



APFC BASED PENALTY REDUCTION FOR INDUSTRIAL POWER CONSUMPTION

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Abstract: For the economic development of country power is required. At a very high rate power consumption is increasing day by day. We are wasting a part of the electrical energy everyday due to the lagging power factor in the inductive loads. Due to these the power factor goes below the standard limit. If power factor goes below standard limit then electrical company charges the penalty on industry. For improving power factor we are using automatic power factor correction using capacitor bank. APFC device reads power factor by using line voltage and line current. Now a days, embedded system is very important technology and by using embedded technology most of product are developed with microcontroller.

Index Terms - Reactive Power, Apparent Power, Capacitor Bank, Automatic power factor correction.

I. INTRODUCTION

Now a days, the industrialization is increasing day by day. In the industry, the lots of machine that is motors are continuously in working phase so that it generates the inductive load. Because of the inductive reactive power, reduction in the power factor of the system get occurs. The electricity board having the standard limit related to the value of power factor. so if the value of power factor get powered than the rated value, then the electrical board charges the penalty to the consumers. Due to the inductive loads the power factor of the system get low so that the efficiency of the system get decreased. To overcomes these problems the architectures are introduced in the system to minimization the losses which are programmable device. When we think about programmable devices then the pictorial representation of technologies are comes into forefront. The most popular technology against the reduction of penalty is microcontroller based embedded technology.

For improving efficient transmission of active power the automatic power factor correction device is very important device. The automatic power factor correction device is used in the improvement of power factor also it helps to maintain the good efficient transmission of active power. The APFC device collects the value of power factor from line voltage and line current.

1. Power Factor Theory:

There are three types of power in the system.

- a) Active Power: The power which is useful for the load or dissipated in the network is called the true power or useful power. The active power is measured in watts it is symbolically represented by capital letter P. the resistance (R) is dissipative element of circuit which is a function of active power.

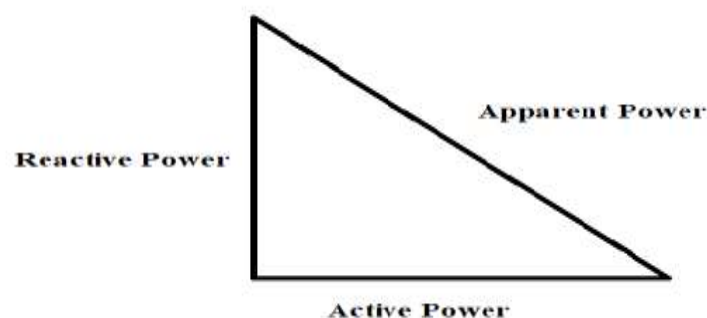


Fig. 1.1 Power Triangle

- b) **Reactive Power:** The inductor and capacitors are the reactive loads, they dissipate zero power or negligible power but they drop voltage and draw current which results in dissipation of power called it as reactive power. The reactive power is measured in volt-amps-reactive (VAR) and symbolically it is represented by Q. Reactive power is a function of reactance (X) of circuit.
- c) **Apparent Power:** By combining the active power and reactive power results in apparent power. Apparent power is the product of current and voltage which is in the form of without reference to the phase angle. The apparent power is measured in the volt Amps (VA) and it is symbolically represented by S. The total impedance (Z) of the circuit is function by apparent power.
- d) **Power Factor:** Power factor is the ratio of active power (KW) to the apparent power (KVA) which is consumed by an total electrical installation or ac electrical equipment.

$$\text{Power Factor (PF)} = \text{Active Power} / \text{Apparent Power}$$

How efficiently electrical power is converted into useful work output i.e. measured by power factor. In general the value of ideal power factor is one or unity. If the power factor becomes less than unity then it is clear that extra power is required to achieve the actual task at hand. The poor factors results in the significant phase difference between voltage and current at the terminal of load; also the poor power factor is due to the inductive load which can be improved by the addition of power factor correction. The poor power factor is due to the higher harmonics content or distorted current waveform. The relation between current and voltage is the power factor. The power factor is mathematically represented as $\cos\theta$ where θ represent the phase difference between current and voltage. The ac power system or circuit contain the capacitive load (like power supplies) or inductive load (like motors) or resistive load (like heaters). According to the load, the current phasor can be in phase with voltage, leading to the voltage or lagging to the voltage. The current is in phase with voltage for pure resistive load. So that the phase difference is $\theta = 0$ so that the power factor is given $\cos\theta = 1$. In this way the power factor purely resistive load is unity. The current lags the voltage in case of purely inductive circuit or network. So that the phase difference between voltage and current $\theta = 90$. Therefore the power factor is lagging. In case of capacitive circuit, the power factor is leading because the current leads the voltage so that phase difference between voltage and current in $\theta = 90$.

