



ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 4, April 2018

Power Factor Correction of Single Phase Induction Motor Using PLC

Elizabeth Paul¹, Muhammed Junaid C², Mohammed Bin Rauf³, Thamjiddh Shafi A K⁴.

Assistant Professor, Dept. of EEE, MA College of Engineering College, Kothamangalam, Kerala, India¹

UG Student, Dept. of EEE, MA College of Engineering College, Kothamangalam, Kerala, India²

UG Student, Dept. of EEE, MA College of Engineering College, Kothamangalam, Kerala, India³

UG Student, Dept. of EEE, MA College of Engineering College, Kothamangalam, Kerala, India⁴

ABSTRACT: Capacitor banks are used for improving power factor. However, there is no need for power factor correction at all times since over correction can lead to machine failure. Here we describe the power factor improvement of an induction motor using condenser operated through a Programmable Logic Controller (PLC). By improving the power factor of induction motor, the energy saving measures are automatically achieved. Power factor is the value of a system that reflects how much power is being borrowed from Power Company for the system. If power factor becomes poor than unity, then organization or industry requires more current for supplying same amount of power. As the current increases line losses also increases because of voltage drop, I^2R . Induction motor is widely used in industries due to their features like low cost, reliability, robustness. At no load, induction motor has very low power factor of about 0.33 as the load goes on increasing the power factor also get improved as we go towards full load. Power factor correction serves to correct low power factor by reducing phase difference between voltage and current phasors. It is difficult to control the power factor of continuously varying load. This work is to make the system that will correct the power factor by switching condenser bank through the PLC.

KEYWORDS: Power Factor Correction, Programmable Logic Controller(PLC), Relays, Capacitor Bank.

I.INTRODUCTION

Power factor is the ratio of true power to apparent power. When the voltage and current phasors are identical to each other then only the power factor is unity. The ideal figure for the power factor should be unity. Because it requires a very small amount of current to transmit a given real power. To find the power of single phase circuits the product of volt and ampere must be multiplied by power factor. Ammeter and voltmeter indicate the consumption or effective value of amps and volts wattmeter indicates the true power for eg:- if wattmeter is indicating the 1600w and voltmeter. Ammeter reading shows the 2000 then the power factor is 0.80 or 80 %. AC Induction motor is largely used in industries and other residential purposes. Induction motor consumes large percentage of energy low power factor is not problems with residential consumers it is the problem of concern for industry where more than one induction motors are employed. Power factor correction acts to improve the low power factor by keeping consumers power factor within the limit prescribed by supply company. The general method for power factor correction is use of capacitor this method is used in our project. The capacitors generate or absorbs the reactive power produced by inductive loads but adding of excessive capacitance may lead to go power factor to leading. So we are using the Programmable Logic Controller (PLC) to intelligently identify the power factor and switch the condenser bank accordingly to maintain the unity power factor. The proposed work focuses on the implementation of PLC based power factor controller the proposed control strategy based according to measured value of phase angle between voltage and current, the design aims to correction of phase angle by initializing the continuously changing variable capacitor value via switching process.



International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 4, April 2018

II. LITERATURE REVIEW

Though correction of power factor is very old practice, we have considered the work done in recent years in our Thesis. Many of the authors below have suggested and prescribe many ways of power factor correction but this work concentrates on Barsoum model: We have considered the work done in the previous years, starting from 1988. Sharkawi et. al. proposed a continuing effort to develop an effective, reliable, and inexpensive adaptive power factor controller (APFC). The APFC was able to compensate adaptively the reactive power of rapidly varying loads without adding harmonics or transients to the power system. Based on thousands of hours of field operation, the APFC had substantially modified to improve its reliability and effectiveness.

Ioannides and Papadopoulos et. al. proposed the speed and power factor of an adjustable speed slip power recovery drive were controlled in order to optimize the operation. This was accomplished by means of a variable-voltage-variable-frequencies power converter. The function of the digital controller of the power converter was to provide 11 the online speed and power factor regulation.

Manual et. al. reports a laboratory model of a microcomputer-based power factor controller (PFC) for compensating the reactive power of rapidly varying loads by switching capacitors sized in a binary ratio, with the help of zero voltage static switches. Four types of control strategies were tried, viz., (1) unity step control method, (2) binary search method, (3) successive approximation method, and (4) look-up table method. Features like (a) independent control of current in each phase, (b) reactive current sensing and capacitor switching in one cycle, (c) zero voltage switching of static switches to prevent the occurrence of transients and harmonics, and (d) switch failure detection logic and their display, are all incorporated in the software programming.

Wole, W.H. et. al. investigates the use of variable inductance (the inductance varies with current), which provides adequate harmonic reduction. Three types of inductors are investigated: an inductor with a fixed air-gap operating with a saturated core, a swinging inductor which has a stepped gap and a novel inductor construction with a sloped air-gap (SAG). Results are presented for a 200 W power supply and it is shown that the SAG inductor has the best performance in terms of harmonic response and size.

Kurachi et. al. proposed a detailed analysis of the ripple current of an electrolytic capacitor in a boost-type power factor control circuit. The ripple current was divided into two components, namely the low-frequency and the high-frequency components. The root-mean-square value of the capacitor current was derived for both components. Barsoum et. al. proposed the programming of PIC micro-controller for power factor correction that described the design and development of a three-phase power factor corrector using PIC (Programmable Interface Microcontroller) chip. This involved sensing and measuring the power factor value from the load using PIC and sensors, then using proper algorithm to determine and trigger sufficient switching capacitors in order to compensate excessive reactive components, thus withdraw PF near to unity.

