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# Power Factor Improvement Using Automatic Power Factor Compensation (APFC) Device

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**ABSTRACT:** This project is mainly proposed for reducing the power loss in industries by using power factor compensation through several shunt capacitors. Power factor is defined as the ratio of real power to apparent power. So, the increase in reactive power (real power) increases the apparent power, so the power factor also decreases. By having a low power factor, the industry needs more energy to meet its demand, so the efficiency decreases. In this system, we proposed the time lag between zero voltage pulse and zero current pulse delay generated by suitable op-amp circuits in comparator mode and fed into two interrupt pins in the microcontroller. The microcontroller displays the power loss due to inductive load on the LCD. This process is continuously actuated until the power loss would be zero by using relays which are used to bring the shunt capacitors into the load circuit. An 8-bit microcontroller is used in this project which belongs to the 8051 family

**KEYWORDS:** Potential Transformer, Amplifier (Op-Amp), Current Transformer, Two Microcontroller, Capacitors, Conductors, Relays, LCD 20x4 (Liquid Crystal Display), Automatic power factor correction, Automatic power factor correction, automatic power factor correction capacitor

## I. INTRODUCTION

Electrical power has been proven to be one of the most important resources in India and due to its high demand and widely used, it has become a very expensive resource. The explanation for its high cost is especially due to the generation cost, transmission cost, and cost. Plus, the demand of commercial and industrial customers varies greatly throughout the day and for them (the industrial consumers) the maximum demand plays an important role in their overall electricity bills. Therefore, they need to ensure that their max demand is low as possible for their substantial savings. This is the main purpose of this project where it is to overcome the unwanted problem, power factors need to be improved by installing Automatic Power Factor Compensation (by adding capacitor load to offset the inductive load present within the power system). The capacitors are often installed at the service door of the plant or on the load side of the metering equipment. These capacitors could provide part or all of the reactive power required by the plant. There are many benefits to having an Automatic Power Factor Compensation device. For industrial usage, the equipment will have a longer life span and the maintenance costs remain low. According to Sandesh, Singh, and Phulambrikar (2012), power factor improvement results in an enormous drop of apparent power drawn from the ac source which successively protects energy and minimizes the transmission losses. This project will make the consumers see the effect of the high and low power system in their consumption of energy. When the power factor is very low, they may be able to see the effect and reach out to make the operating system change as needed. They can increase the power factor by using the automatic power factor compensation which uses capacitor and microcontroller as the main components

### 1.1 Power Factor

Ware, J. (2006) described that the power factor is the ratio between the useful (true) power (kW) to the total (apparent) power (kVA) consumed by an item of alternating current (A.C) electrical equipment or a complete electrical installation. It is a measure of how efficiently electrical power is converted into useful work output. The ideal power factor is unity, or one. Anything but one means extra power is required to realize the particular task at hand. Power factor is expressed as a percentage (%).

$$\text{Power factor} = (\text{REAL POWER (kw)}) / (\text{TOAL POWER (kva)}) * 100 \dots (1)$$

Real power or true power, P is that the power that's wont to work on the load. Active power is measured in watts (W) and the electricity billing, it is stately in kilowatt-hours (kwh). It is the facility drawn by the electric resistance of a

system doing useful work. Reactive power is that the power does not want to work on the load. Kanchi et al. (2013) have described that generally, the power factor is called the cosine of the angle between the voltage and current. In an a.c circuits, there's generally a phase difference between voltage and current. If the circuit is inductive, the current is lags behind the voltage and the power factor is called the lagging power factor and if the circuit is capacitive then the current leads to voltage, and the power factor is said to be the leading power factor.

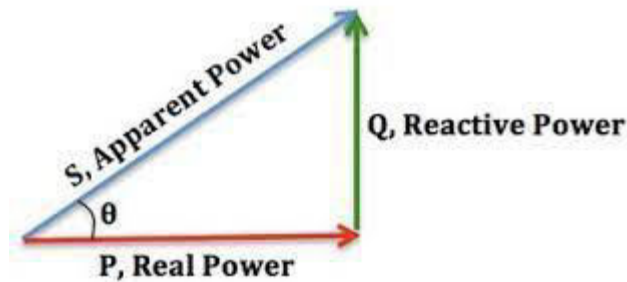


Fig. 1. POWER FACTOR

The power factor of an alternating-current device or circuit is the ratio of the active power P to the apparent power S. Power factor is expressed as a simple number or as a percentage. It is given by the equation;

$$\text{Power factor} = P/S \quad \dots(2)$$

where; P = active power delivered or absorbed by the circuit or device [W]