- e) **Causes of Low Power Factor:** The inductive loads results in the low power factors. The inductive load produces the magnetic fluxes or magnetic field. For that inductive load require the current for desired work. Therefore it increases the reactive as well as apparent power which results in decreasing the power factor or efficiency of the system. Therefore the definition of power is the ratio of KW to KVA. It is observe that power factor becomes low when the value of KW becomes smaller in relation to KVA. An inductive load includes high intensity discharge lighting likes transformers, induction generators and induction motors. The system is distributed due to the inductive load. When these increases that results in large angle between KVA and KW. Power factor decreases due to large angle depending up on manufacture of inductive equipment, the efficiency is dependent on the size, design and age.
- f) **Power Factor Correction:** capacitive power factor correction is applied to circuit which involving induction motors as means of reducing the inductive component of the current and reducing in the supply losses. An induction motor draws current from the supply by adding resistive and inductive component. Due to the leakage reactance the current is depending on the total current drawn by the motor and magnetizing current is independent of the load on the motor. The magnetizing current will be varied between 20% and 60% of the rated full load current of the motor. The magnetizing is very important if the motor is going to operate and also they are produce flux in the iron. The leakage reactance and magnetizing current also known as the passenger component of current that will not affect that the power drawn by motor.

Disadvantages of Low Power Factor:

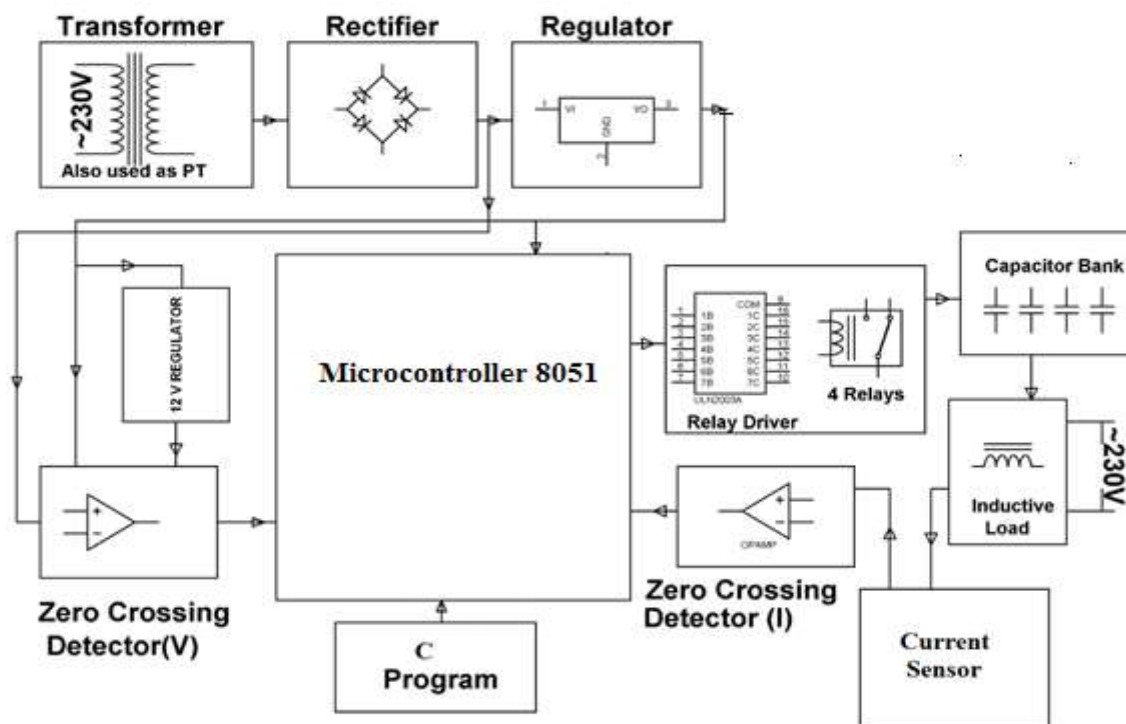
- a) Large line losses.
- b) Large KVA rating and size of electrical equipment.
- c) Poor voltage regulation and large voltage drop.
- d) Low efficiency.
- e) Greater conductor size and cost.
- f) Penalty from electrical power supply.

II. PRINCIPLE

Automatic power factor correction device is build up microcontroller IC. The voltage and current sample is changed into square wave using zero cross detector. The voltage and current sample signal are provided to the microcontroller at INT 0 and INT 1 and the difference between the starting of waveform indicate the phase angle difference.

By using internal timer the difference is measured with high accuracy. The time value is measured also power factor is calculated. The capacitor banks are switched s per the evaluation in steps.

