

# Power Factor Controller-An Approach Through Cross Over Point Identification using a Standard Lab Tool Simulation

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**Abstract:** Industries facing problem of low power factor (P.F) is very common and so are the efforts at improving it through various methods. In general shunt capacitor banks are used to improve the power factor and these banks are located very near and down the final transformer. Attempts will be to maintain the P.F as close to unity as possible. Switching operation of capacitors in a P.F control panel can be achieved by the micro-controller. But it may be very involved and difficult task to write and achieve a running and successful programme on micro-controller for all the power factor values in demand from the same panel. In this work the design procedure of a programme usable in a micro-controller is shown. This is achieved in/and through a lab tool of simulation and can be done also through similar tools.

P.F control devices doing switching operation of capacitors can also be used. But they have associated complexity, extra cost, extra efforts at design and finally limitations imposed by the device in power handling. Hence, the present choice of avoiding P.F Controller may be better. The implicit instructions derived from the use of the lab tool implemented as required through the use of this programme can simplify and be extended easily to wide ranges of power handling leading to energy savings.

**Keywords:** Power Factor, Micro controller, Switched capacitor panel, Shunt capacitor banks, Lab tool simulation devices.

## 1. INTRODUCTION

Power is vital in current circumstances because of specialized transformations. Inductive loads are expanded in view of industrialisation, these will impact on the power factor. So the productivity of the framework is diminished. Framework proficiency can be enhanced with the utilization of force element adjustment gadget. This will build the power factor consider closer to unity. This gadget peruses the power factor variable from the line current and line voltage values.

**Power Factor Correction:** Basic method used to increase power factor depends on the introduction of reactive power (KVAR) into the power system in phase opposition to reactive current.

**Power Factor Improvement:** In A.C. circuit apparent power (KVA) is resolved into useful power (KW), and reactive component (KVA). KVA is the phasor sum of these two components drained from the supply. To increase power factor, system taking KVAR is nearly or approximately equal magnitude of load KVAR but in opposite phase i.e. Leading. That is connected parallel with the load. Then the total KVA is reduced and power factor ( $\cos \phi_2$ ) is improved. This new power factor  $\cos \phi_2$  can be controlled by changing the magnitude of added KVAR.

**Why We Need capacitor Banks:** In the early phases of improvement, it was for the most part mineral protecting oil which was utilized as impregnate. This has now been supplanted by the vast majority of the makers with engineered fluids of chlorinated diphenyl bunch bearing diverse exchange names. Mineral

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protecting oil has low electric conductivity and high dielectric quality. Be that as it may, it has anyway a few downsides:

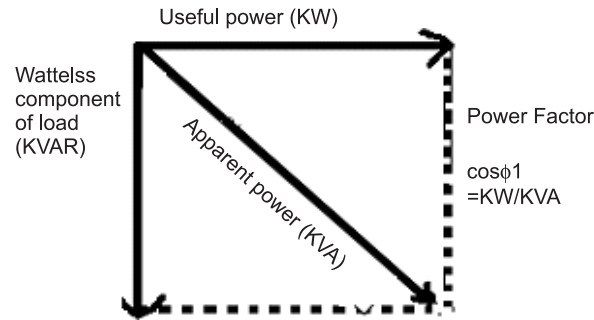


Figure 1: Operation of lagging Power Factor Phasor Diagram

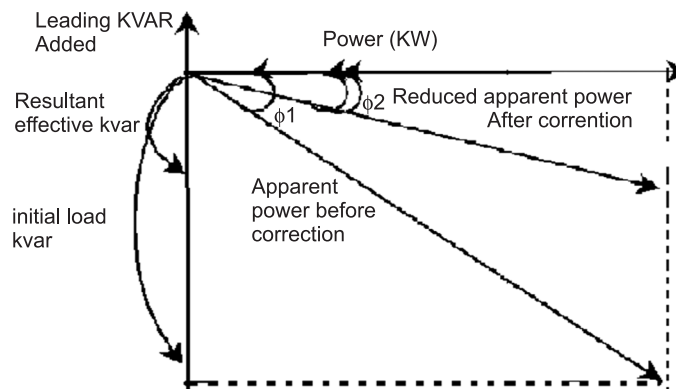


Figure 2: Power Factor Correction by adding Leading KVAR

- (a) It has low dielectric steady.
- (b) The voltage dispersion in the mineral oil is not uniform.
- (c) It is exceptionally inflammable.
- (d) It is subjected to oxidation.

