Minimizing Penalty in Industrial Power Consumption by Engaging APFC Unit

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Abstract- Electrical energy being the only form of energy which can be easily converted to any other form plays a vital role for the growth of any industry. The Power Factor gives an idea about the efficiency of the system to do useful work out of the supplied electric power. A low value of power factor leads to increase is electric losses and also draws penalty by the utility. Significant savings in utility power costs can be realized by keeping up an average monthly power factor close to unity. To improve the power factor to desired level, reactive power compensators are used in the substations. The most common used device is capacitor bank which are switched on and off manually based on the requirement. If automatic switching can be employed for the correction devices, not only it will improve the response time but also removes any scope for error.

I. INTRODUCTION

The power factor of an electrical system gives the idea about the efficiency of the system to do useful work out of the supplied electric power. A low power factor leads to increase in losses and also draws penalty by the utility. Modern industry using mechanized methods suffers from low power factor due to the use of different electric equipment which requires more reactive power. Significant savings in utility power costs can be realized by keeping up an average monthly power factor close to unity. Utilizing shunt capacitor banks for Power Factor Correction (PFC) is an exceptionally established methodology. The recent trend is to automate the switching procedure of capacitors to get greatest advantage in real time basis. Embedded systems based on microcontrollers can be used to monitor and control the switching of correction devices because of its dependability and execution.

II. OBJECTIVES OF THE PROJECT

The primary objective of the project was to design correction equipment which can monitor the power factor of the electrical framework and enhance the power factor to a desired value. The research investigations were carried out with the following objectives:

- To conduct an electrical survey of the existing system in an opencast mine to study the system configuration and load patterns, variation of power factor during the mine operation hours and analyze power factor correction facility, if any.
- Design a microcontroller-based correction equipment to improve the power factor of the system to desired value of greater than 0.95.
- Implement the system and monitor different electrical load models and diverse load patterns to verify the result.
- To carry out economic analysis for power factor improvement.

III. RELATED WORK

A limited number of studies have been attempted on the effect of poor power factor in mines and the corrective measures to mitigate the problem.

Oommen and Kohler (1988) explored the advantages that can be accomplished by proper implementation of power factor compensation. Different compensators along with the sizing and strategic location was also considered. A brief study on the economic analysis was carried out to show the economic viability of compensation [7].

Jiang et al. (1993) proposed a novel single-phase power factor correction scheme based on parallel power factor correction concept which was described to be more efficient than convention two-cascade stage scheme [14].

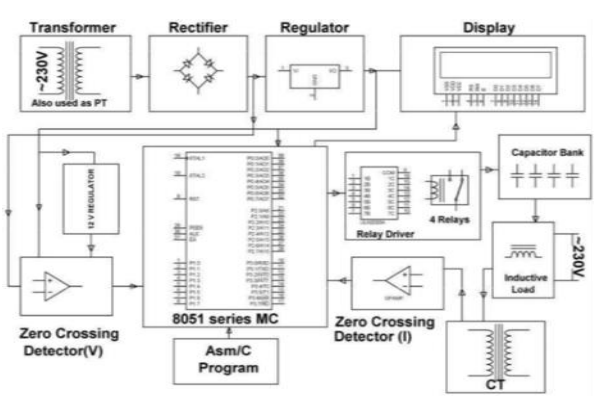
Qureshi and Aslam (1995) outlined the different methods for power factor correction and carried out an experimental case study to explore the areas which will be suitable for compensation. After a practical demonstration to have a significant improvement in power factor was completed, they found that it would release the capacity of distribution transformer and the problem of over voltage under condition of low load was avoided [6].

Novak and Kohler (1998) pointed out the importance of power factor improvement for technological innovation and advancement in deep coal mine power systems. Different protection equipment to check the inherent electrical faults in the mining system were argued. The power factor correction near loads for improved voltage regulation was emphasized within the constraints of high voltage distribution in underground coal mines [8].

IV. METHODOLOGY

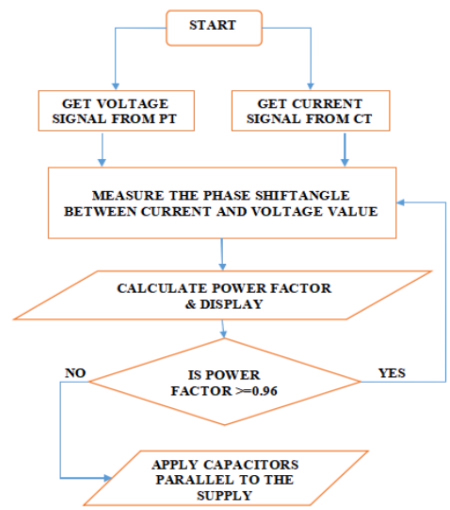
The Automatic Power Factor correction device is developed built on embedded system having 89S52 at its core. The voltage and current signal from the system is sampled and taken as input where the difference between the arrivals of wave forms indicates the phase angle difference. The difference is measured by the internal timer and calibrated as phase angle to calculate the corresponding power factor. The system power factor is compared with the desired level and the difference is measured for switching of required number of capacitors from the bank. The values of power factor shown on a display for convenience.

V. BLOCK DIAGRAM



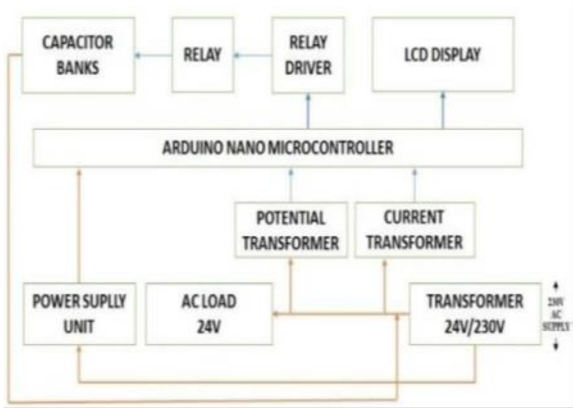
VI. ALGORITHM

The below drawn flow chart 4.1 is the step-by-step procedure for the program and function of the microcontroller.



VII. PROPOSED SYSTEM

The microcontroller is the heart of the automatic power factor correction unit. It processes the algorithm which are specified by the user to ensure the variation in the power factor in specifying limit and maintain power quality. The current transformer and voltage transformer are used to get the current and voltage signal which are input to the microcontroller. The automatic power factor correction unit detects the phase lag between the voltage and current waveform by using zero crossing detector to determine the existing power factor as shown in the fig.1.1. To bring it to unity, it is required to connect capacitor bank in parallel with the system. The number of capacitors that is to be



VIII. ADVANTAGES AND DISADVANTAGES

Advantages:

- It improves system and device effectiveness minimises voltage drop
- shrinking a conductor's and cable's size to save money
- It assists in getting rid of the negative effects of low power factor on the electric supply.
- It lowers the cost of the power bill.
- It increases the efficiency of system and devices
- Reduces the voltage drop
- Reduction in size of a conductor and cable which reduces the cost
- It helps in eliminating the penalty of low power factor from the electric supply
- It provides saving in the electric bill.

Disadvantages:

- Power systems becomes unstable
- Resonant frequency is below the line frequency
- Current ant voltage increases

Applications:

- Can be used in industrial application
- Sub stations and appliances control operation for large power generation dams

CONCLUSION

Power factor correction equipment designed based on microcontroller and capacitor banks was used for measurement and monitoring of modeled electrical load and the following deductions were obtained:

The power factor correction device designed was able to improve the power factor from 0.76 to 0.97 under the test load conditions.

The average savings in energy consumption was about 1.7% for the designed load and different load patterns. With the proper amount of reactive power compensation, the system capacity is released as there is a reduction in current drawn.

The economic analysis suggested the payback period to be around 9 months with a significant amount of savings in energy cost.

FUTURE WORK

- The designed equipment was studied in the laboratory scale; it can be implemented in the mine substations with proper protection to verify the operation in a real time environment.
- In case of automatic PF correction, if the load is changing frequently, the numerous switching of capacitor bank may cause harmonic problem. Suitable filter design as well as an optimum algorithm design can be done based on the frequent load change pattern to avoid regular switching of capacitor bank.
- A comparative study on the location of correction equipment may be employed in the field to find out the optimum location referring to maximum utilization and savings.

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