Experiment: Single Phase AC Series Circuit

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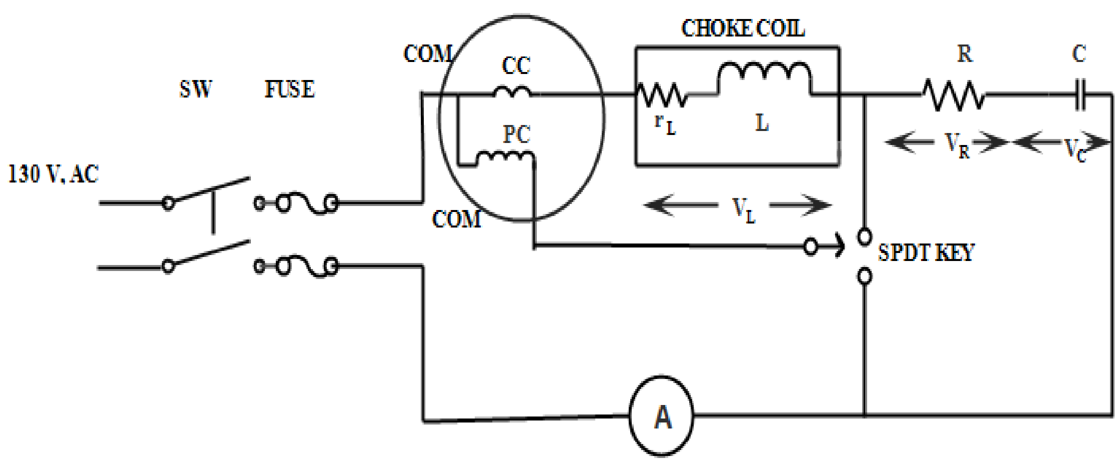
Subgroup – 1H3

Objectives: To determine experimentally;

(1) Voltage distribution in a single phase AC series circuit.
(2) Power and power factor of the (a) circuit (b) choke coil.
(3) The value of the circuit elements R,L &C

Equipments:(1) Resistor **(2)** Choke coil **(3)** Capacitor **(4)** SPDT Key
(5) Wattmeter 250V/1Amp**(6)** AC volt-meter150V **(7)** AC Ammeter- 1Amp



Circuit Diagram

Theory:

For a given AC series circuit, when energized from an ac source, same current flows through series connected resistance R, choke coil L& capacitor C.
The voltage drop across these elements is as follows:

(1) Across Resistance;$\mathbf{V_R = IR}$
(2) Across Inductance;$\mathbf{V_L = IX_L = I(j\omega L)}$
(3) Across Capacitor;$\mathbf{V_c = -jIX_C = I/(j\omega c)}$
(4) The resistance of inductance r_L can be measured by multimeter,so total circuit resistance =$\mathbf{(R + r_L)}$
(5) Total voltage across the circuit is : $\mathbf{V_S = I[R+r_L+j(\omega L-1/\omega C)] = I[R+r_L+j(X_L - X_c)]}$

$$= I\,(R+r_L+jX)=IZ$$

(6) Power consumed in the choke coil =$\mathbf{P_L=I^2(r_L)=V_LICos\Phi}$

(7) Power factor of the circuit $\mathbf{Cos\Phi = (R + r_L)/Z}$

(8) Power consumed in the circuit, $\mathbf{P_t = I^2 (R + r_L) = V_sICos\Phi}$(the extra power I^2r_L is consumed by choke coil)

(9) Power factor of the choke coil = $\mathbf{r_L/\sqrt{r_L^2 + X^2} = P_L / V_LI}$

Where

$X_L = \omega L$; Inductive reactance in ohms;

$\omega = 2\pi f$ in radians (f is frequency in HZ) ;

Now, impendence $Z = \sqrt{\{(R + r_L)^2 + X^2\}}$

$X_C = (1/\omega c)$; Capacitive Reactance in ohms;

$X = X_L - X_C$, the combined reactance in ohms

Procedure:

- Connect the experimental set as shown in the circuit diagram.
- Select AC 130volt from the supply panel and switch on the input supply.
- Measure voltage drop across each component with the help of voltmeter.
- Measure current flowing in the circuit with the help of ammeter.
- Keep SPDT switch at position 1, Wattmeter will give the power consumed (P_L) in the choke coil.
- Shift SPDT switch to position 2, wattmeter will give the power consumed (P_t) by the total circuit.
- Record the readings of the instruments carefully in the observation table.

Precautions:

- Always keep the measuring instruments in horizontal position.
- Select appropriate range of the instruments i.e the range of the instruments should always be more than the existing value of current or voltage in the circuit .
- Do not touch the resistance as it might have been heated up.

Observation Table:

Sr. No.	Applied voltage	Circuit current	Voltage drop across circuit elements			Power consumed (W)	
	V_S	I	Resistance V_R	Choke coil V_L	Capacitor V_C	Across choke coil P_L	Whole circuit P_t
1.	129.5	0.54A	110V	45.5V	86.2V	6W	67W

Report:

- Using the relations given in theory, calculate the following forsupply voltage;Impedance of coil Z_L , Inductive reactance of coil X_L , Capacitive reactance X_C and hence R, L &C.
- Calculate the value of power and power factor of the total circuit and that of choke coil.Comparethese values with the wattmeter readings.
- Draw the phasor diagram for any one of the observations.
- Draw the waveform for voltage and current in the RL series circuit as a function of time.

Points to remember:

1. Multiplication factor of wattmeter =(Voltage range*Current range*pf of wattmeter)/Max scale deflection.
2. Actual reading of wattmeter = multiplication factor * reading of wattmeter.

Calculations:

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Calculations-

Multiplying factor of wattmeter

$\Rightarrow$ $\frac{\text{Voltage range} \cdot \text{current range} * \text{Power factor}}{}$

$$= \frac{150 \times 1 \times 1}{75} = 2$$

1. $V_R = I_R = 110 = \frac{0.54}{R}$ $\quad R \Rightarrow 203.70\Omega$.

2. $V_L = I X_L$

$$\frac{V_L}{I} = X_L = \frac{45.5}{0.54} = 84.26\Omega$$

$$\frac{45.54}{0.54} = L\omega \qquad L = \frac{45.5}{0.54 \times 3.14 \times 100} = 267.7mH$$

3. $V_c = \frac{I}{jc\omega}$ $\quad \frac{V_c}{I} = X_c = \frac{86.2}{0.54} = 159.63\Omega$.

$$\frac{I}{c\omega} = 86.2 \qquad c\omega = \frac{0.54}{86.2 \times 3.14 \times 100} = 19.95\mu F$$

4. $P_L = I^2 r_L$

$$\frac{6}{(0.54)^2} = r_L = 20.570\Omega$$

5. $Z = \sqrt{(R+r_L)^2 + (X_L - X_C)^2}$

$= \sqrt{(203.7+20.576)^2 + (84.26-154.03)^2}$ $(X_C > X_L)$

$Z = 236.60$

6. $V_s = I \times Z = 0.54 \times 236.60 = 127.764\,V$

7. P.F of circuit $= \frac{(R+r_L)}{Z} = \frac{203.7+20.576}{236.60} = \frac{224.276}{236.60}$

$= 0.948.$

8. Power consumed in choke coil $\Rightarrow P_L = V_L I \cos\phi = I^2 (r_L)$

$= (0.54)^2 \times 20.576 = 6W.$

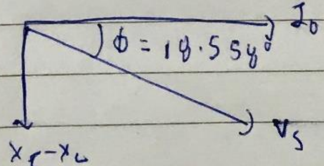
9. P.F of the choke coil $\Rightarrow \frac{r_L}{\sqrt{r_L^2 + X^2}} = \frac{P_L}{V_L I} = \frac{6}{45.5 \times 0.54} = 0.244$

10. Power consumed by whole circuit $\Rightarrow P_t = I^2 (R + r_L) = V_s I \cos\phi$

$127.764 \times 0.54 \times 0.948 = 65.40W$

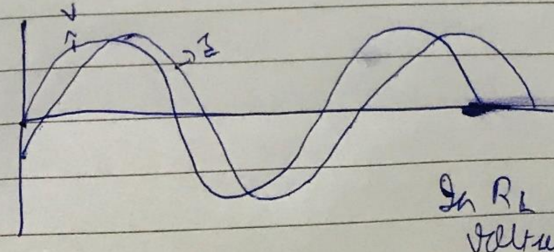
$\cos\phi$ is angle b/w V_s & I

$\phi = \cos^{-1}(0.948)$



{ ∵ $X_c > X_L$ current leads voltage.

Wave form (In RL series current)



In RL series → current lags voltage.

Conclusion- We can see that calculated values of power and power factor are equal or nearly equal to observed values.

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