Course Name:	**EEEE**	**Semester:**	**I**
Date of Performance:	**20/12/2022**	**Batch No:**	**C2-2**
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Faculty Sign & Date:		**Grade/Marks:**	

Experiment No: 7
Title: Power factor improvement (series)

Aim and Objective of the Experiment:

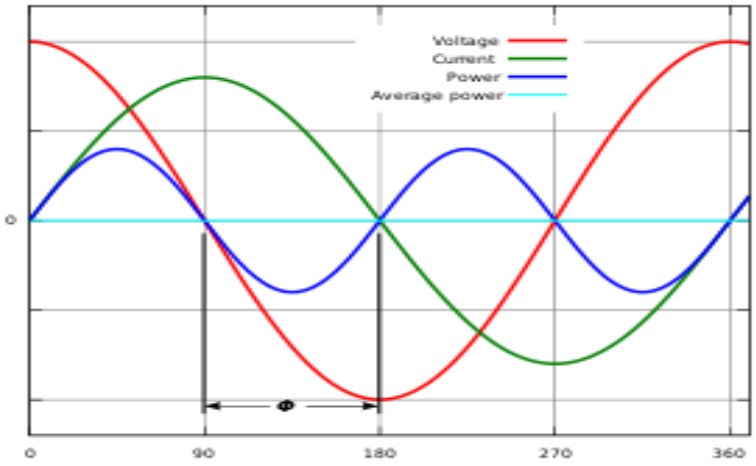
- To improve power factor of a single phase inductive AC circuit using capacitor in series with it.

Requirements:

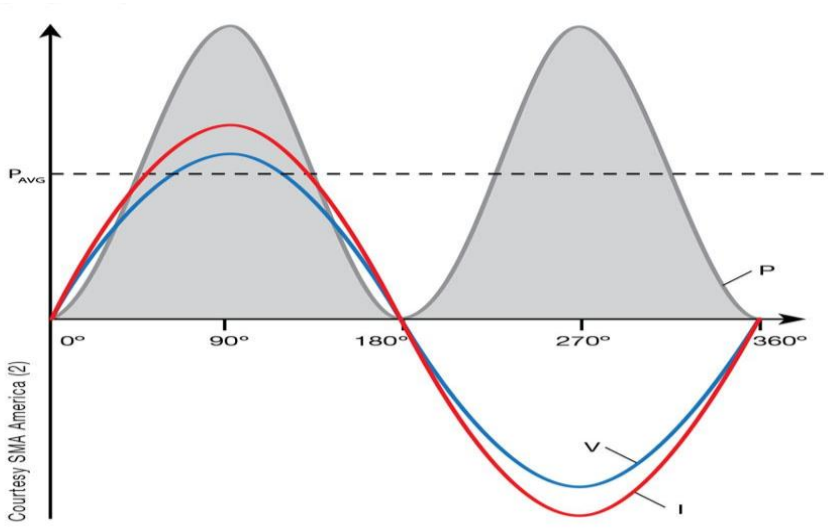
Inductor box, 1 KΩ-3W Resistor, Capacitor box, AC Ammeter and AC Voltmeter.

Theory:

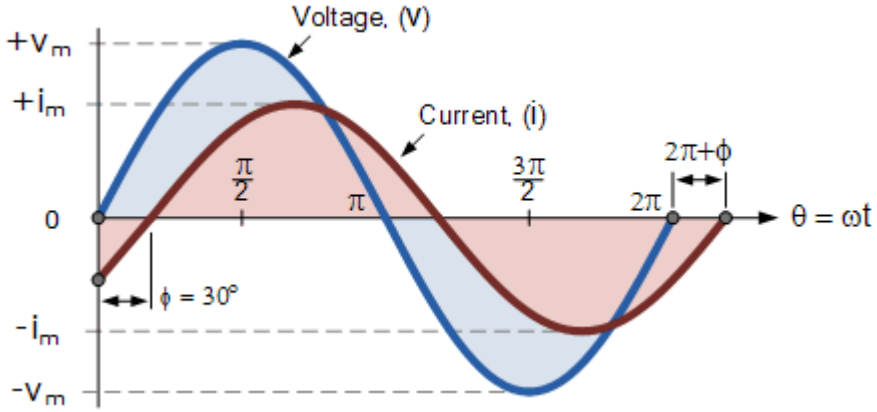
When we need to convert electrical energy to mechanical energy, electric motors are used for it. These AC motors converts electric energy in two forms namely mechanical energy in the form of rotary motion and other is magnetic field. Magnetizing currents are lagging to the supply voltage. This magnetic energy is not a mechanical energy so it is kind of wastage, but without which motor will not run and convert electric energy into mechanical energy. Such form of energy is called as reactive power. Reactive power must be as less as possible so that the load will utilize maximum power and current requirement will be less for the same amount power. As the current requirement is less, so wire thickness will be small in diameter. Installation cost and energy cost will be also reduced. To reduce reactive power of the circuit, different power factor improvement methods are used. One of the most familiar method is the use of capacitor bank. We can use capacitor in series with the load or across the load. Following diagrams are illustrating effect of PF on active power.