With the engineered impregnate it is very conceivable to produce littler capacitor unit with higher voltage rating. The voltage rating of the capacitor unit is confined inside specific breaking points in light of the fact that on low voltage the expense per kilo VAR goes high.

Capacitors comprise of two transmitters that are isolated by a protecting material or dielectric. At the point when an electrical current is gone through the conduit combine, a static electric field creates in the dielectric which speaks to the put away vitality. Not at all like batteries, is this put away vitality not looked after inconclusively, as the dielectric considers a specific measure of current spillage which results in the steady scattering of the put away vitality.

#### Difference between Microcontroller and Lab View:

*Microcontroller having problems like:* First thing is about power supply. Different type of controllers require different power supplies. Also while programming programmer supposed to specify the port using in the program. Another problems Regarding Pull ups. Many controllers requires pull-ups before programing. These are the main common problems while programming the microcontroller.

To overcome this we are going to use the Lab tool.

**Introduction to Lab View:** NI Lab view programming is intended for fluctuated set of uses and commercial ventures for re-enactment of the whole framework based upon pre expected qualities considered while

planning the framework. Lab view is profoundly beneficial creating environment which is utilized for make and benefit client applications that associate with genuine data frameworks or signs in fields, for example, science and innovation particularly in designing.

**Advantages of using Lab View:** There are different favourable circumstances of utilizing a joined advancement environment for re-enactment the arrangement of a force framework system and programming dialect, for example, lab view in today's science and innovative exploration including exploratory registering applications contain the accompanying: After Compiling code rate and capacity to make records distributable and executable documents independently. Lab VIEW is Powerful device as well as adaptable and fit for being scaled a specific force framework outline (it opens and interfaces with outside library documents and outsider reproduction devices, for example, mat lab, multiset, zest and other recreation toolbox instruments). Lab perspective is anything but difficult to learn, use, keep up, furthermore overhauling by suddenly determining graphical programming utilizing different graphical develops accessible. It plays a key instrument for outlining, prototyping and arrangement applications in lion's share building applications.

Advantages of Power Factor Improvement:

1.  $I^2R$  losses will be reduced in transformer and distribution equipment.
2. Voltage drops will be reduced in long cables.
3. Electricity billing charges also reduced.
4. System efficiency will be improved.

## 2. CAPACITOR BANK DESIGN

Capacitor bank design means calculation of required reactive power to make the power system run under unity power factor.

While installation the following points should be considered for capacitor banks.

- Joint criteria to limit the over voltages to 110% of the rated voltage with one unit out.
- Over voltage consideration as per IS13925 (part1) 1998.
- Fault level consideration of power system for designing of capacitor banks.

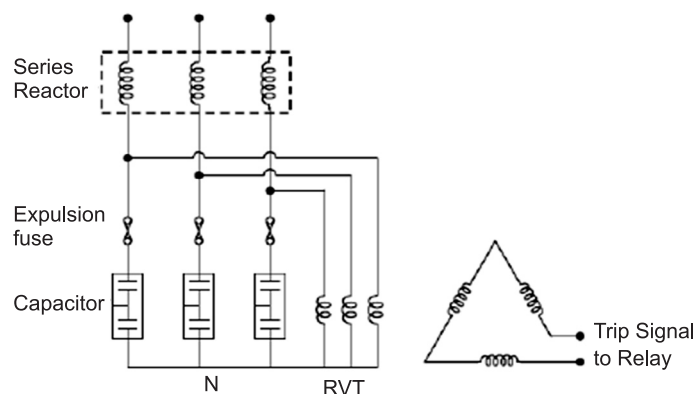


Figure 3: Arrangement of Capacitor bank

This paper covers the designing of capacitor banks considering overvoltage as per IS and the switching operation of capacitor banks control with the help of NI-Lab VIEW.

**Approach Procedure:** The main concept of this paper is to control the power factor. Present in the markets power factor controllers are programmed with the help of microcontroller's. It is difficult to write the code

for the requirements of each and every industry because every industry usage of power and capacity is not same. Also disadvantage of microcontrollers is we get the output through 16 data lines only. So to overcome all these difficulties we are going to develop a program to control the switching operation of capacitor banks very effectively with the help of NI-LAB View software. Also Now A Days so many Industries are going for atomisation in that more companies are using Ni-Labview.

So there is no need to buy extra equipment for controlling power factor.

The proگرامing procedure is as follows:

We are going to develop this program based on the phase difference between input voltage and current wave forms. Depending on the phase difference we can send signals or pulses to the Power Electronic Switches which we want to use here is Silicon Controlled Rectifiers. If the power capacity is more then we will use GTO's.

According to the phase difference Power Electronic Switches will Act and Close the capacitor bank.

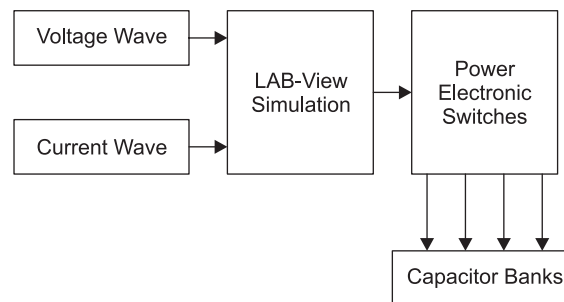


Figure 4: Block Diagram of Proposed

### 3. METHOD

Advantage of this approach is we can number of capacitor banks to control the power Factor more efficiently. So that we can reduce the installation cost. Also It is very easy to use at any capacity of power ratings.

#### Mathematical Calculation:

**Designing of a 39.4 var × 253 V Capacitor Bank: Power factor calculation**

$$\begin{aligned} \text{Pf} &= p/s = 1.5 \text{ KW}/2.211 \text{ KVA} \\ &= 0.6784 \end{aligned}$$

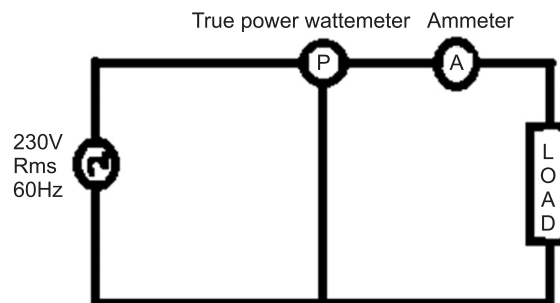


Figure 5: System of 230v 60 HZ

**Step 1:** Calculation of Reactive power

$$\begin{aligned} \text{Reactive power} &= \text{sqrt} ((\text{apparent power})^2 - (\text{true power})^2) \\ Q &= 1.754 \text{ Kvar} \end{aligned}$$

$$Q = E^2/X$$

$$X = E^2/Q = (230)^2/(1.754) = 32.566$$

**Step 2:** Over voltage consideration As per Indian standards 10% of the rated voltage. i.e.. Rated Capacitor voltage ( $230 \times 1.1 = 253$  Volts).

**Step 3:** Required Reactive power for improve the power factor from 0.66 pF to 0.99 Pf with consideration of over voltage at 253 volts.

Reactive power calculated as

$$X = E^2/Q = (230)^2/32.566 = 1624.394 \text{ ohms.}$$

$$\text{Reactive power (var)} = \frac{253 \times 253}{1624.394} = 39.4 \text{ var}$$

Var Calculation After adding 1.96 Kvar capacitor

$$\text{Inductive (KVAR)} - \text{capacitive (KVAR)} = \text{total KVAR}$$

$$1.754 \text{ KVAR} - 1.737 \text{ KVAR} = 17 \text{ VAR}$$

Uncorrected power triangle obtained without adding capacitors

This is the normal procedure to calculate the required rating of capacitors. One more Formula is developed directly to calculate the required kvar for make the system run under unity power factor condition. i.e.

$$C = \frac{I \times \sin \theta 1}{2\pi f v}$$

Where C = Capacitor rating in farads

V = supply voltage or operating voltage

I = supply Current

$\theta 1$  = Phase Difference between Voltage and Current

f = supply Frequency

## Lab view Simulation Results

Lab view back panel logic:

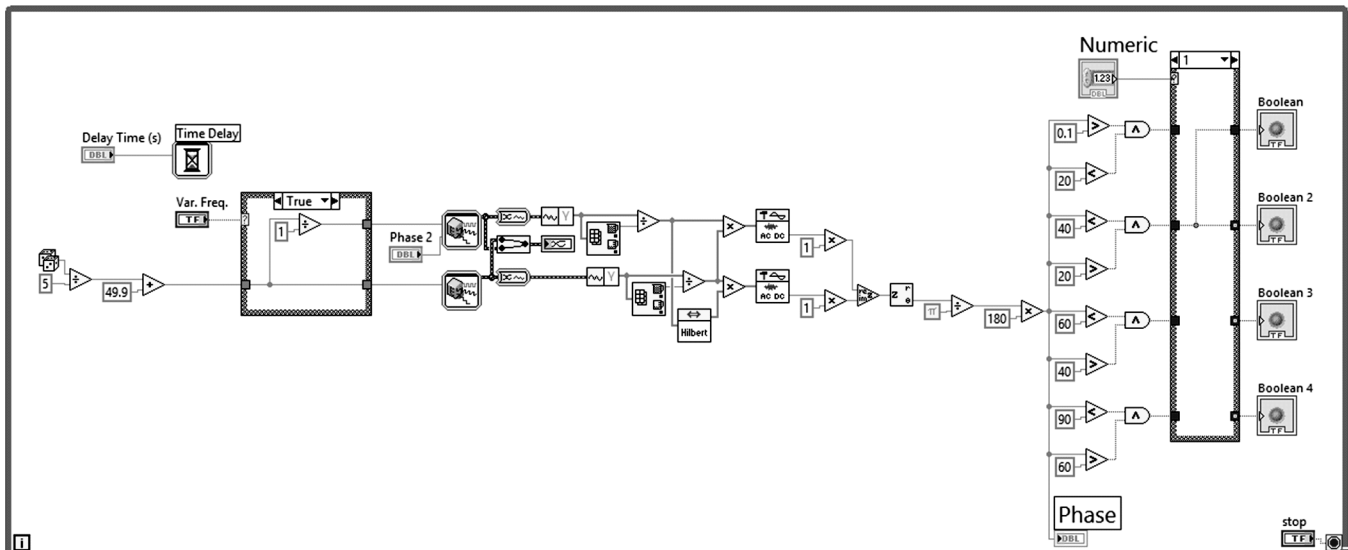


Figure 6: Lab VIEW back panel Logic

**Simulation Output:**

Phase difference is 10 degrees

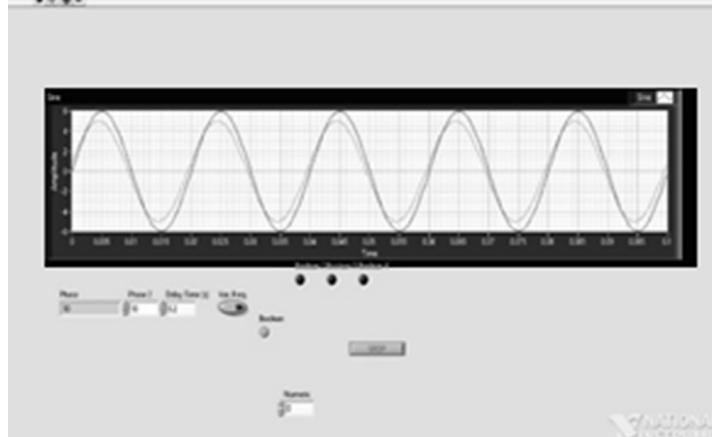


Figure 7: Phase difference is 10 degrees

Phase difference is 23 degrees:

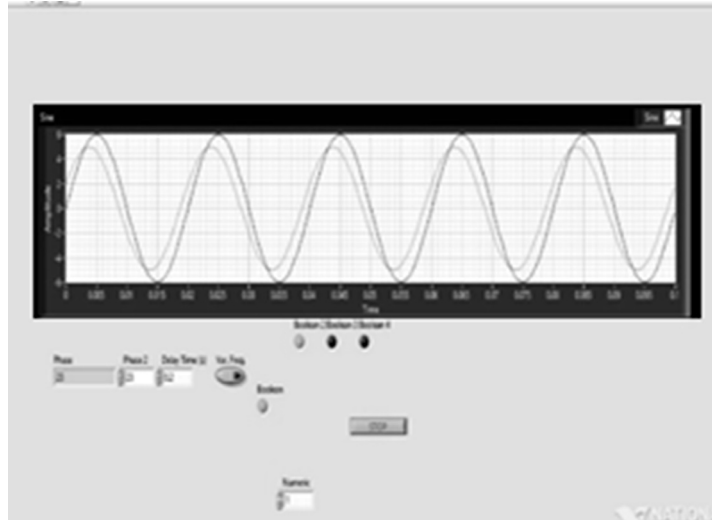


Figure 8: Phase difference is 23 degrees

Phase difference is 45 degrees:

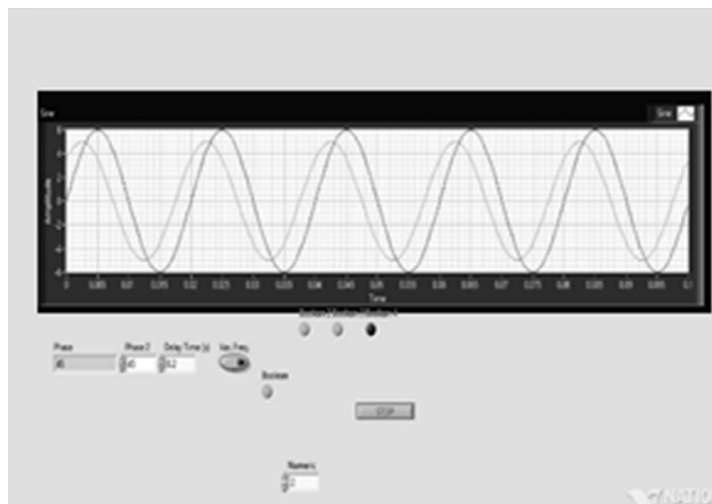
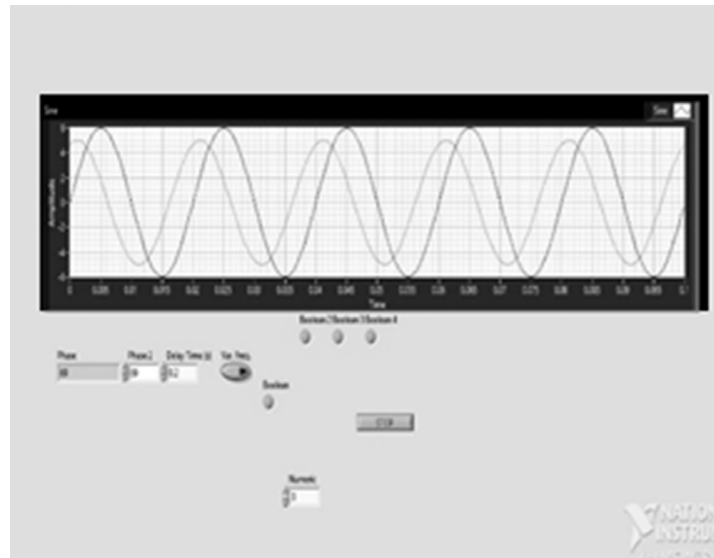


Figure 9: Phase difference is 45 degrees

**Phase difference is 69 degrees****Figure 10: Phase difference is 69 degrees**

**Future Scope:** Now Days Lab VIEW usage is increasing in all the industries. So Industries must use power factor controller to run the system under unity power factor. So by replacing Lab VIEW controller In the place of Normal available power factor controller device. So there will be chance to reduce the cost. This is basic approach we can extend this like Labview code is in built in VLSI chip from there we can send signals to the power Electronics Switches. Also it is simple to use. So the industry employer himself will be able to control the operation.

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