Power Factor Correction for Industrial Loads

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***Abstract*:- Most loads in the industrial environment have a low power factor and are inductive. Because of the low power factor (LPF), the current rises, resulting in additional active power loss. This research intends to create a microcontroller-based system that automatically corrects the power factor by lowering perceived power using a capacitor bank. Furthermore, the system uses a 16x2 LCD display to monitor the power factor of industrial loads. When the inductive load increases, the microcontroller calculates the PWM signal given to it and turns on the capacitors accordingly. The basic goal of the power factor correction is to guarantee that the power system maintains its power factor near to unity. A capacitor bank adjusts its value in the system, if the power factor is low.**

Keywords: APFC unit, Passive Power Factor, Active Power Factor, Capacitor Banks, Synchronous motor at no load, Arduino Microcontroller.

I.INTRODUCTION:

Without manual capacitive bank loading, this project delivers continuous power factor correction. On the LCD display, this project also shows the load's power, voltage, and current ratings. The power factor, V, I, and P are all measured with a digital energy metre[1].

This digital energy meter communicates with an Arduino microcontroller using serial (MODBUS) communication. Without needing to directly detect inductor current, an APFC controller enables power factor correction and peak current limiting for any switch-mode power converter topology [2].

The penalty on Reactive Power in consumer power bill is aimed squarely at businesses who do not demonstrate a strong commitment to energy efficiency. This price is itemized on your electricity statement. Capacitors used in Power Factor Correction is a widely established way of supplying reactive power to electrical load and limiting waste of energy, enhancing the effectiveness of a plant, and lowering the electricity cost, can greatly reduce reactive power charges. It is not always required to achieve a unity power factor. Increasing the power factor to larger than 0.95 can be a cost-effective approach [3 & 4].
This project employs a 5V, 750mA regulated power source. The voltage regulator is a 7805 three terminal voltage regulator. The ac output of the secondary of a 230/12V step down transformer is rectified using a bridge type full wave rectifier.

II.POWER FACTOR

The power factor is a measure of how efficiently power is used. PF is a dimensionless quantity in an AC electrical power system and is defined as the ratio of real power flowing to the load to perceived power in the circuit. We aim to be as close to 1 as feasible in order to have an "efficient system" .The fig 1 shows the power triangle, from which power factor can be obtained.

$$\text{Power factor} = \frac{Real\ power(KW)}{Total\ power(KVA)} \times 100$$

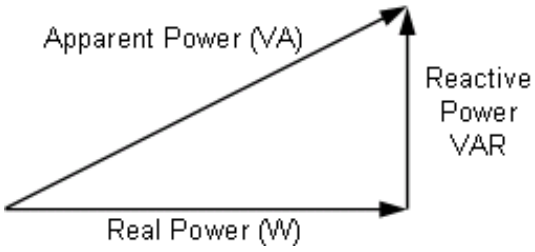

Fig 1: Power Triangle

III.POWER FACTOR SURGE

The power factor is a metric that measures how efficiently electricity is used. On a scale of 0 to 1, this index is calculated.

The power factor must be maintained at 0.85 for consumers receiving power at 33 kV or lower. A power factor surcharge will be applied if the power factor is less than 0.85.

The power factor must be kept above 0.90 for consumers receiving power at 132 kV or above. There will be a power factor surge, if the power factor is less than 0.90.

A better Power Factor value (more than 0.85) suggests that electricity is being used efficiently and low Power Factor (less than 0.85) indicates inefficient electricity use, representing waste of energy.

IV.POWER FACTOR CORRECTION

The electrical utility can use power factor correction to improve the transmission network's stability and efficiency, or the electrical consumer can use it to minimize the costs paid by the electrical provider.

According to T. Wildi (2006), power factor correction (or enhancement) is cost-effective, when the annual cost of electricity decreases more than the cost of placing requisite capacitors. In few circumstances, the client has to follow the utility company's lowest power factor requirements. Use of capacitors at the commercial organization or the factory's can improve the power factor [5]. If the power factor is extremely low, the device or machine's power factor may need to be rectifying individually [6].

Power factor correction is the technique of reducing the phase angle between voltage and current by correcting the lagging current with leading current. The power loss will be zero, if both current and voltage are in phase, the power factor can be improved to almost or even unity. The operation is carried out by placing capacitors in the system, with a sufficient capacitance value in order to adjust the power factor [7 & 8].

The loads which operate on AC require apparent power and is calculated as sum of actual and reactive power. The existence of reactive power results in more apparent power than real power, which results in lower power factor of the load. As a result, power providers suffer financial losses, forcing them to ask its consumers, particularly those who use heavy loads, to maintain high power factor [9].

V.MOTIVATION FOR THE PRESENT PROJECT

Electricity is essential in practically in every industry, especially in mining engineering. It would be difficult in mining to complete their work without it. Mine sites, however, are particularly vulnerable to power outages since they are frequently located at far away from grid and operate with heavy machinery. Mining sites are trying to be competent in market and maintain their operations running as smoothly as possible while the cost of energy continues to rise. Mines are generally targeted by electrical companies and allied institutions because they are also regarded very major power users. In order to increase production and minimize technical problems while minimizing energy costs, enterprises must maintain power quality. When the power factor reaches 1, it means that the energy wastage is less in the system. However, because mining sites frequently employ complicated machinery, power factor 1 is rarely achieved. Any power factor greater than.95 is considered an efficient use of energy in the mining industry. An industries usual uncorrected power factor is between 0.65 and 0.8. Reduced utility expenditures, technical issue evacuation, reduced carbon footprints, meeting legal commitments, and so on are all advantages of bringing the power factor closer to unity. In the future, appropriate corrective equipment must be developed to monitor the system power factor and make necessary modifications when it goes below the specified level [10 & 11].

VI. OBJECTIVES

The project's main goal is to develop corrective tools that could supervise the power factor of electrical equipment in the industry and boost it to a specified value.

The research was carried out with a set of goals. They are as follows:

- Conduct an electrical survey of the industry's current system.
- Examine the system configuration and load patterns, as well as the fluctuation in power factor throughout operating hours and power factor improvement capability.
- Develop a system to increase the system's power factor to the desired value [12].

VII. CAPACITOR BANKS / CAPACITIVE COMPENSATORS:

In industrial distribution networks, shunt capacitors are widely employed. They provide reactive power to compensate for an inductive load's out-of-phase current requirement. The use of shunt capacitor banks reduces the size of the source current and improves the power factor. Fixed, switched, or a mixture of fixed and switched capacitor banks are available. Manual or automatic switching is possible. Capacitor banks are durable and easy to set up and use [13 & 14].

VIII. SYNCHRONOUS MOTORS AT NO LOAD

A fixed-rate compensator has long been used with synchronous motors. It is also called as Synchronous Condensers. This gadget has the disadvantage of being electromechanical and requiring some maintenance. Because the degree of compensation is predetermined, as with a fixed capacitor bank, synchronous condensers have less appeal than capacitors. As a result, their use in the industry has been restricted [15].

Any installation should take into account the following factors.

- The equipment to be installed's dependability.
- Approximate life.
- Cost of capital.
- Cost of maintenance.
- Operating costs.
- Space requirements and installation ease.

IX. PROJECT OVERVIEW

An embedded system is a software and hardware combination that performs a specific task. Microprocessors and microcontrollers are two of the most common embedded devices.

Because they merely accept data, process it, and output the results, microprocessors are referred to as general-purpose processors. A microcontroller, on the other hand, not only accepts data as inputs but also manipulates, interacts, regulates, and therefore generates the result. The complete block diagram of the proposed project is shown in fig 2.

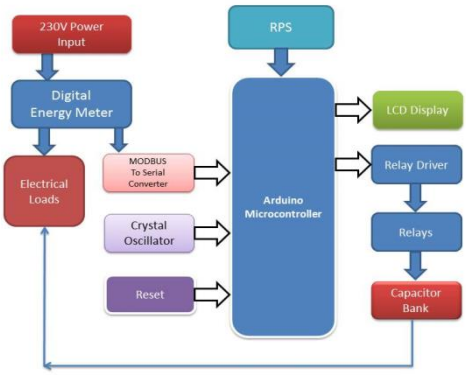

Fig 2: Block Diagram

X. RESULT AND DISCUSSION

The power factor of the load is calculated using the basic equations based on these measured values. Solid state relays are discovered to have the required capacitance based on the values. The voltage and Power Factor system were then displayed on a liquid crystal display. As a safety measure, a relay is connected in series earlier than the bank and the load. The system is turned off, if there is an under/over voltage or a significant current flow. A bypass relay is also added so that the capacitor bank can be unplugged from the mains without interrupting the load, if maintenance is required. Figure 3 depicts the hardware assembly for the proposed project.

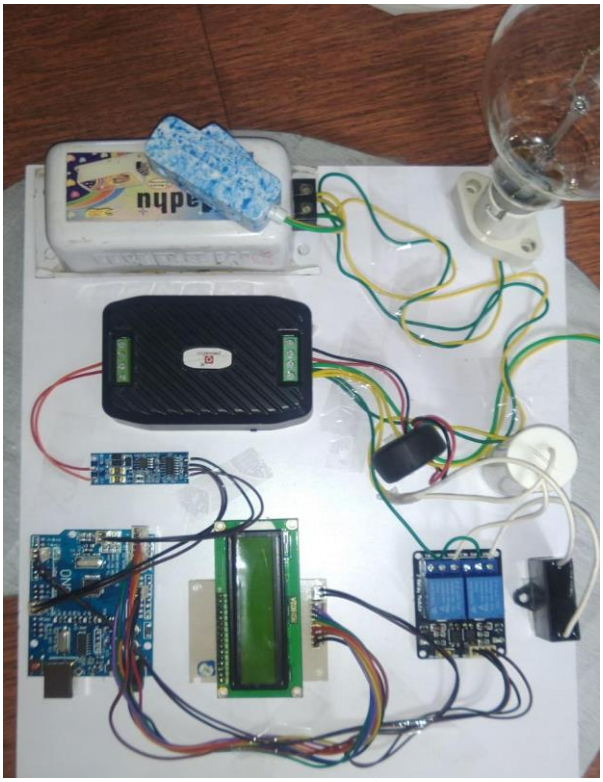

Fig 3.Hardware Assembly of the project

XI. CONCLUSION

This project study describes one of the ways for overcoming various power losses caused by low power factor in many general household and smaller industrial units. The power factor is measured in the system and then capacitors are added as needed. The influence of switching automated power factor panels has been evaluated at quickly fluctuating loads and distributed loads, according to APFC research. When compared to the absence of the capacitor, the intended power factor improved significantly from 0.78 to around 0.95, virtually unity, reducing the effect of high power bills as well as substantial penalties from the electricity board.

XII. FUTURE SCOPE

- The designed equipment was tested in the laboratory and can be applied in industries with suitable protection to verify operation in a real-world setting.
- If the load changes often during automatic PF correction, the multiple capacitor bank switches may generate a harmonic problem.
- To avoid regular capacitor bank switching, a suitable filter and an optimal algorithm can be designed based on the regular load change pattern.
- In the field, a comparison research on the location of corrective equipment might be used to determine the best location in terms of maximum usage and cost savings.

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