S = apparent power of the circuit or device [VA]

### 1.2 Power Factor Correction

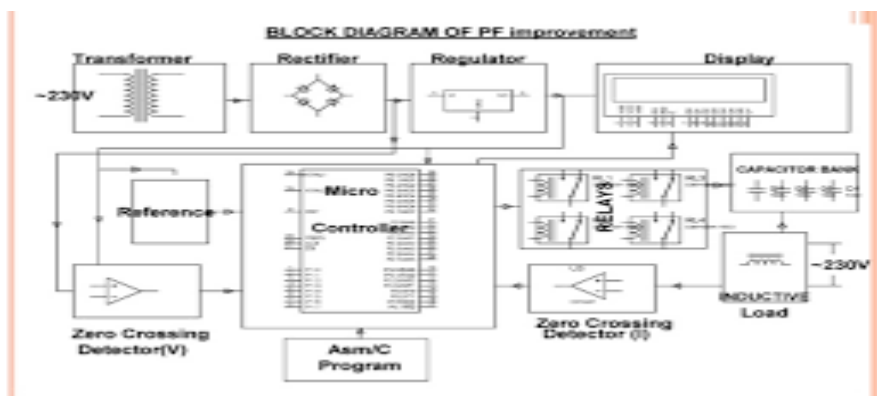
Power factor correction are often applied by the electrical utility to enhance the steadiness and efficiency of the transmission network or, it are often installed by the electrical consumer to reduce costs charged by the electrical provider. Wildi, T. (2006) mentioned that power factor correction (or improvement) is economically practicable whenever the decrease in the annual cost of electricity exceeds the payback cost of installing the required capacitors. In some cases, the customer has no choice but must obey the minimum power factor specified by the utility company. The power factor may be amended by installing capacitors at the commercial enterprise or the service entrance of the factory. In other cases, if the power factor is particularly low, it may be necessary to correct the power factor of the device or machine individually. Power factor compensation are often defined as a process of correcting the lagging current by producing a number one current in order that the angle between voltage and current reduces. There will be no power loss if the current and voltage are in phase, thus it can improve the power factor value to near unity or even unity. The process is completed by connecting few capacitors at the service door where the facility factor is attuned by an adequate value of capacitance. The electrical loads that employment on AC need apparent power which is that the product of real power and reactive power. The reason why the electrical load has a power factor less than one is, the existence of reactive power makes the apparent power higher than real power. The reactive power increases the current flow from the power sources and the load. When this happens, power losses increase in both distribution and transmission lines. Thus, this results in financial losses for power providers like Tenaga Nasional Berhad (TNB) which made them require their consumers and customers, especially those who use large loads to maintain their power factor above 0.85 or higher. Besides the increase in operation costs, reactive power requires the use of higher current capacitance components like wires, switches, transformer, and circuit breakers. Power factors are often improved by few methods like installed capacitor banks in parallel, synchronous condenser, and phase advancer.

## II. RELATED WORK

- I. The automatic power factor correction thus gives us an efficient technique of capacitor switching technique which utilized in improving the power factor of the system to maintain it near unity as much as possible which can give various advantages to industrial consumers and also the commercial consumers. So by using automatic power factor correction, the system calibrates the power factor in real-time and according to the condition of the power factor signal of switching is given to the capacitor banks connected[1]
- II. The Power Factor is improved and therefore the value becomes nearer to 0.9 to 0.95 by installing suitably sized power capacitors into the circuit thus line losses are improved if the system is highly improved. Precautions should

be taken for overcorrection otherwise the voltage and current increases due to which the power system or machine will not remain stable and the life of the capacitor bank decreases[2-5]  
 The automatic power factor correction by using capacitive load banks is very efficient as it decreases the cost by reducing the power drawn from the supply. As it operates automatically, no manpower is required and this Automated Power factor Correction by using capacitive load banks is often used for the industries purpose within the future. Further the project can be intensified by using thyristor control switches in place of relay control so that contact pitting is avoided which is often resulted in the switching of capacitors due to the flow of high in the rush curve.[6-7]