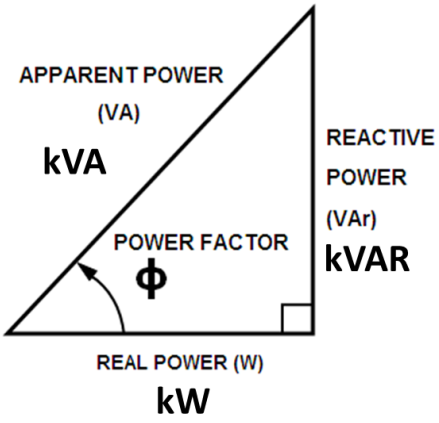
In the above figure instantaneous and average power calculated from AC voltage and current with a zero power factor. The blue line shows all the power is stored temporarily in the load during the first quarter cycle and returned to the grid during the second quarter cycle, so no real power is consumed by the load which is shown by sky-blue colour line.



In the above figure instantaneous and average power calculated from AC voltage and current with a unity power factor. The gray part shows all the power is absorbed in the load during the first half cycle as well as the second half cycle, so real power is fully consumed.



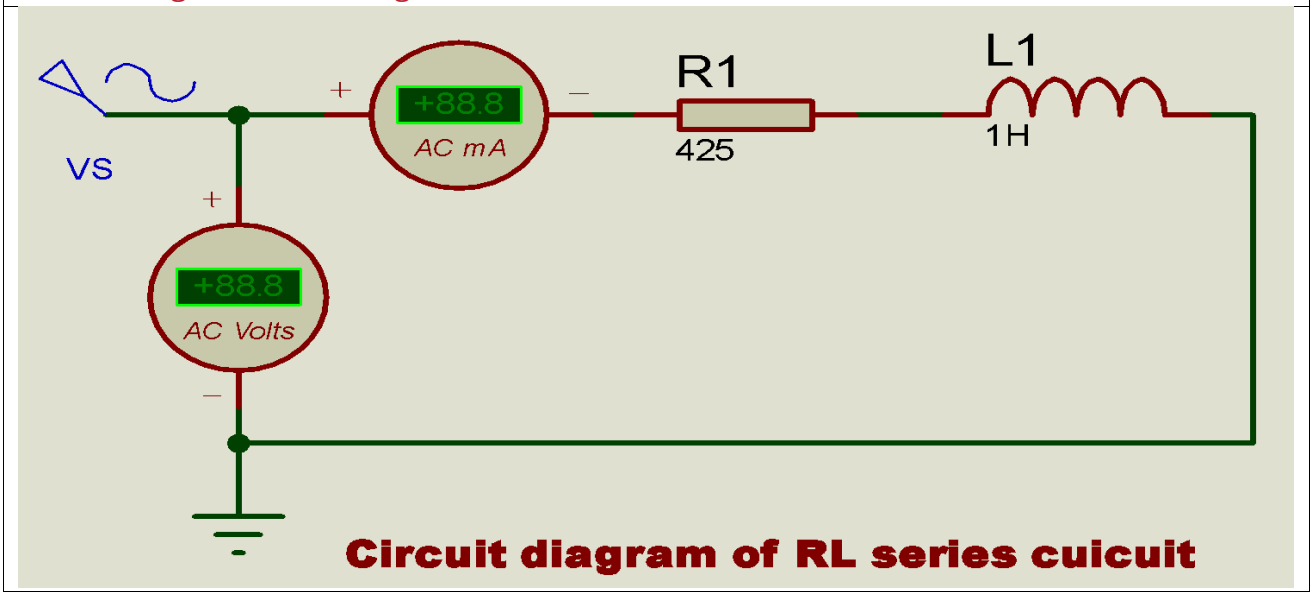
When power factor is between zero and unity, then real power consumed by the load depends upon PF of the circuit. Greater the power factor is always better to consume power.

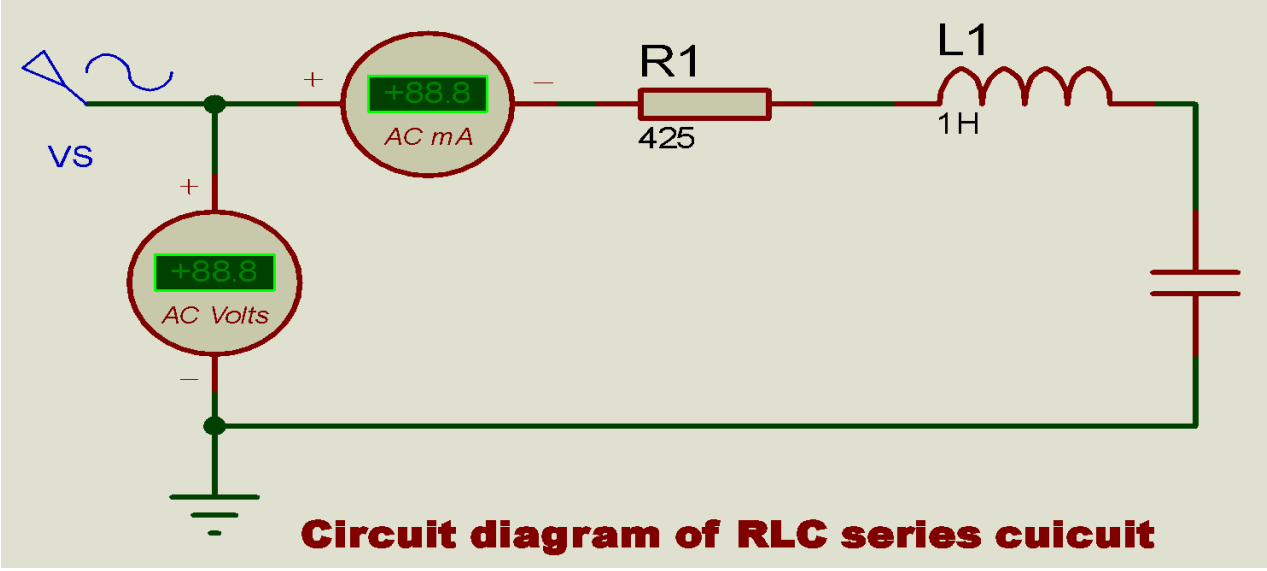


$$\text{Power Factor} = \frac{\text{True Power}}{\text{Apparent Power}}$$

$$\text{Power Factor} = \cos\Phi = \frac{kW}{kVA}$$

Circuit Diagram/ Block Diagram:





Stepwise-Procedure:

1. Connect series R and L circuit across 230V, 1ø, 50 Hz AC supply and note down circuit voltage and current.

2. Calculate practical value of circuit power factor by taking ratio of active power (P) and apparent power (S).

3. Connect required value of capacitor in series with R-L load and switch on power supply to note circuit current.

4. Calculate practical value of circuit power factor by taking ratio of active power (P) and apparent power (S).

5. Compare theoretical and practical values of PF before connecting the capacitor and after connecting capacitor.

Observation Table:

Sr No	Type of load	Voltage (V)		Current (mA)		P (W)	S (VA)	Power factor
		Th	Pr	Th	Pr	Th	Th	Th
	R-L	7	7.4	6.4	4.22	0.0117	0.0231	0.506
	R-L-C	7	7.4	5.83	6.95	0.0367	0.0408	0.9

Sample Calculations:

Theoretical Calculations to find circuit current and PF of the inductive load:

I=V/R=7/1078.8=0.0064

Practical calculations to find PF of the inductive load:

PF= cos ϕ=P/S=0.506

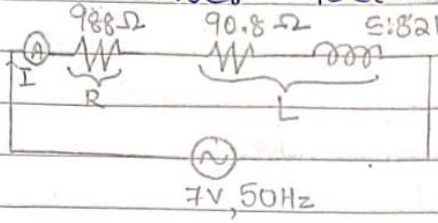
Calculations to find value of the capacitor to be connected with the load:

I=V/Z=7/1198.67 ANGLE 25.84°=5.83 mA ANGLE (-25.84°)

Output Snap shots:

Date

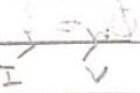
Power Factor Improvement (series Capacitor)



