Course Name:	EEEE	Semester:	I
Date of Performance:	27/12/22	Batch No:	C2-2
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Faculty Sign & Date:		Grade/Marks:	

Experiment No: 8
Title: Power factor improvement (parallel)

Aim and Objective of the Experiment:

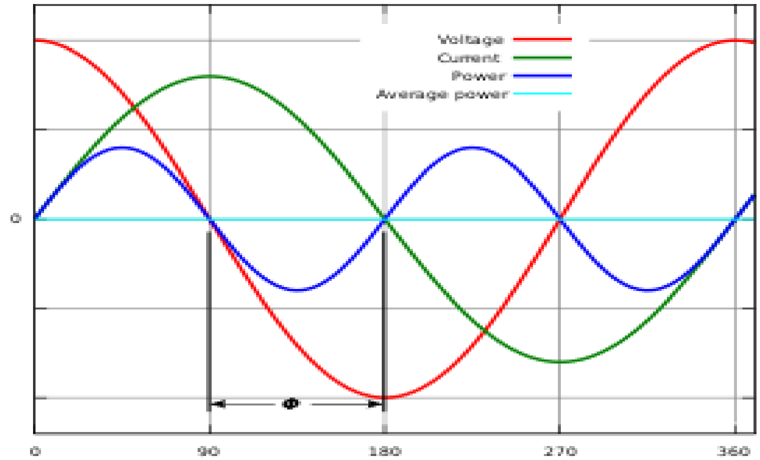
- To improve power factor of a single phase inductive AC circuit using capacitor across the load.

Requirements:

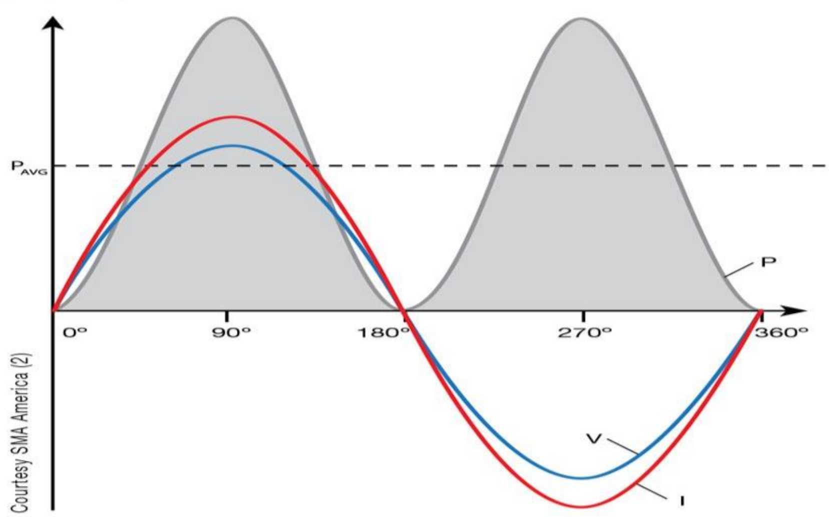
Inductor box, 1 KΩ-3W Resistor, Capacitor box, AC Ammeter and AC Voltmeter.

Theory:

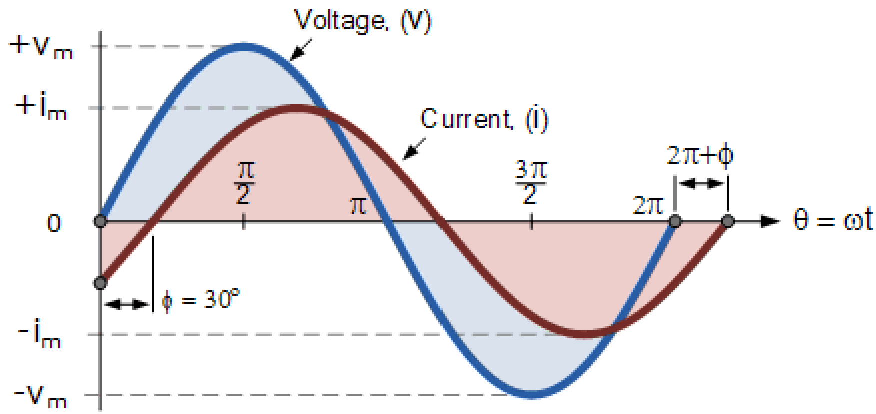
When we need to convert electrical energy to mechanical energy, electric motors are used for it. These AC motors converts electric energy in two forms namely mechanical energy in the form of rotary motion and other is magnetic field. Magnetizing currents are lagging to the supply voltage. This magnetic 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.



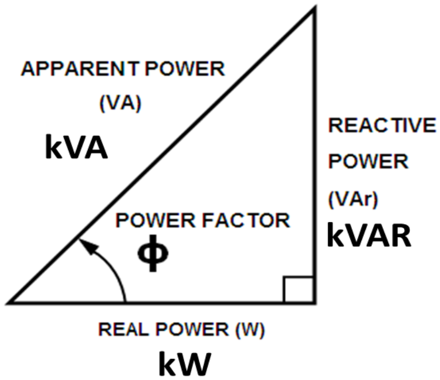
In the above figure instantaneous and average power calculated from AC voltage and current with a zero power factor. The blue line shows all the power is stored temporarily in the load during the first quarter cycle and returned to the grid during the second quarter cycle, so no real power is consumed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



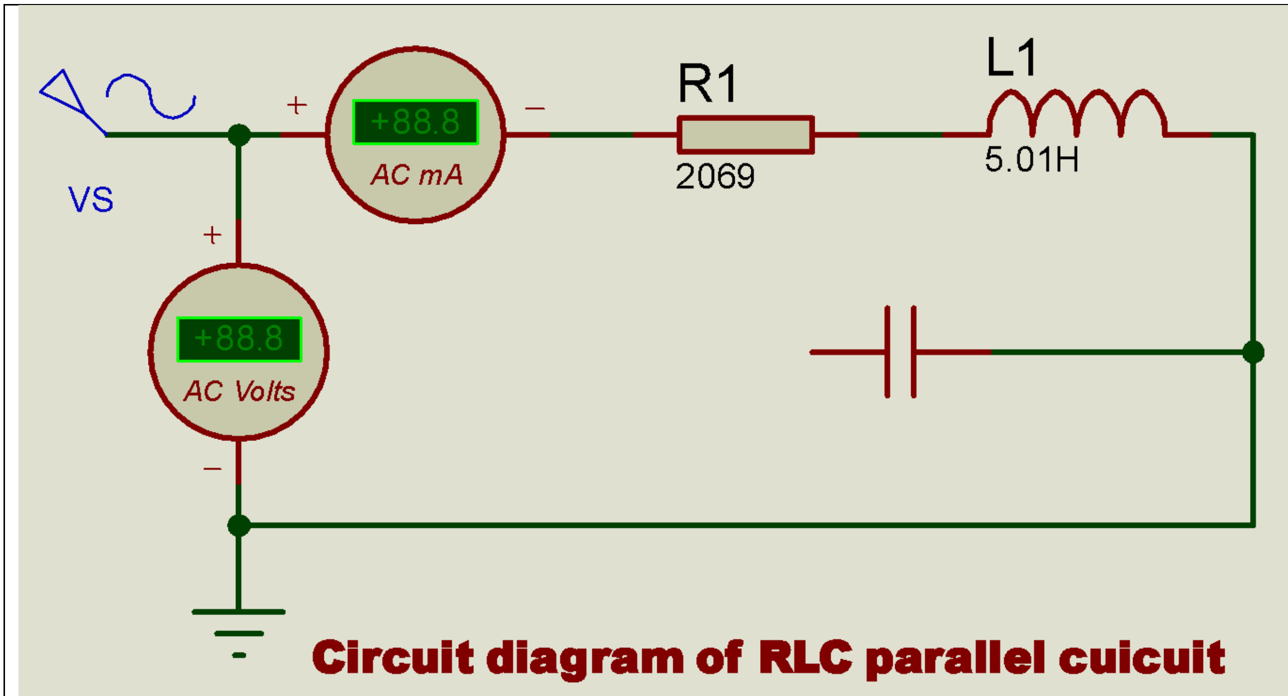
When power factor is between zero and unity, then real power consumed by the load depends upon PF of the circuit. Greater the power factor is always better to consume power.



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

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

Circuit Diagram/ Block Diagram:



Stepwise-Procedure:

1. Connect series R and L circuit across 100V, 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 parallel with R-L load and switch on power supply to note circuit voltage and 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) = I^2R	S (VA)= V_s*I_L	Power factor = P/S
		Th	Pr	Th	Pr			
1	R-L	7	7.4	3.87	4.05	0.01625	0.028	0.56
2	R-L-C	7	7.4	6.21	6.88	0.0413	0.0459	0.9

Output snap shots:

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

I=V/R=7.4/1085.4=0.00681

Practical calculations to find PF of the inductive load:

PF= cos ϕ=P/S=0.56

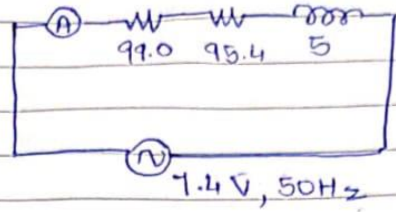
Calculations to find value of the capacitor to be connected across the load:

C= 1/ 2 * pi*F*Xc=1.09 micro F

Practical calculations to find improved PF of the circuit:

PF= cos ϕ=P/S=0.9

Power factor Improvement (Parallel circuit)



I = 4.05 A
(across R and L)

$V_R = IR$ $\quad$ $V = IZ$

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

X_L = Inductive reactance

$= \omega L$

$= 2\pi f L$

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

Impedance $(Z) = \sqrt{R^2 + X_L^2} = R + jX_L = Z\angle\phi$

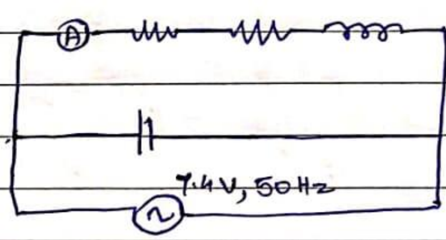
In polar form, $PF = \cos\phi$ $\quad$ $I = \frac{V}{Z}$

$P = I^2 R$

$S = V \times I$

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

→ For power factor improvement



$PF_n = 0.9$

$\cos\phi_n = 0.9$

$\phi = 25.84$

→ Observation:

Load	Voltage Th	Voltage Pr	Current Th	Current Pr	$P=I^2R$	$S=VI$	$Pf=\cos\phi = P/S$
1) R-L	7	7.4	3.87	4.05	0.01625	0.028	0.56
2) R-L-C	7	7.4	6.21	6.88	0.0413	0.0459	0.9

→ Calculations:

$I = 4.05$ (across R and L) Practical Value

$R_{Total} = 990 + 95.4 = 1085.4\,\Omega$

$V_R = IR$

$I = \frac{7.4}{1085.4} = 0.006817\,A$

$X_L = \omega L = 2\pi f L$

$= 2 \times 3.14 \times 50 \times 5$

$X_L = 1570\,\Omega$

$V_L = IX_L$

$= 0.006817 \times 1570$

$V_L = 10.727\,V$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{(1085.4)^2 + (1570)^2}$

$= 1908.66\,\Omega$

$I = \frac{V}{Z} = \frac{7.4}{1908.66} = 0.00387\,A = 3.87\,mA$ Theoretical Value

$P = I^2R = (0.00387)^2 (1085.4)$

$= 0.01625$

$S = V \times I = 7.4 \times 0.00387 = 0.028$

$\cos\phi = \frac{P}{S} = \frac{0.01625}{0.028} \doteq 0.56$

$\phi = \cos^{-1}(0.56) = 55.944$

$Z = \frac{R}{\cos\phi_n} = \frac{1085.4}{0.9} = 1206$

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

$X_L - X_C = Z\sin\phi_n$
$= 1908.66 \times 0.4358$
$= 831.907$

$X_C = 1570 - 831.907 = 738.1$
$C = \frac{1}{2\pi f X_C} = 4.31 \times 10^{-6}\ F = 4.31\ \mu F$

$Z = 991 + 82 + 5.087j \times 100\ \Omega$
$= 1073 + 1597.32j$
$= 1924.26 \angle 56.11$

$\cos\phi = 0.56$

$I_n = \frac{I_c \cos\phi_c}{\cos\phi_n} = \frac{3.65 \times 0.56}{0.9} = 2.279\ mA$

$I_n \sin\phi_n = I_c \sin\phi_c - I_c \sin 90$
$I_c = 2.025\ mA$
$X_c = \frac{1}{(2\pi f c)} = 3.457$

$I_n \cos\phi_n = I_c \cos\phi_c$

$I_n = 2.83\ mA$

$\therefore I_c = 2.55\ mA$

$X_c = \frac{V}{I_c} = \frac{7.4}{2.55} = 2.90$

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

$C = \frac{1}{2 \times 3.14 \times 100 \times 2.9} = 0.001098$ E00.

$C = 1.09\ \mu F$

$P = I^2R = (0.0062)^2 1085.4$

$= 0.0413$

$S = VI = 7.4 \times 0.0062$

$= 0.0459$

$PF = \cos\phi = \frac{P}{S} = \frac{0.0413}{0.0459}$

$= 0.9$

Post Lab Subjective/Objective type Questions:

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

When capacitors are used to improve power factor , the following benefits will accrue:

1. Reduced electrical power bills

2. Reduces I2R losses in electrical conductors

3. Reduces loading on transformers by releasing system capacity

4. 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 learned to improve power factor of a single phase inductive AC circuit using capacitor across the load.

Signature of faculty in-charge with Date: