MEASUREMENT OF POWER AND ENERGY

MEASUREMENT OF POWER

Aim of the experiment

Three phase power measurement by two wattmeter method.

Theory

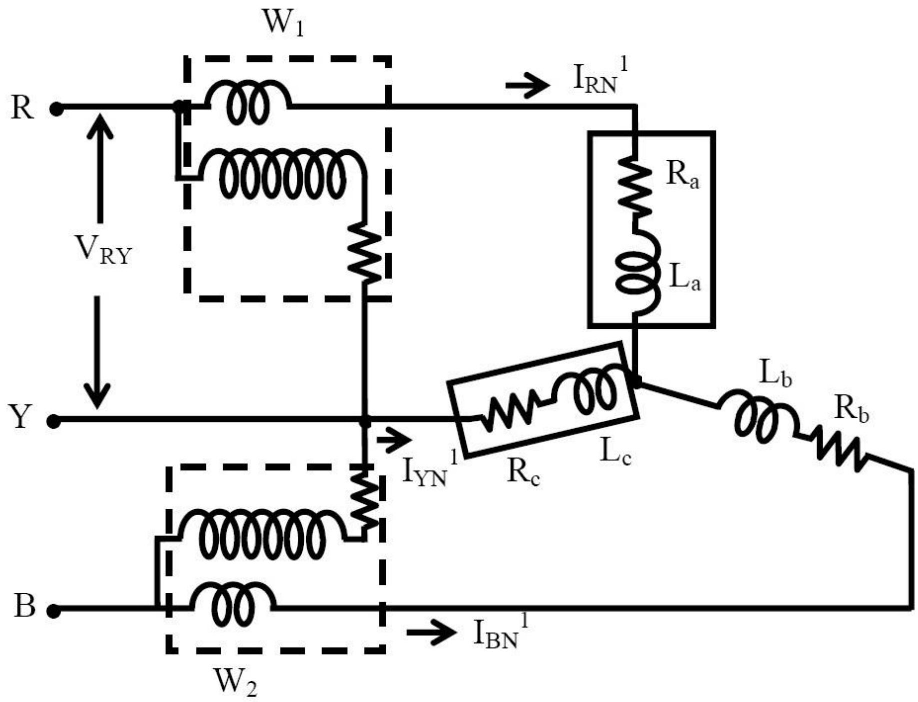


Fig 1: Connection diagram for three phase power measurement using two wattmeter method

The connection diagram for the measurement of power in three phase power measurement circuit using two wattmeter's method is shown in figure 1. This is irrespective of the circuit connection star or delta. The circuit may be taken as balanced or unbalanced one, balanced type being only a special case. Please note the connection of two wattmeter's. The current coil of the wattmeter's 1 and 2 in series with R and B phase with the pressure voltage coils being connected across R-Y and B-Y respectively. Y is the third phase in which no current coil is connected.

If star connected circuit is taken as an example the total instantaneous power consumed in the circuit is,

$$W = I_{RN} * V_{RN} + I_{YN} * V_{YN} + I_{BN} * V_{BN} \ldots (1)$$

Each of the terms in the above expression equation (1) is the instantaneous power consumed by the phases. From the connection diagram, the circuit in and the voltages across the respective (current, pressure or voltage) coils in the wattmeter, W1 are IRN and.

$$V_{RY} = V_{RN} - V_{YN}$$

So, the instantaneous power measured by the wattmeter W1 is.

$$W_1 = I_{RN} * V_{RY}$$

Similarly the instantaneous power measured by the wattmeter W2 is .

$$W_2 = I_{BN} * V_{BY} = I_{BN} * (V_{BN} - V_{YN})$$

Some of the two readings as given above is,

$$W_1 + W_2 = I_{RN}(V_{RN} - V_{YN}) + I_{BN}(V_{BN} - V_{YN})$$

$$= I_{RN}V_{RN} + I_{BN}V_{BN} - V_{YN}(I_{RN} + I_{BN}) \ldots . (2)$$

$$and\ I_{RN} + I_{BN} + I_{YN} = 0$$

$$applying\ in\ equation\ (2),$$

$$W_1 + W_2 = I_{RN}V_{RN} + I_{BN}V_{BN} + V_{YN}I_{YN} \ldots .. (3)$$

Equation (1) is compared with equation (3) to give the total instantaneous power consumed in the circuit . They are found to be same. The phasor diagram of three phase balanced star connected circuit is shown in figure 2.

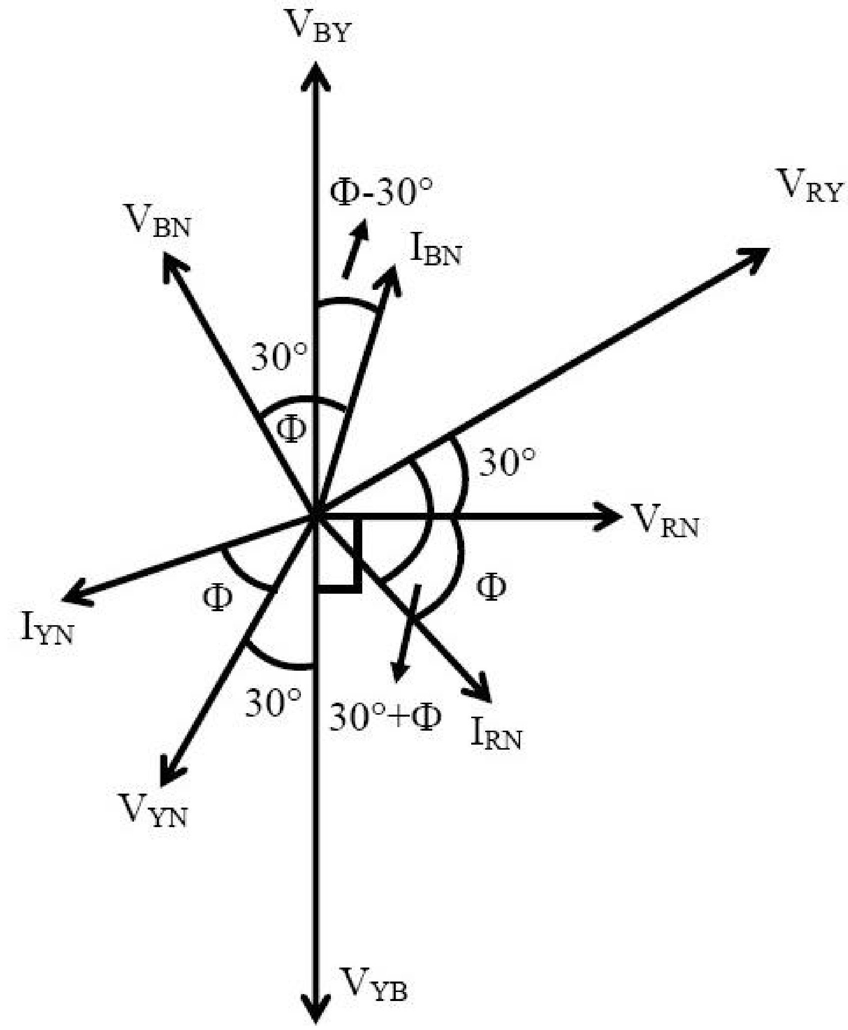


Fig 2: Phasor diagram of three phase balanced star connected circuit Procedure

Procedure:

BALANCED LOAD :

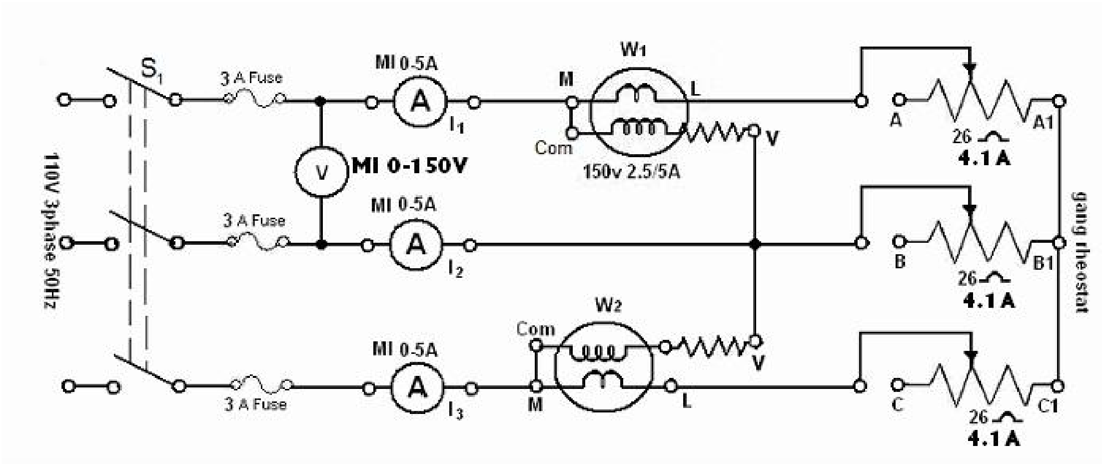


Fig. 1. Three phase power measurement circuit under balance condition

1. Connect the circuit as shown in Fig. 1.
2. Adjust the ganged rheostat for the maximum resistance.
3. Switch on the supply.
4. Close switch S1.
5. Read the meters to obtain VL, I1, I2 and I3. Note the wattmeter reading W1 and W2`(Note the multiplying factor on the wattmeter).
6. Vary the load resistance and obtain at least five sets of observations, the current should not exceed the limit (4.1 A).

UNBALANCED LOAD :

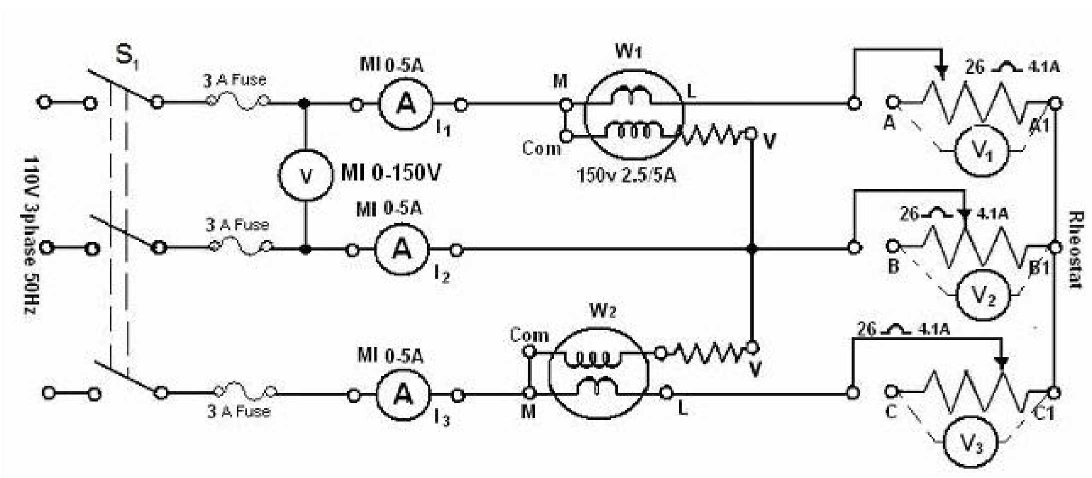


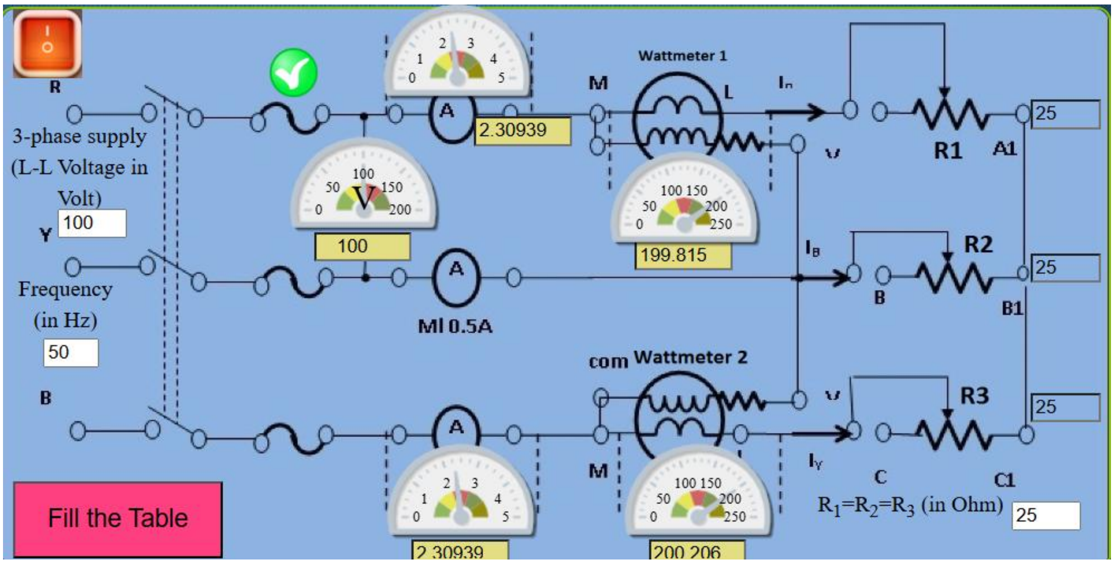
Fig. 2. Three phase power measurement circuit under unbalance condition

i. Connect the circuit as shown in Fig. 2.
ii. Replace the ganged rheostat by three separate rheostats of 26 Ω, 4.1 A and connect in a star.
iii. Adjust the three rheostats at the maximum values.
iv. Switch on the supply and set the autotransformer to 110 V.
v. Close switch S1 and take five sets of observation for different rheostat settings such that the reading of I1, I2 and I3 in each set is appreciably different to create unbalanced loading condition. The current should not exceed the limits in each arm.

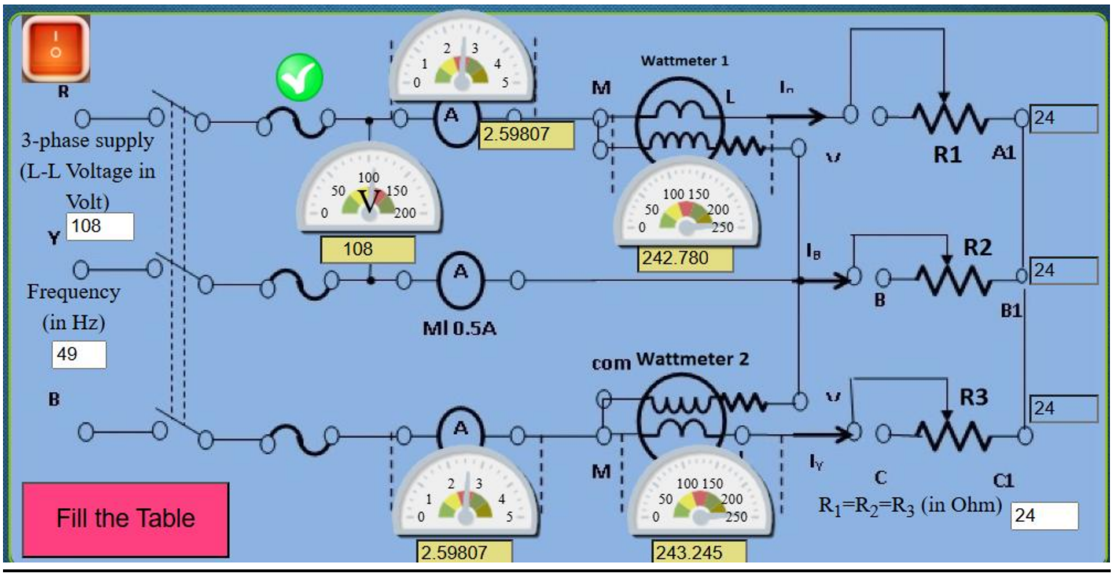
SIMULATION

BALANCED:

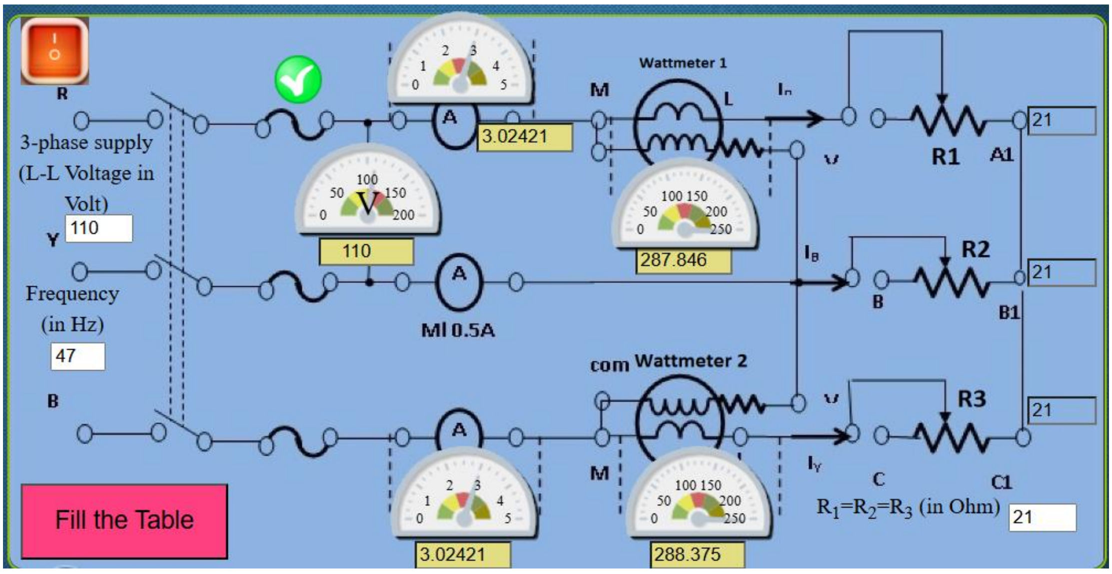
Case 1:



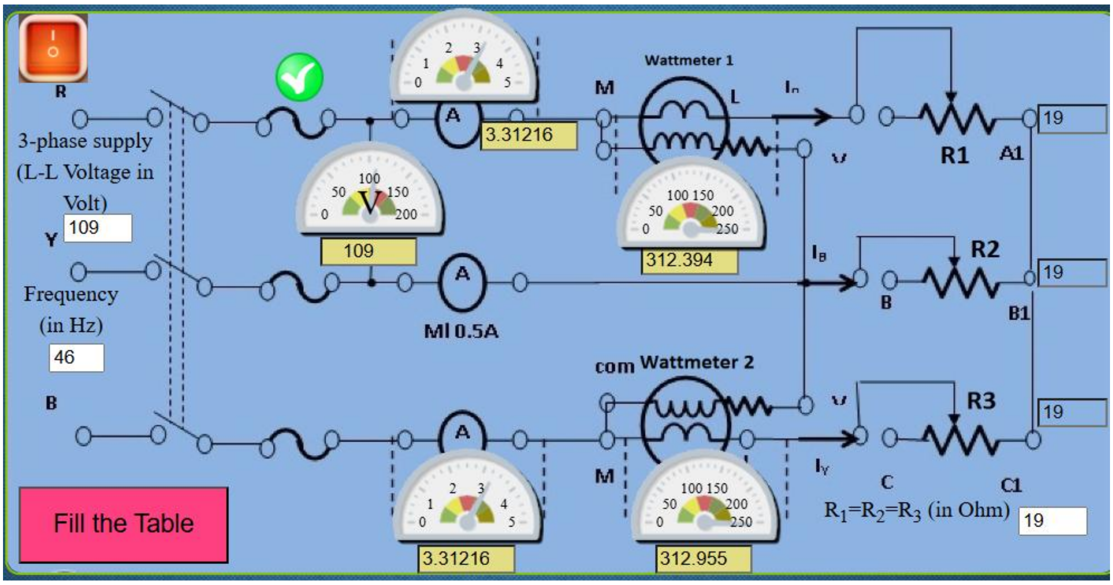
Case 2:


R
3-phase supply
(L-L Voltage in
Volt)
Y
108
Frequency
(in Hz)
49
B
Fill the Table
2.59807
108
MI 0.5A
2.59807
Wattmeter 1
242.780
com Wattmeter 2
243.245
R1
A1
24
R2
B
B1
24
R3
C
C1
24
R1=R2=R3 (in Ohm)
24

Case 3:

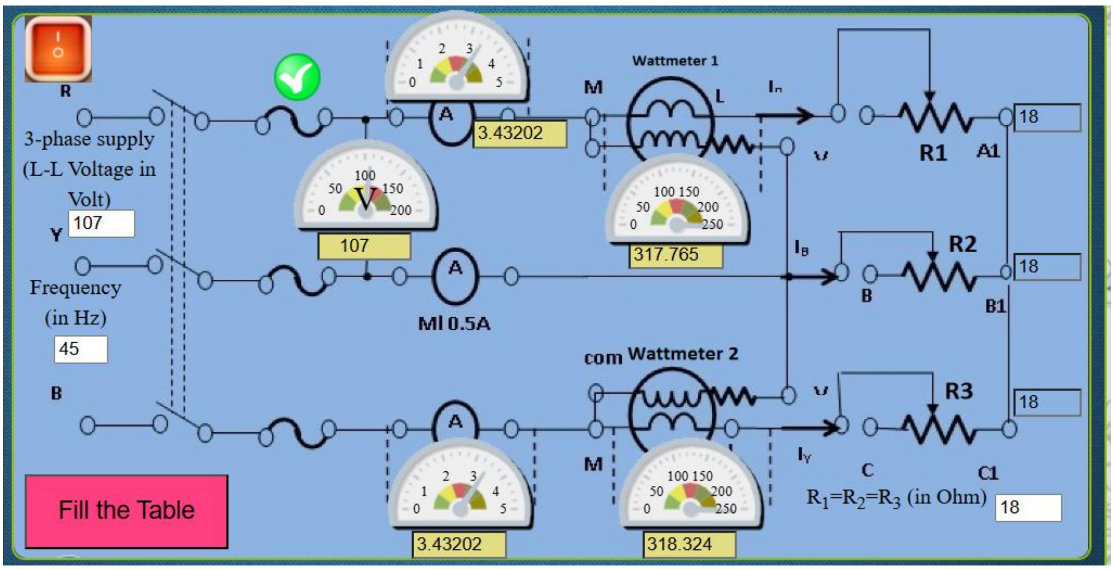

R
3-phase supply
(L-L Voltage in
Volt)
Y
110
Frequency
(in Hz)
47
B
Fill the Table
3.02421
110
MI 0.5A
3.02421
Wattmeter 1
287.846
com Wattmeter 2
288.375
R1
A1
21
R2
B
B1
21
R3
C
C1
21
R1=R2=R3 (in Ohm)
21

Case 4:



R
3-phase supply
(L-L Voltage in
Volt)
Y
109
Frequency
(in Hz)
46
B
Fill the Table
3.31216
109
312.394
Wattmeter 1
M
L
MI 0.5A
com Wattmeter 2
M
3.31216
312.955
R1
A1
R2
B
B1
R3
C
C1
19
19
19
$R_1=R_2=R_3$ (in Ohm)
19

Case 5:



R
3-phase supply
(L-L Voltage in
Volt)
Y
107
Frequency
(in Hz)
45
B
Fill the Table
3.43202
107
317.765
Wattmeter 1
M
L
MI 0.5A
com Wattmeter 2
M
3.43202
318.324
R1
A1
R2
B
B1
R3
C
C1
18
18
18
$R_1=R_2=R_3$ (in Ohm)
18

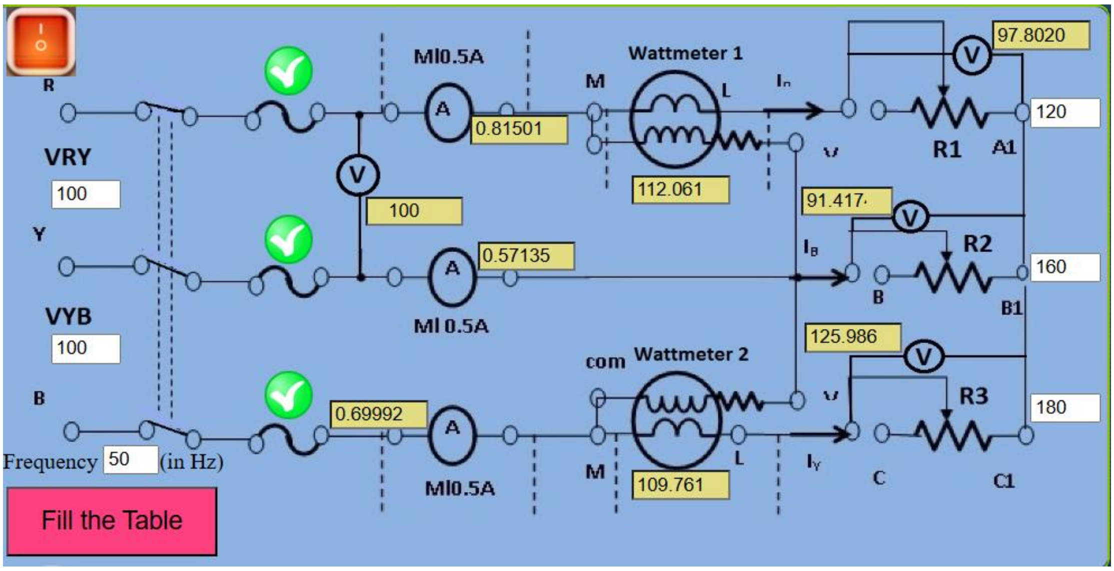
Tabulation for Balanced load:

Observation Table

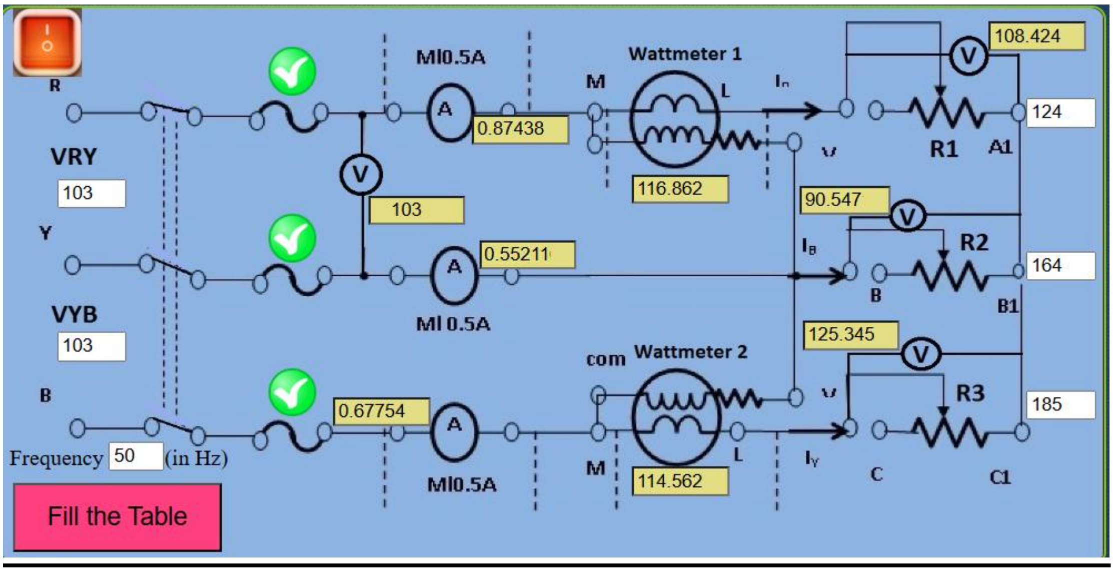
Serial no. of Observation	V_{RY}	I_R (Amp)	Cos(V_{RY}, I_R)	V_{BY}	I_B (Amp)	Cos(V_{BY}, I_B)	I_3(Amp)	W_1	W_2	W_C (Calculated power)	W_M(Measured Power=W_1+W_2)
1st	100	2.3093977	0.8652280	100	2.3093977	0.8669190	2.3093977	199.81557	200.20609	399.99885	400.02166
2nd	108	2.5980726	0.8652449	108	2.5980726	0.8669021	2.5980726	242.78069	243.24568	485.99866	486.02637
3rd	110	3.0242118	0.8652789	110	3.0242118	0.8668684	3.0242118	287.84654	288.37533	576.18901	576.22187
4th	109	3.3121633	0.8652958	109	3.3121633	0.8668516	3.3121633	312.39413	312.95579	625.31427	625.34993
5th	107	3.4320226	0.8653128	107	3.4320226	0.8668347	3.4320226	317.76573	318.32461	636.05408	636.09035

Unbalanced:

Case 1:

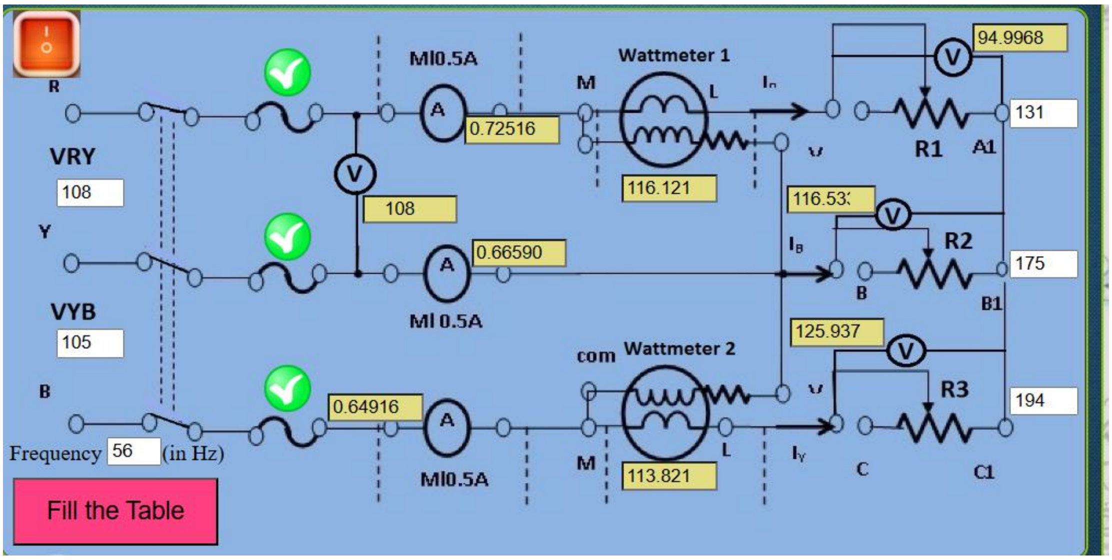


Case 2:



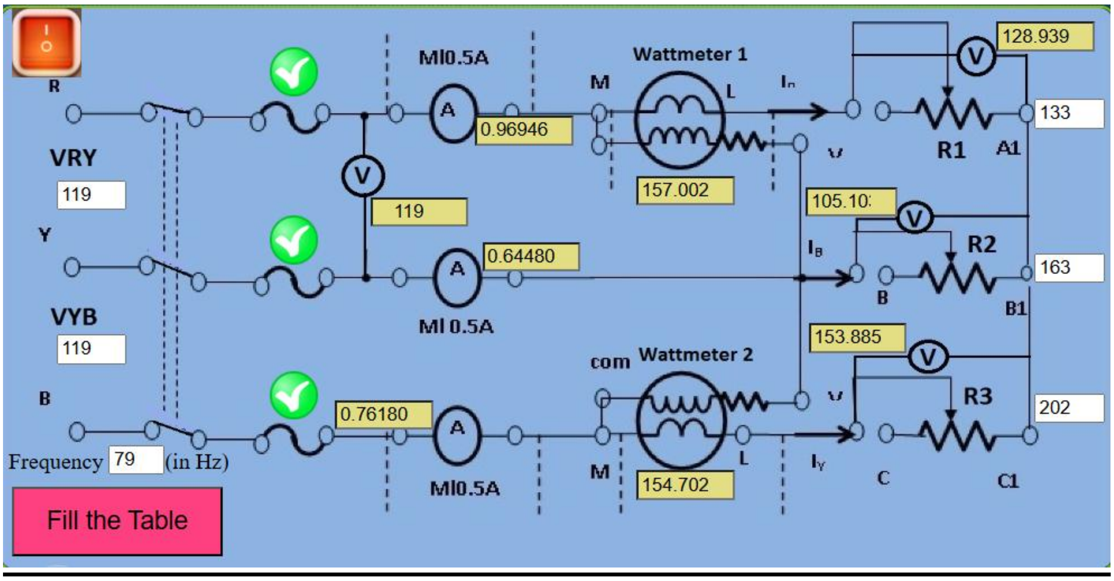
R
VRY
103
Y
VYB
103
B
Frequency
50
(in Hz)
Fill the Table
MI0.5A
0.87438
V
103
0.55211
MI 0.5A
0.67754
MI0.5A
Wattmeter 1
M
L
116.862
com
Wattmeter 2
M
L
114.562
108.424
124
R1
A1
90.547
R2
164
B
B1
125.345
R3
185
C
C1

Case 3:

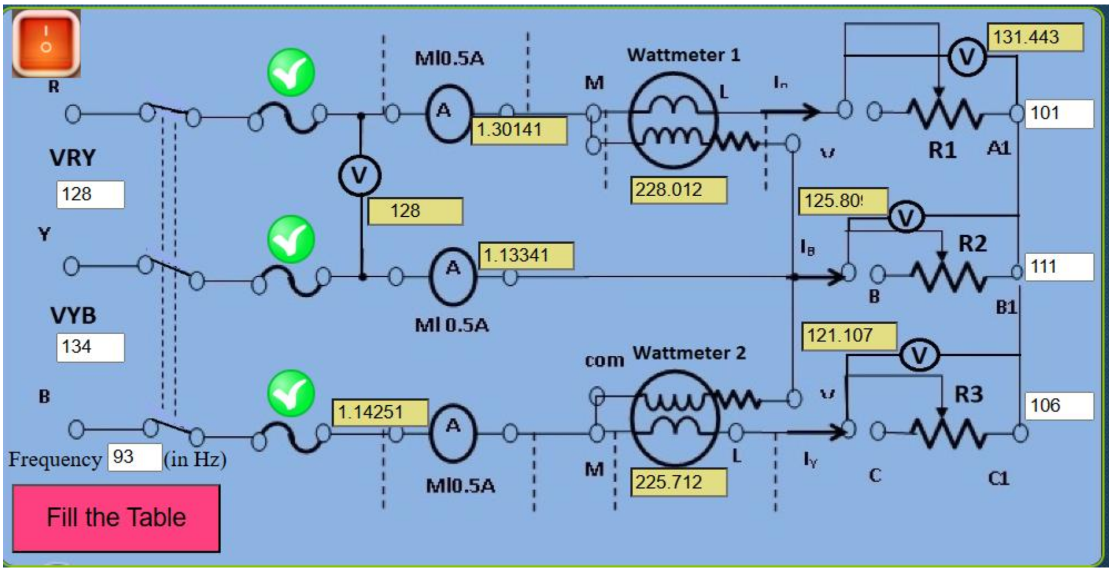


R
VRY
108
Y
VYB
105
B
Frequency
56
(in Hz)
Fill the Table
MI0.5A
0.72516
V
108
0.66590
MI 0.5A
0.64916
MI0.5A
Wattmeter 1
M
L
116.121
com
Wattmeter 2
M
L
113.821
94.9968
131
R1
A1
116.53
R2
175
B
B1
125.937
R3
194
C
C1

Case 4:


MI0.5A
Wattmeter 1
128.939
M
L
133
R
0.96946
R1
A1
VRY
157.002
105.10:
119
119
R2
Y
0.64480
163
B
B1
MI 0.5A
VYB
153.885
119
com
Wattmeter 2
R3
B
0.76180
202
Frequency
79
(in Hz)
M
L
C
C1
MI0.5A
154.702
Fill the Table

Case 5:


MI0.5A
Wattmeter 1
131.443
M
L
101
R
1.30141
R1
A1
VRY
228.012
128
125.80!
128
R2
Y
1.13341
111
B
B1
MI 0.5A
VYB
121.107
134
com
Wattmeter 2
R3
B
1.14251
106
Frequency
93
(in Hz)
M
L
C
C1
MI0.5A
225.712
Fill the Table

Tabulation for unbalanced load:

Observation Table

Serial no. of Observation	V_R	V_y	V_b	I_R (Amp)	I_Y (Amp)	I_B (Amp)	W_C (Calculated power)	W_1	W_2	W_M(Measured Power=W_1+W_2)
1st	97.802081	91.417450	125.98662	0.8150173	0.5713590	0.6999256	220.12385	112.06192	109.76192	221.82385
2nd	108.42402	90.547178	125.34560	0.8743873	0.5521169	0.6775438	229.72436	116.86218	114.56218	231.42436
3rd	94.996842	116.53391	125.93768	0.7251667	0.6659081	0.6491633	228.24356	116.12178	113.82178	229.94356
4th	128.93946	105.10327	153.88519	0.9694696	0.6448053	0.7618078	310.00500	157.00250	154.70250	311.70500
5th	131.44323	125.80938	121.10700	1.3014181	1.1334178	1.1425188	452.02425	228.01212	225.71212	453.72425

RESULT:

Thus the Measurement of Power is Simulated and validated

Exp:2.2:Measurement of Energy

Aim:

*Understanding the use of Energy-meter

* In depth knowledge on Energy metering

* Understanding the calculation of Energy meter error in three types of loading conditions

Theory:

Introduction:

The Energy Meter is a continuously operating measuring device that displays and records the electric energy consumed over a period by multiplying the measured instantaneous voltage and current. Induction type of energy meters is universally used for the measurement of energy in domestic and industrial a.c. circuits. Induction type of meters possess lower friction and higher torque/weight ratio. Also they are inexpensive and accurate, and retain their accuracy over a wide range of loads and temperature conditions.
There are four main parts of the operating mechanism:
(i) Driving system
(ii) Moving system
(iii) Braking system
(iv) Registering system

Driving System:

The driving system of the meter consists of two electromagnets. The core of these electromagnets is made up of silicon steel laminations. The coil of one of the electromagnets is excited by the load current. This coil is called the 'current coil'. The coil of second electromagnet is connected across the supply and, therefore, carries a current proportional to the supply voltage. This coil is called the 'pressure coil'. Consequently the two electromagnets are known as series and shunt magnets respectively. Copper shading bands are provided on the central limb. The position of these bands is adjustable. The function of these bands is to bring the flux produced by the shunt magnet exactly in quadrature with the applied voltage.

Moving System:

This consists of an aluminium disc mounted on a light alloy shaft. This disc is positioned in the air gap between series and shunt magnets.

Braking System:

A permanent magnet positioned near the edge of the aluminium disc forms the braking system. The aluminium disc moves in the field of this magnet and thus provides a braking torque. The position of the permanent magnet is adjustable, and therefore, braking torque can be adjusted by shifting the permanent magnet to different radial positions.

Registering (Counting) Mechanism:

The function of a registering or counting mechanism is to record continuously a number which is proportional to the revolutions made by the moving system.

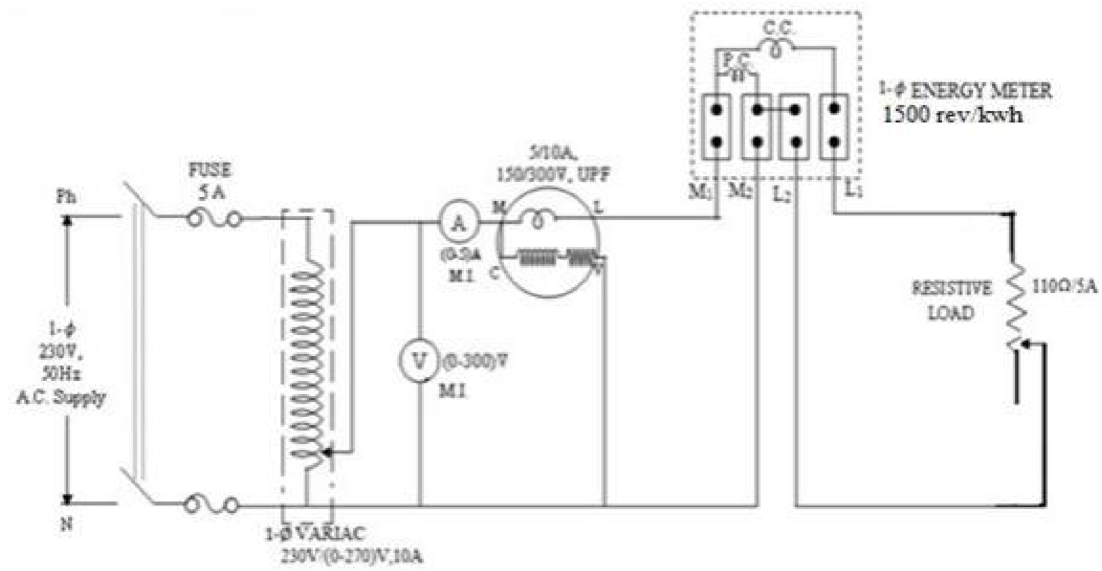


Fig. 1 Calibration and Testing of Single Phase Energy Meter

In all induction instruments we have two fluxes produced by currents flowing in the windings of the instrument. These fluxes are alternating in nature and so they produce emfs in a metallic disc or a drum provided for the purpose. These emfs in turn circulate eddy currents in the metallic disc or the drum. The breaking torque is produced by the interaction of eddy current and the field of permanent magnet. This torque is directly proportional to the product of flux of the magnet, the magnitude of eddy current and effective radius ‘R’ from axis of disc. The moving system attains a steady speed when the driving torque equals the braking torque.

The term testing includes the checking of the actual registration of the meter as well as the adjustments done to bring the errors of the meter within prescribed limits. AC energy meters should be tested for the following conditions:

1. At 5% of marked current with unity pf.
2. At 100% or 125% of marked current.
3. At one intermediate load with unity pf.
4. At marked current and 0.5 lagging pf.

Advantages of Energy Meter:

1. It calculates the electricity consumption quickly.
2. It provides real-time data.
3. It minimises blackout and electric failures.
4. It reduces distribution losses.
5. The electricity meter is energy efficient.

Disadvantages of Energy Meter:

1. The electricity meter can abruptly stop showing readings.
2. If there are power fluctuations, it might show error.

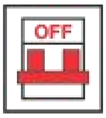
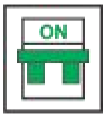
Procedure:

Step 1: Make Connections as per the instructions given below:

1. **S1** of MCB - **A1** of Ammeter and **A2** of Ammeter - **V1** of Voltmeter
2. **V1** of Voltmeter - **Mw** of Wattmeter and **Mw** of Wattmeter - **C** of Wattmeter
3. **S2** of MCB - **V** of Wattmeter and **V** of Wattmeter - **N1** of Energy Meter
4. **N2** of Energy Meter - **L2** of Load and **Le** of Energy Meter - **L1** of Load
5. **L** of Wattmeter - **M** of Energy Meter and **S2** of MCB - **V2** of Voltmeter

NOTE : If wire is wrongly connected, Click on node number to detach the wire.

Step 2: Click on CHECK button for checking the connections.

Step 3: Click on the  MCB to Turn ON  the supply.

Step 4: Select the number of Bulbs from the Lamp Load.

Step 5: Count the number of times Green LED blinks in 1 min (Meter Counter) by using **'Stopwatch'**.

Step 6: Enter the number of times Green LED blinks in 1 min (Meter Counter).

Step 7: Click on ADD button to add the readings to the Observation Table.

Step 8: Add different readings to the table by selecting different number of bulbs.

Step 9: Click on PRINT button to print the webpage.

Step 10: Click on RESET button to refresh the webpage.

FORMULA:

Actual Energy (A) = VIT1000 kw-hr

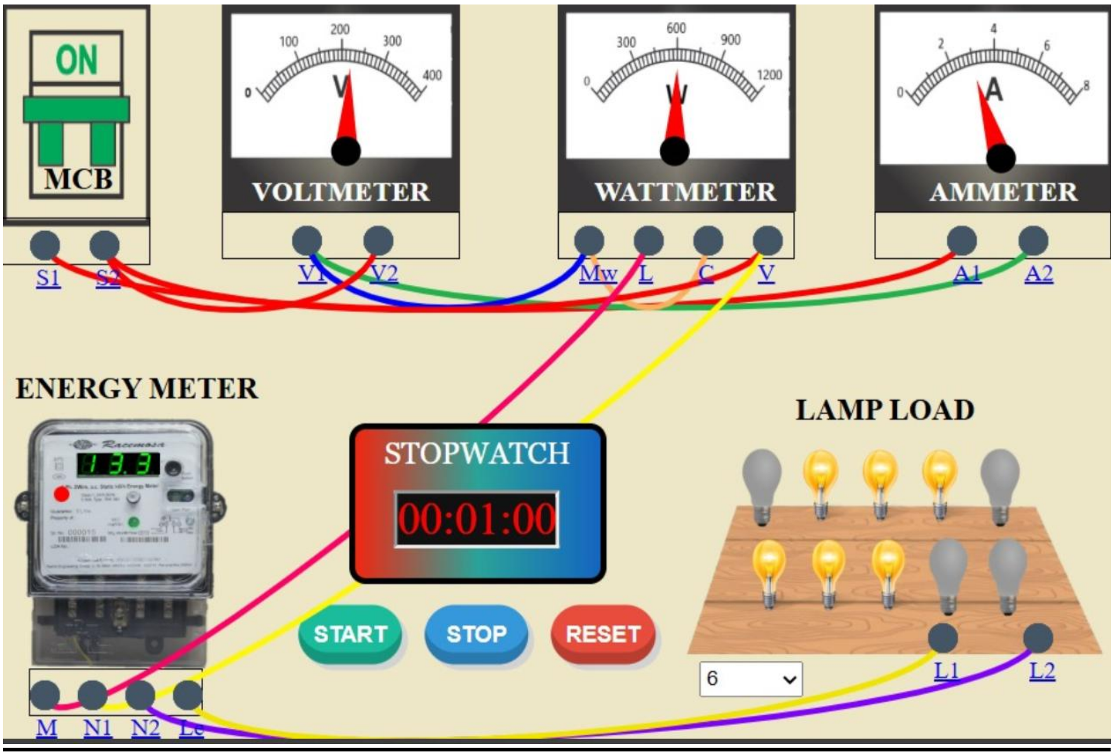
Recorded Energy (R) = Number of Impulse (1min)/Meter Constant

Meter Constant = 3200 Imp/kw-hr

Relative Error = R-AA*100%

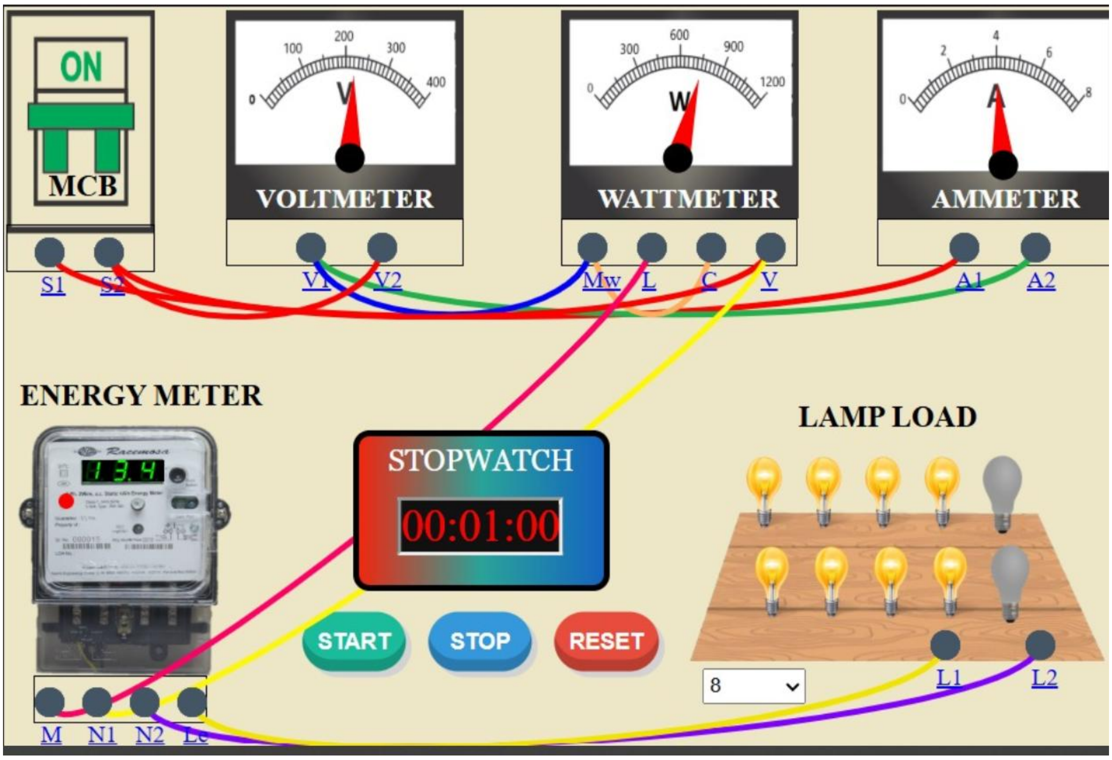
Simulation:

Case 1:



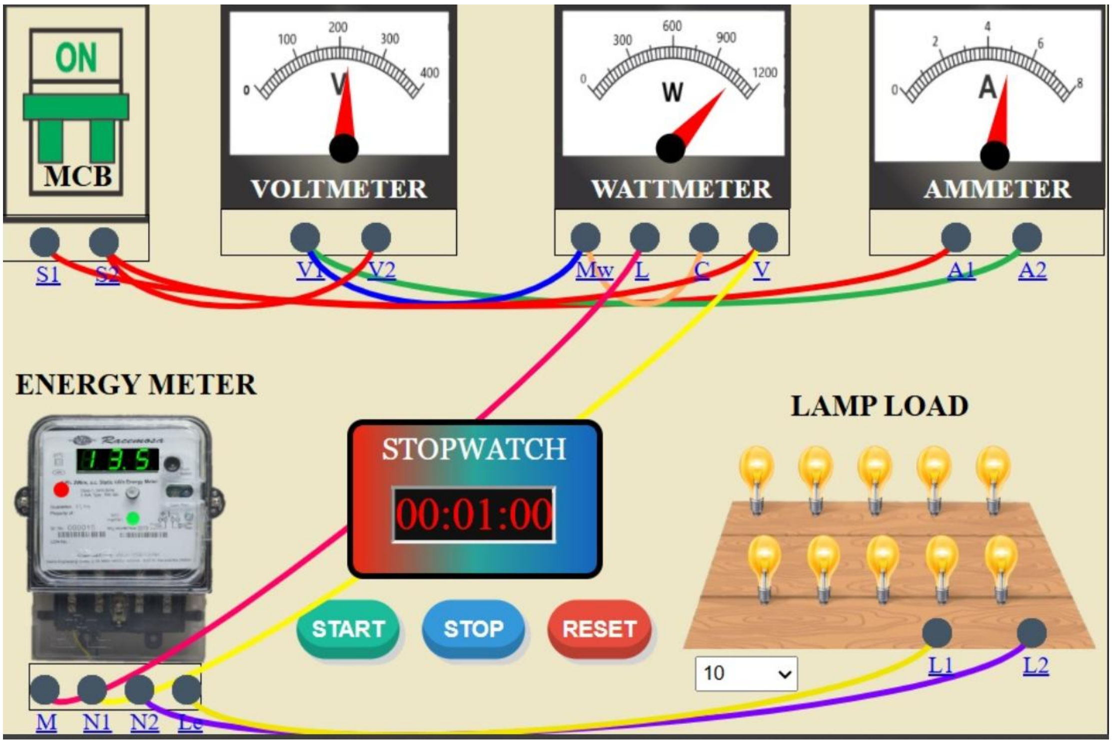
ON
MCB
S1
S2
VOLTMETER
V1
V2
WATTMETER
Mw
L
C
V
AMMETER
A1
A2
ENERGY METER
13.3
STOPWATCH
00:01:00
START
STOP
RESET
LAMP LOAD
6
L1
L2
M
N1
N2

Case 2:



ON
MCB
S1
S2
VOLTMETER
V1
V2
WATTMETER
Mw
L
C
V
AMMETER
A1
A2
ENERGY METER
13.4
STOPWATCH
00:01:00
START
STOP
RESET
LAMP LOAD
8
L1
L2
M
N1
N2

Case 3:



TABULATION:

OBSERVATION TABLE

S.NO.	LOAD (KW)	VOLTAGE (V)	CURRENT (A)	NUMBER OF IMPULSE	ACTUAL ENERGY (KWh)	RECORDED ENERGY (KWh)	RELATIVE ERROR (%)
1	0.6	220	3	36	0.0109	0.0112	2.75
2	0.8	220	4	48	0.0146	0.015	2.73
3	1	220	4.5	54	0.0165	0.0168	1.81

Result:

Thus the measurement of energy is simulated and validated