Experiment 5 **Date: 29/8/25**

Measurement of Power and Power Factor in a single-phase RL using 3- voltmeter method

Aim:

To measure the power dissipated in a single-phase R-L series circuit and to calculate power factor of the circuit by 3 voltmeter method.

Apparatus Required:

S.No.	Name of the apparatus	Range/Type	Quantity
1.	Transformer	1-$-\phi$ AC supply, 230/24/12	1
2.	Inductive Coil	20 mH, 20A	1
3.	Multimeter	-	1
4.	Resistor	100Ω	1
5.	Wires	-	Few

Theory:

To measure the power and power factor in the AC circuit, wattmeter and power factor meters are available. While wattmeters and power factor meters provide direct and convenient measurements, the three voltmeter method offers a more analytical approach that relies on basic electrical laws like Ohm's Law and the power formula $P = VI\cos\phi$. It is especially useful in labs where wattmeters may not be available due to cost constraints, or where higher precision is needed at low power levels.

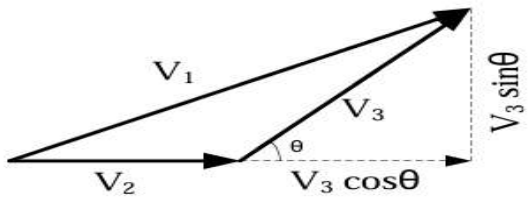
In this method, a non-inductive resistor (standard resistor) is connected in series with the unknown load (Inductive coil). The current through the circuit is the same for all series components. By measuring the voltage drops across the known resistor and the load, and the total supply voltage, we can determine the current and compute the power and power factor in the single-phase RL series circuit. Power factor is the cosine of the angle between phase voltage and current. The maximum value of power factor is unity, i.e. for pure resistive load and minimum value is zero.ie for pure inductive load (lagging) or pure capacitive load (leading). For an R-L circuit, the current lags voltage by certain angle, which is called the power factor angle θ. Three voltmeters measure:

V1: the total voltage across the series combination (resistor + load),

V2: the voltage across the standard resistor R

V3: the voltage across the unknown load (i.e., RL).

The vector diagram is shown in figure. Current I is taken as the reference, V2 in phase with I (since current through pure resistance- in phase with V,), V3 Leads current I by angle θ, (since current through pure resistance- in phase with V,), V1 is the vector sum of V2 and V3.



$$V_1^2 = (V_2 + V_3\cos\theta)^2 + (V_3\sin\theta)^2$$
$$V_1^2 = V_2^2 + V_3^2cos^2\theta + 2V_2V_3\cos\theta + V_3^2sin^2\theta$$
$$V_1^2 = V_2^2 + V_3^2 + 2V_2V_3\cos\theta$$

Power factor

$$\cos\theta = \frac{V_1^2 - V_2^2 - V_3^2}{2V_2V_3}$$

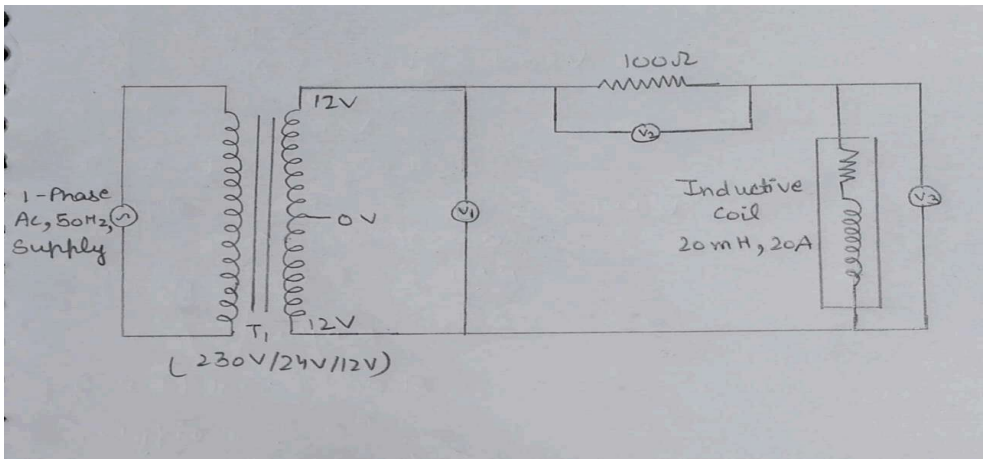
Since the resistor is non-inductive, the current I in the circuit can be calculated using Ohm's Law:

$$I = \frac{V_2}{R}$$
$$V_1^2 = V_2^2 + V_3^2 + 2IRV_3\cos\theta$$
$$V_1^2 = V_2^2 + V_3^2 + 2R(V_3I\cos\theta)$$

Power consumed by the load is given by

$$P = V_3I\cos\theta$$
$$P = \frac{V_1^2 - V_2^2 - V_3^2}{2R}$$

Circuit Diagram:



Procedure:

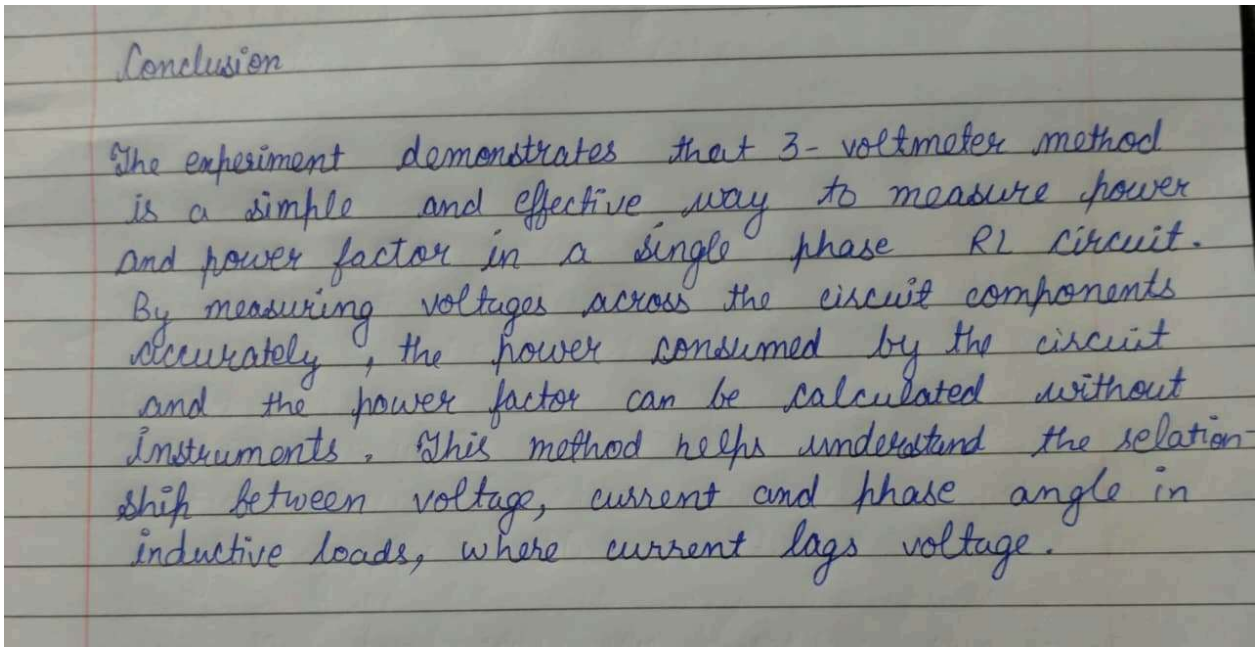
1. Connect the circuit as per the circuit diagram.
2. Set single phase auto Transformer at zero voltage position before switching on the supply.
3. Gradually increase the voltage using the autotransformer till the supply voltmeter reads required
voltage level.
4. Note down the voltage values across supply, non-inductive resistance and inductive coil using
multi-meter.
5. Calculate the power consumed by the inductive coil and calculate power factor.

Observation Table:

S.No.	Supply Voltage (V)	V_1(V)	V_2(V)	V_3(V)	Power (W)	Power Factor
1.	12	13.16	12.8	0.66	0.527	0.044
2.	24	25.5	25.1	0.97	0.396	0.096

Result (Image):

Result (Conclusion):



Conclusion

The experiment demonstrates that 3-voltmeter method is a simple and effective way to measure power and power factor in a single phase RL circuit. By measuring voltages across the circuit components accurately, the power consumed by the circuit and the power factor can be calculated without instruments. This method helps understand the relationship between voltage, current and phase angle in inductive loads, where current lags voltage.