Course Name:	EEEE	Semester:	I
Date of Performance:	24-1-22	Batch No:	A3
Faculty Name:		Roll No:	16010121070
Faculty Sign & Date:		Grade/Marks:	

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

Aim and Objective of the Experiment:

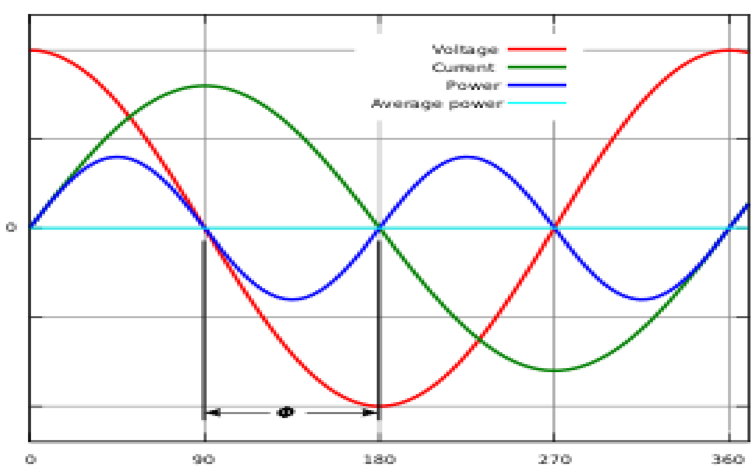
- To improve power factor of a single-phase inductive AC circuit using capacitor across the load.

Requirements:

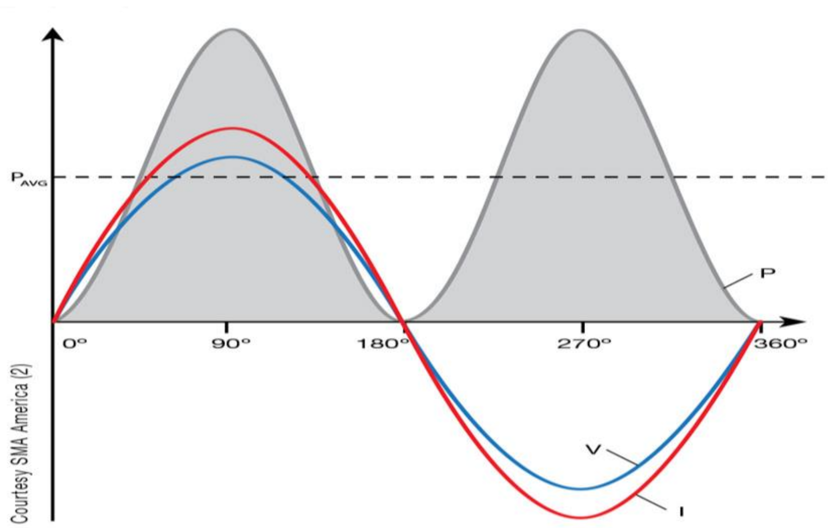
Inductor box, 1 KΩ-3W Resistor, Capacitor box, AC Ammeter and AC Voltmeter.

Theory:

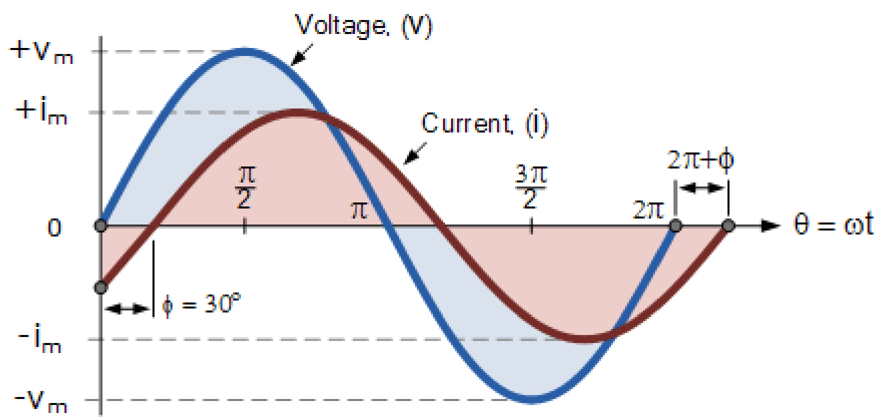
When we need to convert electrical energy to mechanical energy, electric motors are used for it. These AC motors converts electric energy in two forms namely mechanical energy in the form of rotary motion and other is magnetic field. Magnetizing currents are lagging to the supply voltage. This magnetic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



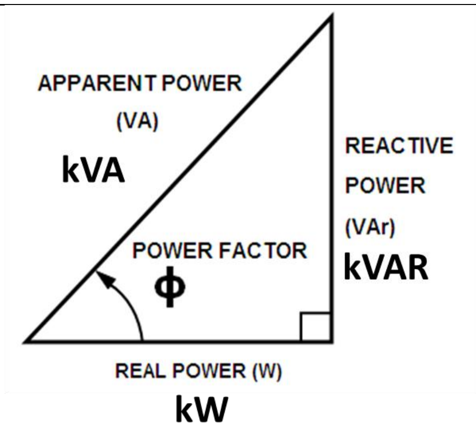
In the above figure instantaneous and average power calculated from AC voltage and current with a zero power factor. The blue line shows all the power is stored temporarily in the load during the first quarter cycle and returned to the grid during the second quarter cycle, so no real power is consumed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



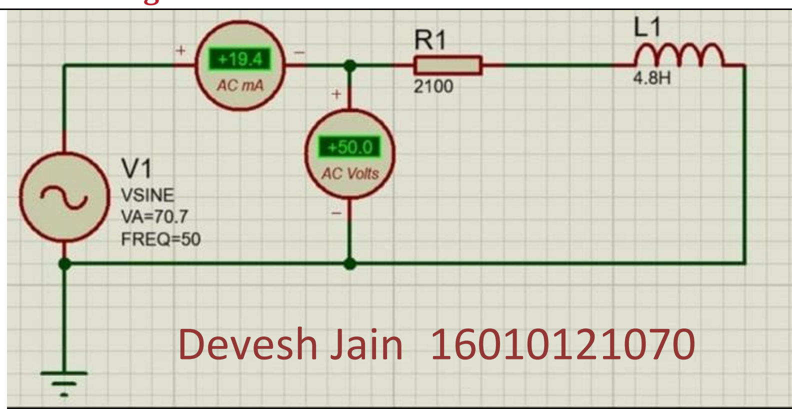
When power factor is between zero and unity, then real power consumed by the load depends upon PF of the circuit. Greater the power factor is always better to consume power.

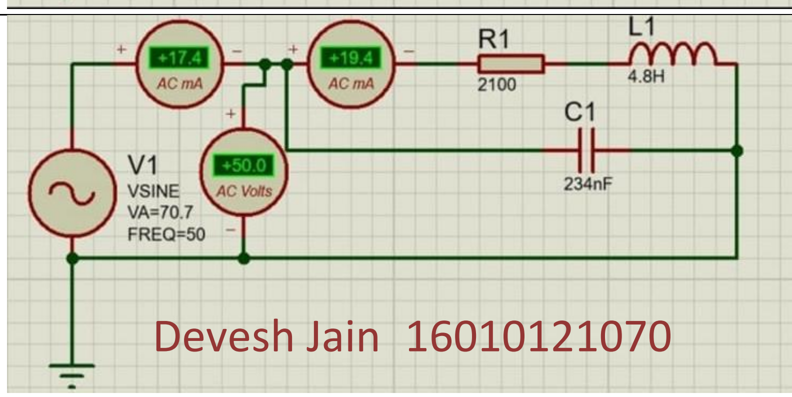


$$\text{Power Factor} = \frac{\text{True Power}}{\text{Apparent Power}}$$

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

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 parallel with R-L load and switch on power supply to note circuit voltage and current.

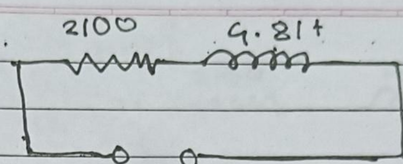
4. Calculate practical value of circuit power factor by taking ratio of active power (P) and apparent power (S).
5. Compare theoretical and practical values of PF before connecting the capacitor and after connecting capacitor.

Observation Table:

Sr No	Type of load	Voltage (V)		Current (I) (mA)		P (mW)= $(Icoil)^2$ xR		S (mVA) VX In		Power factor	
		Th	Pr	Th	Pr	Th	Pr	Th	Pr	Th	Pr
1	R-L	50	50	19.33	19.4	784	790.3	966.5	970	0.81	0.81
2	R-L-C	50	50	17.39	17.4	784.6	790.3	869.5	870	0.9	0.9

1. **Calculations of R-L circuit.**

1) R-L Circuit



$I = \frac{V}{Z} = \frac{50\angle 0}{Z}$ 50∠0°. 50Hz

$Z = R + jX_L$

$= 2100 + j \cdot 2\pi \times 50 \times 9.8$

$= 2584.88 \angle 35.60°$

$I = 19.33$ mA $\angle -35.86°$

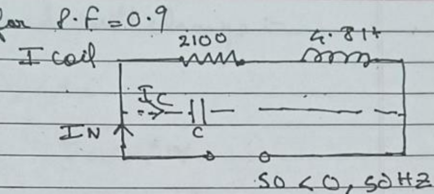
$P = (0.01933)^2 \times 2100 = 784$ mW

$S = (0.01933)50 = 966.5$ mVA

$\cos\phi = \frac{P}{S} = \frac{784}{966.5} = 0.81$

2. Finding C for Pf=0.9

2. Finding C for P.F = 0.9



$Pf_N = \cos\phi_N = 0.9$

$I_N =$ ~~cos~~ $I_{coil} + I_C$

$\phi_N = \cos^{-1}(0.9) = 25.84°$

Real part of current remains same.

$I_R = 17.39mA$

$P = (I_N)^2 R = (19.33)^2 \cdot 2100 = 784.6\,mW$

$S = VI_N = 869.5$

$\cos\phi = \frac{P}{S} = 0.9$

$I_{coil} = I_{coil}\cos\phi_{coil} + jI_{coil}\sin\phi_{coil}$

$= I_R + I_L$

Imaginary part will change :-

Real part of current:

$I_{coil}\cos\phi_{coil} = I_N \cos\phi_N$

$I_N = \frac{I_{coil}\cos\phi_{coil}}{\cos\phi_N} = \frac{(19.33\times10^{-3})(\cos(35.66))}{0.9}$

$= 17.39mA$

Imaginary :-

$I_N \sin\phi_N = I_{coil}\sin\phi_{coil} - I_N \sin\phi_N$

$= 3.69mA$

$X_C = \frac{50\angle0°}{I_C} = \frac{50}{3.69} = 13550\,\Omega$

$C = \frac{1}{2\pi f C} = 234\,nF$

3. Calculations for R-L and C in parallel to verify PF

$I_n = 17.39\,mA$

$P = (I_N)^2 R = (19.33)^2\, 2100 = 784.6\,mW$

$S = V I_N = 869.5$

$\cos\phi = \frac{P}{S} = 0.9$

Post Lab Subjective/Objective type Questions:

1. What are benefits of connecting capacitor across the load to improve circuit PF?
   In an AC circuit, magnetic reversal due to phase difference between current and voltage occurs 50 or 60 times per second. A capacitor helps to improve the power factor by relieving the supply line of the reactive power. The capacitor achieves this by storing the magnetic reversal energy.
   Electrical loads that have a low power factor consume more power that it is needed to perform a task. This can result in a considerable power loss in a network and high transformer losses. Such increases in energy consumption increase the cost of running equipment or installations.
   - Improving power factor with the help of capacitors can help to cut the electricity bill by a significant margin.
   - Helps reduce I2R losses in electrical conductors
   - A capacitor helps to improve the power factor by relieving the supply line of the reactive power. The capacitor achieves this by storing the magnetic reversal energy.
   - 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.

   In most industries, a system of capacitors controlled by a power factor correction controller is installed for reactive power compensation. When designing a power factor correction system, it is important to avoid adding excess capacitance to the network. Adding excess capacitance to a circuit can lead to over-correction as illustrated in figure below.

Conclusion:

From this experiment we learned that in a single-phase AC inductive circuit, when a capacitor is connected across the load, the power factor is improved considerably

Signature of faculty in-charge with Date: