DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

Measurement Laboratory (EE2171) 3rd Semester EE students

Expt. No. 1.

"CALIBRATION OF SINGLE PHASE A.C. KWh/ENERGY METER"

Object : *a) to measure Energy by an a.c. house service meter at different resistive load.*

Procedure : Make connections as shown in figure 1 Switch on the supply and adjust voltage and current to rated values Note that the test meter runs freely in proper direction. Allow it to run for some time to warm up to operating condition.

Run-1 : Short time test on unity power factor load

With rated load current at unity power factor observe time T in seconds take for a certain number N of complete revolutions of the meter disc. The measured time interval, usually must correspond to three revolutions of the disc or not less than 100 sec. Whichever is larger period. But in any case full number of revolutions must be counted. The load must be kept constant during this period. Note the wattmeter reading 'W' in watts and the time taken for a certain number of revolutions. Calculate for error will be as follows :

Observed meter constant

$$K_0 = \frac{N}{\frac{W}{1000} \times \frac{T}{3600}} = \frac{36 \times 10^5 \times N}{W \times T} \text{ rev / kwH}$$

Percent error =

$$\frac{K_0 - K}{K} x100$$

Where k in rev./kWh. Is the nominal meter constant (given on the name plate of the test meter). Repeat the test for 50% and 10% of rated load. Record the results in **TABLE – 1**

Run-2 : Dial tests (Long duration)

Adjust at the 100% rated load at unity power factor. Take initial reading if the meter dials. With the load held constant, allow the meter to run for a relatively long time (at least 15 minutes) at the end of which note the final reading of the meter dials. Note the wattmeter reading during this test. Calculate as follows :

Observed Dial Advance (D_o) = Final reading (kWh) – initial reading (kWh)

Actual energy during test

$$D_T = \frac{W}{1000} \times \frac{T}{3600} = \frac{W \times T}{36 \times 10^5}$$

where "W" is in watts and "T" is in sec.

Percent error =

$$\frac{D_O - D_T}{D_T} \times 100$$

Run-3 : Creep test

Disconnect the load, keep the potential coil circuit of the energy meter excited at rated voltage. If the meter disc rotates continuously for more than one revolution, creep is said to be present

Report :

1. Draw the circuit diagram of the apparatus actually used
2. List of the apparatus in tabular form
3. Enter test data of the various runs in table no 1 & 2
4. Show sample calculations for runs 1 & 2
5. Justify the necessity of each run
6. Why it is necessary to test the meter at other power factors (say at 0.5 lag)
7. If the creep is present in a meter who will be looser? The consumer or the supplier?

Ref. :

1. Indian Standards Specification for a.c. electricity meters IS - ...... parts (I) & (II)
2. Electrical Measurements and Measuring Instruments – Rajendra Prasad.
3. Electrical Measurement and Measuring Instruments – Golding & Widdis.

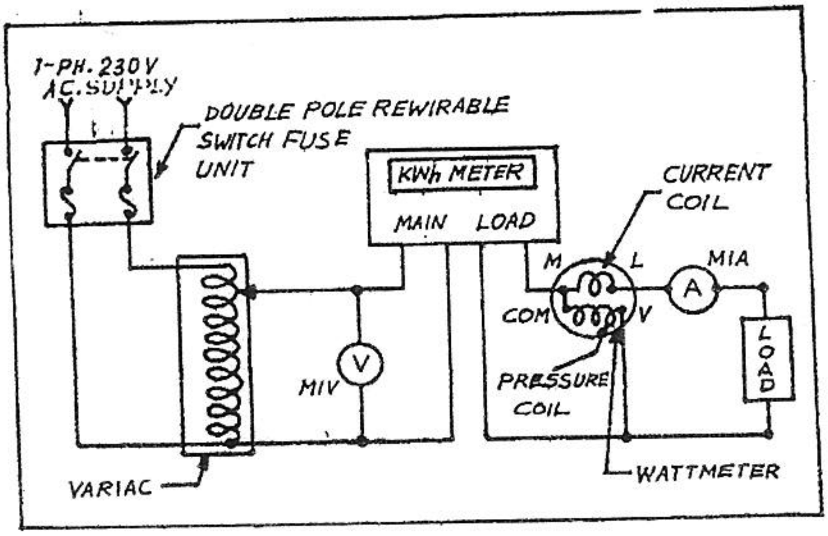

Fig 1 : Connection Diagram

DATA SHEET

"CALIBRATION OF SINGLE PHASE A.C. KWh/ENERGY METER"

Name : ______________________________ **Roll No. :** ___________

Date : ______________

Apparatus used :

Sl. No.	Item	Range	Maker's Name	Lab No.
1.				
2.				
3.				
4.				
5.				
6.				
7.				

TABLE – 1

Percentage Of rated Load	Wattmeter Readings In watts	No. of Revolutions 'R'	Time taken in 'R' Revolutions in 'T' Seconds	Observed Meter constant 'K_o'	Percentage error

TABLE – 2

Percentage Of rated load	Initial dial Readings In watt (kWh)	Final dial Reading (kWh)	Observed Dial reading (D_o) in kWh	Wattmeter Reading In watts	Time 'T' in sec.	Actual Energy (D_i)	Percentage Error

(Signature of the Teacher)

DEPARTMENT OF ELECTRICAL ENGINEERING
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Measurement Laboratory (EE2171) 3rd Semester EE students

Expt. No. 2

"EXTENSION OF INSTRUMENT RANGES USING C.T. AND P.T."

OBJECT : Connect instrument transformers along with ammeter, voltmeter and wattmeter as shown in fig. 1. Ensure that the C.T. secondary is connected across the current of the wattmeter. Switch on the supply with variac in minimum voltage position. Set the voltage at 230 volts and vary the load.

Record the readings in Table No. 1.

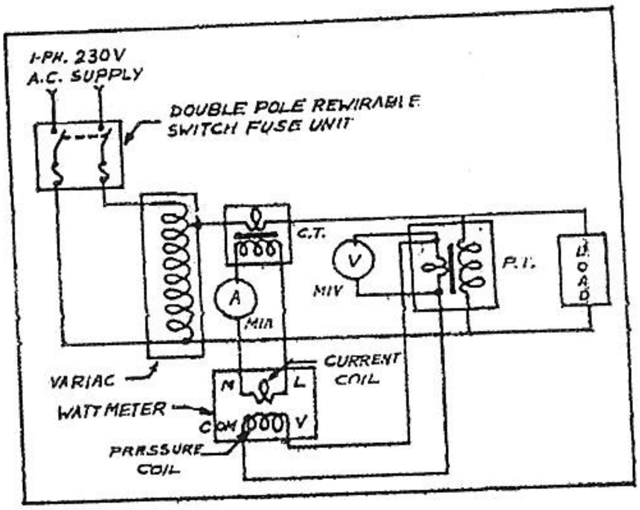

FIG. 1 : Connection Diagram

Report :

1. Apparatus used including range, maker's name. Lab.
2. Show the connections of the instrument transformers to extend wattmeters for the measurement of power in a three phase circuit.
3. Answer the following questions and submit this sheet along with your report.
4. Indicate whether the following statements are **TRUE** or **FALSE**
   a. C.T. can extend instrument range
   b. A high current (A.C.) can be measured by a low current range ammeter using C.T.
   c. Primary current of a C.T. is dependent on its secondary current

d. C.T. can electrically isolate the metering circuit from the main circuit.

e. Secondary of a measuring C.T. is practically short circuited by an ammeter.

f. A C.T. with a rating of 100/IC can be expressed as 10/1 by canceling the numerator and denominator.

g. A 100/10 C.T. and a 10/1 C.T. can carry maximum current of 1000 amps and 10 amps respectively through their primaries and the corresponding secondary currents will be 10 amps and 1 amp.

h. The primaries of a 100/10 and 10/1 C.T. are connected in sories and 10 amps is following through the primary windings. The secondary current in both the C.Ts. will be 1 amp.

i. The Secondary of a C.T. should never be open circuited.

j. 'Normal ratio' and 'actual ratio' of a C.T. are not same due to the presence of exciting current.

k. Shunt can extend the instrument range.

l. Shunt can electrically isolate the metering circuit from the main circuit like C.T.

m. P.T. is used to extend the range of a voltmeter & not ammeter.

n. A high voltage (A.C.) can be measured by a low range voltmeter using P.T.

o. P.T. can electrically isolate the measuring circuit from the main circuit.

p. Secondary of a measuring P.T. is practically short circuited like C.T.

q. Secondary voltage of a P.T. is dependent on primary voltage.

r. Potential divider can extend instrument range like P.T.

s. Potential divider can electrically isolate the measuring circuit from the main circuit.

t. If 100 volts a.c. is applied across the primaries of a 1000/100 and 100/10 P.T. the secondary voltage in both the cases will be 10 volts.

DATA SHEET

"EXTENSION OF INSTRUMENT RANGES USING C.T. AND P.T."

Name : ______________________________ **Roll No. :** __________

Date : ____________

Sl. No.	Apparatus	Range	Lab Number
1.	Ammeter		
2.	Voltmeter		
3.	Wattmeter		
4.	Current Transformer (C.T.)	C.T. Ratio ____________, VA ____, Class ______	
5.	Potential Transformer (P.T.)	C.T. Ratio ____________, VA ____, Class ______	
6.	Variae		
7.			

Experiment Data :

Sl. No.	Ammeter Reading In amps	C.T. Ratio	Circuit Current In Amps	Voltmeter Reading In Volts	P.T. ratio	Circuit Voltage In Volts	Wattmeter Reading In Volts	Multiplying Factor (MF) Of wattmeter	Actual Power Consumed By the Load in Watts

(Signature of the Teacher)

DEPARTMENT OF ELECTRICAL ENGINEERING
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Measurement Laboratory (EE2171) 3rd Semester EE students

Expt. No.**3**

Title Of Experiment : Kelvin Double Bridge

Object: To measure the unknown low value resistances using Kelvin Double Bridge.

Procedure: Procedure and connection diagrams are given in the **Instruction manual**.

SAMPLE DATA SHEET

Name :_______________________________ Roll No :_____________

Date :______________

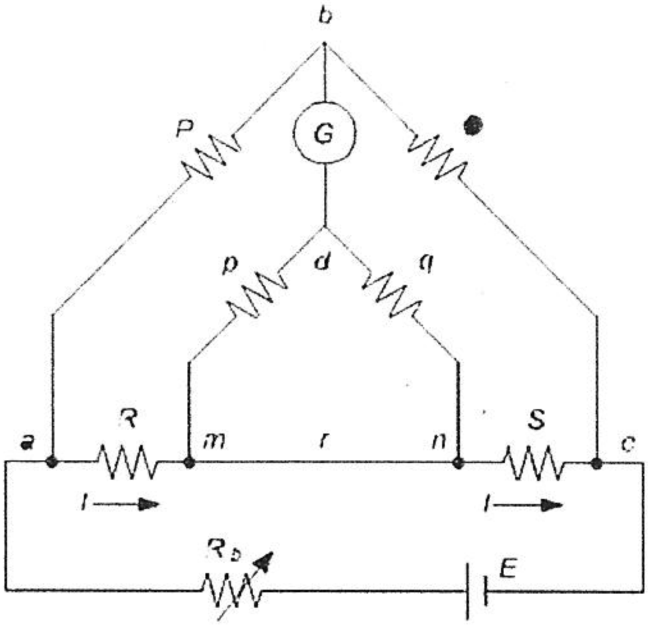
Apparatus used:

Sl. No	Item	Range	Maker's Name	Lab No

Results:

Sl. No	Sample material	Range Multiplier (m)	Value of S at balance			Value of unknown resistance ($R_X = M \times S$)	Temperature Of the sample
			At Normal current	At Reverse current	Mean		

(Signature of the teacher)



The kelvin double bridge incorporates the idea of a second set of ratio arms - hence the name double bridge- and the use of four terminal resistors for the low resistance arms. Fig.1. shows the schematic diagram of kelvin bridge. The first ratio arms is P and Q. The second set of ratio arms p and q is used to connect the galvanometer to a point d at the appropriate potential between points m and n to eliminate the effect of connecting lead resistance r between the unknown resistance R and the standard resistance S.

The ratio p/q is made equal to P/Q. Under balance conditions there is no current through the galvanometer which means that the voltage drop between a and b, E_{ab} is equal to voltage drops E_{amd} between a and c.

$$E_{ab} = \frac{P}{P+Q} E_{ac} \text{ and } E_{ac} = I\left[R + S + \frac{(p+q)r}{p+q+r}\right]$$

$$\text{,and } E_{amd} = I[R + \frac{p}{p+q}\left\{\frac{(p+q)r}{p+q+r}\right\}] = I[R + \frac{pr}{p+q+r}]$$

for zero galvanometer deflection, $E_{ab}=E_{amd}$

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

$$\text{or } R = \frac{P}{Q}S + \frac{qr}{p+q+r}[\frac{P}{Q} - \frac{p}{q}] \text{ - - - - - - - - - - - - } (1)$$

now if

$$\frac{P}{Q} = \frac{p}{q} \text{ Eq (1) becomes, } R = \frac{P}{Q}S \text{ - - - - - - - - - } (2)$$

Eq (2) is the usual working equation for the kelvin bridge. It indicates that the resistance of connecting lead, r, has no effect on the measurement, provided that the two sets of ratio arms have equal ratios.

OPERATING MANUAL

FOR

KELVIN BRIDGE

CAT.NO. PL39.

Manufactured by:

TOSHNIWAL INDUSTRIES PVT.LTD.,
INDUSTRIAL ESTATE,
MAKHUPURA,
AJMER - 305 002.

Tel: 0145-2695171, 2695205 Fax: 0145-2695174 Email: ajmer@tipl.com

1. THEORY OF OPERATION

Compare the simple circuit (Fig.1) with the comprehensive circuit of our instrument (Fig.2). It will be seen that :

2.1 The ratio arms MQ and mq have five ratio positions for range multiplication. (XO.01, XO.1, X1, X10,X100).

2.2 The left-hand ratio arms (M & m) connections are via contact wipers to the standard resistance "S" which takes the form of ten steps of 10 milli ohms in series with a 0-10 milli ohms.

