Under and over frequency Relay with automatic Power Factor Control using Arduino Uno

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ABSTRACT

The aim behind the publishing this paper is to implement an incipient technology for power factor increment for a single as well as three phase inductive load, as power factor enhancement is necessary for domestic as well as industrial consumption of power & to bringing the value of power factor nearer to unity by avoiding the penalty from distributors. As we know the widely used motors in the industries are the conventional induction motors and induction motors exhibit the low power factor. The most of the household appliances which are generally used are too have low power factor. In today’s advanced and globalized world the power is very paramount for the economical perspective. So we require ascertaining the factors reinforcing the power loss and amending the performance of the power system. Due to the industrial revolution, the inductive load is highly employed and hence the efficiency of the power system decreases. So the amendment of the PF with a felicitous method becomes necessary. The embedded technology always comes into forefront whenever there is a need to contemplating any programmable devices. Nowadays The embedded technology is at the pinnacle of popularity and hence many of the electrical and electronic appliances were designed with a microcontroller (ARDUINO) based embedded technology.

In this paper, we are proposing Power factor amendment scheme utilizing capacitive bank with ARDUINO UNO

Keywords: Arduino-Un0, Relay card, Induction Moto, Capacitive Bank, LCD, Power factor meter.

1. INTRODUCTION

All motors that consume an AC current needs apparent power for their working, but apparent power is consist of two powers namely reactive power and active power. The power which is utilized by the load is active power while Reactive power is the power inductively utilized by the load and returned to the power source of the load [1].

The easy way to designate power factor is

Power factor is the division of the utilizable power i.e. real power which is expressed in terms of KW to the total power i.e. the apparent power which is expressed in terms of KVA utilized by an electrical equipment operated by AC current or motor. Power factor is a quantification of how efficaciously electrical power is consumed to do a utilizable work. The unity power factor is considered as an ideal power factor. If power factor drops down below the unity then it indicates that extra electrical power is required to perform or achieve the authentic work.

2. IDEA TO IMPROVE POWER FACTOR

The fundamental conception of PF rectification of a motor or electrical system we should have to insert a capacitance by using a capacitor in parallel with the electrical system or machine which is having less power factor. One of traditional custom for power factor enhancement is static type compensation which employs a static type capacitor for PF rectification.

3. WORKING OF CAPACITORS

The apparent power can be obtained by using the right angle triangle rule with having active power on one arm of the triangle & reactive power at other sides of right angle triangle.
KVA$^2 = $ KW$^2 + $ KVAR$^2$

To minimize the KVA value, overall current requisite for any electrical load given, we should abbreviate the segment of the triangle that shows the KVAR value. The same function can be done by the capacitor. The actual power to apparent power division is conventionally shown in percentage and is referred as power factor[1]. The following figure shows the power triangle.

![Power Triangle](image)

**Fig 1. Power Triangle**

### 4. METHODS FOR POWER FACTOR CORRECTION

A. Static compensation: In this method for power factor amendment static capacitors are connected in parallel with the machine which works on low power factor. These static capacitors provide a leading current which eliminates lagging component of load current and amends power factor[1],[2]. There are two methods of static compensation namely shunt compensation and series compensation. In shunt compensation technique current is injected and in series compensation technique voltage is injected.

B. Synchronous condenser: When a synchronous motor operates at no load and at over-excited condition then it is called synchronous condenser. When a synchronous condenser is over excited then it provides leading current and works like a capacitor. When a synchronous condenser connected across supply then it procures leading current and partially removes a reactive component and thus amends power factor[2].

C. APFC scheme: Here we are going to propose a system which is predicated on the technique of perpetual monitoring of the parameters of the system such as voltage and current with the utilization of potential transformer and current transformer respectively. Through perpetual monitoring phase angle of these quantities will be calculated perpetually and depending upon the phase difference correspondingly appropriate amount of capacitors will be switched ON or OFF in the system in order to ameliorate power factor as proximate as unity. As there is no moving part in capacitors hence switching losses are less as compare to that of static compensation withal no extra motor is required for power factor rectification and hence cost is much less as compared to that of power factor correction by synchronous condenser technique[3].

In this scheme motor is connected to relay card and relay card is connected to the capacitive bank. When a lagging current is drawn by the motor, the capacitive bank is added parallel in the circuit.

