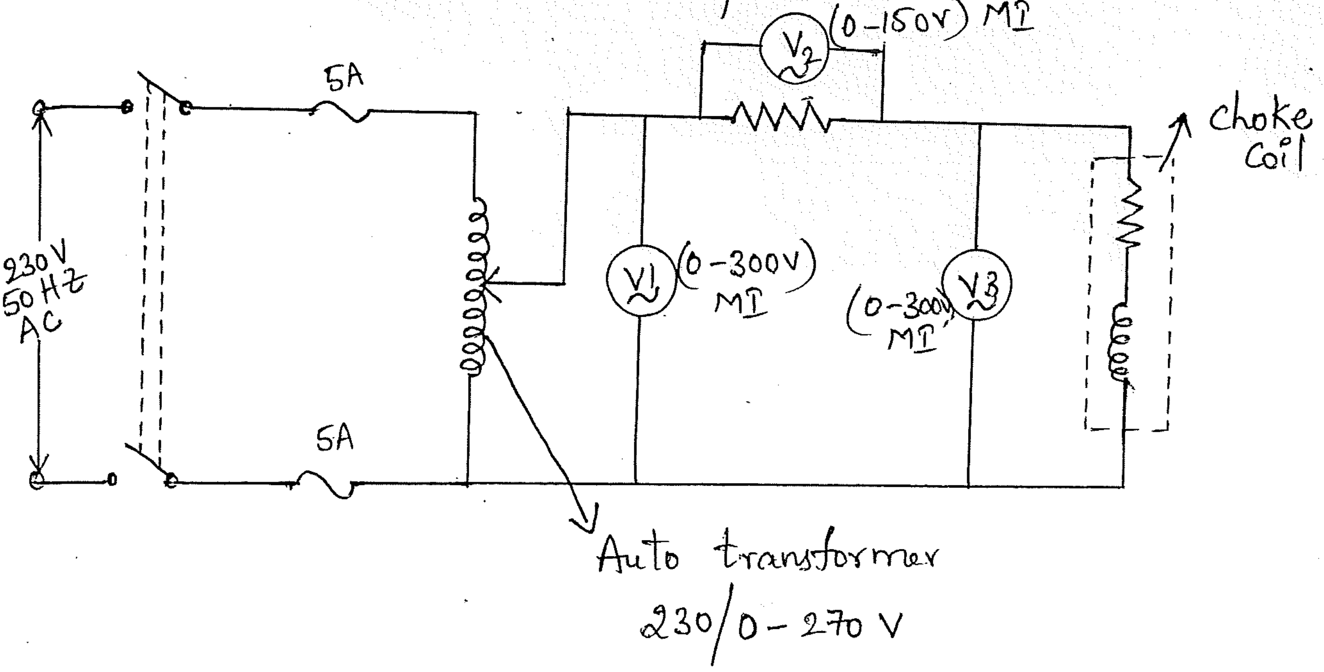
Auto Transformer 230V/0-270V ----- 1 No
Ammeters 0-10A(MI) ------------------ 1 No
0-5A (MI) ------------------- 2 No's
Voltmeters 0-300V ---------------------- 3 No's
Choke coil 230V, 5A, 0.8 p.f ---------- 1 No

Circuit Diagram:

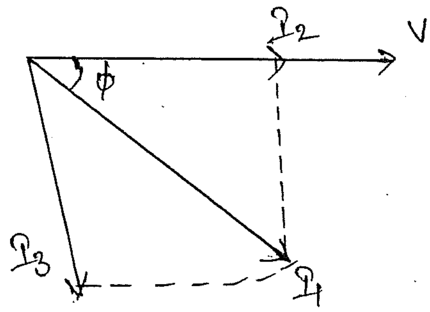
3- Ammeters Method:



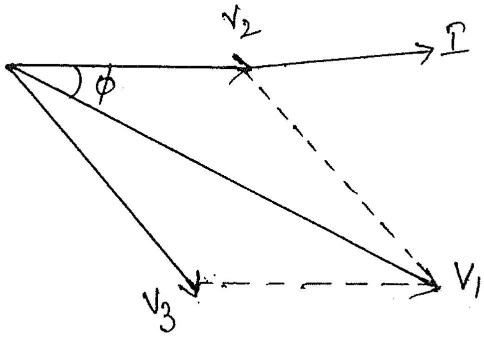
3- Voltmeters Method:



Phasor Diagrams:



3- Ammeters Method



3- Voltmeters Method

This method is also used for measurement of power (without wattmeter) and power factor.

Procedure:

(a) 3 - Ammeters Method:

1. Make the connections as shown in the figure.
2. Keep the Auto transformer at minimum output position.
3. Gradually varying auto transformer vary the current in choke coil. And note down the current reading of other ammeters.
4. Repeat the test till choke coil ammeter reads it rated current value.
5. Tabulate the results.
6. Care must be taken that A_2 & A_3 should not more than 5A during the experiment.

(b) 3- Voltmeters Method:

1. Make the connections as shown in figure.
2. Keep the Auto transformer at minimum output position.
3. Gradually increase the output voltage and note down the readings on voltmeters.
4. Repeat the test for different values of output voltage (V_3) till rated value (230V).
5. Tabulate the results.

Observation Table:

3- Ammeter method:

S No	I_1 (A)	I_2 (A)	I_3 (A)	P_i (W)	Cos Φ	r (Ω)	L (H)

3 - Voltmeter method:

S No	V_1 (V)	V_2 (V)	V_3 (V)	P_i (W)	Cos Φ	r (Ω)	L (H)

Calculations:

(a) 3 - Ammeter method:

From phasor diagram(i)

$$I_1^2 = I_2^2 + I_3^2 + 2\, I_2\, I_3 .\ \mathrm{Cos}\ \Phi$$

$$I_3 .\ \mathrm{Cos}\ \Phi = \frac{I_1^2 - I_2^2 - I_3^2}{2\, I_2\, I_3}$$

But $I_2 = V/R$ & $\mathrm{Cos}\ \Phi = \frac{I_1^2 - I_2^2 - I_3^2}{2\, I_2\, I_3}$

Power in $= V.\ I_3\ \mathrm{Cos}\ \Phi$

Choke coil $= V.\dfrac{(I_1^2 - I_2^2 - I_3^2)}{2(V/R)}$ $= VI_3 \cos\phi$

$= R/2\,(I_1^2 - I_2^2 - I_3^2)$

$P_i = R/2\,(I_1^2 - I_2^2 - I_3^2)$

Let 'r' & 'L' be the resistance and inductance of choke coil then,

$P_i = V.\, I_3 \cos \Phi = I_3^2 .\, r$

$r = P_i / I_3^2$

$r = \dfrac{R}{2.\, I_3^2}(I_1^2 - I_2^2 - I_3^2)$

Impedance of the choke coil, $Z = \dfrac{V}{I_3}$

$$= \frac{I_2.\, R}{I_3}$$

$$Z = \frac{I_2.\, R}{I_3}$$

$X_L = Z^2 - r^2$

& Inductance of choke coil , L is given by

$$L = \frac{Z^2 - r^2}{2\pi f}$$

(b) 3 - Voltmeters Method:

From phasor diagram(ii)

$V_1^2 = V_2^2 + V_3^2 + 2V_2 V_3.\cos\Phi$

$\cos\Phi = \dfrac{V_1^2 - V_2^2 - V_3^2}{2\,V_2\,V_3}$ & $V_3 \cos\Phi = \dfrac{V_1^2 - V_2^2 - V_3^2}{2\,V_2}$

Power in choke coil,

$Pv = V_3\, I.\cos\Phi$

$Pv = \dfrac{V_1^2 - V_2^2 - V_3^2}{2R}$

Resistance of the choke coil

$r = V_3^2/P \quad = (2R.\ V_3^2) / (V_1^2 - V_2^2 - V_3^2)$

$Z = V_3/I \quad = V_3.\ R/V_2$

$X_L = Z^2 - r^2$

$$L = \frac{Z^2 - r^2}{2\prod f}$$

Result: