بسم الله الرحمن الرحيم

AUTOMATIC POWER FACTOR CORRECTION USING MICROCONTROLLER

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Dedication

To All of Our Respectful Teachers and Dear Friends,

Thank you for everything.

To Our Families,

Thank you for your continuous encouragement and support.

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In the name of ALLAH, who is the most merciful, the most compassionate; the one and only supreme power, the one whose makes everything possible and the one without whose will the simplest is impossible.

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Abstract

Wasted energy capacity, also known as poor power factor, is often overlooked. It can result in poor reliability, safety problems and higher energy costs. The lower your power factor, the less economically your system operates. The actual amount of power being used, or dissipated, in a circuit is called true power. Reactive loads such as inductors and capacitors make up what is called reactive power. The linear combination of true power and reactive power is called apparent power. Power system loads consist of resistive, inductive, and capacitive loads. Examples of resistive loads are incandescent lighting and electric heaters. Examples of inductive loads are induction motors, transformers, and reactors. Examples of capacitive loads are capacitors, variable or fixed capacitor banks, motor starting capacitors, generators, and synchronous motors.

Power factor correction (PFC) is usually achieved by adding capacitive load to offset the inductive load present in the power system. The power factor of the power system is constantly changing due to variations in the size and number of the motors or inductive loads of any kind being used at one time. This makes it difficult to balance the inductive and capacitive loads continuously. There are many benefits of having power factor correction. As a customer the cost does not get passed on for having a low power factor. As a utility company, equipment has a much longer life span and maintenance costs remain low.

In recent years, the power quality of the AC system has become a great concern due to the rapidly increased number of inductive loads, electronic equipment, power electronics and high voltage power systems. In order to reduce line losses and improve the transmission efficiency, power factor correction research became a hot topic. Many control methods for the Power Factor Correction (PFC) were proposed. This project report describes the design and development of a single-phase (240V, 50Hz) capacitor bank power factor correction device using PIC (Peripheral Interface Controller) micro-controlling chip. Power factor correction using capacitor banks reduces reactive power consumption which will lead in minimization of losses and at the same time increases the electrical system's efficiency. Power saving issues and reactive power management has

brought us to the creation of single phase capacitor banks for domestic applications. The development of this project is to enhance and upgrade the operation of single phase capacitor banks by developing a micro-processor based control system. The control unit will be able to control capacitor bank operating steps based on the varying load current. This project applies the Peripheral Interface Controller (PIC) microcontroller to produce switching commands in order to control the capacitor bank steps. Intelligent control using this micro-processor control unit ensures even utilization of capacitor steps, minimizes number of switching operations and optimizes power factor correction. Transformer-type variable inductive load specially designed to meet the requirements of this project is used as load in this single phase capacitor bank developments. This transformer-type variable inductive load is varied over various ranges and different load values by using variable resistance dimmer to enable capacitor bank model to be controlled systematically. This project involves measuring the power factor value from the load using current transformer, potential transformer, and zero crossing detector, then using proper algorithm of switching on and switching off the capacitors in order to compensate excessive reactive power, thus withdraw PF near to unity (0.9 approximately) as a result acquires higher efficiency and better quality AC output.

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CHAPTER 1

INTRODUCTION

1.1 Literature Review

Fuld et al. developed a combine power factorcontrol with buck and boost technique applied at threephase input supply, which present necessitate vantagesat high AC voltage, desired output voltage, e.g. 400 V,wide input voltage varieties and no extra inrush clipperrequired.

Freitas et al. developed a dynamical studycorrespondence to the effects of AC generators (induction and synchronous machines) and distributionstatic synchronous compensator devices on thedynamic behavior of distribution networks.

Jones and Blackwell developed a technique forsustaining a synchronous motor at unity power factor (orminimum line current) from no-load to full-loadconditions, insuring peak efficiency.

Kim et al. purposed a high-efficient lineconditioner with excellent performance. The line conditionercomprises of a three-leg rectifier-inverter,which functioned as a boost converter and a buckconverter.

Kiprakis and Wallace purposed the entailmentof the enhanced capability of the synchronous

generators at the distant ends of rural distributionnetworks where the line resistances were high and the(cosφ) or the power factor ratios were small. Localvoltage variation was specifically analyzed.

Above described research work and much morehas been presented in the area of power factor

improvement of inductive loads. However we haveproposed a new algorithm for automatic detection andcontrolling of Power Factor for an inductive loadcomprising of both induction motors as well as resistiveload. Proposed algorithm along with developedhardware setup works efficiently. Moreover detection and correction of power factor is very fast.

Microcontroller manipulates the developed algorithm tomeasure the needed reactive power (VAR) that will besupplied through automatic switching of capacitorbanks for the improvement of power factor of the load.

1.2 Background

Electrical energy efficiency is of prime importance to industrial and commercial companies operating in today's competitive markets. Optimum use of plant and equipmentis one of the main concerns that industry tries to balance with energy efficiency, for botheconomical and environmental reasons. Low Power Factor in the power distribution systeminduces the energy crisis in the supply voltage.Most of industrial electric loads have a low powerfactor not transcending (increasing) from 0.8 and thus imparts to thedistribution losses.There are different methods of low power factor correction. One of the ways isto use a fixed capacitor as a source of reactive powerfor compensating local reactive power demand.This approach is more reliable because it implies thecount of lagging current in the power factor with very precise step setting in term of calculating the phaseangle in power factor correction schemes.Power factor correction is an old practice anddifferent researchers are working hard to design anddevelop new system for the power factor correction.

Historically, utilities have implemented power factor correction at their substations by installing banks of capacitors. The substations are where the utilities reduce the voltage (usually greater than 132 or 66k volts) from the transmission wires to lower voltages (33 or 11k volts) for distribution throughout the service area. The voltages are further reduced to the range of 220 to 440 volts at the transformers on the utility poles or in underground vaults located near the customer premises. The problem with implementing power factor correction at the substations is that the reactive power present on the distribution system, not serviced by those capacitors, is inducing thermal losses. Furthermore, the distribution system with its lower voltages and higher currents already accounts for the majority of the losses on the system. In addition, more thermal losses occur on the customer side of electric meter, within the customer premises. On the Transmission and Distribution

System, 27% of the energy lost and almost 75% of the "Accounted For" energy losses occur on the lower voltage Distribution Portion of the system. Those figures do not include losses from reactive load that occur after the customer meters. While the utility does not bill for reactive power in most cases, excess thermal losses after the meter caused by reactive load would be measured in watts and would be billed. The losses, while relatively small for any single location, when aggregated throughout the country, are very significant.

Traditional thinking assumes that the losses only occur in the wires. Calculations have been done on the losses based on the ohms per meter of a length of copper wire. However, in many buildings, especially older buildings, the majority of the losses occur at the junctions. These include screw connections on switches, receptacles, and breaker panels, the metal-metal interface of a switch or of a plug in a receptacle, circuit breakers, and wires in junction boxes connected by wire nuts. As these copper and copper alloy connections age, they oxidize. This oxidation increases resistance and the associated losses.

The result is that any excess current will increase thermal losses within customer premises. As many of the buildings in the country are older and have older electrical services, the connections will have more oxidation and higher resistances (R). That will result in higher I^2R (thermal) losses at those connections. Any system that can reduce currents in the aging wires and connections will result in an energy savings. As higher operating temperatures in system components causes more rapid aging of those parts, reducing currents and the associated heat will also add longevity to the system and devices attached to it. By reducing the currents at the load, the savings mount up from the load all of the way back to the first substation where power factor correction is traditionally employed. In addition, by increasing the power factor on the distribution system, existing capacitance is freed at the substation to be used to further raise the power factor on the transmission system on hot days when there are increased loads. That would yield additional energy savings on the transmission system.

The average efficiency of delivered energy to the customer, after factoring in generating losses and transmission and distribution losses, is approximately 33%. Of every three watts of energy produced at the generating plant, only two watt reaches the customer's meter. More energy is lost through inefficiencies after the meter, within the customer premises. Any system that can reduce load, including load caused by distribution losses, will save approximately three times that amount of energy at the generating plant.It can be seen that losses during the summer months are 2.2 times higher than during the winter months. The higher summertime electric load results in heating of all components of the transmission and distribution system. In addition, there is less convective cooling of components as a result of the higher ambient air temperatures. More direct sunlight and more hours of daylight result in a far greater solar load. When all of these factors are combined, the result is that the entire system operates at an elevated temperature. As the temperature of electrical conductors increases, their resistance increases proportionally.

As society becomes increasingly conscious of itsimpact on the environment, reduced energy consumption becomes more desirable, which,is an achievable goal for everyone. Through the use of measures such as power factorcorrection, electricity consumption is optimized, which ultimately leads to reduced energy losses.Within a cost conscious market, payback considerations are also important. Thisreport identifies the most appropriate application for power factor correction based onenergy consumption, tariff metering and cost payback. Power factorcorrection is an appropriate means which improves the power quality of aninstallation. Its application is dependent though on the size of the installation and the extentthat power factor correction needs to be applied. The opportunity however exists to make asignificant environmental contribution whilst simultaneously providing economic benefit.Currently, the effective use of the capacitor bank as power factor correction device isproduced for its domestic installation. Also known as energy stability, it will correctpower factor base capacitor concept as compensator to reactive current in the single phaseelectric circuits.

The project titled “Automatic Power Factor Correction” is developed to enableoperation of single phase capacitor bank to control and follow load changes. Transformer-type variable inductive load specially designed to meet the requirements of this project is used as load in this single phase capacitor bank power factor development project.

1.3 Problem Statement

This project is developed to improve the weakness of static capacitor bank. Staticcapacitor bank is a traditional method used to improve the power factor by usingcapacitor banks. In the configuration of static capacitor bank, the value of capacitance wasfixed and cannot be controlled. The weaknesses of the static capacitor banks, which are addressed using automatic power factor correction device, are:

i. Capacitive compensation does not change according to increase or reductionin loads.

ii. Could not detect load rating that changes inefficiently.

iii. Operation and power factor correction is not optimized.

1.4Objectives of the Project

Objectives of this project are stated as follows:

i. To automate and regulate power factor of energy systems.
ii. Reduction of energy losses.
iii. To improve voltage regulation and system efficiency.
iv. To extend the life of protection systems.
v. To minimize MDI (Maximum Demand Indicator) readings and low power factor penalties.
vi. To provide an automatically controlled PFC unit that will bring the power factor to as near to unity as practical (typically 0.9) and have sufficientcapacity for future PFC requirements or expansion.

1.5 Scope of the Project

Scope of the project includes following applications:

- Continuous monitoring of power factor of domestic consumers.
- Regulating power factor of single phase power systems automatically.
- By adding CT, PT with this, we can use it in high power applications.
- Reduces man power.
- Marketable device.