2.3 The right-hand ratio arm (Q & q) connections are to terminals P & P which serve to connect the "x" resistance under test in conjunction with terminals C & C.

2.4 Links across terminals CP & C_1 P_1 are shown in a position for one type of "x" connection. Other types of connections are described in paragraph 4.5 below.

2.5 Terminals G_1,S & G_2 are for the connection of the external galvanometer null detector to the ratio arm apex, via the two balance keys, the use of which is described in greater detail in paragraph 5.4 and 5.5. below .

2.6 The external D.C. supply is connected to the terminal marked CURRENT INPUT and is switched into circuit via the three position current switch..

3. PANEL CONTROLS

3.1 Fig. 3 shows the layout of the panel controls etc.

3.2 The five position ratio arms (x0.01, x0.1, x1, x10, x100) are selected by the RANGE MULTIPLER switch mounted in the top right hand corner.

3.3 The MILLIOHMS decade (bottom left -hand corner) and the milliohms slide wire (central knob and circular scale) and the "S" section of the bridge in conjunction with the RANGE MULTIPLIER they indicate the resistance measure.

3.4 Terminals P & P_1 (middle bottom) are for connecting the resistance under test, with the links C, P & C_1, P_1 in position.

3.5 Terminals G_1 S and G_2 situated on the right -hand side are for connection of the external galvanometer (see paragraph 5.4 below). Fig. 4 and Fig.5 show different types of connection.

3.6 INITIAL and FINAL galvanometer keys are situated together at the bottom right hand corner.

3.7 Terminals marked CURRENT INPUT (left-hand side) are for connecting to an external d.c. supply (See paragraph 5.1)

3.8 The CURRENT SWITCH (top left-hand corner), serves to connect, disconnect or reverse the d.c. supply.

4. PRINCIPLE OF OPERATION

resistance required for critical damping. The following formula is given to determine the resistor values. The circuit arrangement is shown in Fig.4.

If R_g is the galvanometer coil resistance, R_d the external resistance to critically damp the galvanometer , and X the sensitivity reduction factor, thea.

$R_2 = XR_d$
$R_1 = R_d - R_2$
and R_S =

5.6 Recommend Galvanometer ,Cat.No. PL64 for moderate accuracy.

6. OPERATION

6.1 Ensure that the CURRENT SWITCH is off

6.2 Connect the current supply to the terminals marked CURRENT INPUT, in case of variable supply, set limiter to minimum current.

6.3 Connect galvanometer to bridge as shown in Fig.4 and Fig.5 whichever is required.

6.4 Checkzero of milliohm slide wire (circular scale).

6.4.1 Set milliohm decade switch to zero.

6.4.2 Connect terminals C to C_1 and P to P_1 with small thick wires.

6.4.3 Adjust current to desired value.

6.4.4 Set Range Multiplier to any value

6.4.5 Operate desired Galvanometer key and observe galvanometer and adjust milliohm slide wire to obtain a balance. The milliohm slide wire scale should read zero.

6.5 Connect the resistance under test to the bridge terminals C. C_1 and P. P_1 according to the methods outlined in paragraphs 7, 8 and 9, ensuring that all connections make goods contact. This is most important because dirty or insecure connections will result in unstable reading and inaccuracies.

6.6 Set CURRENT SWITCH to NORMAL and in case of variable supply, adjust the current to the required value.

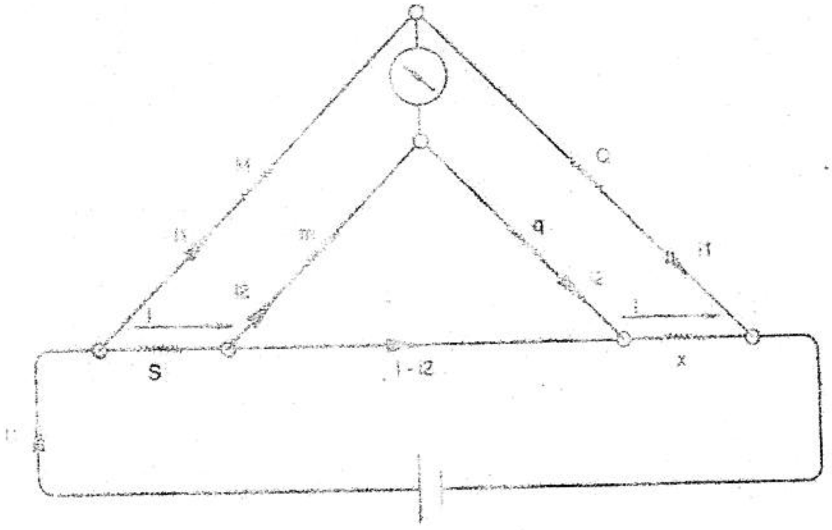
6.7. Set all externally operated galvanometer shunts (if in use) to a minimum sensitivity

6.8. Set the RANGE MULTIPLIER to "x100".

6.9.1 Operate Galvanometer keys by depressing the INITIAL KEY intermittently (if in use), otherwise depress the FINAL KEY intermittently.

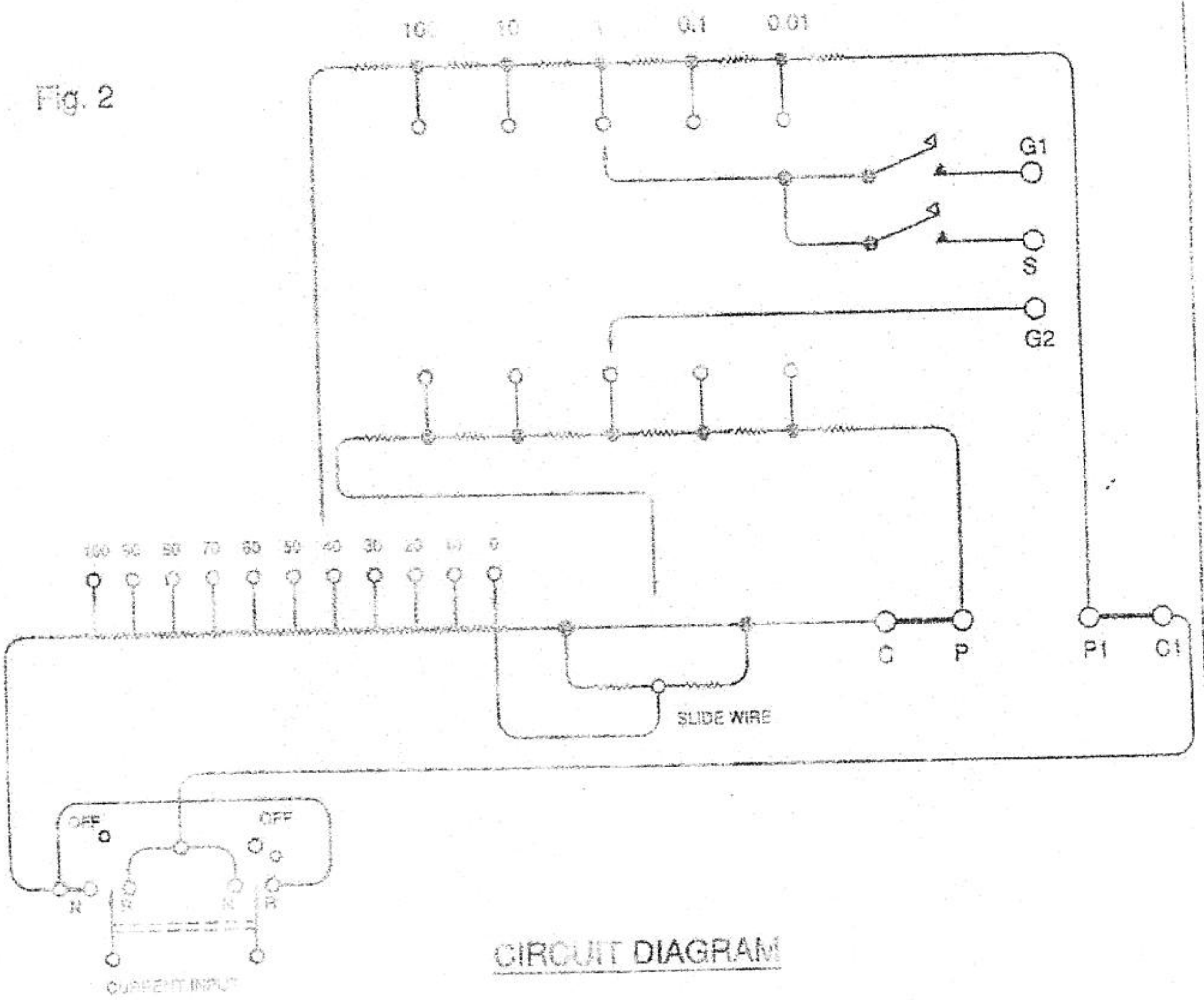
CIRCUIT DIAGRAM OF KELVIN BRIDGE

Fig. 1



PRINCIPLE OF OPERATION

Fig. 2



CIRCUIT DIAGRAM

DRN.	CHD.	APPD.		DRAWING NO.
MAHESH 8/10/2003	BM GUPTA	BM GUPTA	TOSHNIWAL INDUSTRIES PVT. LTD. AJMER-305 002	K 1 (4)

LAYOUT DIAGRAM OF KELVIN BRIDGE

TIPL

Fig. 3

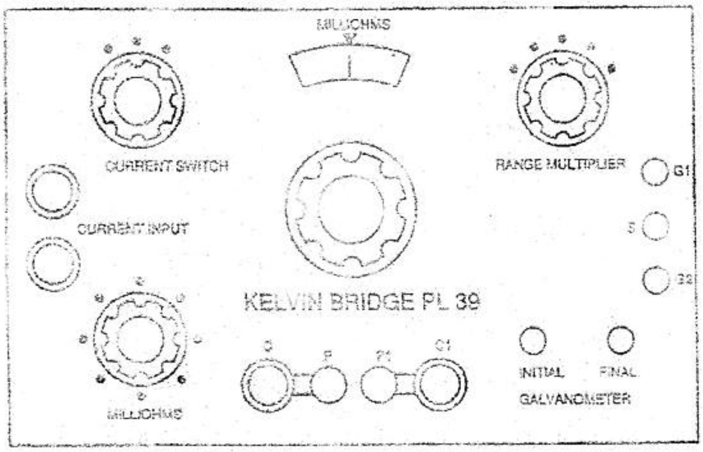


Fig. 4

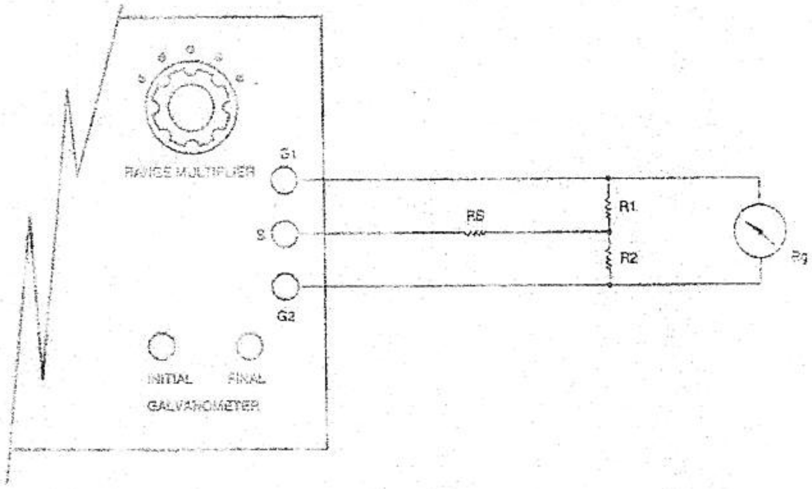
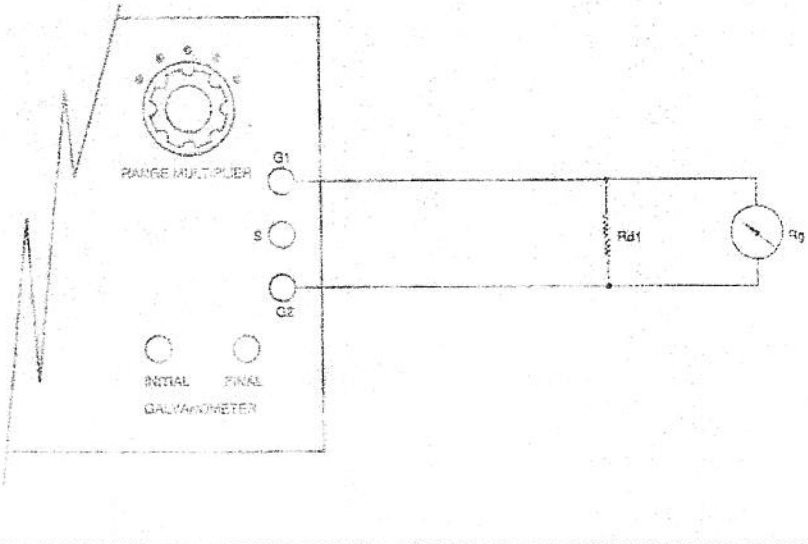


Fig. 5

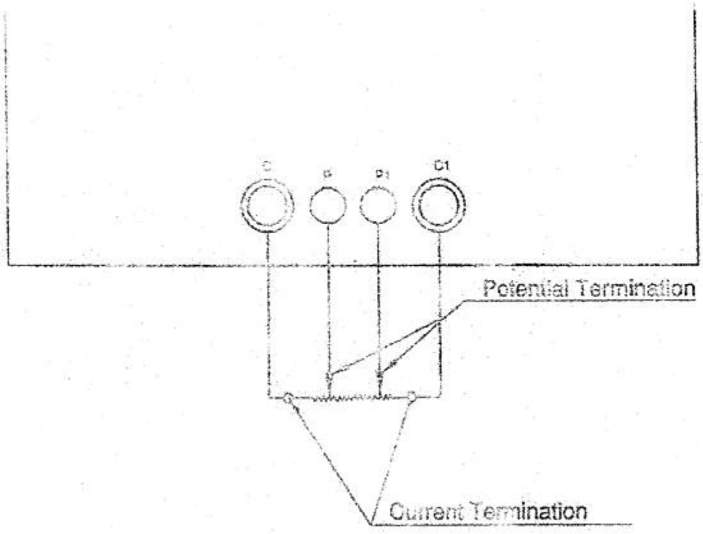


DRN. MAHESH 8/10/2003	CHD. BM GUPTA	APPD. BM GUPTA	TOSHNIWAL INDUSTRIES PVT. LTD. AJMER-305 002	DRAWING NO. K 2 (4)

CIRCUIT DIAGRAM OF KELVIN BRIDGE

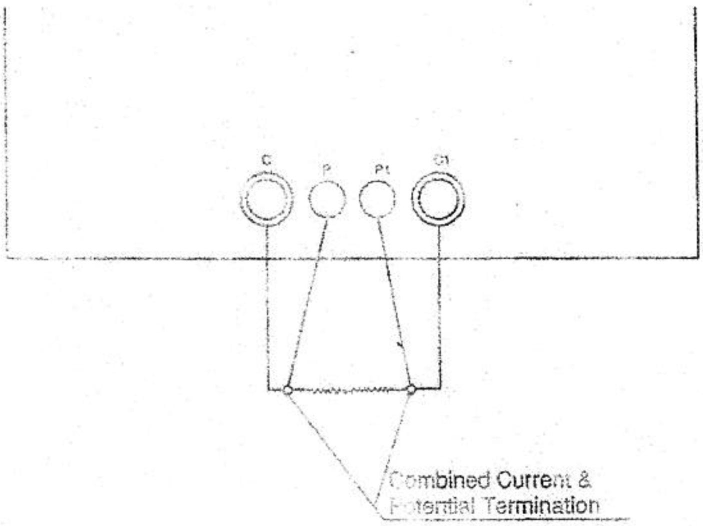
TIPL

Fig. 6



RESISTANCE MEASUREMENT OF FOUR TERMINAL RESISTANCE

Fig. 7



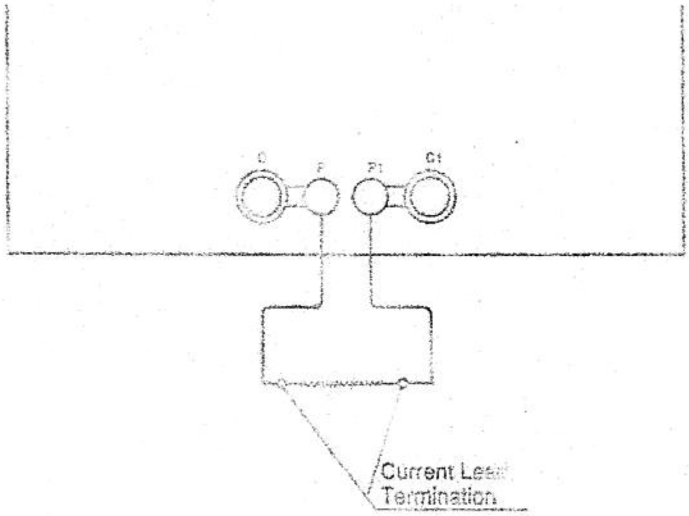
RESISTANCE MEASUREMENT OF TWO TERMINAL RESISTANCE BY FOUR TERMINAL METHOD

DRN.	CHD	APPD		DRAWING NO.
MAHESH 8/10/2003	BM GUPTA	BM GUPTA	TOSHNIWAL INDUSTRIES PVT. LTD. AJMER-305 002	K 3 (4)

CIRCUIT DIAGRAM OF KELVIN BRIDGE

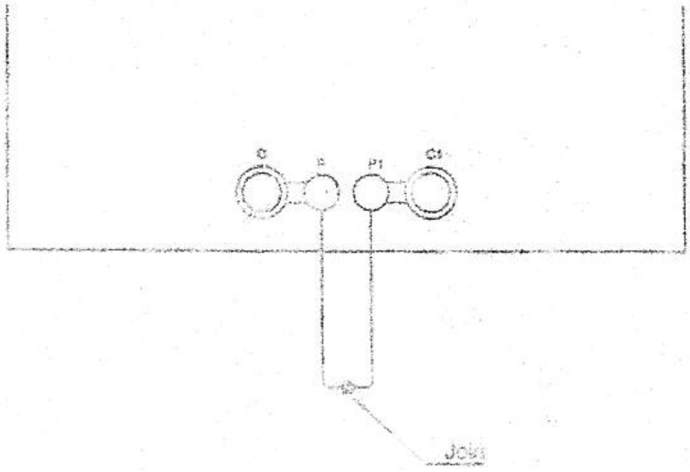
TIPL

Fig. 8



RESISTANCE MEASUREMENT BY TWO TERMINAL METHOD

Fig. 9



LEAD RESISTANCE MEASUREMENT

DRN. MAHESH 8/10/2003	CHD BM GUPTA	APPD BM GUPTA	TOSHNIWAL INDUSTRIES PVT. LTD. AJMER-305 002	DRAWING NO. K 4 (4)

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

Measurement Laboratory (EE2171) 3rd Semester EE students

Expt. No. 4.

TITLE OF EXPERIMENT: PHASE ANGLE & FREQUENCY MEASUREMENTS BY ELECTRONIC METHOD

OBJECT:
1. To understand the principle of the phase shifting Bridge Circuit.
2. To measure Phase Angle with a CRO.
3. To calibrate a high impedance Moving Coil Voltmeter with an electronic phase sensitive detector attachment for using it as a phase angle meter.
4. To measure mains frequency comparing with that of a standard oscillator in a CRO.

APPARATUS: (Note Item, Range, Type/Model, Make, Sl./Lab. No. etc. in a table)

1. Phase-shifting bridge,
2. Oscilloscope,
3. PMMC Voltmeter/DMM
4. Resistance box,
5. Standard Capacitor
6. Function Generator

EXPERIMENTAL PROCEDURE:

(For objects 1. 2 & 3)

1. Study the principle and circuit diagram of the phase shifting bridge (Fig.1) and the vector diagram (Fig. 2).
2. Make connections to the CRO as per Figs. 2 and 3. Depending on the phase difference between V_B or V_C and V_O, which can be varied by adjusting R_V or C_p, a Liss'ajous pattern will be obtained on the screen of the CRO in the form of an ellipse or a circle or a straight line. Adjust the X and Y axes sensitivities so that the deflections along them are equal. Note down various parameters and the measured values as shown in Table-I for different values of R so that phase angle varies between 0° and 180° through 90°.
3. A Moving Coil Voltmeter connected to a phase sensitive detector (right half of Fig.1) can be calibrated in terms of the phase angle difference between V_B and V_C. Make connections as per Fig. 1. Adjust R_V of the phase shifter circuit to the value ($R_V = 1/\omega\ C_p$) so that exact 90° phase shift is obtained between voltages V_B and V_C. Connect CC'. Under this condition the voltmeter should read zero (check by adjusting *r*). Change the value of R_V in suitable steps and note down the voltmeter readings in Table II.

(For object 4)

4. Make the connection as in Fig.4 and obtain a stationary Liss'ajuous pattern by varying the oscillator frequency. Note down the number of peaks or closed loops and also note whether they are arranged horizontally or vertically (TABLE III).

REPORT:

1. (a) Comment on the working principles of the phase shifting bridge and phase Detector circuits with the help of Phasor diagram.
   (b) Discuss the effect of replacing capacitor C_p by an inductor.
2. Calculate the phase angle theoretically and using the Methods I and II and compare the results.
3. Plot a curve of calculated phase shifts vs. voltmeter readings (ordinate).

Table – I

No. of Obs.	C_p (μF)	R_V (Ω)	Method- I		Method-II		Phase Angle Φ		
			Y_1	Y_2	m	M	Theoretical	Method-I	Method-II

Method-I : $\sin\Phi = Y_1 / Y_2$

Method-II : $\tan(\Phi/2) = m/M$

Table – II

No. of Obs.	C_p (μF)	R_V (Ω)	Calculated Phase-Shift	Voltmeter Reading

Table – III

No. of Obs.	Oscillator Frequency	No. of Peak with orientation	Calculated Mains Freq.

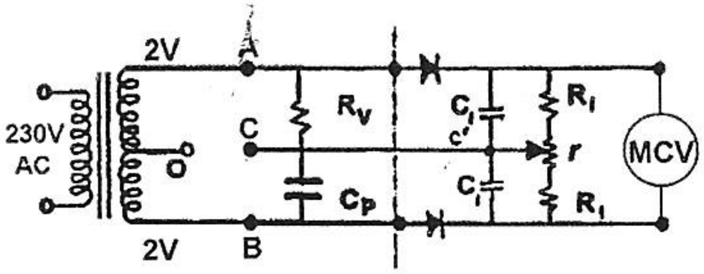


Fig. 1

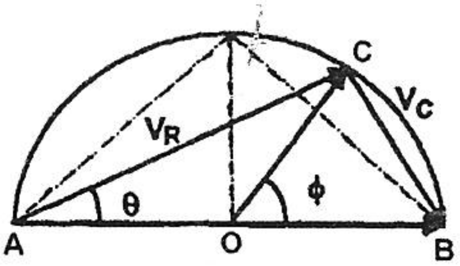


Fig. 2

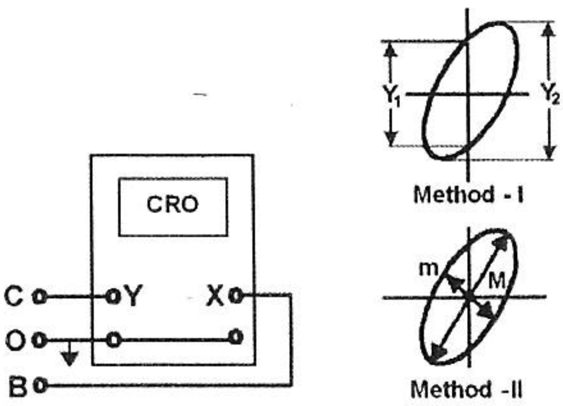


Fig. 3

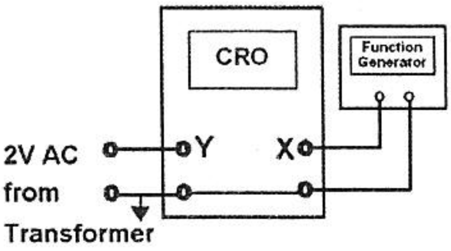


Fig.4

DEPARTMENT OF ELECTRICAL ENGINEERING
INDIAN INSTITUTE OF ENGINERING SCIENCE AND TECHNOLOGY, SHIBPUR

Electrical&Electronic Measurement Laboratory (EE-2171) **3rd Semester EE students**

Expt. No.5

TITLE OF EXPERIMENTS : STUDY ON AC BRIDGES

OBJECT: a) To study the operation and use of Schering Bridge to determine the value of a capacitance and its dissipation factor.

b) To study the operation and use of Anderson Bridge to measure the self-inductance value and Q factor of an inductance.

REFERENCE : [1] Cooper - Electrical Instrumentation & Measurement Techniques.
[2] Rajaram - Electrical Measurement and Instrumentation.
[3]R.K.Rajput - Electrical Measurements and Measuring Instruments

INTRODUCTION :

A. **Schering Bridge**: It is one of the important A.C. bridges widely used for the measurement of low loss capacitor, its dielectric loss and power factor. Fig. 1 below shows the basic circuit elementsof Schering bridge. The capacitor $C_2$is high quality capacitor (low loss) is used as a standardcapacitor for measurement. The general balance equation from the bridge circuit of Fig. 1, unknown impedance $Z_x= Z_2 Z_3 Y_4$.

Equating real and imaginary parts of impedances,
$C= R_2 C_1/ R_1$
Where R_1 and R_2 are known standard resistance and C_1 is a known standard capacitor.

The dissipation factor is $D= \omega C R$.
Where $\omega=2\pi f$
C=Capacitance of capacitor
R= Series resistance of a capacitor representing the loss in the capacitor
F=frequency of oscillator which is 1kHz.

Anderson Bridge: It is used for precise measurement of inductance over a wide range in terms of a standard capacitor. Both high-Q and low-Q inductors can be measured. Fig. 2 below shows the basic circuit elements of Anderson bridge. The capacitor C is high quality standard capacitor. Equating real and imaginary parts of impedances in bridge balance equation;
$L= CR(Q+2r)$
Where Q, R and r are known standard resistance and C is a standard known capacitance.
The Q-factor $Q=L / R$

Figure 1

Figure 2

LIST OF APPARATUS & EQUIPMENT :(Note Item, Range, Type/Model, Make, Sl.No. in a Table).

PROCEDURE & OBSERVATIONS:

A. Study on Schering bridge:

1. Study the Schering bridge Setup.
2. Connect the AC supply 1kHz with the terminal marked **SUPPLY**, unknown capacitor with the terminals marked **C** and digital null detector with the terminal marked **D** in the circuit diagram.
3. Set the resistance dial **R** to zero position and also set capacitance dial $\mathbf{C_2}$ to zero position. Set resistance dial $\mathbf{R_1}$ at 1000 Ω.
4. Set the capacitor $\mathbf{C_1}$ say at 0.01uF.
5. Now adjust the decade resistance dial $\mathbf{R_2}$ to minimize the readings in the digital null detector.
6. Note the value $\mathbf{R_1}$, $\mathbf{R_2}$ and $\mathbf{C_1}$in Table-1 and calculate the value of unknown capacitor using above formula.
7. Repeat the same experiment on another value of $\mathbf{R_2}$ and another value of unknown capacitors.

B. Study on Anderson Bridge:

1. DC BALANCE.

i). Connect DC supply 5 volt in the circuit, select any one unknown inductance say at 4 and connect it with the terminals marked **L**, and digital null detector with the terminals **D** in the circuit.

ii). Set the null detector AC/DC switch to **DC** position.

iii). Now adjust the decade resistance dial **R** to find out balance point in the digital null detector. Note the value of **R**. (During DC balance resistance**r** should be at Zero position.)

2. AC BALANCE.

i). After DC balance without disturbing the position of the bridge, connect the **AC** supply 1kHz instead of DC supply and set the null detector AC/DC switch to **AC** position.

ii). set the capacitor switch **C** at 0.1uF.

iii). Now adjust the decade resistance dial **r** to find out balance point in the digital null detector.

iv). Note the value of **r&C**in Table-2 and calculate the value of unknown inductance by using above given formula.

v). Repeat the experiment with another value of **C** and other unknown inductance.

SAMPLE DATA SHEET

Table -1(Schering Bridge)

Sl.No	R_1	R_2	C_1	**C**	R	D (Dissipation factor)

Table-2 (Anderson Bridge)

Sl.No	C	Q	R	r	L

REPORT:

1. Make the respective tables of data. Find the values of the unknown parameters.
2. Draw the phasor diagram for both the bridges taking any one set of data from the table
3. Write advantage and disadvantage of Schering Bridge.
4. Write advantage and disadvantage of Anderson Bridge.

DEPARTMENT OF ELECTRICAL ENGINEERING

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

Measurement Laboratory (EE2171) 3rd Semester EE students

Expt. No 6. THREE PHASE POWER MEASUREMENT BY TWO WATTMETER METHOD.

A. Object : To measure the total power in a 3-phase, 3-wire balanced and unbalanced circuits by

(a) Two-wattmeter Method ;

(b) A single Wattmeter and a "Wattmeter Board".

Procedure : (a) Two Wattmeter Method for :

(1) Resistive Load (U.P.F. Load)

(2) Resistive – capacitive load (Leading P.F. Load)

1. Resistive load :–

1.1 Connect two wattmeters to measure total power taken by 3-phase delta connected resistive load as shown in fig. 1.

1.2 Set the line voltage at 100 volts. Adjust the resistances so that the readings of three ammeters are equal (below 1 amp.)

1.3 Take down voltmeter, ammeter and wattmeter readings and record in Table No. 1.

1.4 Change the resistance values so that three ammeters show different readings.

Repeat procedure 1.3.

2. Resistive-capacitive load :–

2.1 Connect ammeter, voltmeter and wattmeters to a delta connected capacitive load as shown in fig.2.

2.2 Set line voltage at 200 volts. Adjust the resistances of the load in such a way that all the three ammeters show equal readings (around 1 amp.) and both the wattmeters give positive readings.

2.3 Record the readings of ammeters, wattmeters, etc. in Table No. 2.

2.4 Vary the resistances of the load until (i) one of the wattmeters reads zero ; (ii) one of the wattmeters reads negative and the other positive, while all three ammeters indicate equal readings in each case. Repeat Procedure 2.3.

2.5 Short all resistances and repeat procedure 2.3.

(c) *A single wattmeter and a "Wattmeter-Board"* :

By using a single wattmeter and a switching device (Wattmeter Board) 3-phase power can be measure by two-wattmeter method as above.

In switch position 1 of the "Wattmeter Board" as shown in fig. 3a the current coil of the wattmeter is connected in R-phase and the pressure coil across R & B phase.

So the reading W_1 will be taken.

In switch position 2, as shown in fig. 3b, the current coil of the wattmeter is connected in X-phase and the pressure coil across Y & B phase.

So the reading W_2 will be taken.

Algebric sum of the two readings will be the total power consumed by the load.

Sequence of operation of switches from position 1 to position 2 are as follows :–

i) Close the knife switch SW_1.

ii) Throw the D.P.D.T. switch to other side as shown in fig. 3b.

iii) Open the knife switch SW_2.

Similar procedure starting from SW_2 will be followed while going from position 2 to position 1.

Procedure :– Connect the 3-phase delta connected resistive capacitive load using the "Wattmeter Board" as shown in fig. 3a. Repeat procedure 2.2 and 2.4 to measure total power. Record readings in Table No. 2.

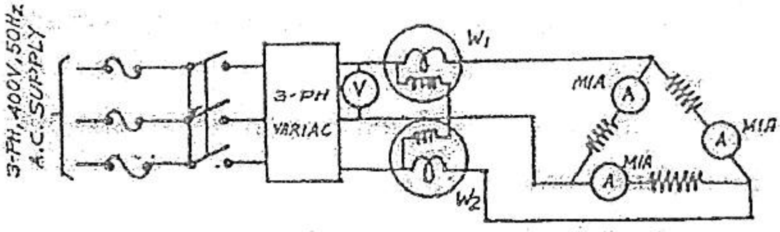


FIGURE – 1

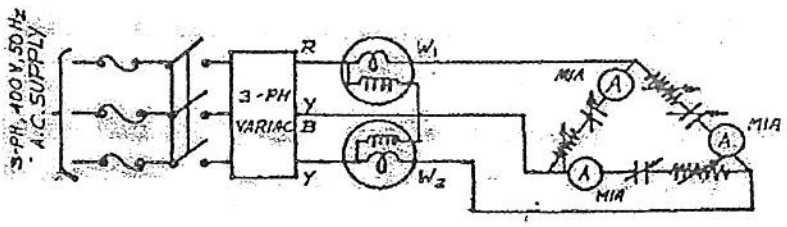


FIGURE – 2

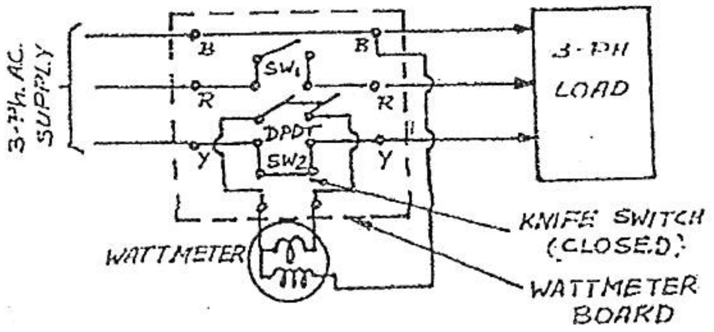


FIG. 1.2 (a) SWITCH POSITION-1.

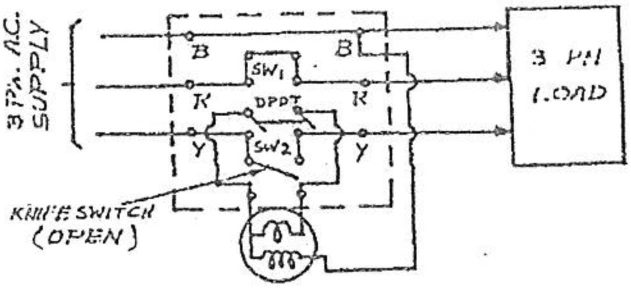


FIG. 1.2 (b) SWITCH POSITION-2.

Report :–

1. Tables 1 and 2 properly filled.
2. Compute power and power factor for capacitive load only from wattmeter readings and from the knowledge of voltage current and capacitance. Record and data in Table No. 2.
3. Show one sample calculation.
4. Answer the following questions and submit this sheet along with your report.

Give √ mark for your answer in the space provided for :

Marks may be deducted for wrong answer.