III. METHODOLOGY



1.2: Block Diagram of APFC System

- i. **Power Supply:** We are using step down transformer in power supply. Input supply 230 volt ac is given to primary of transformer without changing its frequency. The transformer transforms the power from one circuit to another. It is electromechanical static device. The flux induced in primary due to the magnetic effect of the coil is change to secondary coil.
- ii. **Rectifier:** rectifier main function is to convert the ac voltage to the dc output. In most of the rectifier circuits the diode is a primary component hence it conduct in one direction. It contain both ac and dc components. This property of diode transfer the sinusoidal voltage with zero average value into waveforms. The rectifier is a full wave bridge rectifier.
- iii. **Voltage Regulator:** It is main function is to convert the variable output dc voltage into the constant dc voltage which is used for the supply to the microcontroller and zero crossing detector.
- iv. **Zero Crossing detectors:** The zero crossing detector circuit is an essential application of the op- amp comparator circuit. It is required to detect sine wave zero crossing from positive half cycle to negative half cycle. It also known as sine to square wave convector. The reference voltage with which the input voltage is to be balanced must be made zero. The input sine wave is considered as an V_{in} . To calculate the difference between two waves we need to detect zero crossing of two waves. Zero crossing detector generates output state change whenever the input crosses the reference input. In which the reference input attached to ground. It is shown in fig. when the input signal passes through zero to positive direction the output is driven into $-V_{sat}$. Similarly, when input signal passes through zero to negative direction the output switches to $+V_{sat}$.
- v. **Microcontroller:** The main function of microcontroller is that execute programs for controlling other devices or machines. It is integrated circuit chip i.e. IC. It is micro in size i.e. small as an integrated circuit chip. They are used to control of other device and machine therefore is known as microcontroller. It includes RAM, ROM and I/O parts. In APFC panel 8051 microcontroller is used. In the line it receive the load current and gives the signal to the relay driver and also connect the capacitor as per the requirement.
- vi. **Relay:** They are electrically operated switch several relays used an electromagnet to operate a switching mechanism mechanically but other operating principles are also used. It is necessary to control a circuit by low power signal the relay is used. Or where many circuits must be controlled by one signal. Current flowing through the coil of the relay produced a magnetic field which attract a level and changes the switch contacts. The relays have two switch position therefore the coil current can be ON or OFF and most have double throw switch.

- vii. Relay Driver: Relay driver is attached with the microcontroller output. It is used to operate the multiple relays as per the compensation required.
- viii. Liquid Crystal Display: LCD means Liquid crystal display. It is flat panel display or other electronic visual display that produce the light modulating properties of liquid crystals. LCD is used to displayed the present power factor. 16*2 LCD is attached with 8051 microcontroller. It is easily available in 16 pin package with back light, contrast adjustment function and each dot matrix has 5*8 dot resolution.
- ix. Capacitor Bank: capacitor involved compensation of power factor through relay. It is a group of many capacitors of the same rating that are connected in series or parallel with each other to store electrical energy. It is used to stored electrical energy. The mainly used for ac power supply error correction is in industrial environment which include large number of transformer and electric motors. Hence using an inductive load they are capable to phase shifts and power factor lags in positive power supply which can obtained result in loss of efficiency of system if left in corrected. A capacitor bank in the system by incorporating, the power lag can be corrected at the lowest cost for the company when compared to making available changes to the company power grid or system that is supplying the equipment.

IV. REQUIREMENTS

1) Hardware Requirements:

Microcontroller 8051
IC LM339
LCD
Relays
Relays Driver IC
Switches
Resistors
Capacitors
Transformers

2) Software Requirements:

i. Embedded C- language:

Embedded C is a combination of language extension for the C programming language by the C standard committee to address commonality issues that lives between extension for difference embedded system. C language in order to supportive features like as arithmetic, multiple distinct memory bunks and basic input output operation. By using embedded C languages programming of 8051 is done and then changing to hex code to be dump into microcontroller IC.

ii. Compiler:

Compiler are problem used to change high level languages into object code. Desktop compiler generates an output object code for underlying microprocessor, but not for other microprocessor. The program compose in one of the HLL such C will compile the code to run on system for a particular processor such 8051. The compiler obtain its name from the way it works, looking at the entire piece of source code and gathered and rearranged the instruction. See there is a small difference between compiler and an interpreter. Interpreter just explain whole program at a time while compiler examine and distinguish each line of source code in succession without looking at the entire program. The advantages of interpreter is that they can distinguish a program immediately secondly program obtained by compilers run much faster than the same program distinguish by an interpreter. Before an executable program compiler required some time. Now as compiler changes source code into object code which is uncommon for each type of computer, various compilers are available for the same languages.

V. EXPECTED RESULTS:

- 1) It is beneficial for improved power factor.
- 2) Improved utilization of electrical machines.
- 3) Improved utilization of electrical lines.
- 4) Decreasing in losses
- 5) Reduce monthly energy cost.
- 6) Adequate electrical system.
- 7) Supply system of efficiency is increases.

VI. CONCLUSION:

The conclusion is that in this paper minimizing penalty in industrial power consumption by engaging APFC unit by using AVR and APFC unit. This method usually used in industries also house hold to make them stable and efficiency of the system increases.

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