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DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING

ELECTRICAL MEASUREMENTS AND INSTRUMENTATION LAB

CLASS : II YEAR (EEE)
SEMESTER : IVth SEM (EEE)
SUBJECT CODE :EE09 408 (P)
SUBJECT : ELECTRICAL MEASUREMENTS AND INSTRUMENTATION

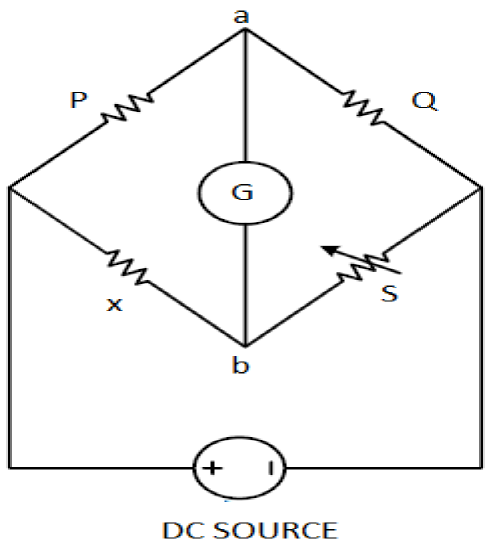
ammini College of Engineering

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

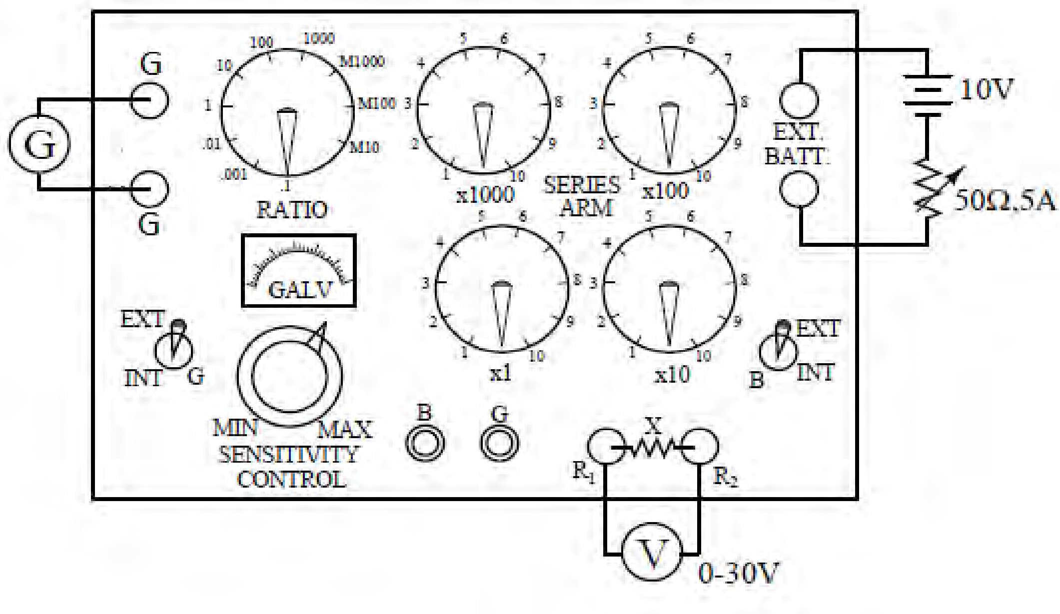
EE09 408(P): ELECTRICAL MEASUREMENTS AND INSTRUMENTATION LAB

LIST OF EXPERIMENTS

CIRCUIT DIAGRAM



PORTABLE FORM OF WHEATSTONE BRIDGE



Expt No:1

MEASUREMENT OF RESISTANCE USING WHEATSTONE BRIDGE

Aim

To measure the given medium resistances using Wheatstone bridge.

Apparatus Required

SI.No.	NAME OF THE APPRATUS	RANGE	TYPE	QTY
1	Wheat stone Bridge kit	-	-	1
2	Rheostat	15Ω, 5A	Wire wound	1
3	Voltmeter	0-30V	MC	1
4	Galvanometer	-	-	1
5	DC source	-	-	1

Principle

The Wheatstone bridge is the most widely used circuit for precisely measuring resistance by the comparison method. The Wheatstone bridge is designed to be used for precision resistance measurements in the laboratory. Values of resistance from 0.001 to 9,999,000 ohms can be measured with this instrument. When the instrument is used as a Wheatstone bridge, the Ration Multiplier switch allows selection of seven multipliers from 0.001 to 1,000. Multiplying the reading obtained from the decade dials by the ratio selected yields the value, in ohms, of the unknown resistance. Ratio resistances are accurate to ±0.05%.

Procedure

The given voltmeter(unknown resistance) is connected to the terminal marked X on the bridge. The toggle switches are adjusted for external battery and galvanometer. An external battery is connected to terminals BB through a rheostat. A galvanometer is connected to the terminals marked GG. on the bridge. The P/Q ratio (Multiplier) is suitably selected. The resistance ‘S’ is varied by varying the four decade resistances (one at a time starting from the highest range) till null deflection is observed in the galvanometer, when the ‘B’ and ‘G’ keys are pressed. Adjustments are made till null deflection is obtained, The reading of the ‘Multiplier’ and

Tabular Column

Sl.no.	Unknown resistance	P/Q ratio (multiplier)	S_1 (Ω)	S_2 (Ω)	S_3 (Ω)	S_4 (Ω)	$S = s_1+s_2+s_3+s_4$ (Ω)	Unknown Resistance X=(p/q)*s (Ω)

Sample Calculation

$\frac{P}{Q}$=……………………………….

S1=…………………..

S2=…………………

S3=…………………..

S4=…………………..

S=S1+S2+S3+S4=……………………

X=(P/Q)*S=…………………………..

the four dials of the variable resistance ‘S’ are noted. The readings are tabulated as shown. The experiment is repeated for rheostat instead of voltmeter.

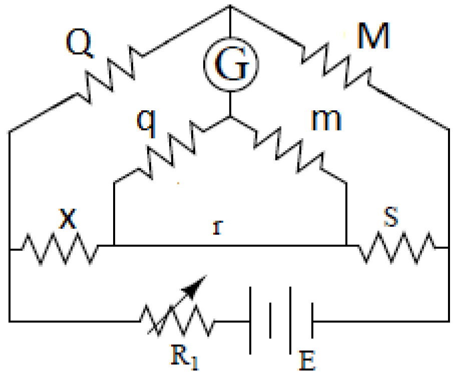
Result

Measured the given voltmeter using Wheatstone bridge.

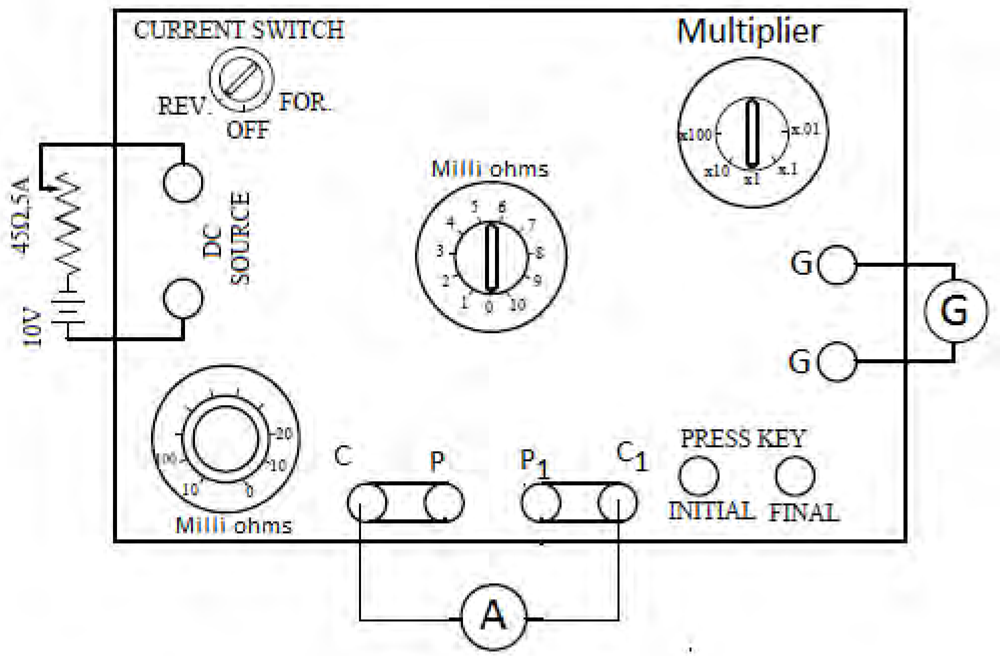
Resistance of voltmeter =…………………..

Resistance of Rheostat=………………………..

CIRCUIT DIAGRAM



KELVIN DOUBLE BRIDGE



Expt No:2

RESISTANCE MEASUREMENT USING KELVINS DOUBLE BRIDGE

Aim

To measure the resistance of the given ammeter(0-2.5A) using Kelvins double bridge.

Apparatus Required

SI.NO	NAME OF THE APPRATUS	RANGE	TYPE	QTY
1	Kelvins Double Bridge	-	-	1
2	D.C source	(0-30V)	DC	1
3	Ammeter	(0-2.5A)	MC	1
4	Galvanometer	-	-	1
5	Rheostat	45,5A	Wire wound	-

Principle

This method is the best available for precise measurement of low resistances(less than 1). In the figure 'X' is the low resistance to be measured and 'S' is a standard variable resistance of the same order of magnitude, M,Q, p and q are four non-inductive resistances, one pair of which are variable. These are connected to form two sets of ratio arms, which are used for range selection. The ratio Q/M is kept same as q/m ratio along with 'S' being varied till null deflection of the galvanometer is obtained.

Then $\frac{Q}{M} = \frac{X}{S} = \frac{q}{m}$

Procedure

Connections are made as shown in the figure. Choose a suitable range multiplier. Set the current switch in forward position. Press the galvanometer initial key first and adjust main dial and slide wire to get null deflection in the galvanometer. Then press the galvanometer final

Tabular Column

SI No.	Unknown Resistance	Remarks	Range Multiplier	S_1 (mΩ)	S_2X10^{-4} (Ω)	$S=S_1+S_2$ (Ω)	X (mΩ)	Mean Resistance (mΩ)
1	Ammeter+ leads	Direct						
		Reverse						
2	Leads only	Direct						
		Reverse						

Sample Calculation (Set No……………..)

For Direct:

Range multiplier=………………….

S1=…………………………………

S2=…………………………………

S=S1+S2=………………………...

X1=(Range Multiplier) X (S)=…………………

For Reverse:

Range multiplier=………………….

S1=…………………………………

S2=…………………………………

S=S1+S2=………………………...

X2=(Range Multiplier) X (S)=…………………

Mean Resistance X=(X1+X2)/2=…………………………..

Resistance of ammeter= (Resistance of ammeter + leads) - (Resistance of leads alone)=………

key and check whether the galvanometer reads null deflection. If not, adjust the dial readings to get null deflection. The readings of the main dial and slide wire are noted down.The current switch is then put to the reverse position. This reverses the direction of current in circuit. The main dial and slide wire are adjusted to get null deflection and the readings are noted again. The mean of the two is taken as the correct value. This is done to eliminate errors due to thermal effect. The ammeter is then disconnected and the resistance of the connecting leads alone is measured using the same method. The experiment is repeated with different values of range multiplier. The readings are tabulated as shown.

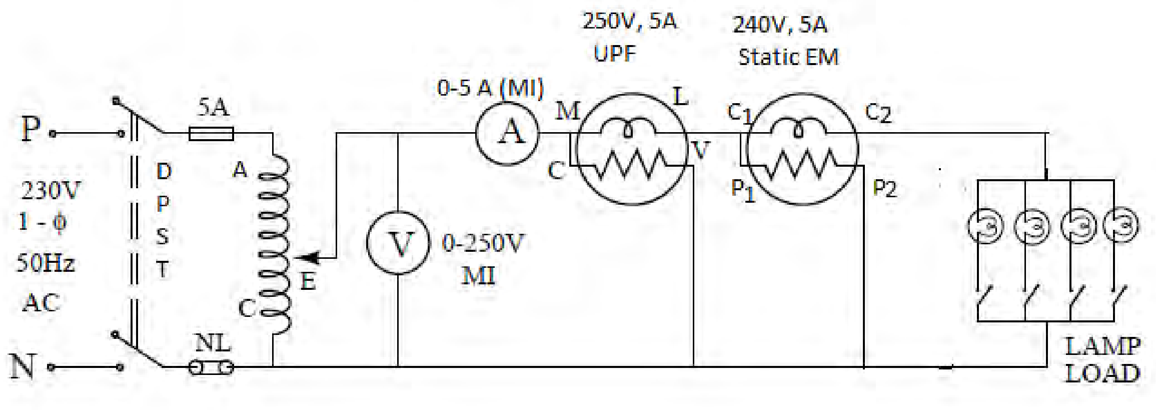
Resistance of ammeter = (Resistance of ammeter + leads) - (Resistance of leads alone)

Result

Measured the resistance of the given ammeter using Kelvins double bridge.

Resistance of given ammeter =

CIRCUIT DIAGRAM



Tabular Column

SI. No.	Volt meter Reading (V)	Ammeter Reading (A)	Wattmeter Reading (W)	Time for 5 Impulses t_1 (s)	Time for 1 Impulse t_2 (s)	Indicating Reading IR(ws)	True Reading TR (ws)	Error IR-TR (ws)	%Error

Expt No:3

CALIBRATION OF SINGLE PHASE STATIC ENERGY METER

Aim

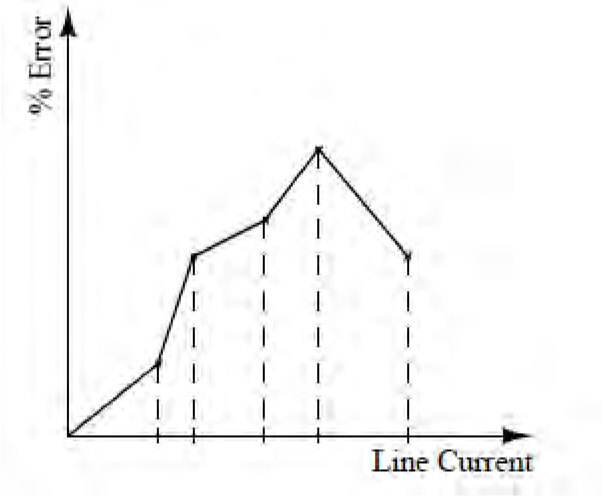
To calibrate the given single phase static energy meter at unity power factor by direct loading.

Apparatus Required

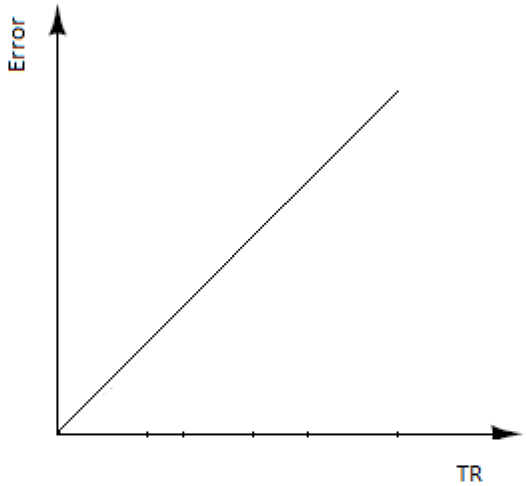
SI.NO	NAME OF THE APPRATUS	RANGE	TYPE	QTY
1	Autotransformer	0-270 V	-	1
2	Ammeter	0-5A	MI	1
3	Voltmeter	0-300V	MI	1
4	Wattmeter	250V, 5A	UPF	1
5	Energy Meter	240V, 5A 3200 imp/kWhr	Static	1
6	Lamp Load	-	-	-