$V_R = IR$

$V_L = IX_L$

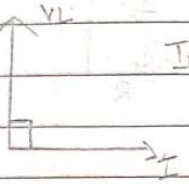
$V = IZ$



X_L = Inductive reactance

$= \omega L \ (\Omega)$

$= 2\pi f L \ (\Omega)$

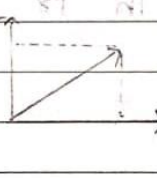


voltage across $L = V_L = L\frac{di}{dt}$

Impedance $= Z = \sqrt{R^2 + X_L^2}$

or $Z = (R + jX_L) \ \Omega$

$= Z \angle \phi$



For given ckt

$Z = R + j\omega L$

In polar form

$Z = Z \angle \phi$

Power Factor = PF = $\cos\phi$

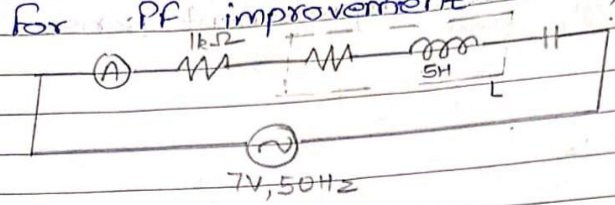
$I = \frac{V}{Z}$

$\cos\phi = \frac{P}{S}$

$P = I^2R$ - active power

$S = V \times I$ - Apparent power

for PF improvement



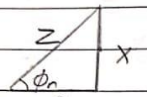
$PF_n = 0.9$

$\cos \phi_n = 0.9$

$\phi_n = ?$

$V_{red} = V_s \cos \phi_n$

$Z_{total} = Z + j(X_L - X_C)$



$Z = \frac{R}{\cos \phi_n}$

$\sin \phi_n = \frac{X}{Z}$

$Z = X_L - X_C$

find C

Observation

Sr. No.	Type of Load	Voltage (volts) Th	Voltage (volts) Pr	Current (mA) Th	Current (mA) Pr	Power (w) $P=I^2R$ Th	Power (w) $P=I^2R$ Pr	Power $S=V \times A$ Th	Power $S=V \times A$ Pr	Power factor $\cos\phi = P/S$ Th	Power factor $\cos\phi = P/S$ Pr
1	R-L	7	7.4	6.4	4.22	0.0117		0.0231		0.506	
2	RLC	7	7.4	5.83	6.95	0.0367		0.0408		0.9	

$L_s = 5.821$ H

$r = 90.8\ \Omega$

$R = 1078.8\ \Omega$

$C = 3.096\ \mu F$ Pr

$C = 3.5\ \mu F$ Th

$V_R = IR$

$7 = I\ (1078.8)$

$I = 0.0064$

$V_L = IX_L$

$V_L = 0.0064 \times 2 \times 3.14 \times 50 \times 5.821$

$V_L = 11.698$

$X_L = 1827.79$

$V_L = L \cdot \frac{di}{dt} = 5$

$Z = \sqrt{R^2 + X_L^2}$

$= \sqrt{(1078.8)^2 + (1827.79)^2}$

$= \sqrt{1163809.44 + 3340816.2841}$

$= \sqrt{4504625.7241}$

$= 2122.41$

$I = \frac{V}{Z} = \frac{7}{2122.41} = 0.0033$

$P = I^2R = (0.0033)^2 (1078.8)$

$= 0.0117$

$S = VI = 7 \times 0.0033 = 0.0231$

$\cos\phi = \frac{P}{S} = \frac{0.0117}{0.0231} = 0.506$

$\phi = 59.6$

Data

$V_{real} = V\cos\phi_n = 7 \times 0.9 = 6.3$

$Z_T = 1078.8 + j(X_L - X_C)$

$Z = \frac{R}{\cos\phi_n} = \frac{1078.8}{0.9} = 1198.67$

$\sin\phi_n = \frac{X}{Z}$ $\qquad \phi_n = 25.84$

$(X_L - X_C) = Z\sin\phi_n$

$X_L - X_C = 2122.41 \times 0.436 = 925.370$

$X_L = 2\pi FL = 2 \times 3.14 \times 50 \times 5.821 = 1827.79$

$X_C = X_L - 925.370$

$= 1827.79 - 925.370$

$X_C = 902.42$

$X_C = \frac{1}{2\pi f C}$

$C = \frac{1}{2 \times 3.14 \times 50 \times 902.42}$

$C = 3.5 \times 10^{-6} F$

$C = 3.5\ \mu f$

$Z_T = 1078.8 + j(1827.79 - 902.42)$

$= 1078.8 + j\,925.370$

$= 1198.67 \angle 25.84°$

$I = \frac{V}{Z} = \frac{7}{1198.67 \angle 25.84} = 0.00583 \angle -25.84°$

$= 5.83\,mA \angle -25.84°$

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$P = I^2R = (0.00583)^2\ 1078.8$
$= 0.0367$

$S = V \times I$
$= 7 \times 0.00583$
$= 0.0408$

$PF = \cos\phi = \frac{P}{S} = \frac{0.0367}{0.0408}$
$= 0.899$
$= 0.9$

Post Lab Subjective/Objective type Questions:

1. What are benefits of connecting capacitor across the load to improve circuit PF?

The benefits of connecting capacitor across the load to improve circuit PF are:

- Reduced electrical power bills.
- Reduces losses in electrical conductors.
- Reduces loading on transformers by releasing system capacity.
- Improves voltage on the electrical distribution system thereby allowing motors to run more efficiently and cooler. This helps to prolong the operation and life to the motor.

Conclusion:

Thus, we learnt how to improve power factor of a single phase inductive AC circuit using capacitor in series with it.

Signature of faculty in-charge with Date: