Three phase power measurement			
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Experiment No:	5	**Reg. No:**	21BAI1604

Aim:

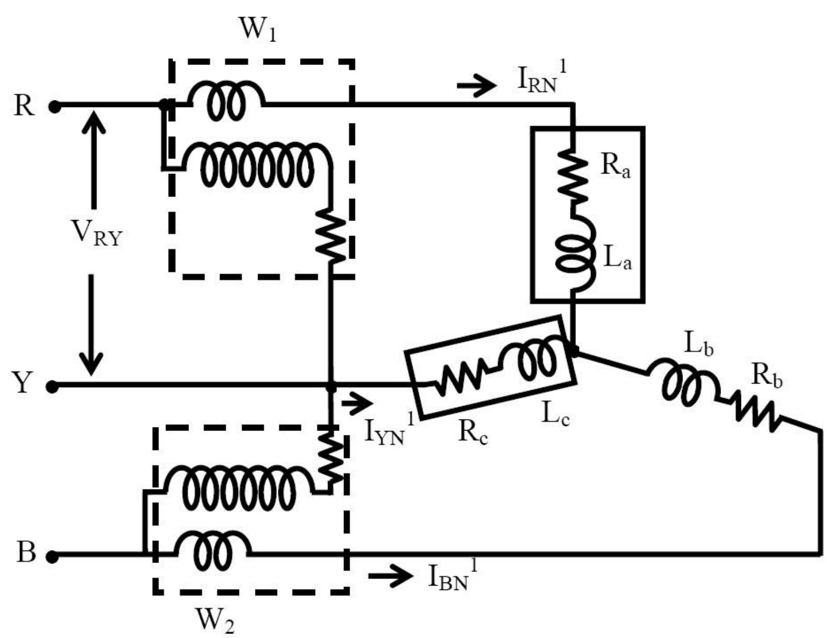
To measure the power consumed by a given three phase AC load.

Software required: LTSpice

Apparatus required:

S.No.	Apparatus Name	Type	Range	Qty
1	Voltmeter	MI	(0-600)V	1
2	Ammeter	MI	(0-10)A	1
3	Wattmeter	UPF	600V, 10A	2
4	Three phase resistive load	Tubular	7kW	1
5	Connecting wires	Multi strand	-	As required

Circuit diagram:

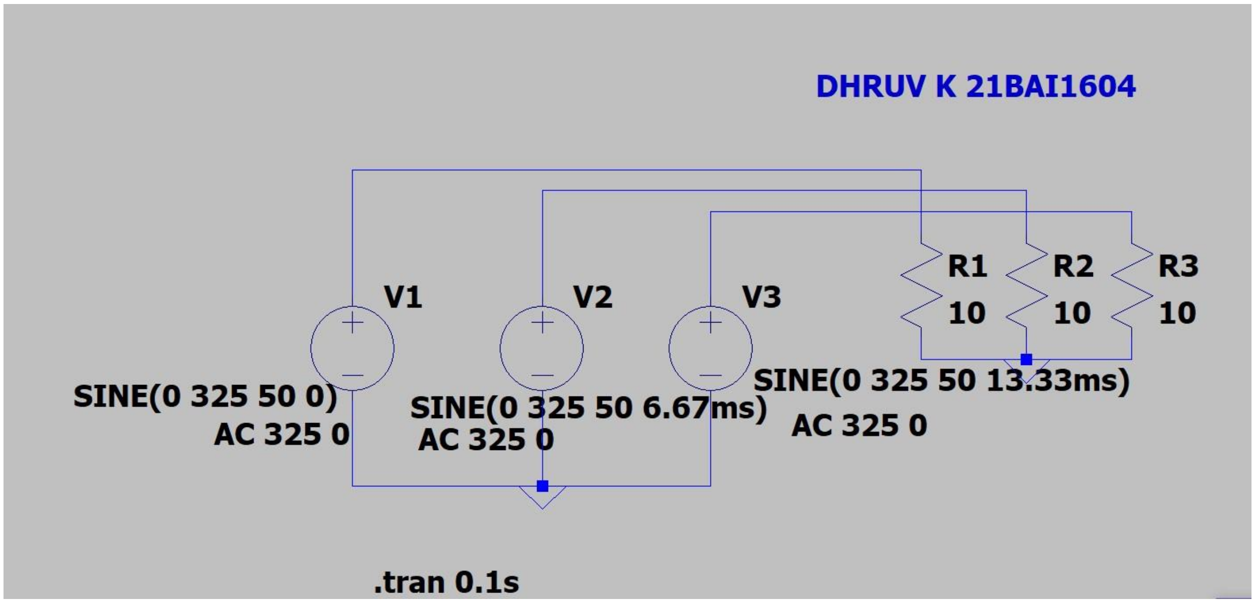


FORMULAE

Power factor = cos ϕ

$$\cos\phi = \cos\left[\tan^{-1}\left[\sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}\right]\right]$$

LTSpice circuit diagram:

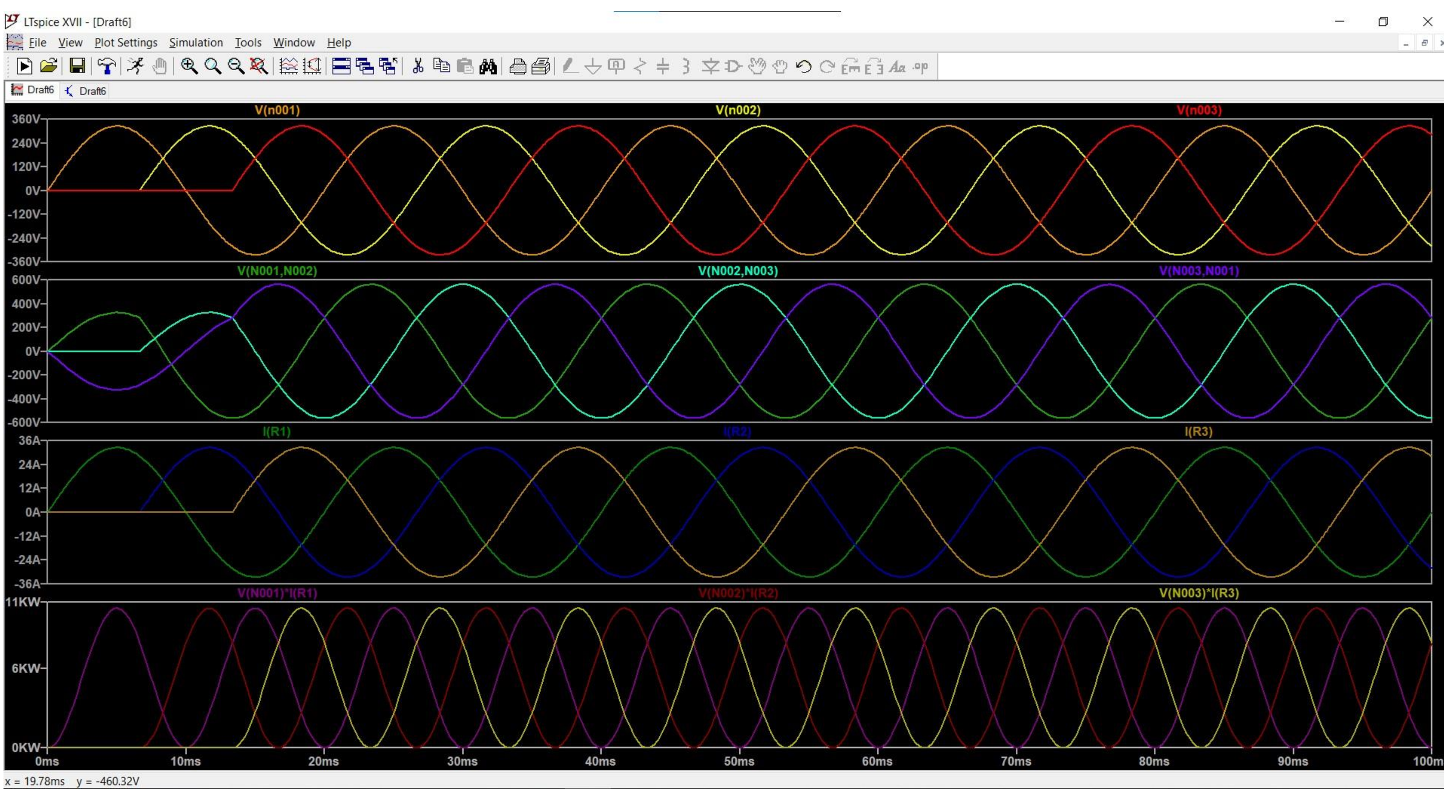


Procedure:

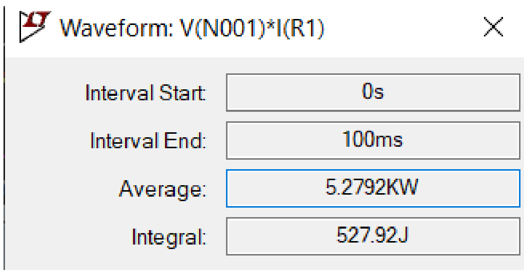
1. Open a new file
2. Select voltage source from components list and convert into AC voltage source by selecting ‘advanced’ option while feeding the parameter to the source.
3. Choose sine
4. Feed amplitude, frequency and delay time
5. In small signal analysis (right side), feed amplitude and phase angle value.
6. In a 3-phase circuit, the delay time for R-phase is zero
7. For Y-phase, the delay angle is 6.67 ms as in Figure 3 for a frequency of 50 Hz which is corresponding to 120 degree phase shift with respect to R-phase.
8. For B-phase, the delay angle is 13.22 ms as in Figure 4 for a frequency of 50 Hz which is corresponding to 240 degree phase shift with respect to R-phase
9. Connect the sources at one end and further connect it to ground.

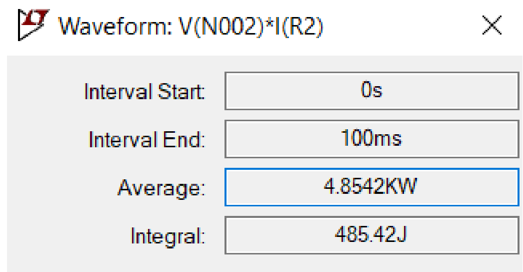
10. Connect 3-phase resistive load to the circuit.
11. Save the file
12. Edit simulate cmd
13. Choose transient
14. Specify the stop time (0.1 s)
15. Run the file
16. Measure all line voltages and phase currents
17. To measure the instantaneous power dissipated or supplied by a component, hold the "alt" key and click on the component to be measured.
18. After selecting the instantaneous power of a component, hold the "ctrl" button and click on the name of the measurement in the measurement window. A new window will open displaying the average power and energy
19. Measure the power and energy for different load values and tabulate it.

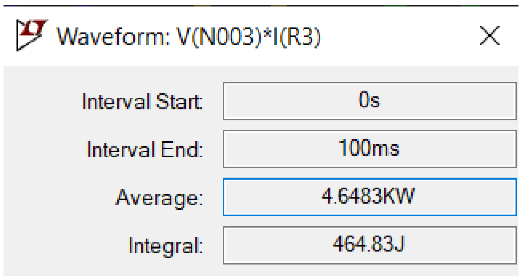
Screenshot of waveforms and results:



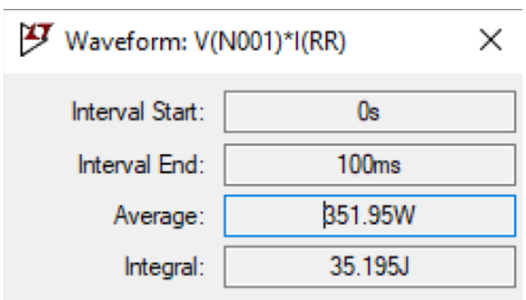
For 10 ohms power :

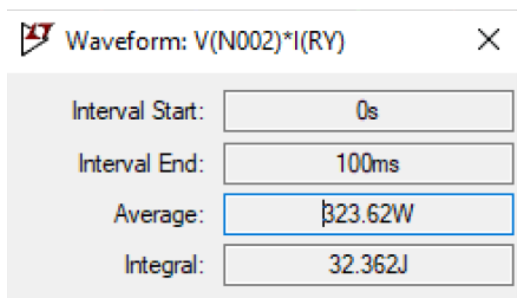


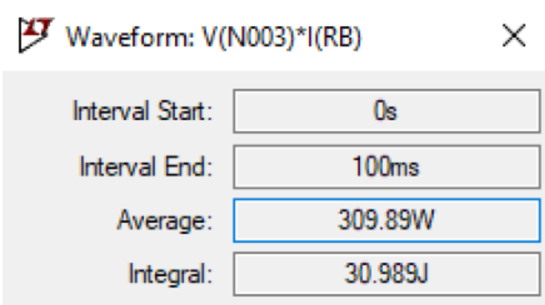




For 150 ohms power :







Tabular column for balanced Resistive load:

S.No.	Voltage Volts	Current Amperes	W_1 (Watts)		W_2 (Watts)		Real Power (W_1+W_2) Watts	Power factor Cos φ
			Observed	Actual = Obs*MF	Observed	Actual= Obs*MF		
1	415V	2A	300	600	320	640	1240	0.9984
2	415V	2.8A	480	960	500	1000	1960	0.9994
3	415V	5A	840	1680	840	1680	3360	1
4	415V	6.9A	1160	2320	1200	2400	4720	0.9995

Theoretical calculations for balanced load:

W_1 (watt)
Observed = 480 W
Actual = 480 x 2
= 960 W

W_2 (watt)
Observed = 500 W
Actual = 500 x 2
= 1000 W

Total = $W_1 + W_2$ = 1960 W

Power factor: $\cos\phi$

$$\cos\phi = \cos\left[\tan^{-1}\left[\sqrt{3}\ \frac{W_1 - W_2}{W_1 + W_2}\right]\right]$$

$$= \cos\left[\tan^{-1}\left[\sqrt{3} - \frac{\cancel{40}}{\cancel{1960}\ 49}\right]\right]$$

$$= \cos\left[\tan^{-1}(-0.035)\right]$$

$$= \cos[-2.024]$$

$$= 0.9994$$

$$\text{Power} = \sqrt{3}\ V_L I_L \cos\phi$$

$$= \sqrt{3} \times 415 \times 2.8 \times 0.9994$$

$$= 2011.435$$

Result & Inference:

- The power consumed by a 3-phase AC load is calculated theoretically
- The power consumed by a 3-phase AC load is measured practically
- The power and energy consumed by a 3-phase AC load is verified by LTspice simulation

Therefore it can be concluded that :

- 2-wattmeter method efficiently measures the power in a three-phase system.
- LTspice can also be used for measuring power.
- Error could be due to overheating of the circuit or due to leaking current.