**III.METHODOLOGY**



**Fig2:** Automatic power factor controller by the microcontroller

**FUNCTIONING OF BLOCK DIAGRAM**

Automatic Power Factor Correction (APFC) Panel Power Factor Improving:

1. Please check if the required kVAr of capacitors are installed.
2. Check the type of capacitor installed is suitable for application or the capacitors are de-rated.
3. Check if the capacitors are permanent 'ON'. The Capacitor is not switched off
4. when the load is not working, under such conditions the average power factor is found to be lower side.
5. Check whether all the capacitors are operated in APFC depending upon the load operation.
6. Check whether the APFC installed in the installation is working or not. Check the CT connection is taken from the main incomer side of the transformer, after the fix compensation of transformer.
7. Check if the load demand in the system is increased.
8. Check if power transformer compensation is provided.

Thumb Rule if HP is known

- The compensation for motor should be calculated taking the details from the rating plate of motor Or the capacitor should be rated for 1/3 of HP Kvar Required For Transformer Compensation: Transformer Required Kva
- $\leq 315 \text{ kVA T.C} = 5\% \text{ of KVA}$
- $315\text{kVA To } 1000 \text{ kVA} = 6\% \text{ of KVA}$
- $\geq 1000 \text{ kVA} = 8\% \text{ of KVA}$

Where to connect capacitor:

- Fix compensation should be provided to take care of the power transformer. Power and distribution transformers, which work on the principle of electromagnetic induction, consume reactive power for their own needs even when its secondary is not connected to any load. The power factor will be very low in such a situation. To improve the power factor it is required to connect a fixed capacitor or capacitor bank at the LT side of the Transformer. For approximate kVAr of capacitors required
- If the installation is having various small loads with a mixture of large loads then the APFC should be recommended. Note that APFC should have a minimum step rating of 10% as a smaller step.
- If loads are small then the capacitor should be connected parallel to load. The connection should be such that whenever the loads are switched on the capacitor also switches on along with the load.





- Note that the APFC panel can maintain the power factor on the L.T side of the transformer and it is necessary to provide fixed compensation for the Power transformer.
- In case there is no transformer in the installation, then the C.T for sensing power factor should be provided at the incoming of the main switch of the plan

#### IV. EXPERIMENTAL RESULTS

Table1 provides the data recorded from the smart home system.

The load used in APFC for the smart home system:

- 1) Fluorescent Light (FL)
- 2) Ceiling Fans in the house (fan)
- 3) Refrigerator
- 4) Water Pump motor
- 5) Television (TV)

The experimental results of APFC on equipment

Appliances	P (W)	S (VA)	V (V)	I (A)	PF	Q(VAR)	C <sub>μ</sub> F	State
3 FL +2fan	368.7	431	227	1.9	0.86	224	No	Before correction
	352.8	364.3	225	1.6	0.97	90.8	10	After correction
6FL +1fan+water pump	696.8	813.7	217	3.7	0.86	418	No	Before correction
	687	688.8	215	3.2	0.99	38	25	After correction
5 FL+ 2refregrator +2fan	832.5	1108.6	218	5.1	0.75	742	NO	Before correction
	837.5	860.2	218	3.9	0.97	204	35	After correction
12 FL+6fan+ 3refregrator+ TV	1664.9	2055.6	218	9.4	0.81	1196	NO	Before correction
	1652	1755.7	218	8	0.94	623	35	After correction
10 FL+7fan+ 3refregrator+ 2TV	2401.2	2703.1	216	12.5	0.89	1242	NO	Before correction
	2414.9	2527.3	218	11.6	0.96	716	35	After correction

As shown in Table I, we note that the value of the power factor before the addition of the capacitance was low, i.e. less than 0.9, while at the addition of the capacitance we note that the power factor value is close to 1

(This table is taken from Automated Power Factor Correction for Smart Home Article in Iraqi Journal for Electrical And Electronic Engineering · December 2018 )

#### V. CONCLUSION

It can be concluded that power factor correction techniques can be applied to the industries, power systems, and also households to make them stable and due to that the system becomes stable and the efficiency of the system, as well as the apparatus, increases. The use of a microcontroller reduces the costs. Due to the use of microcontroller multiple parameters can be controlled and the use of extra hard wares such as timer, RAM,ROM, and input-output ports reduces



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