IC160P-Electrical Systems Around Us Lab

Frequency Response of R – C and R – L – C Circuits

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1.AIM

Power Factor Correction Using Capacitor in 1-φ Load

2.Apparatus Required

S.N.	Name
1	1-Phase Auto Transformer (230V/0-270V V, 10A)
2	Wattmeter (150/300/600V, 5/10 A, 750Watt)
3	Voltmeter (150 V)
4	Ammeter (5/10 A)
5	Inductors (0-40 mH and 150mH)
6	Resistor(0-50 ohm)
7	Capacitor (20-60 µFD)
8	Switches
9	Connecting Wires

The Real and reactive power consumed in a series RL load is given as follows

$$P_R = I_L^2 R \text{ watt and } Q_L = I_L^2 X_L \text{ VAr}$$

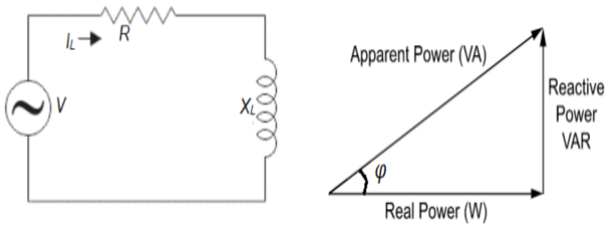


Fig.1 : R-L Load and its power triangle

The Apparent power in the circuit is given by :

$$S = VI_L^* = VI_L cos\varphi + jVI_L sin\varphi = I_L^2 R + jI_L^2 X_L$$

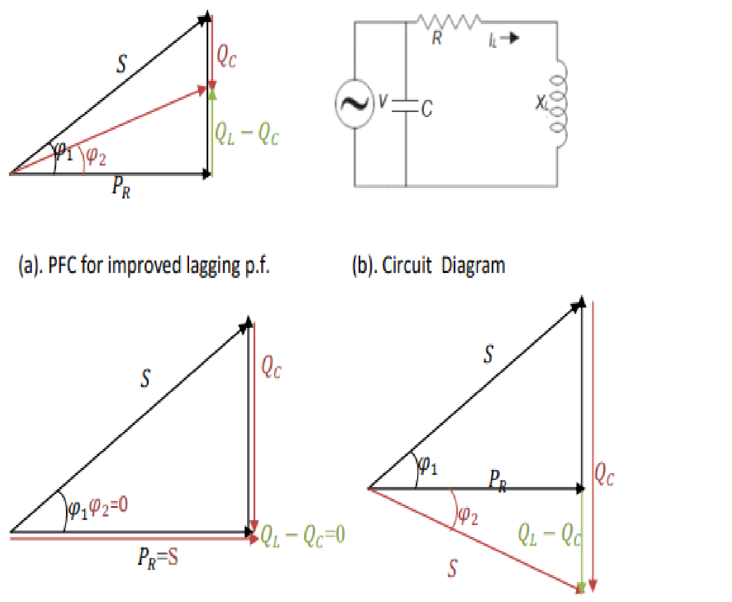
$$p.f. = cos\varphi = \frac{P_R}{S}$$

To improve the power factor of the circuit we need to provide the reactive power source which is the capacitor.

Reactive power in the capacitor is :

$$Q_C = V^2 \omega C$$

3.Theory



(a). PFC for improved lagging p.f. (b). Circuit Diagram

(c). PFC for unity p.f. (d). PFC for leading p.f.

Fig.2: Power factor improvement using capacitor.

From fig. 2. We can see if power factor is needed to be improved to $cos\varphi_2$ from $cos\varphi_1$ we need Q_c reactive power from the capacitor. The ammount of $Q_c$supplied from the capacitor will determine the new power factor. The cases are possible for power factor improvement.

<u>Case-1.</u> *Lagging power factor case*:If $Q_c<Q_L$ then the improved power factor will remain lagging only.

$$Q_L = I_L^2 X_L = VI_L sin\varphi_1 > Q_C = V^2 \omega C$$

Required value of capacitance

$$C < \frac{I_L sin\varphi_1}{V\omega}$$

<u>Case-2.</u> *Unity power factor case*: If $Q_c=Q_L$ then the improved power factor will becomeunity.

$$Q_L = I_L^2 X_L = VI_L sin\varphi_1 = Q_C = V^2 \omega C$$

Required value of capacitance

$$C = \frac{I_L sin\varphi_1}{V\omega}$$

<u>Case-3.</u> *Leading power factor case*: If $Q_c>Q_L$ then the improved power factor will become unity.

$$Q_L = I_L^2 X_L = VI_L sin\varphi_1 < Q_C = V^2 \omega C$$

Required value of capacitance

$$C > \frac{I_L sin\varphi_1}{V\omega}$$

3.Procedure and Circuit Analysis

1. Connect the circuit diagram as per fig. 3.

2. Connect a R-L load for 25 Ohm and 40/120mH.

3. Adjust the Variac output voltage to 78 volt.

4. With the help of wattmeter, ammeter and voltmeter find the circuit power factor.

5. Find the required value of capacitor to make the circuit power factor to unity or near to unity.

6. Connect the capacitor and find the power factor.

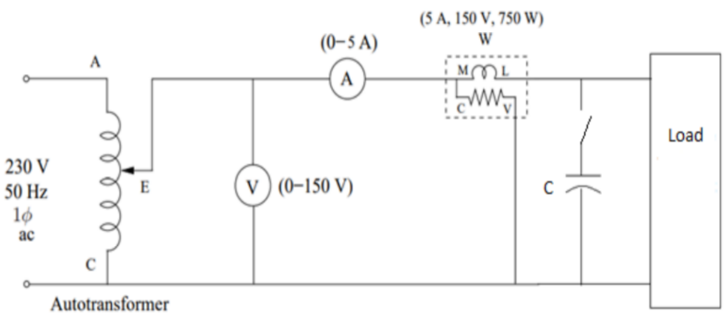


Fig.3: Circuit Diagram

Observations

Without Capacitor

Voltage(V)	Current(I)	Power(W)	Power factor (cos φ)	Capacitor Required for unity power factor (μF)
78.6	**2.54**	**161**	**0.81**	**60.79**

With Capacitor

Voltage(V)	Current(I)	Power(W)	Power factor (cos φ)	Capacitor used (μF)
78.6	**2.2**	**172**	**0.99**	**60**

*****There is some approximation due to unavailability of exact capacitor in lab.

3. Practical Applications:

1. Induction motors always have low power factor, so a delta connected capacitor bank is installed at the terminals of large 3-phase induction motors to improve the power factor.

2. Most of the loads available in the industry are of inductive in nature. Utilities penalise the industries for low power factor. Hence most industries need to install capacitor bank at mains terminal.

4.Conclusion

On using inductor, Voltage of circuit will lead current in phaser. This may cause some loss of useful power as per cicuit capacity. To reduce this effect, we can use required capacitor in circuit which will minimise the effect due to it's lagging effect.

Vice-versa is also true.

5.Questions:

1. In unity power factor case, the source current becomes non-sinusoidal after switching on the capacitor in the circuit. What could be the reasons for this?

No

Current will be sinusoidal only the phase angle between voltage and current will minimises which makes the power factor close to or 1.

2. In wattmeter, if 'M' and 'L' connections are interchanged, how will the wattmeter behave?

No change will happen in magnitude as inductor is connected between them but sign reverses it's polarity.

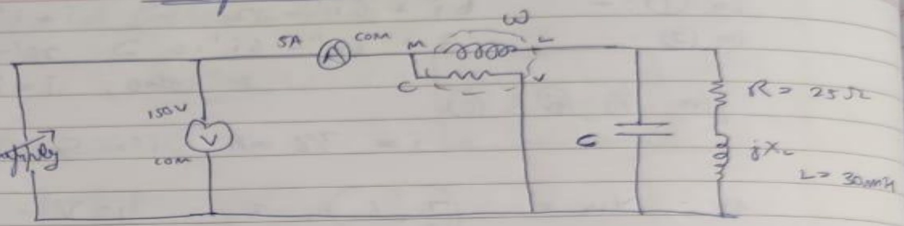
3. Can a charged capacitor be connected into the circuit? Justify your answer using proper reasoning.

No,

Charged capacitor have some potential drop and will effect the circuit due to this and charge loss happens a with time but it may be some scenario where it cancelles loss as due to ac voltage source.

Experiment

Circuit :-



(I) No capacitor

$V = 78.6\,V$

$I = 2.54\,A$

Wattmeter reading = 80.5 so, $P = 80.5 \times 2 = 161\,W$

$L = 30\,mH$, $R = 25\,\Omega$, $f = 50\,Hz$, $\omega = 314.25$ rad/s

Real power = $P = VI\cos\phi$

$161 = (78.6)(2.54)\cos\phi$

$\Rightarrow \cos\phi = .8064$

$\phi = 36.254^\circ$

$\sin\phi = .5913$

Reactive Power = $Q = VI\sin\phi$

$= (78.6)(2.54)\sin\phi$

$Q = 118.049$ VAr

To find C such that $\cos\phi = 1$

$Q = V^2/X_C \Rightarrow X_C = V^2/Q$

$= \dfrac{(78.6)^2}{118.049} = 52.33\,\Omega$

$\omega C = \dfrac{1}{X_C} = .0191$

$C = 60.79\,\mu F$

Experimental readings :- $V =$ ~~786~~ $78.6\,V$

$I = 2.2\,V$

Wattmeter reading = 86 $\Rightarrow P = 86 \times 2 = 172\,W$

$P = 172 = VI\cos\phi = (78.6)(2.2)\cos\phi$

$\cos\phi = .9946$

Amit