### 5. BLOCK DIAGRAM

![Block Diagram](image)

**Fig 2. Block Diagram**

First Press PUSH button ON. Arduino-Uno program will start. The program first check the supply frequency. If the frequency is 50 Hz then automatically motor will start. The capacitive bank will be added in line to improve PF. If supply frequency is less or greater than 50 Hz then, Wait for 3msec. If frequency does not recover. Turn OFF motor and disconnect capacitive bank from the motor. When supply frequency recovers then.
6. FLOWCHART

![Flow Chart](image)

**Fig. 3 Flow Chart**

7. MAJOR COMPONENTS

A. Microcontroller (Arduino): The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be utilized as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, and a reset button. It contains everything needed to fortify the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get commenced. We are utilizing the compiled software Arduino Uno to execute the programs and it downloads to the controller board through USB cable. LCD display is utilized to show the current, voltage and power factor.

![Arduino Uno](image)

**Fig. 4 Arduino Uno**

B. Driver unit (Relays): Relays are used to switch the capacitance value with the help of the output of microcontroller. The relays driver board is depicted below:

![Relay Card](image)

**Fig.5 Relay Card**

C. Capacitors: Capacitors are acclimated to increment the real power, it gives a leading power factor load so we are integrating the capacitors in inductive loads. The capacitor is a reactive current generator, so it is utilized for the power factor improvement. It is rated in KVAR.
8. POWER FACTOR CORRECTION AND CAPACITOR CALCULATION

The input to the microcontroller is taken from another Arduino Uno which generates square wave pulses.

\[
\text{POWER FACTOR} = \cos \phi
\]

When there is an incrementation in reactive power, the capacitance will be connected automatically and reduces the reactive power. The capacitance values are rated in KVAR. Here there are two calculations for the capacitor calculation first method is to add the capacitance by referring the standard capacitor table, but this method can be appropriate for manual operations only.

9. EXPERIMENTAL KIT

In this experimental kit, we have used two Arduino Uno, Realy card, Power factor meter, capacitive bank, LCD, Induction motor, and Potentiometer.

Fig. 6 shows the kit in ON condition.

![Fig. 6 Experimental Kit](image)

10. OBSERVATIONS

Table I Before adding capacitive bank

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Motor</th>
<th>Current</th>
<th>Voltage</th>
<th>Power Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5 KW</td>
<td>2.4 Amp</td>
<td>221 Volt</td>
<td>0.64</td>
</tr>
<tr>
<td>2</td>
<td>1 KW</td>
<td>5 Amp</td>
<td>221 Volt</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Table II After adding capacitive bank

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Motor</th>
<th>Current</th>
<th>Voltage</th>
<th>Power Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5 KW</td>
<td>1.6 Amp</td>
<td>221 Volt</td>
<td>0.91</td>
</tr>
<tr>
<td>2</td>
<td>1 KW</td>
<td>3.9 Amp</td>
<td>221 Volt</td>
<td>0.89</td>
</tr>
</tbody>
</table>
11. RESULTS

![Fig.7 Without Capacitive Bank](image1)

![Fig.8 With Capacitive Bank](image2)

12. ADVANTAGES OF POWER FACTOR IMPROVEMENT

Advantages which can be achieved by employing proper power factor correction scheme are:

- Efficiency enhances due to Reduction of power consumption.
- Due to reduced power consumption, there will be high power reservation and decrement in load shedding.
- Reduction in an electrical penalty for consumers.
- Extra KVA can obtain from the same existing supply.
- The losses occur in distribution equipment as well as transformers i.e. FR losses can be reduced in considerable extent.

13. APPLICATION

- It can be used in industries where ac motor load is present.
- It can be used for a domestic purpose like for tube well motor, mixer, grinders etc.

14. FUTURE SCOPE

- By applying this circuit for a number of motors and various loads in industries, we can calculate the exact value of power factor and perform necessary adjustments of capacitive banks so that power factor will be improved by exact calculation. So overall industry will be in benefit.
- This project is just for one motor but in future, we can use this for many motors. When more than one motors are made on Arduino will on particular capacitor banks to the supply to reduce reactive power.
- The number of motors when runs at a time then one by one motor will be disconnected, when under and over frequency condition occurs so that necessary production will continue without break.

15. CONCLUSION

Before capacitor connected across Motor, the power factor seems to be too lagging but when the capacitor is connected to motor it is improved towards unity and hence reactive power, penalty decreases which increases the reliability.

16. REFERENCES


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