EXPERIMENT – 2

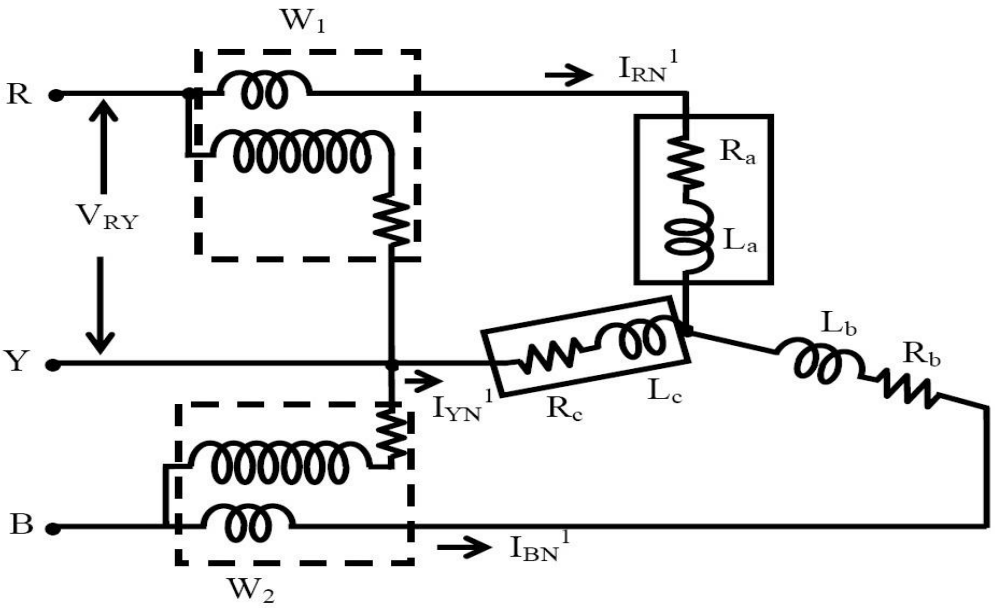
MEASUREMENT OF POWER

Aim

Three phase power measurement by two wattmeter method.

Theory

Circuit diagram



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, W_1 are I_{RN} and

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

So, the instantaneous power measured by the wattmeter W_1 is

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

Similarly the instantaneous power measured by the wattmeter W_2 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.

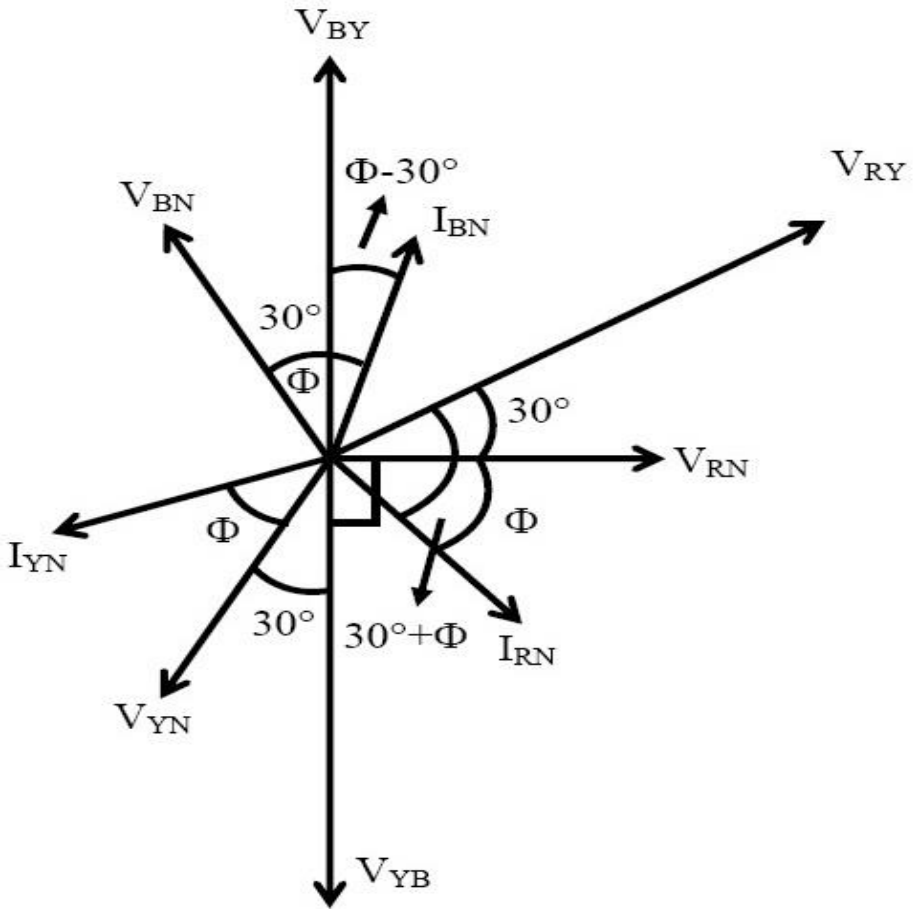


Fig 2: Phasor diagram of three phase balanced star connected circuit

Procedure

BALANCED LOAD:

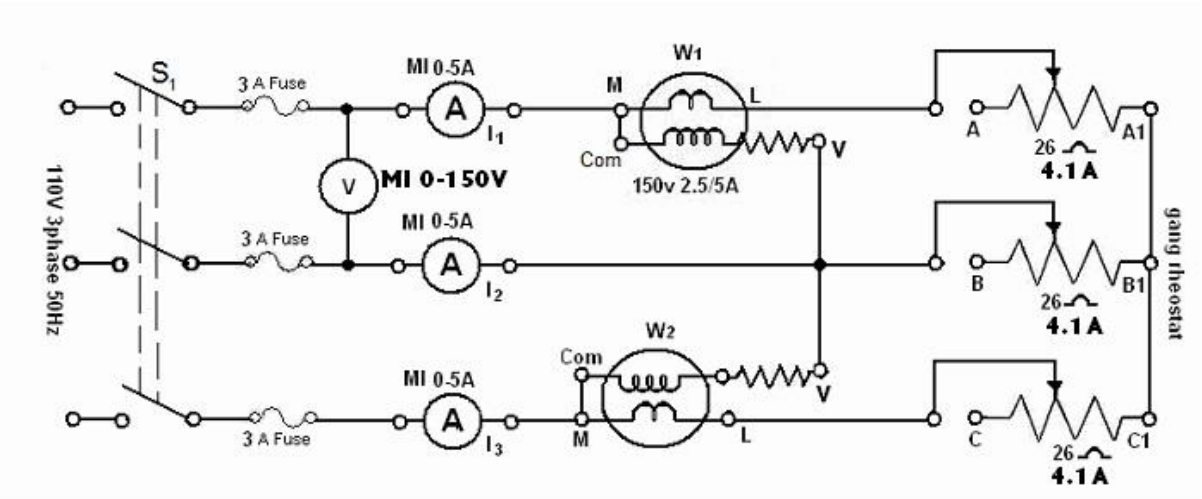


Fig.1. Three phase power measurement circuit under balance condition

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 S_1.
5. Read the meters to obtain V_L, I_1, I_2 and I_3. Note the wattmeter reading W_1 and W_2`(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 :

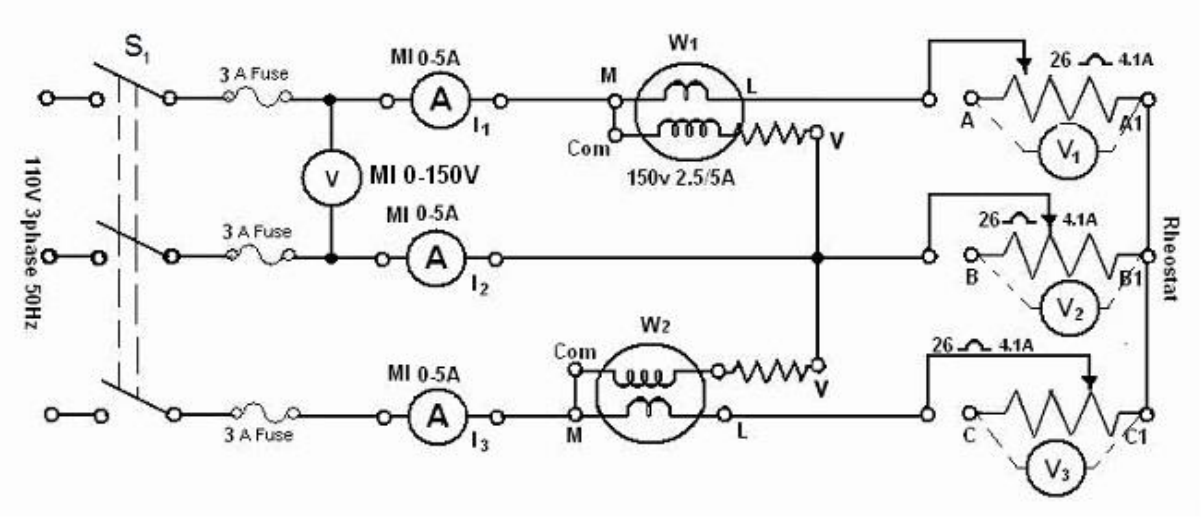


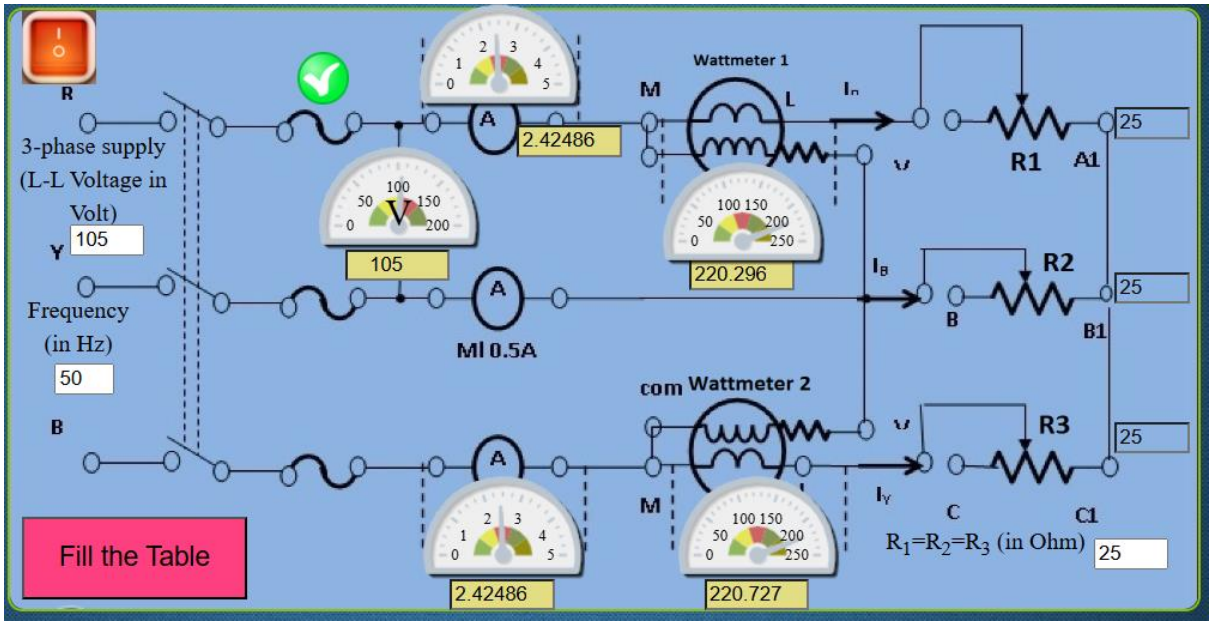
Fig. 2. Three phase power measurement circuit under unbalance condition

1. Connect the circuit as shown in Fig. 2.
2. Replace the ganged rheostat by three separate rheostats of 26 Ω, 4.1 A and connect in a star.
3. Adjust the three rheostats at the maximum values.
4. Switch on the supply and set the autotransformer to 110 V.
5. Close switch S_1 and take five sets of observation for different rheostat settings such that the reading of I_1, I_2 and I_3 in each set is appreciably different to create unbalanced loading condition. The current should not exceed the limits in each arm

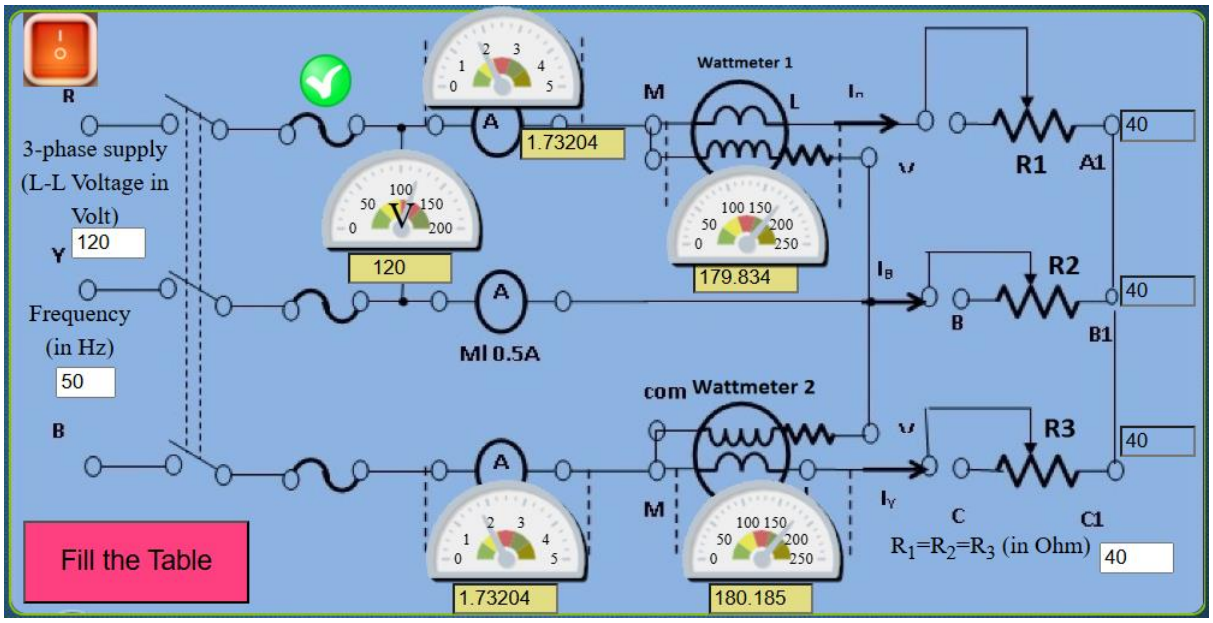
SIMULATION

BALACED LOAD:

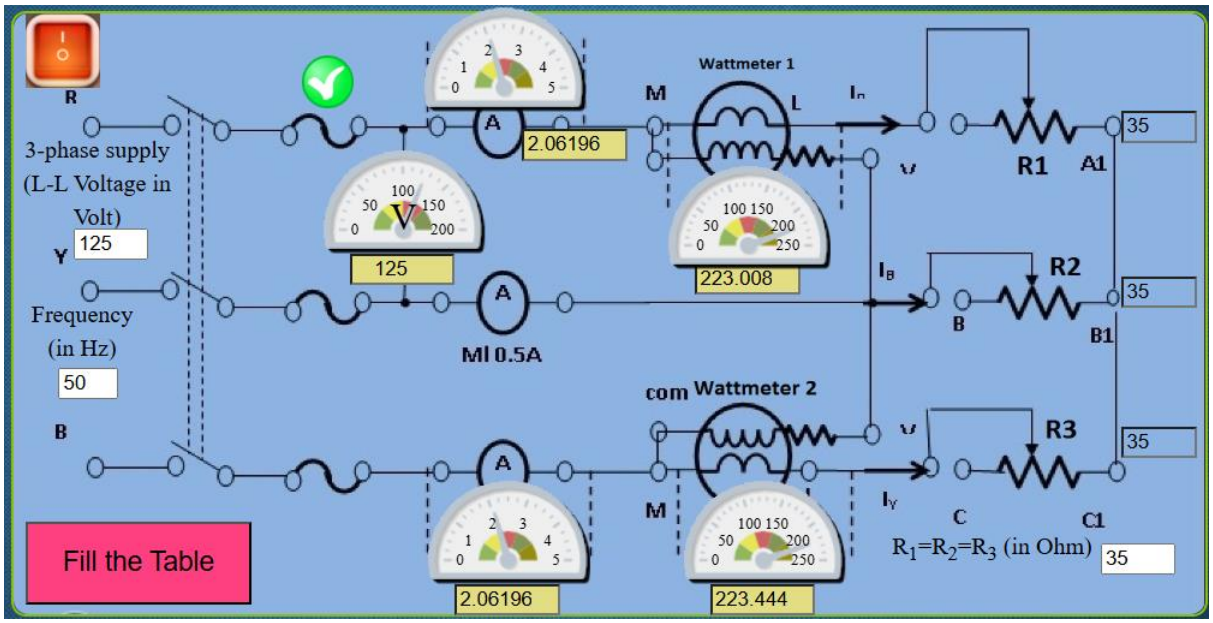
CASE : 1



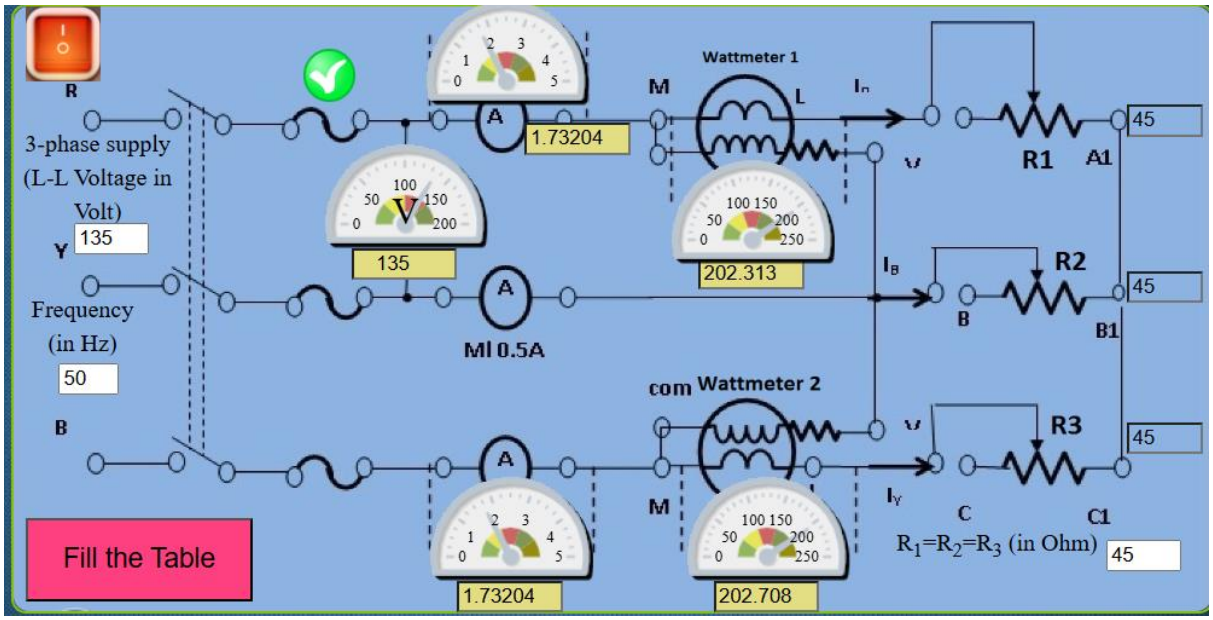
CASE : 2



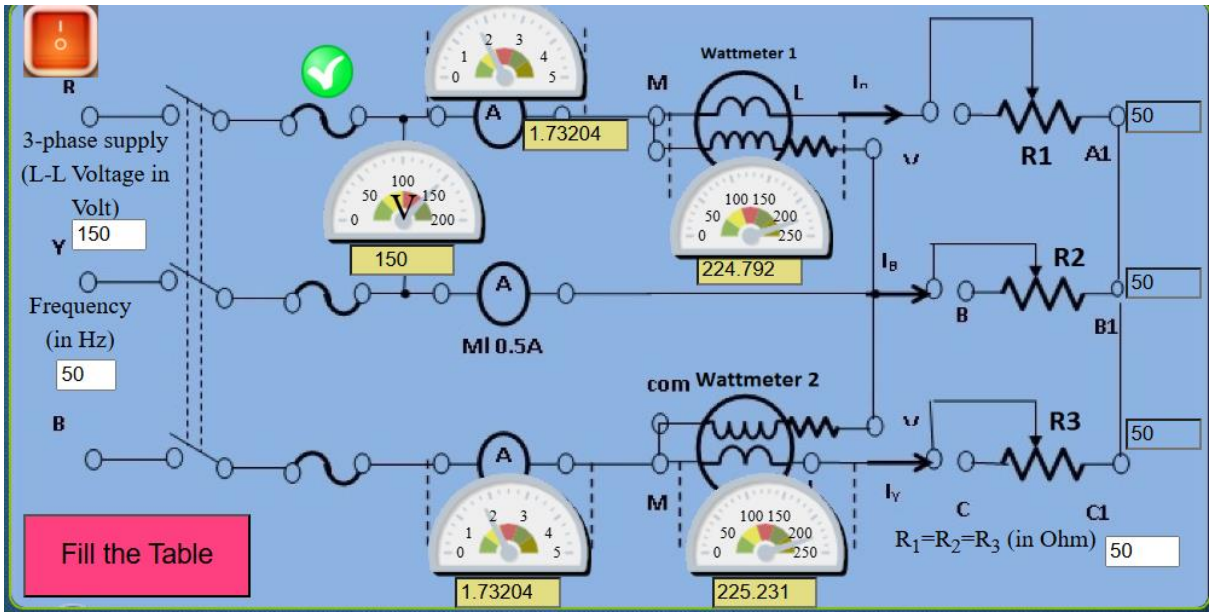
CASE : 3


R
3-phase supply
(L-L Voltage in
Volt)
Y
125
Frequency
(in Hz)
50
B
Fill the Table
2.06196
125
Ml 0.5A
Wattmeter 1
M
L
223.008
com Wattmeter 2
M
223.444
2.06196
R1
A1
R2
B
B1
R3
C
C1
R1=R2=R3 (in Ohm)
35
35
35
35