Sample Graph

Error Curve



Calibration Curve



Principle

An energy meter is an instrument used to measure electrical energy. It keeps a record of the total energy consumed in a circuit during a particular period. It is an integrating type of instrument. Calibration involves comparing the energy measured by an energy meter with a standard instrument. The standard chosen here is a wattmeter. Since the wattmeter measures only the power, it has to be multiplied with time to get the energy reading. The readings are then compared to find the error in the energy meter.

Calibration can be done either by direct loading or phantom loading. In direct loading both the current and pressure coils are fed from the same supply at rated voltage. Energy meters of high rating when tested by direct loading would involve large amount of power. Such meters are thus tested using phantom loading, wherein the pressure coil is supplied from rated supply and current coil circuit from a separate low voltage supply.

Procedure

Connections are made as shown in the connection diagram. The supply is switched on, keeping the autotransformer in the minimum position. The autotransformer is then varied to get the rated voltage. The lamp load is then switched on and the ammeter reading adjusted for a small value of current. The corresponding readings of voltmeter, ammeter and wattmeter are noted down. The time for five impulse of the energy meter disc is also noted. The experiment is repeated in steps adding loads till the rated current of the energy meter is reached. The true energy and indicated energy is evaluated and the error found out. The error curve and calibration curve are then plotted as shown.

Sample calculation(Set No………..)

Energy meter constant k = ...

Voltmeter reading (V) = ...

Ammeter reading (I) = ...

Time for 5 impulse of energy meter(t_1)= . . . .

Time for 5 impulse of energy meter (t_2)= $\frac{t_1}{5}$ =……………..

Indicated energy for 1 impulse of energy meter (IR)=$\frac{1}{K} * 60 * 60 * 1000$=…………….

Wattmeter reading (W) = ...

True energy for 't_2' seconds (TR) = W × t_2 = ...

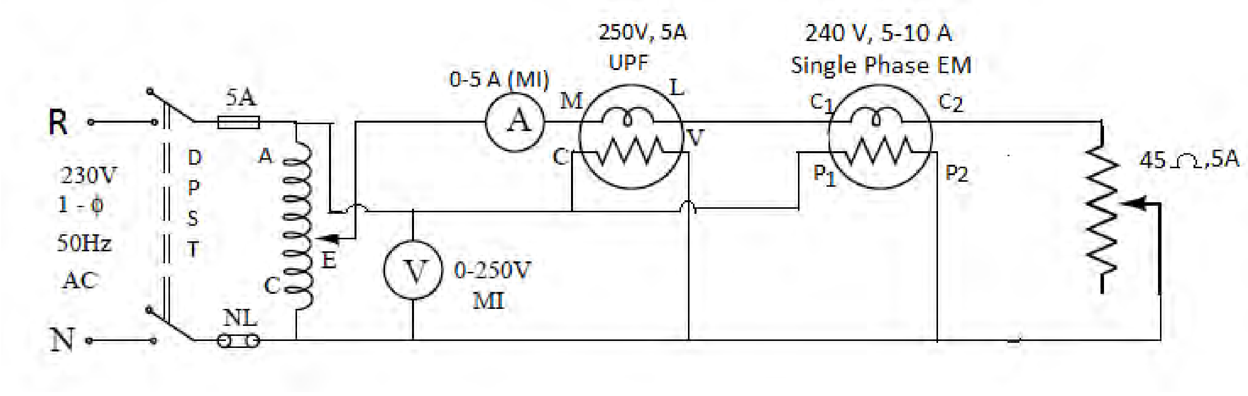
Error =$IR - TR$

%Error=$\frac{IR-TR}{IR}$*100=………………………

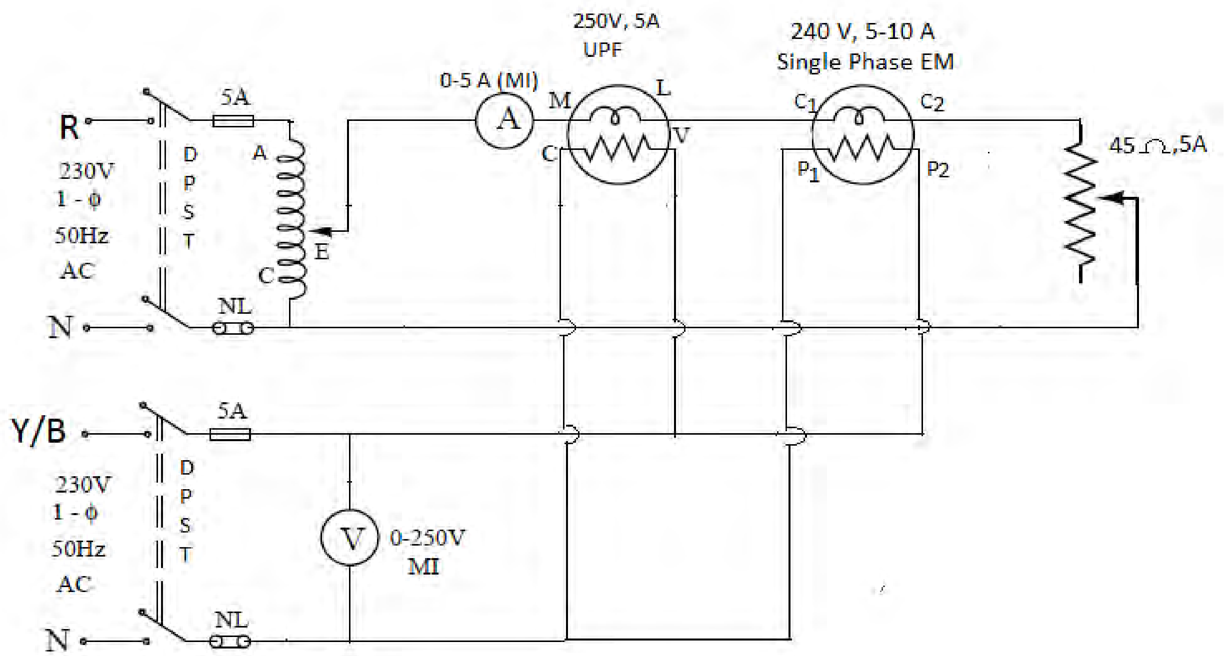
Result

Calibrated the given single phase static energy meter at unity power factor by direct loading.

CIRCUIT DIAGRAM FOR UPF (FIG 1)



CIRCUIT DIAGRAM FOR 0.5 LAG/LEAD (FIG 2)



Expt No:4

CALIBRATION OF SINGLE PHASE ENERGY METER BY PHANTOM LOADING WITHOUT USING PHASE SHIFTING TRANSFORMER

Aim

To calibrate single phase energy meter by phantom loading without using phase shifting transformer

Apparatus Required

SI.No.	NAME OF THE APPRATUS	RANGE	TYPE	QTY
1	Autotransformer	0-270 V	Single Phase	1
2	Ammeter	0-5A	MI	1
3	Voltmeter	0-300V	MI	1
4	Wattmeter	300V, 10A	UPF	1
5	Energy meter	240V,5-10A	Single Phase	1
6	Resistive Load	45Ω, 5A	Wire Wound	1

Tabular Column

For UPF:

SI No.	Voltmeter Reading (V)	Ammeter Reading (A)	Wattmeter Reading (W)	Time for 5 Revolution(t_1) (s)	Time for 1 Revolution (t_2) (s)	Indicative Reading IR (W)	True Reading TR (W)	Error	%Error

For 0.5 lag:

SI No.	Voltmeter Reading (V)	Ammeter Reading (A)	Wattmeter Reading (W)	Time for 5 Revolution(t_1) (s)	Time for 1 Revolution (t_2) (s)	Indicative Reading IR (W)	True Reading TR (W)	Error	%Error

For 0.5 lead:

SI No.	Voltmeter Reading (V)	Ammeter Reading (A)	Wattmeter Reading (W)	Time for 5 Revolution(t_1) (s)	Time for 1 Revolution (t_2) (s)	Indicative Reading IR (W)	True Reading TR (W)	Error	%Error

Principle

When a energy meter is designed for high current loads, it is uneconomical to arrange such loads for testing purposes as it involves a considerable waste of time and power. To avoid this problem "phantom” loading is done.

In phantom loading, pressure coil is excited from normal supply voltage and current coil is excited from a separate low voltage supply. The low impedance of current coil circuit makes it possible to circulate the required current even with low supply voltage.

Procedure

For testing energy meter at upf condition connections are done as shown in fig 1. Keep the autotransformer position in minimum and loading rheostat position in maximum. Supply is given and apply rated voltage across pressure coil of energy meter and wattmeter. Current in the current coil of the circuit is adjusted by varying auto transformer. First adjust auto transformer to low value of current (say 1A) and increase the current to rated current (say up to 5A). The voltmeter, ammeter, wattmeter and time for 5 revolution of energy meter are noted for various loads current.

For a power factor of 0.5, connections are made as shown in figure2. Keep the autotransformer position in minimum. The current coil of wattmeter and energy meter is connected in series to R-phase and pressure coil to Y-phase for lead and B-phase for lag. Supply is given and applies rated voltage across pressure coil of energy meter and wattmeter. If the wattmeter reads negative the pressure coil connections are interchanged. Current in the current coil of the circuit is adjusted by varying auto transformer. First adjust auto transformer to low value of current (say 1A) and increase the current to rated current (say up to 5A). The voltmeter, ammeter, wattmeter and time for 5 revolution of energy meter are noted for various loads current. Calculate indicating reading, true reading, error and %error. Then plot error and calibration curve.

Sample calculation (Set No…..)

Energy meter constant k = ...

Voltmeter reading (V) = ...

Ammeter reading (I) = ...

Time for 5 revolutions of energy meter disc(t_1)= . . . .

Time for 5 revolutions of energy meter disc (t_2)= $\frac{t_1}{5}$ =……………..

Indicated energy for 1 revolutions of energy meter disc (IR)=$\frac{1}{K} * 60 * 60 * 1000$=…………….

Wattmeter reading (W) = ...

True energy for 't_2' seconds (TR) = W × t_2 = ...

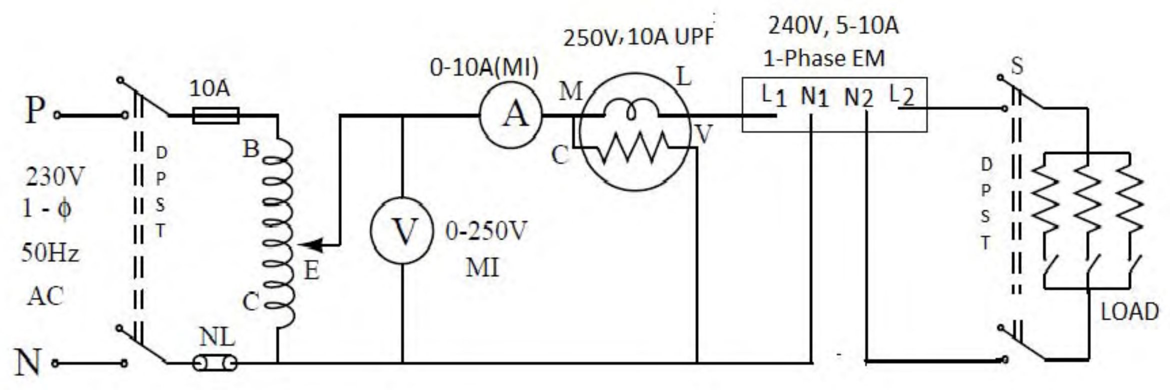
Error =$IR - TR$

%Error=$\frac{IR-TR}{IR}$*100=………………………

Result

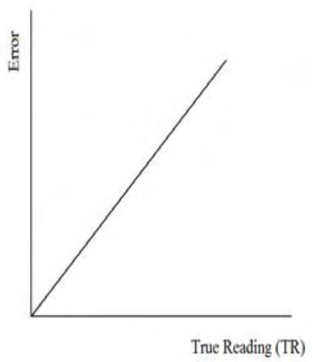
Calibrated single phase energy meter by phantom loading without using phase shifting transformer.

CIRCUIT DIAGRAM

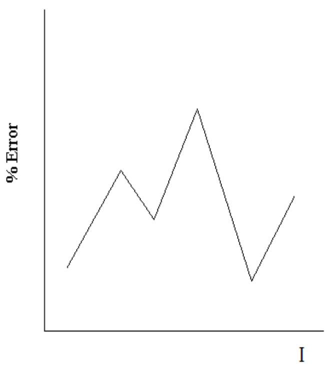


Sample Graph

Calibration curve



Error Curve



Expt No:5

CALIBRATION OF SINGLE PHASE ENERGY METER BY DIRECT LOADING

Aim

To calibrate the single phase energy meter by direct loading at unity power factor .

Apparatus Required

SI.NO	NAME OF THE APPRATUS	RANGE	TYPE	QTY
1	Autotransformer	0-270 V	-	1
2	Ammeter	0-5A	MI	1
3	Voltmeter	0-300V	MI	1
4	Wattmeter	250V, 5A	UPF	1
5	Energy Meter	240V, 5A 1800 rev/kWhr	Dynamic	1
6	Load	-	Resistive	-

Principle

In order to check the calibration of a single phase energy meter, the reading of the energy meter is compared with that of a standard instrument. For determining the true energy consumption, a standard wattmeter and an accurate stopwatch is used. From the calculated true energy, the error and the percentage error in the energy meter reading is determined.

In direct loading, the current coils of the energy meter and wattmeter are connected to a single phase supply in series with the loading device (say rheostat) whereas the pressure coils are connected directly to the supply. The loading device is adjusted to get the required current. Then the energy consumption is determined by observing the time for a fixed number (say N) of revolutions. The true energy is calculated from the wattmeter reading and the time indicated by the stopwatch.

Tabular Column

SI No.	Voltmeter Reading (V)	Ammeter Reading (A)	Wattmeter Reading (W)	Time for 5 Revolution(t_1) (s)	Time for 1 Revolution (t_2) (s)	Indicative Reading IR (W)	True Reading TR (W)	Error	%Error

Sample calculation (Set No…..)

Energy meter constant K = ...

Voltmeter reading (V) = ...

Ammeter reading (I) = ...

Time for 5 revolutions of energy meter disc (t_1)= . . . .

Time for 5 revolutions of energy meter disc (t_2)= $\frac{t_1}{5}$ =……………..

Indicated energy for 1 revolutions of energy meter disc (IR)=$\frac{1}{K} * 60 * 60 * 1000$=…………….

Wattmeter reading (W) = ...

True energy for 't_2' seconds (TR) = W × t_2 = ...

Error =$IR - TR$

%Error=$\frac{IR-TR}{IR}$*100=………………………

Procedure

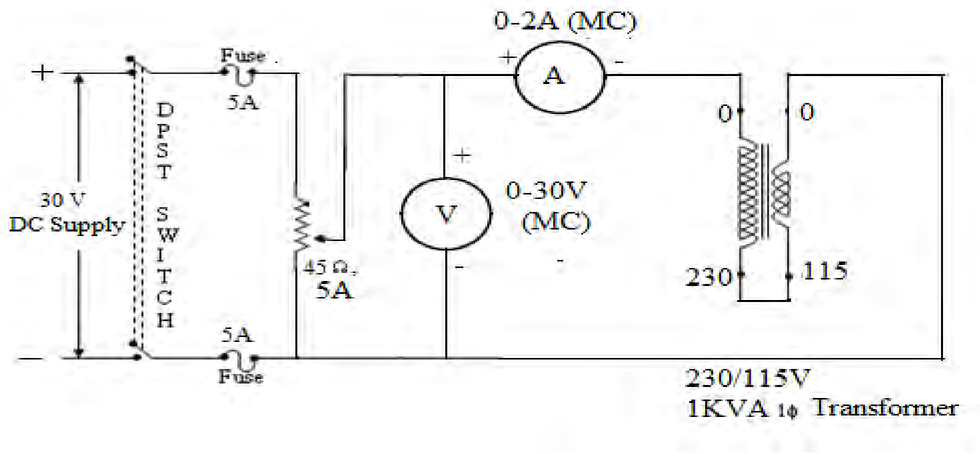
The connections are done as shown in the circuit diagram. Adjust the auto transformer to minimum position. Supply is switched on and rated voltage is applied. Remove the loads completely. The current is varied using loading rheostat till the rated current step by step. The ammeter reading, voltmeter reading, wattmeter reading and time for 5 revolutions of energy meter disc are noted in each step. Remove the load step by step. Adjust the auto transformer to minimum position and switch off supply.

Result

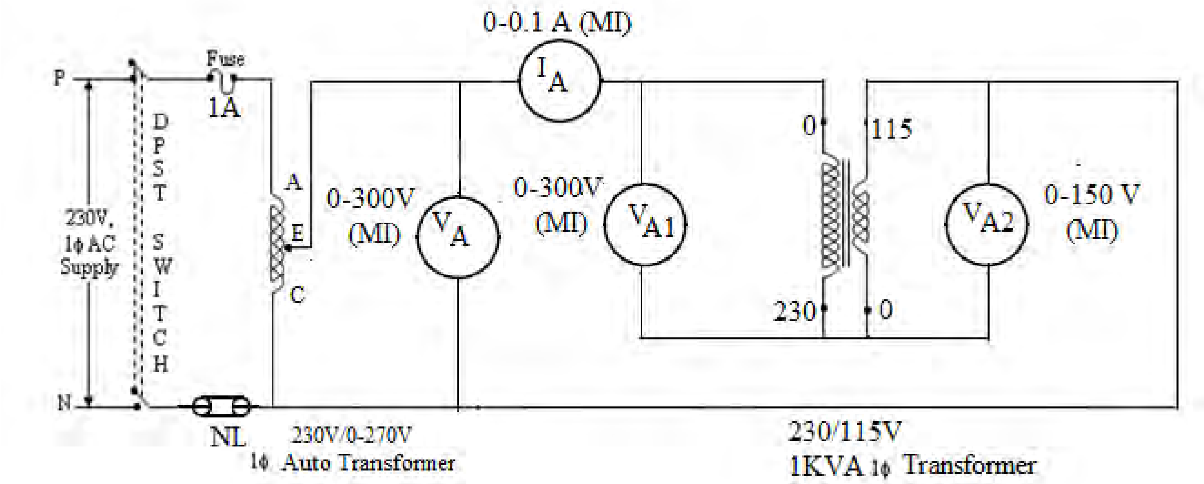
Calibrated the single phase energy meter by direct loading at unity power factor and plotted the graph.

CIRCUIT DIAGRAM

For Resistance (R):



Aiding Flux Circuit:



Expt No:6

MEASUREMENT OF SELF INDUCTANCE, MUTUAL INDUCTANCE AND COUPLING COEFFICIENT OF TRANSFORMER COILS

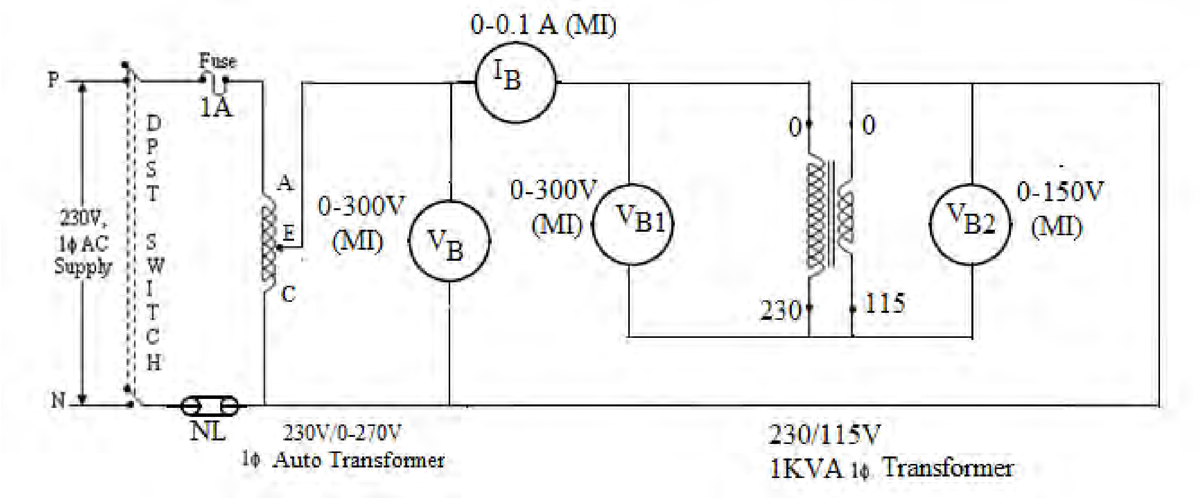
Aim

To determine the self inductance, mutual inductance and coupling coefficient of the given iron cored transformer windings.

Apparatus Required

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-0.1)A (0-2)A	MI MC	1 1
2	Voltmeter	(0-300)V (0-150V) (0-30V)	MI MI MC	2 1
3	Transformer	1KVA, 230/115V Single phase		1
4	Rheostats	45Ω, 5A	Wire Wound	1
5	Auto transformer	230V/(0-270V), single phase	-	1
6	Connecting Wires	2.5sq.mm.	Copper	Few

Opposing Flux Circuit:



Tabular Column

For Aiding Flux Circuit:

S.No.	V_A (V)	V_{A1} (V)	V_{A2} (V)	I_A (A)	$V_A=V_{A1}+V_{A2}$ (V)
1					

For Opposing Fux Circuit:

S.No.	V_B (V)	V_{B1} (V)	V_{B2} (V)	I_B (A)	$V_B=V_{B1}-V_{B2}$ (V)
1					

Principle

Inductance is the property of a circuit element by which energy is capable of being stored in a magnetic flux field and any circuit element exhibit the property of inductance is called an inductor.

Self Inductance of a coil is the property by which it opposes any flux through it. Mutual inductance of a coil is the ability to produce an emf in the neighbouring coil by induction, when the current in the first coil changes.

Consider two magnetically coupled coils of self inductance L1 and L2. Let M be the mutual inductance of the coils connected in series so that flux is produced by current I through the coils are in the same direction, then the effective inductance

$L_A = L_1 + L_2 + 2M$

If coils are connected such that the flux produced by the current in opposite direction, then effective inductance

$L_B = L_1 + L_2 - 2M$

Therefore mutual inductance $M= (L_A -L_B) / 4$

Coupling coefficient $k = M / ((L_1\ L_2)^{1/2}$

In the first case, if V_1 and I_1 are the applied voltage and current, then

$Z_A=V_1 / I_1$, $X_{LA} = Z_A-R$, $L_A = X_{LA}/(2\pi f)$

Similarly for the second case

$Z_B=V_2 / I_2$, $X_{LB} = Z_B-R$, $L_B = X_{LB}/(2\pi f)$

$$\left(\frac{L_1}{L_2}\right) = \left(\frac{N_1}{N_2}\right)^2 = \left(\frac{230}{115}\right)^2 = 4$$

$$L_1=4L_2$$

$$L_2 = \frac{L_A - 2M}{5}$$

From the above equations L_1 , L_2 , M and k can be found out. The experimental determinations of the above parameters are carried out for a pair of transformer winding.

Sample Calculation

For Aiding flux circuit $V_A=V_{A1}+V_{A2}$

For opposing flux circuit $V_B=V_{B1}-V_{B2}$

Resistance of transformer winding R =……………………

Applied voltage for aiding circuit V_A=………………………

Applied current for aiding circuit I_A=………………………...

Applied voltage for opposing circuit V_B=………………………

Applied current for opposing circuit I_B=………………………...

$Z_A= (V_A / I_A)$ =……………..

$X_{LA} =(Z_A^2-R^2)^{1/2}$=………………

$L_A = X_{LA}/(2\pi f)$=……………….

$Z_B= (V_B / I_B)$ =……………..

$X_{LB} = (Z_B^2-R^2)^{1/2}$ =………………

$L_B = X_{LB}/(2\pi f)$=……………….

Mutual inductance $M= (L_A - L_B) / 4$=…………………………..

$L_2 = \frac{L_A-2M}{5}$ =……………………

$L_1=4L_2$=……………………….

$k = M / (L_1 \ L_2)^{1/2}$=…………………………

Procedure

For aiding flux circuit:

1. Connections are made as shown in the first figure(Aiding flux circuit).
2. Supply is switched on with autotransformer in the minimum position.
3. The autotransformer is adjusted to get the rated voltage in voltmeter V_A.
4. The corresponding readings in all meters are noted down. In this case the fluxes produced by both the coils are additive in nature (ie, $V_A = V_{A1} + V_{A2}$).
5. Adjust the auto transformer to minimum position and switch of supply.

For opposing flux circuit:

1. Connections are made as shown in the second figure(Opposing flux circuit)
2. Supply is switched on with autotransformer in the minimum position.
3. The fluxes produced by the two coils are now in subtractive polarity (ie, $V_B = V_{B1} - V_{B2}$).
4. Adjust the auto transformer till the voltmeter V_{B1} reading equal to V_{A1} reading of flux aiding circuit.
5. This is done to maintain the same flux in both the cases.
6. The readings of all meters are noted down and tabulated.
7. Adjust the auto transformer to minimum position and switch of supply.

Result

Determined the self inductance, mutual inductance and coupling coefficient of the given iron cored transformer windings.