Three phase circuit

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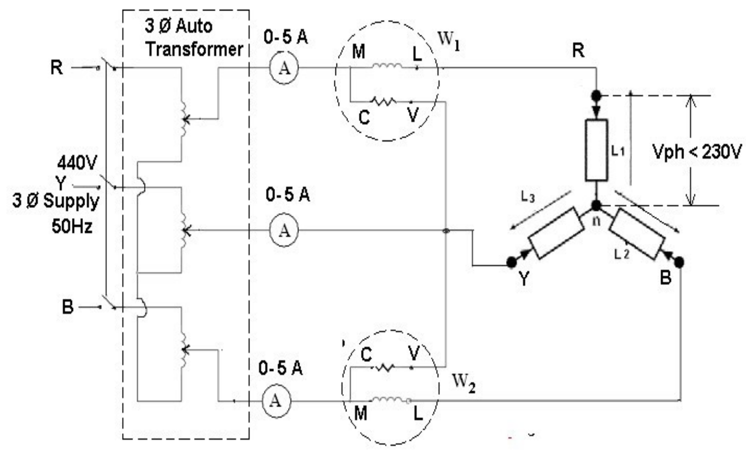
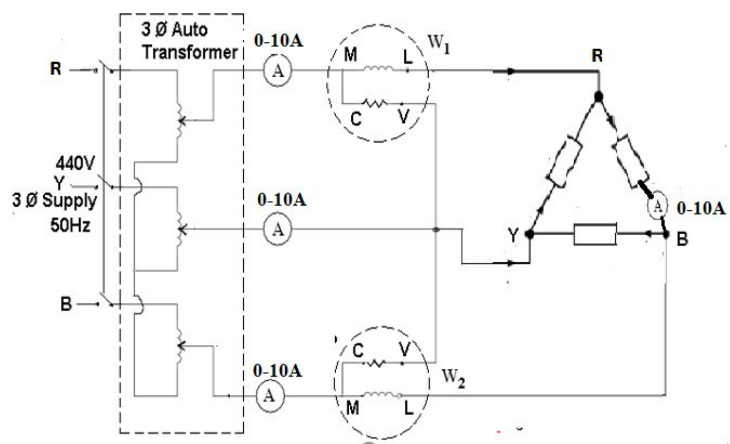
CIRCUIT DIAGRAM:

Part 1: Star connection



Part 2: Delta connection



OBSERVATION TABLE:

For Part 1: Star connection

Sr. No	V_{ph} ($V_R/V_Y/V_B$) (V)	V_L ($V_{RY}/V_{YB}/V_{BR}$) (V)	I_{ph} ($I_R/I_Y/I_B$) (A)	I_L ($I_{RY}/I_{YB}/I_{BR}$) (A)	$\sqrt{3}V_{ph}$ ($\sqrt{3}V_R$) (V)	W_1 (W)	W_2 (W)	$V_{ph}I_{ph}$ (V_RI_R) (W)	3(1-Φ power) =3($V_R \times I_R$)	W_1+W_2 (W)	% Error
1	106	179.6	0.47	0.52	183.6	80	80	49.82	149.46	160	6.5
2	119.1	200	0.5	0.55	206.11	120	120	59.55	178.65	240	25.5
3	130.9	220.9	0.53	0.58	226.72	140	140	69.37	208.11	280	25.71

For Part 2: Delta connection

Sr. No	V_{ph} ($V_R/V_Y/V_B$) (V)	V_L ($V_{RY}/V_{YB}/V_{BR}$) (V)	I_{ph} ($I_R/I_Y/I_B$) (A)	I_L ($I_{RY}/I_{YB}/I_{BR}$) (A)	$\sqrt{3}I_{ph}$ ($\sqrt{3}I_R$) (A)	W_1 (W)	W_2 (W)	$V_{ph}I_{ph}$ (V_RI_R) (W)	3(1-Φ power) =3($V_R \times I_R$)	W_1+W_2 (W)	% Error
1	221.5	221.9	0.75	1.31	1.29	240	300	166.12	498.3	540	7.7
2	221.2	221.1	1.52	2.59	2.63	480	540	336.22	1008.6	1020	1.1
3	219.8	219.6	2.27	3.86	3.93	700	780	498.94	1496.82	1480	1.08

CALCULATIONS:

EXPERIMENT No: 7 **DATE: / / 2022**

Three phase circuit

AIM: 1) To verify the relationship between line/phase voltage/ current in star and delta connection
2) To verify measurement of power in a 3 phase circuit using two wattmeter method for balanced load.

APPARATUS AND COMPONENTS REQUIRED:

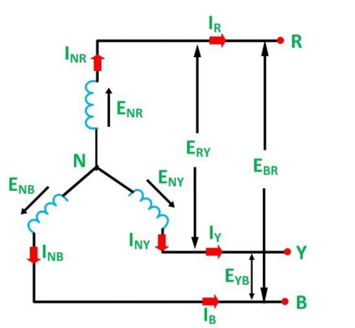
3- Φ Auto transformer, Ammeters (Range), Voltmeters (Range), Wattmeters (Rating), Lamp load, Connecting wires

THEORY: Write theory related with following questions:

1) Define line voltage, line current, phase voltage, phase current, balanced load.
LINE VOLTAGE : the voltage of a power transmission circuit or distribution circuit up to the point of transformation or utilization.
LINE CURRENT : Line current is the measured amount of direct current flowing in a pipeline. It is an indicator of the degree of reactivity and corrosion experienced on the pipeline's surface.
PHASE VOLTAGE: The voltage measured between any line and neutral.
PHASE CURRENT : Phase current is the current through any one component comprising a three-phase source or load.
BALANCED LOAD : A load connected to an electric circuit (as a three-wire system) so that the currents taken from each side of the system are equal and the power factors are equal.

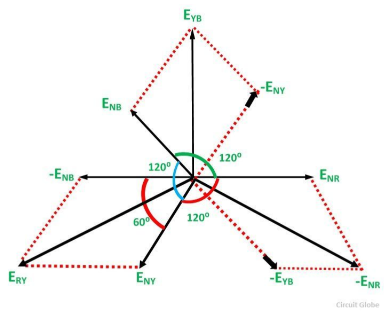
2) Obtain the relationship between line/phase voltage and line/phase currents in case of star and delta connection.

The **Star connection** is shown in the figure below:



As the system is balanced, a balanced system means that in all the three phases, i.e., R, Y and B, the equal amount of current flows through them. Therefore, the three voltages E_{NR}, E_{NY} and E_{NB} are equal in magnitude but displaced from one another by 120° electrical.

The **Phasor Diagram** of Star Connection is shown below:



The arrowheads on the EMFs and current indicate direction and not their actual direction at any instant.

Now, $E_{NR} = E_{NY} = E_{NB} = E_{ph}$ (in magnitude)

There are two-phase voltages between any two lines.

Tracing the loop NRYN

$$\overline{E_{NR}} + \overline{E_{RY}} - \overline{E_{NY}} = 0 \quad \text{or}$$

$$\overline{E_{RY}} = \overline{E_{NY}} - \overline{E_{NR}} \quad \text{(vector difference)}$$

To find the vector sum of ENY and –ENR, we have to reverse the vector ENR and add it with ENY as shown in the phasor diagram above.

Therefore,

$$E_{RY} = \sqrt{E_{NY}^2 + E_{NR}^2 + 2E_{NY}E_{NR}\cos 60^\circ} \quad \text{or}$$

$$E_L = \sqrt{E_{ph}^2 + E_{ph}^2 + 2E_{ph}E_{ph} \times 0.5} \quad \text{or}$$

$$E_L = \sqrt{3E_{ph}^2} = \sqrt{3}\, E_{ph} \quad \text{(in magnitude)}$$

Similarly,

$$E_{YB} = E_{NB} - E_{NY} \quad \text{or} \quad E_L = \sqrt{3}\, E_{ph} \quad \text{and}$$

$$E_{BR} = E_{NR} - E_{NB} \quad \text{or} \quad E_L = \sqrt{3}\, E_{ph}$$

Hence, in star connection line voltage is root 3 times of phase voltage.

$$\text{Line voltage} = \sqrt{3} \times \text{Phase voltage}$$

The same current flows through phase winding as well as in the line conductor as it is connected in series with the phase winding.

$$I_R = I_{NR}$$

$$I_Y = I_{NY} \quad \text{and}$$

$$I_B = I_{NB}$$

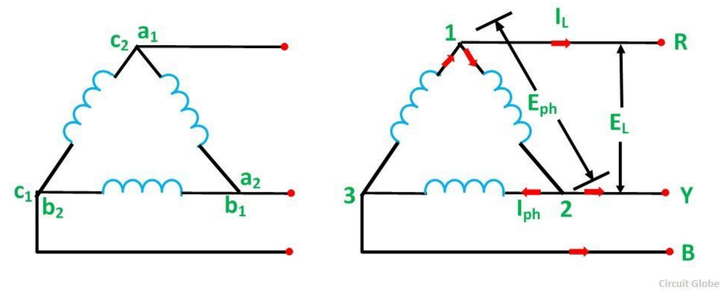
Where the phase current will be:

$$I_{NR} = I_{NY} = I_{NB} = I_{ph}$$

The line current will be:

$$I_R = I_Y = I_B = I_L$$

Hence, in a 3 Phase system of star connections, the line current is equal to phase current.



To obtain the **delta connections**, a_2 is connected with b_1, b_2 is connected with c_1 and c_2 is connected with a_1 as shown in the above figure. The three conductors R, Y and B are running from the three junctions known as **Line Conductors**.

The current flowing through each phase is called **Phase Current (Iph)**, and the current flowing through each line conductor is called **Line Current (I_L).**

The voltage across each phase is called **Phase Voltage (E_{ph})**, and the voltage across two line conductors is called **Line Voltage (E_L).**

Relation Between Phase Voltage and Line Voltage in Delta Connection

To understand the relationship between the phase voltage and line voltage in the delta connection, consider figure A shown below:

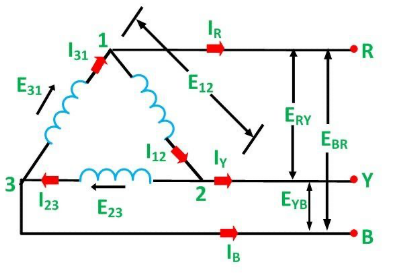


Figure A

It is clear from the figure that the voltage across terminals 1 and 2 is the same as across the terminals R and Y. Therefore,

$$E_{12} = E_{RY}$$

Similarly,

$$E_{23} = E_{YB} \quad \text{and} \quad E_{31} = E_{BR}$$

: the phase voltages are

$$E_{12} = E_{23} = E_{31} = E_{ph}$$

The line voltages are:

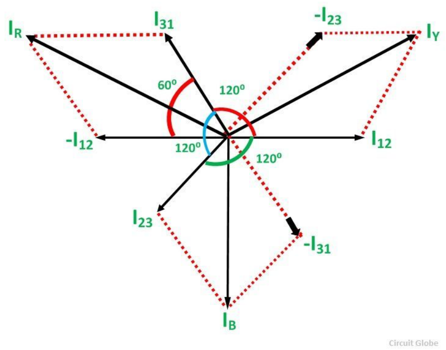
$$E_{RY} = E_{YB} = E_{BR} = E_L$$

Hence, in delta connection line voltage is equal to phase voltage.

Relation Between Phase Current and Line Current in Delta Connection

As in the balanced system the three-phase current I_{12}, I_{23} and I_{31} are equal in magnitude but are displaced from one another by 120° electrical.

The **phasor diagram** is shown below:



Hence,

$$I_{12} = I_{23} = I_{31} = I_{ph}$$

If we look at figure A, it is seen that the current is divided at every junction 1, 2 and 3.

Applying Kirchhoff's Law at junction 1,

The Incoming currents are equal to outgoing currents.

$$\overline{I_{31}} = \overline{I_R} + \overline{I_{12}}$$

And their vector difference will be given as:

$$\overline{I_R} = \overline{I_{31}} - \overline{I_{12}}$$

The vector I_{12} is reversed and is added in the vector I_{31} to get the vector sum of I_{31} and $-I_{12}$ as shown above in the phasor diagram. Therefore,

$$I_R = \sqrt{I_{31}^2 + I_{12}^2 + 2I_{31}I_{12}\cos 60^\circ} \quad \text{or}$$

$$I_L = \sqrt{I_{ph}^2 + I_{ph}^2 + 2I_{ph}I_{ph} \times 0.5}$$

As we know, $I_R = I_L$, therefore,

$$I_L = \sqrt{3I_{ph}^2} = \sqrt{3}I_{ph}$$

Similarly,

$\overline{I_Y} = \overline{I_{12}} - \overline{I_{23}}$ or $I_L = \sqrt{3}I_{ph}$ and

$\overline{I_B} = \overline{I_{23}} - \overline{I_{31}}$ or $I_L = \sqrt{3}I_{ph}$

Hence, in delta connection line current is root three times of phase current.

Line Current $= \sqrt{3}$ x Phase Current

3) How two wattmeters can be used to measure three phase power?

To measure power in a 3-phase system, it would seem necessary to use three wattmeters, each connected to neutral for a common terminal, and each responding to a line-to-neutral voltage and a line current. One would then add up the powers indicated on each wattmeter. Analysis of such a circuit shows that one wattmeter is redundant, hence the two-wattmeter method of measuring 3-phase power was developed for three wire systems. This method is satisfactory even if the loads are unbalanced. It is necessary to connect the wattmeters taking into account the polarity of their coils. When the current enters the marked terminal of the current coil and the voltage positive is connected to the marked terminal of the voltage coil, the reading represents power absorbed. In that case the *algebraic* sum of the wattmeters determines the total load power. In reactive circuits it may be necessary to reverse the current coil of one wattmeter in order to get an upscale deflection. This reading is taken as negative when the total power is determined algebraically

4) In which case will get more power, star or delta? Why?

In delta connection more power is present.

PROCEDURE:

1) Connect the circuit for star connection as shown in the circuit diagram.
2) Adjust the 3-ϕ transformer phase voltage to any value below 230V.
3) Vary the lamp load in 3 phases considering balanced load.
4) Measure V_L, V_{ph}, I_L, I_{ph}, W_1, W_2
5) Take 3 such readings.
6) Connect the circuit for delta connection as shown in the circuit diagram.
7) Repeat steps 2) to 5).

CONCLUSION:

In this experiment, We have verifyed The relationship between line/Phase voltage/current in star and delta Connection. We also verifyed the two wattmeter method measurement of power in a 3 phase circuit using for balanced load.