

# Automatic Power Factor Correction

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**Abstract :** Automatic power factor correction techniques let the system becomes stable and efficient as well as of the reactive power increases power factor correction using capacitor banks to reduce reactive power consumption which will lead to minimization of losses and at the same time increases the electrical system's efficiency but capacitor have short service life these capacitors are easily damaged if the voltage exceeds the rated value The Automatic Power factor Correction device is a very useful device for improving efficient transmission of active power. This paper focused on design an automatic power factor correction using an Arduino for Improving the poor power factor by adding parallel capacitors that are inserted by an electronic component TRIAC instead of a CONTACTOR to develop an automatically corrected power factor to establish design parameter simulate the established control concept relative to its corresponding input and output relationship and control frame work.

**Keywords—** Automatic power factor correction; ARDUINO UNO; TRIAC; Simulation of Circuit.

## 1. INTRODUCTION

Power factor is the relation between the kW and the kVA drawn by an electrical load where the kW Is the actual load power and the kVA is the apparent load power It is a measure of how effectively the current is being converted in to useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply The power factor is expressed in decimal or percentage Low power factor is usually associated with transformers and motors an incandescent bulb would have a power factor of close to 1.0.A one hp motor has a power factor of about 0.80. With low power factor loads the current flowing through electrical system components is higher than necessary to do the required work these result in excessive heating, which can damage or shorten the life of the equipment ,A low power factor will also cause low-voltage conditions resulting in dimming of lights and sluggish motor operation Low power factor is usually not that much of a problem in residential houses It does however become a problem in industries where multiple numbers of large motors are used So there is are requirement to correct the power factor in industries generally, the power factor correction capacitors are used for power factor correction, Reactive Power produces no productive work which requires in inductive load to generate and sustain a magnetic field in order to operate it measured in (Kvar) or (Mvar) Apparent Power Working power and reactive power make up the apparent power (or) the combination of reactive power and true power is called as apparent power It measured in (Kva) or (Mva).

### 2.1 AC RESPONSE OF RESISTOR, INDUCTOR AND CAPACITOR:

#### 2.2 Resistor Load

A Resistor with AC supply is shown in the figure (2.1) a long with the wave form and phasor diagram represented in figure (2.2), which shows that the phase angle between current and voltage in case of a capacitor the phase angle between current and voltage is  $0^{\circ}$  For ordinary currents and frequencies the behavior of a resistor is that of a dissipative element which converts electrical energy into heat It is independent of the direction of current flow and the frequency So we say that the AC impedance of a resistor is the same as its DC resistance.

Where:

$$I = \frac{I_m}{\sqrt{2}} \quad \dots(01)$$

$$V = \frac{V_m}{\sqrt{2}} \quad \dots(02)$$

I represent the RMS current

V represent the RMS voltage.

$I_m$  represent the maximum current.

$V_m$  represent the maximum voltage

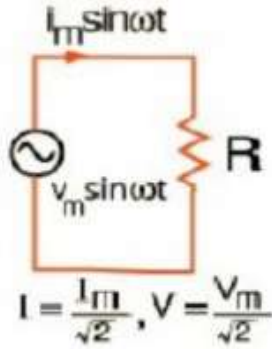


Fig 1: resistor with A.C supply

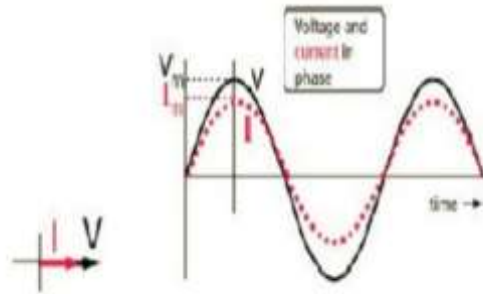


Fig 2: The phasor diagram

### 2.3 Inductor Load

An inductor with AC supply is shown in the figure (2.3) along with its phasor diagram represented in figure (2.4), which shows the phase angle between current and voltage. In case of an inductor voltage leads current by  $90^\circ$ . The voltage across an inductor leads the current because the Lenz's law behavior resists the buildup of the current and it takes a finite time for an imposed voltage to force the buildup of current to its maximum.

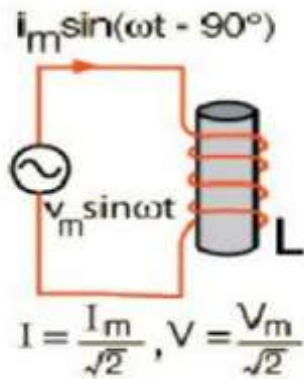


Fig 3: An inductor with AC supply

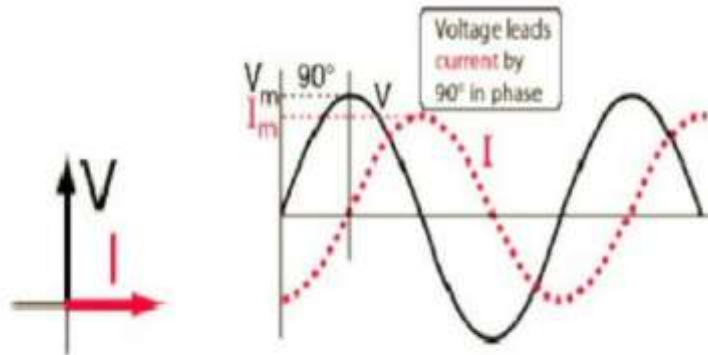


Fig 4: The Phasor diagram

### 2.4 Capacitor Load

A capacitor with AC supply is shown in the figure (2.5) along with the wave form and Phasor diagram shown in figure (2.6), which shows that the phase angle between current and voltage in case of a capacitor voltage lags behind the current by  $90^\circ$ . The voltage across a capacitor lags the current because the current must flow to buildup charge and the voltage is proportional to that charge which is built up on the capacitor plate.

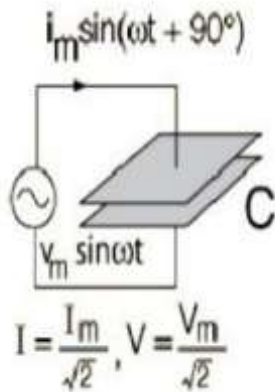


Fig 5: A capacitor with AC supply

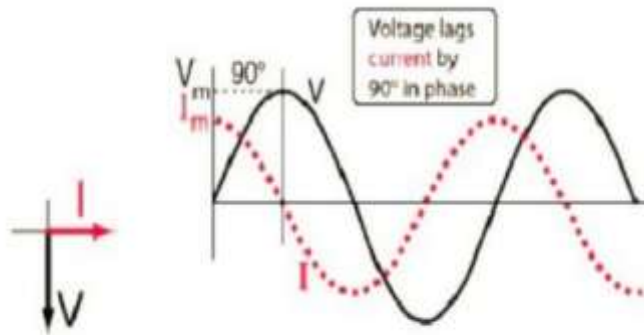


Fig 6: The Phasor diagram

### 3.1 Power Factor Control System

The main component of automatic power factor correction system is current transformer, potential transformer, ZCD and Arduino.

Power supply consist of two main measurement component (CT,VT) The voltage and current in the circuit are stepped down using a potential transformer and a current transformer respectively that detect and gives stepped down values of current and voltage respectively, both waves converted from sin form to square form by IC741,The ZCD signals are then added in order to obtain pulses which represent the time difference between the zero crossing of the current and voltage signals . time period of these signals is measured by the internal timer of the Arduino and calculate the power factor then the fairly amount of capacitor switch.

### 3.2 The main system block diagram:

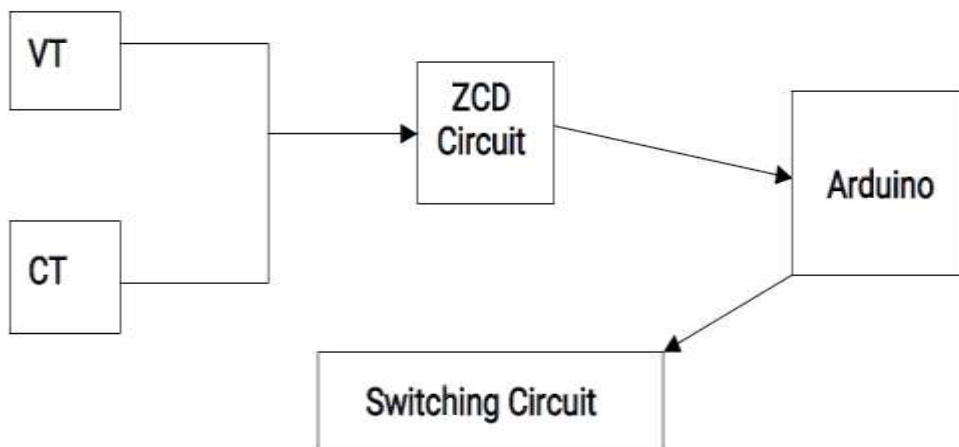


Fig 7: main block diagram

### 3.3 The main component of automatic power factor correction system:

- I. Current Transformer (CT)

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- II. Potential Transformer (PT)
  - III. Zero Crossing Detector (ZCD)
  - IV. Summer /Adder (X-OR) gat
  - V. ARDUINO UNO
  - VI. Switching
  - VII. Opto-Isolator
  - VIII. Triac
  - IX. Power supply
  - X. Diode / Light Emitting Diodes (LED)
  - XI. Resistor / Ceramic Capacitor / Electrolytic Capacitor
  - XII. Voltage Regulators (7805,7812)

#### 4.1 SYSTEM OPERATION:

Automatic Power Factor Correction system is based on the AVR microcontroller ATmega328. The voltage and current in the circuit are stepped down using a potential transformer and a current transformer respectively. These transformed A.C signals are next fed to a Zero crossing Detector (ZCD) circuit. The output of the Zero Crossing Detector (ZCD) is a square wave, in which each change of state represents a zero crossing of the A.C wave form. The signal goes high on the first zero crossing of the current or voltage wave form and then goes low on the next zero crossing of the signal, thereby generating a square wave. Two separate Zero Crossing Detector (ZCD) circuits are used for voltage and current wave form. The two square waves are then summed using an Exclusive OR (X-OR) gate. The output of the summer gives the phase angle difference which is given to the Arduino microcontroller on one of its digital I/O pins (pin13). The value on the pin is read using the function `pulseIn (Pin,High)` where the parameter `pin` depicts the number of the pin on which you want to read the pulse (`int`), `High` depicts the type of pulse to read. The function reads a pulse (`HIGH`) on a pin when value is `HIGH`, `pulseIn ()` waits for the pin to go `HIGH`, starts timing, then waits for the pin to go `LOW` and stops timing. It finally returns the length of the pulse in microseconds or gives up and returns 0 if no pulse starts within a specified time out. The timing of this function has been determined empirically and will probably show errors in longer pulses. Hence it works efficiently on pulses from 10 microseconds to 3 minutes in length. The difference is measured with high accuracy by using internal timer.

This time value obtained is in microseconds ( $\mu\text{s}$ ), it is converted in seconds ( $\text{s}$ ) and is then calibrated as phase angle  $\theta$  using the relation:

$$\Theta = T * 10 * (360 * f) \quad \dots (03)$$

$T \equiv$  time difference in seconds( $\text{s}$ ).

$F \equiv$  frequency

The corresponding power factor is calculated by taking cosine of the phase angle obtained above (i.e.,  $\cos\theta$ ). The values are displayed in the serial monitor which in this case is the computer screen. The display can also be obtained on a separated display by using the serial transmission pins: Serial Transmission(Tx) and Serial reception(Rx) of the Arduino but that would require appropriate interfacing circuitry. The microcontroller then based on the algorithm then switches on the required number of capacitors from the capacitor bank by operating the Triac. The power factor is normalized to the set limit.

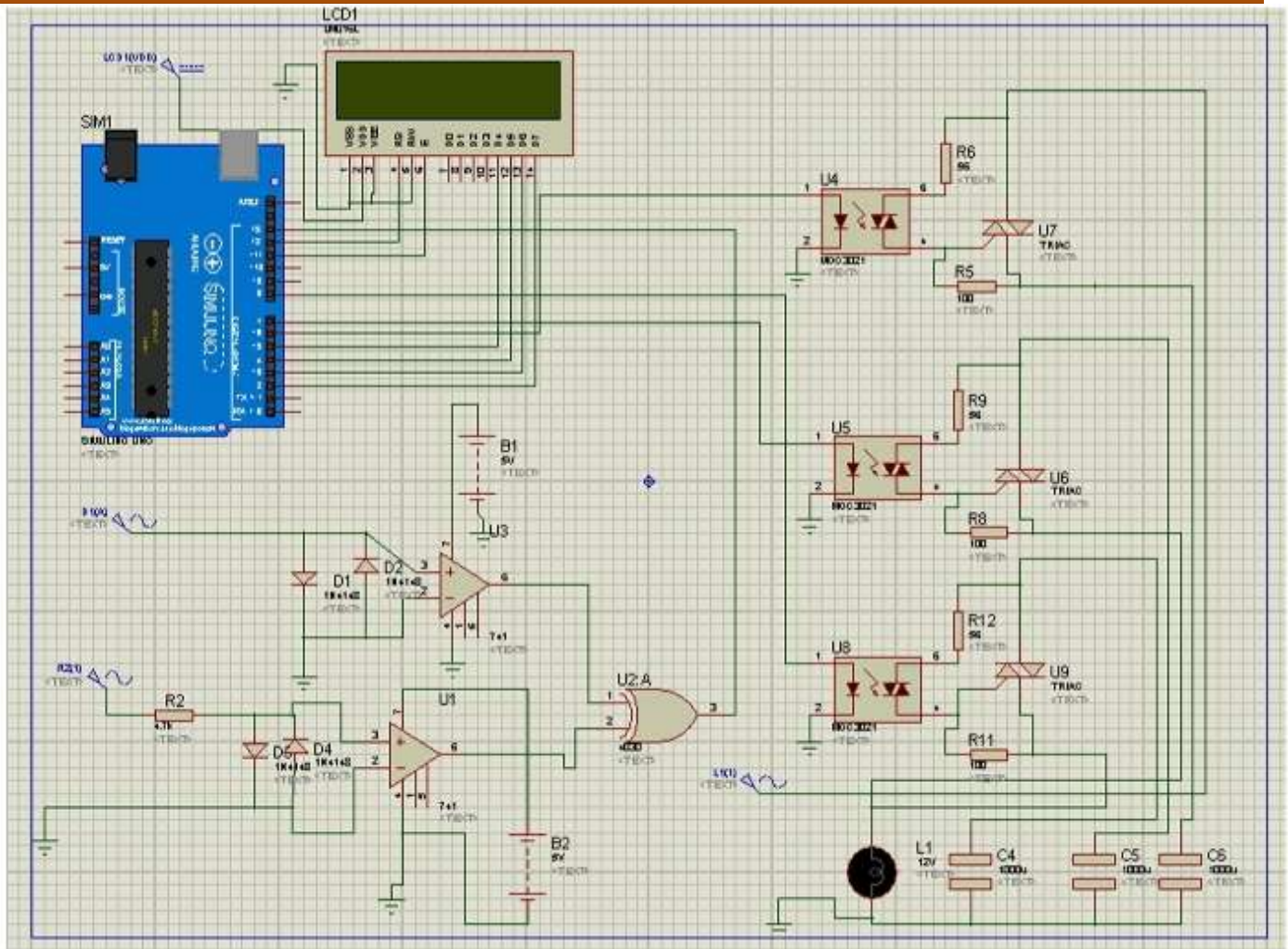


Fig 8: simulation of the circuit

Table 1 : Power Factor Obtained for different Loads

SI No	Load	Power factor displayed
1	Incandescent Lamp 100W	0.77 – 0.80
2	Exhaust Fan 60W	0.71 – 0.75
3	Glow type zero bulb 10W	0.45 – 0.47

**4.2 Use of the Function:**

Void get pf ()

```
{
    For (ctr=0; ctr<=4; ctr++)// Perform 4 measurements then reset
```

```

{
// 1st line calculates the phase angle in degrees from differentiated time
Pulse
//Function COS uses radians not Degree's hence conversion made by
Dividing angle/57.2958
Angle = (((pulseIn (pin,HIGH))*nano)*degree)*frequency);
//pf=cos(angle/rads);
if(angle>angle-max)//Test if the angle is maximum angle
{
Angle-max=angle;//If maximum record in variable "angle-max"
Power-factor =COS(angle-max/ rads);//Calc PF from "angle-max"
}}

```

## 5 CONCLUSION :

Automatic power factor system detected and correct the power factor of group of loads by using automatic system that manage by Arduino to detect the short in VAR and compensation the short by switching a group of static capacitors static capacitors have many benefits as shown as they have low losses, they require little maintenance as there are no rotating parts and they can be easily installed as they are light and require no foundation, In areas where a KVA demand clause or some other form of low power factor penalty is incorporated in the electric utility's power rate structure, removing system KVAR improves the power factor, reduce power bills by reducing the KVA Most utility bills are influenced by KVAR usage. – Increase system capacity: The power factor improvement releases system capacity and permits additional loads (motors, lighting, etc.) to be added without over loading

The system in atypical system.

- Improve System Operating Characteristics (Gain Voltage): A good power factor (0.95) provides a " stiffer" voltage, typically a 1-2% voltage rise can be expected when power factor is brought to +\-0.95, Excessive voltage drops can make your motors sluggish, and cause them to overheat. Low voltage also interferes with lighting, the proper application of motor controls and electrical and electronic instruments. Motor performance is improved and so is production.

- Improve System Operating Characteristics (Reduce Line Losses) Improving power factor at the load points shall relieve the system of transmitting reactive current Less current shall mean lower losses in the distribution system of the facility since losses are proportional to the square of the current ( $I^2R$ ). therefore, fewer kilowatt-hours need to be purchased from the utility.

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