CASE : 4

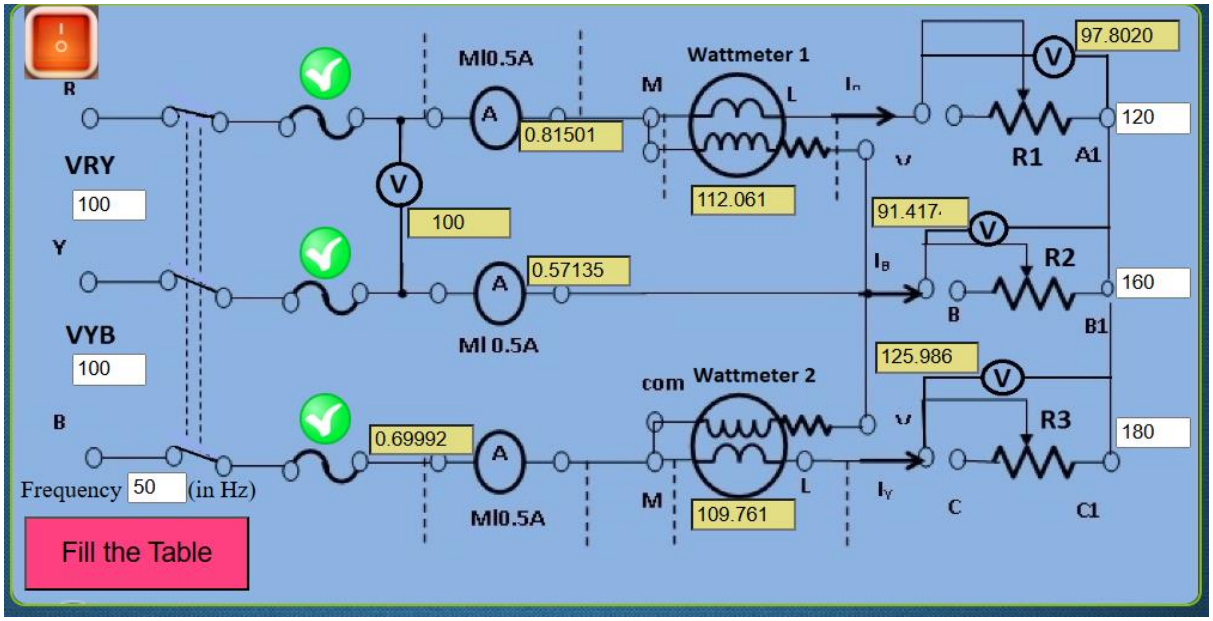

R
3-phase supply
(L-L Voltage in
Volt)
Y
135
Frequency
(in Hz)
50
B
Fill the Table
1.73204
135
Ml 0.5A
Wattmeter 1
M
L
202.313
com Wattmeter 2
M
202.708
1.73204
R1
A1
R2
B
B1
R3
C
C1
R1=R2=R3 (in Ohm)
45
45
45
45

CASE : 5

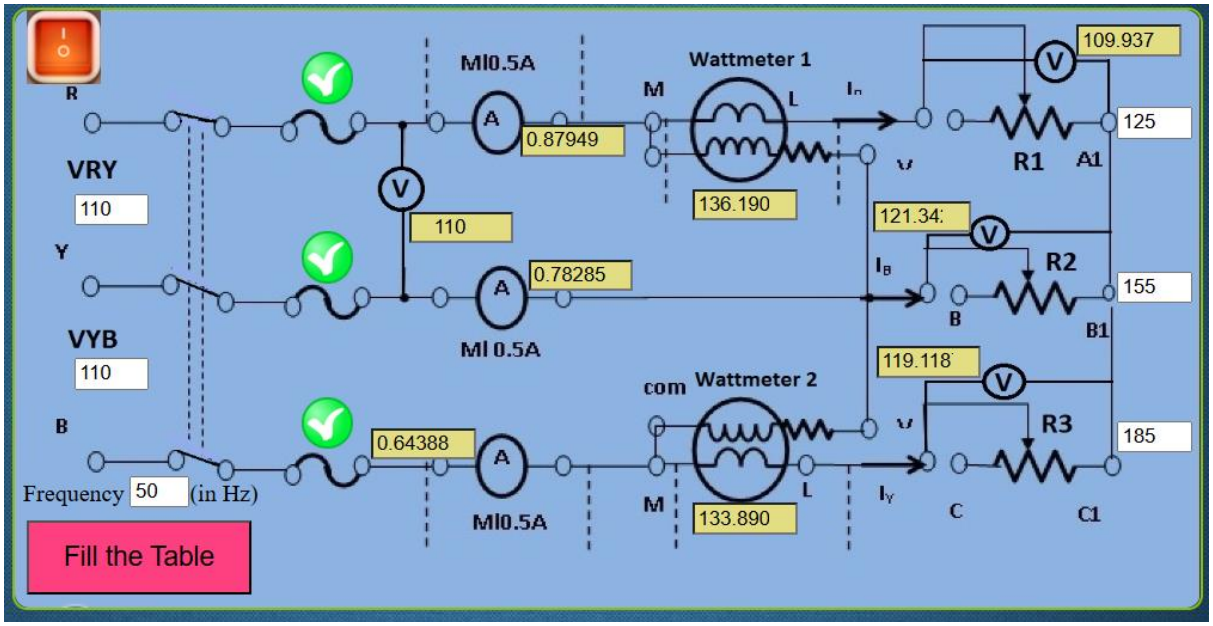


UNBALANCED LOAD:

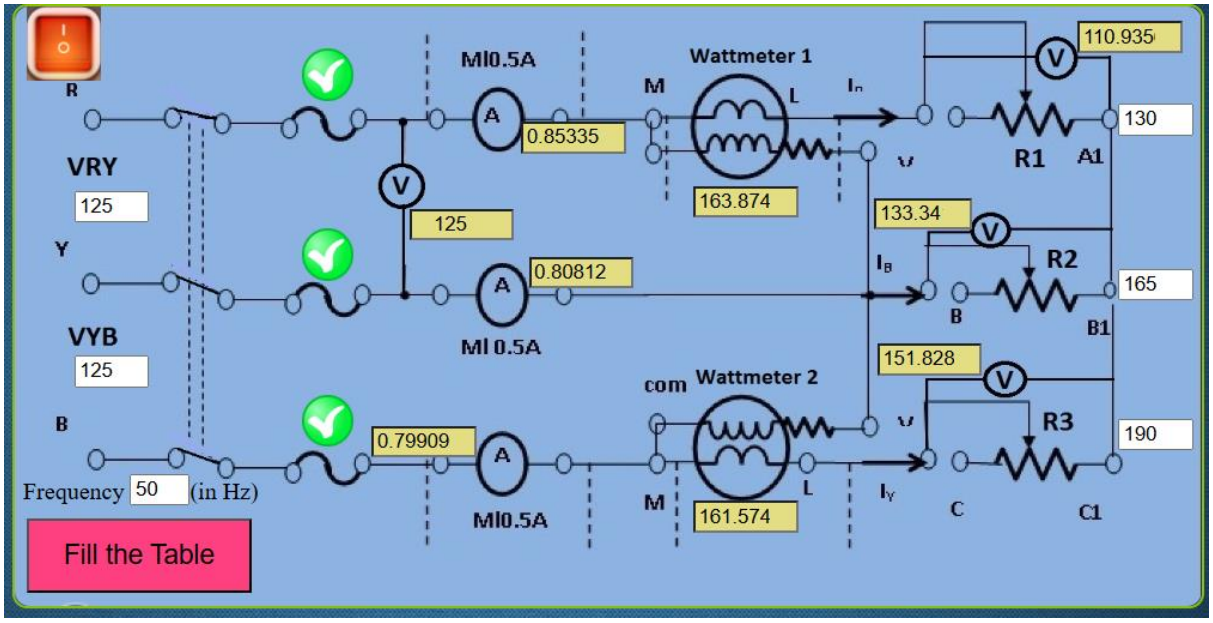
CASE : 1



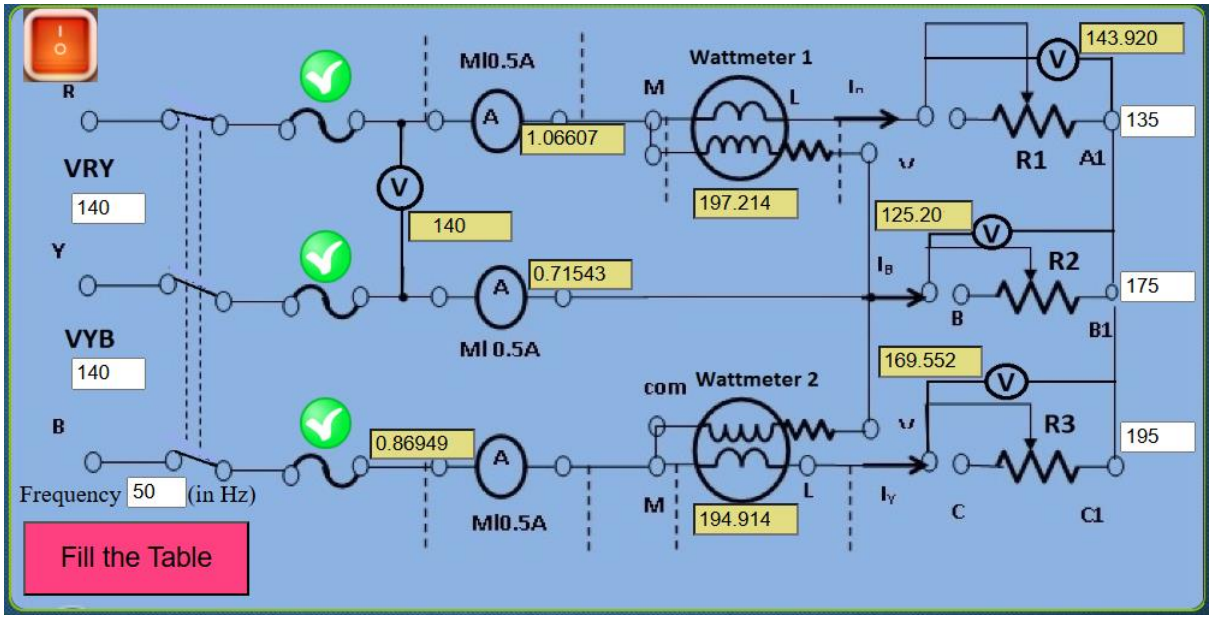
CASE : 2


R
MI0.5A
A
0.87949
Wattmeter 1
M
L
In
109.937
V
125
R1
A1
VRY
110
V
110
136.190
121.34
Y
0.78285
IB
R2
155
B
B1
VYB
110
MI 0.5A
119.118
com
Wattmeter 2
B
0.64388
R3
185
Frequency
50
(in Hz)
MI0.5A
133.890
IY
C
C1
Fill the Table

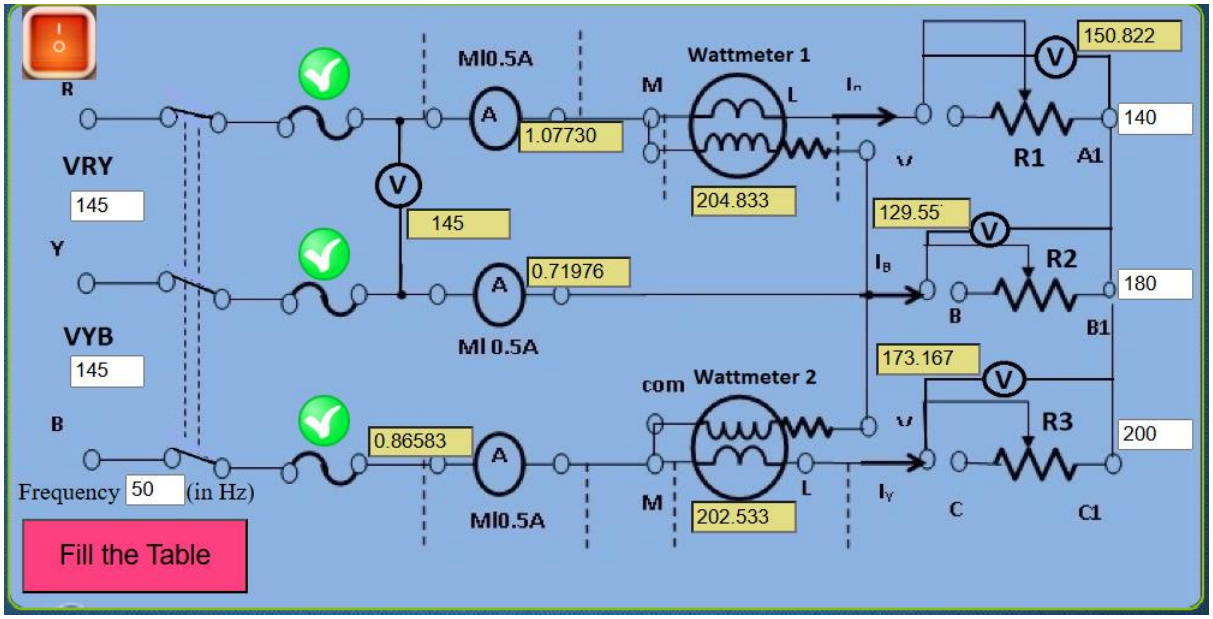
CASE : 3


R
MI0.5A
A
0.85335
Wattmeter 1
M
L
In
110.935
V
130
R1
A1
VRY
125
V
125
163.874
133.34
Y
0.80812
IB
R2
165
B
B1
VYB
125
MI 0.5A
151.828
com
Wattmeter 2
B
0.79909
R3
190
Frequency
50
(in Hz)
MI0.5A
161.574
IY
C
C1
Fill the Table

CASE : 4


R
MI0.5A
A
1.06607
Wattmeter 1
M
L
143.920
V
135
R1
A1
VRY
140
V
140
197.214
125.20
Y
0.71543
R2
175
B
B1
VYB
140
MI 0.5A
169.552
com
Wattmeter 2
B
0.86949
R3
195
C
C1
Frequency
50
(in Hz)
MI0.5A
194.914
Fill the Table

CASE : 5


R
MI0.5A
A
1.07730
Wattmeter 1
M
L
150.822
V
140
R1
A1
VRY
145
V
145
204.833
129.55
Y
0.71976
R2
180
B
B1
VYB
145
MI 0.5A
173.167
com
Wattmeter 2
B
0.86583
R3
200
C
C1
Frequency
50
(in Hz)
MI0.5A
202.533
Fill the Table

OBSERVATION TABLE

BALANCED LOAD:

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	105	2.4248676	0.8652280	105	2.4248676	0.8669190	2.4248676	220.29666	220.72721	440.99873	441.02388
2nd	120	1.7320483	0.8652280	120	1.7320483	0.8669190	1.7320483	179.83401	180.18548	359.99897	360.01949
3rd	125	2.0619622	0.8652280	125	2.0619622	0.8669190	2.0619622	223.00844	223.44430	446.42729	446.45275
4th	135	1.7320483	0.8652280	135	1.7320483	0.8669190	1.7320483	202.31326	202.70867	404.99884	405.02193
5th	150	1.7320483	0.8652280	150	1.7320483	0.8669190	1.7320483	224.79251	225.23185	449.99871	450.02437

UNBALANCED LOAD:

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	109.93727	121.34222	119.11875	0.8794982	0.7828530	0.6438851	268.38155	136.19077	133.89077	270.08155
3rd	110.93566	133.34135	151.82803	0.8533512	0.8081293	0.7990949	323.74916	163.87458	161.57458	325.44916
4th	143.92008	125.20194	169.55242	1.0660746	0.7154397	0.8694996	390.42977	197.21488	194.91488	392.12977
5th	150.82224	129.55746	173.16795	1.0773017	0.7197637	0.8658397	405.66754	204.83377	202.53377	407.36754

RESULT

Thus, the measurement of power is simulated and validated