POWER IN 3-PHASE CIRCUITS

Objective:

To measure power in a 3-phase circuit with a balanced load by one-wattmeter and two-wattmeter methods and to estimate the power from the results.

Theory:

Power in a 3-phse balanced system

The load in a 3-phsase system may be connected in star or delta. A balanced load is that in which the loading in each phase is exactly the same. The power in a 3-phase system is always equal to the sum of the powers in each of he three phases.

$$P = P_1 + P_2 + P_3 \qquad (1)$$

With a balanced load, the total power is

$$P = 3 P_3 = 3 V_p I_p \cos\phi \qquad (2)$$

Where
Vp = phase voltage
Ip = phase current
Cosϕ= power factor of any phase
ϕ= phase angle between phase voltage and phase current
V_L = line voltage
I_L = line current

The total power of a balanced star or delta connected load is given by

$$P = \sqrt{3} V_L I_L \cos\phi \qquad (3)$$

If the neutral point in a star-connected system is accessible, the power may be calculated from the readings of one wattmeter whose current coil has to carry the phase current and the voltage coil the phase voltage of the same phase. The total power is three times the power in one line (see FIG.1)

$$P = 3 . P_3 \qquad (4)$$

In a delta or star connected system with no access to neutral point, the power may be calculated from the readings of two wattmeters whose current coils are carrying line currents & the voltage coil are connected between the same lines and the third line. The total power is the algebraic sum of the two-wattmeter readings:

$$P = P_1 + P_2 \qquad (5)$$

Power factor from the 2-wattmeter method

An indication of the power factor is given by the two wattmeters, whose readings vary with load power factor as follows:

$\cos\phi = 1$	$P_1 = P_2$	$1 > \cos\phi > 0.5$	$P_1 > 0$, $P_2 > 0$
$\cos\phi = 0.5$	$P_2 = 0$	$0.5 > \cos\phi > 0$	$P_1 > 0$, $P_2 < 0$

The power factor may be found from the expression:

$$\tan\phi = \sqrt{3}\,(P_1 - P_2)/(P_1 + P_2) \qquad (6)$$

For power factors less than 0.5, one of the wattmeters will read negative when calculating total power.
The power factor may also be calculated from the ration of the total power to the volt-amperes in the circuit:

$$\cos\phi = P/(\sqrt{3}\,V_L I_L) \qquad (7)$$

Procedure:

1. Connect the circuit as shown in FIG.1.
2. Switch on the supply taking care that the variac is kept on its zero output position and adjust the variac to give 230 V line voltage.
3. Switch on a resistive load and take the readings at power factor =1. Keeping the load current to about 3 A. Record Vp, VL, I_L, P_1, P_2 and P_3.
4. Decrease the resistive load, switch on an inductive load and set both loads to obtain different positive readings in P_1, and P2 at I_L = 3 A ($\cos\phi > 0.5$).
5. Set both loads to obtain zero reading in one of the wattmeters keeping I_L 3 A ($\cos\phi = 0.5$).
6. Set both loads to obtain negative reading in one wattmeter at I_L 3 A ($\cos\phi < 0.5$).
7. In each case record Vp, VL, I_L, P_1, P_2 and P_3.
8. Tabulate the readings and calculations as shown below;

S.No.	Vp	V_L	I_L	P_1.	P_2	P_3	P= 3. P_3	$P=P_1+P_2$	Cos ϕ From Eq.6	Cosϕ From Eq.7
	V	V	A	W	W	W	W	W	-	-

Report

1. Calculate the total power from the readings of the on wattmeter & two-wattmeter methods.
2. Calculate the power factor from readings of steps 3 & 4 of the procedure.
3. Tabulate the results of calculations

FIG.1