1. Two-wattmeters are used-in the conventional way to measure active power of 3-phase balanced load and it is found that one of the wattmeters indicated zero.

   a) What may be the power factor of the load?

   i) 0.5 leading only ☐ v) 0.8 lagging only ☐

   ii) 0.5 lagging only. ☐ vi) 0.8 leading or lagging ☐

iii) 0.5 leading or lagging ☐ vii) Unity ☐

iv) ..... leading only. ☐

b) What may be the p.f. angle of the load?

i) 30^0 ☐ ii) 60^0 ☐

iii) 90^0 ☐ iv) 0^0 ☐

c) What may be the type of the load?

i) Resistive only ☐ ii) Capacitive only ☐

iii) Inductive only ☐ iv) Resistive or Inductive only ☐

2. In a 400V, 3 phase 50 hz balanced resistive load, the power consumed by the load is being measured by two wattmeters W1 & W2 respectively. If the reading of W1 is 100 watts, what will be the reading of W2?

(a)100 watts positive ☐ (b) 100 watts negative ☐

(c) None of these. ☐

3. *What will be the relation between the two wattmeters readings when connected properly* **to measure active power of a 3-phase balanced pure capacitive or inductive load?**

a) **Readings of the two wattmeters will be equal and positive.** ☐

b) Readings of the two wattmeters will be equal and negative. ☐

c) Readings of the two wattmeters will be equal but one positive and one negative ☐

d) **Readings of both the wattmeters will be zero.** ☐

DATA SHEET

3 – Phase Power Measurement

Name : ______________________________ Roll No. : __________

Date : ______________

Apparatus used :

Sl. No.	Item	Range	Maker's Name	Lab No.
1.				
2.				
3.				
4.				
5.				
6.				
7.				

Experimental results :–

Table No. 1

Type of Load	Line Voltage	Ammeter Readings			Wattmeter Readings In watts		Total power In watts
		I_1	I_2	I_3	W_1	W_2	
Resistive (balanced							
Resistive (Unbalanced)							

Resistive-Capacitive load :–

Table No. 2

Two wattmeter method :

Line voltage	Value of Capacitor In uF	Ammeter Readings In amps.			Wattmeter Readings In watts		Total power In watts
		I_1	I_2	I_3	W_1	W_2	

A single wattmeter and a "Wattmeter Board" method :–							

Table No. 3

	Total power From wattmeter Readings in watts	Total power from V, I & Cos φ	Power factor from Wattmeter readings	p.f. or V, I from V, I end and R
With two Wattmeters				
With single Wattmeters & A wattmeter Board :				

(Signature of the Teacher)

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Expt. No 6. THREE PHASE POWER MEASUREMENT BY TWO WATTMETER METHOD.

Object **:** Measurement of reactive power in three phase systems.

Introduction to meter testing bench : In a Meter testing bench arrangements ammeters, voltmeters, wattmeters or energy meters etc. of any range can be tested under any power factor conditions are provided. In a testing bench phantom loading arrangements instead of the ordinary loading arrangements are provided to avoid excessive loss of energy for the purpose of testing only. In a phantom loading arrangement current circuits are excited from a low voltage source whereas normal voltages excite voltage circuits. Any power factor condition can be simulated by introducing proper phase angle difference between voltage and sources. The phase angle of the voltage system is changed with respect to the current system using an induction regulator in the voltage circuit.

Measurement of three phase reactive power **:** Using wattmeters, reactive power can be measured if by proper connections the supply to the pressure coils can be phase shifted by 90°. The necessary connections for balanced and unbalanced cases are shown.

With the connection shown, the true reactive power can be obtained when the observed reading is multiplied by a factor called Correction factor.

Procedure **:**

1) Get acquainted with the meter-testing bench
2) Connect wattmeters in reactive power measurement mode and take readings (a) u.p.f. and (b) at 0.5 p.f. (Lagging).

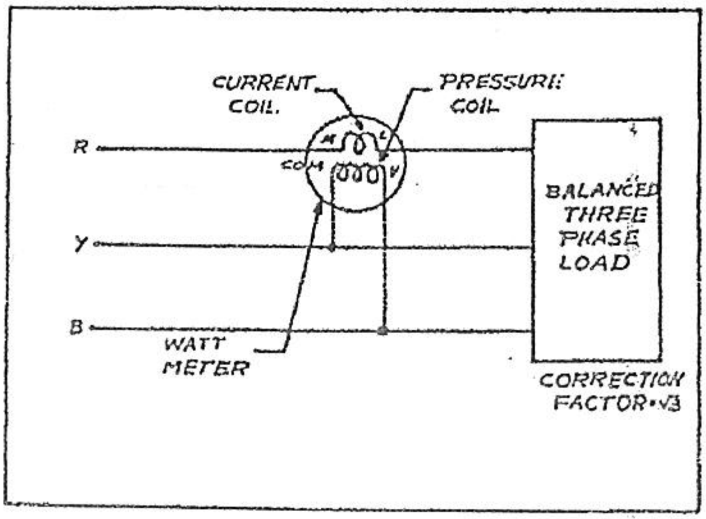

Fig. : Fig. 2 : Three Phase Reactive Power Measurement

(Cross Phasing Method for Balanced Load)

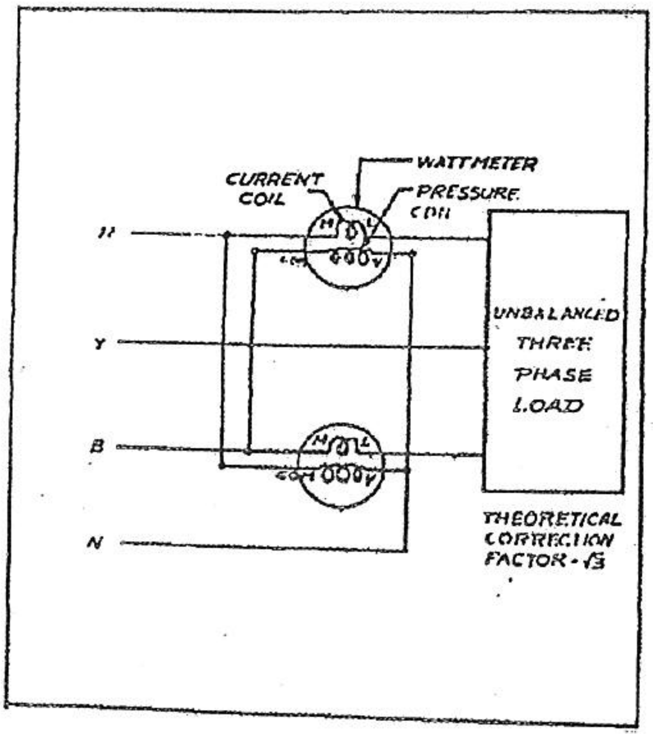

Fig. 2 : Three Phase Reactive Power Measurement

(Cross Phasing Method for Balanced Load)

Report :

Determine correction factors and compare the results with the theoretical value.

DATA SHEET

"THREE PHASE REACTIVE POWER MEASUREMENT (BALANCED LOAD)"

Name : ______________________________ **Roll No. :** ___________

Date : ______________

Apparatus used :

Sl. No.	Item	Range	Maker's Name	Lab No.
1.				
2.				
3.				
4.				
5.				
6.				
7.				

____

(Signature of the Teacher)