Tinggren et. al. proposed a new integrated power quality device-power factor controller (PFC) for power distribution system and industrial power circuit applications. A PFC integrated breaker-switched capacitor banks into a compact design with low cost sensing elements and an intelligent control unit. The device provided more accurate voltage control and power factor correction than traditional shunt capacitor bank installations. Ali et. al. proposed a power factor controller (PFC) for a three-phase induction motor (IM) utilized the programmable logic controller (PLC). It focused on the implementation of a laboratory model for a PLC based PFC to improve the power factor of a three-phase induction motor. During the online process a set of capacitors 13 sized in a binary ratio would be switched on or off with the help of zero voltage static switches according to a control strategy to obtain a pre-specified power factor. This control strategy relied on a look-up table and an expert system.

Consoli et. al. proposed an innovative converter topology that improved the performance of a switched reluctance motor drive, aimed to equip home appliances. It was based on a modified C-dump converter configuration, where the energy recovery stage acted as an active power factor controller for off line operation.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 4, April 2018

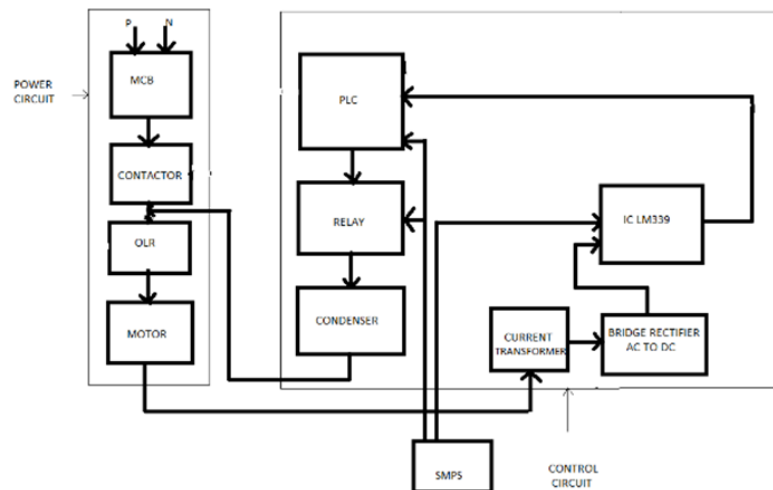
Borlotti et. al. proposed a general description of new functions integrated in the medium voltage switchboard to meet the power quality challenge. They described circuit breakers with magnetic actuators that were easy to justify economically and gave low cost power quality solutions. Mather, B.A. et. al. introduced a single-phase digital power-factor correction (PFC) control approach that requires no input voltage sensing or explicit current-loop compensation, yet results in low-harmonic operation over a universal input voltage range and loads ranging from high-power operation in continuous conduction mode down to the near zero load. The controller is based on low-resolution A/D converters and digital pulse width modulator, requires no microcontroller or DSP programming, and is well suited for a simple, low-cost integrated-circuit realization, or as a hardware description 14 language core suitable for integration with other power control and power management functions.

Venkateswarlu, N et. al. proposed a novel compensator, where in-phase and quadrature components of the supply current are vector-controlled. Implementation of this compensator in a power electronic system operating with a very poor power factor (and hence high THD) shows that the system then draws a leading current. A conventional power electronic system with one of the traditional static VAR compensators and the conventional power electronic system incorporated with the proposed compensator are simulated and the simulation results are obtained. It is shown that the proposed method offers only 0.7% THD, which also implies that the power factor is improved. Shuffling et. al. presents an intelligent power factor compensation controller that can perform power factor correction without exciting harmonic resonance under varying demand conditions. Practical and robust control algorithms are proposed for the purpose of easy implementation in a micro-controller. In addition, the controller relies on common low cost sensing devices and does not require additional measurements. As a result, the proposed controller can be constructed as a retrofitting device to replace existing power factor correction controllers with little effort.

III. POWER FACTOR CORRECTION OF SINGLE PHASE INDUCTION MOTOR USING PLC

Power factor correction acts to improve the low power factor by keeping consumers power factor within the limit prescribed by supply company. The general method for power factor correction is use of capacitor this method is used in our project. The capacitors generate or absorbs the reactive power produced by inductive loads but adding of excessive capacitance may lead to go power factor to leading. So we are using the PLC to intelligently identify the power factor and switch the condenser bank accordingly to maintain the unity power factor. . We focus on the implementation of PLC based power factor controller. The control strategy is based according to measured value of phase angle between voltage and current. The design aims to correct of phase angle by initializing the continuously changing variable capacitor value via switching process.

Figure 1: Block diagram of power factor correction using PLC



The figure shows the basic block diagram PF correction using plc. It consists of a contractor, motor load, relay, capacitors, current transformer, PLC. Contactor together with motor load forms a power circuit. Whereas PLC, relay,



ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 4, April 2018

capacitor, C.T forms a control circuit. When motor starts through the 1 phase 230V 50HZ power supply. The current transformer is connected across the one phase to sense the current drawn by motor. Current transformer used in this circuit is 1A/1mA the output of current transformer is given to bridge rectifier which converts the AC value of voltage into DC. DC values are given to IC LM339 which is nothing but the comparator. IC LM339 consists of four outputs and four input pairs. One of this input pair provided with 24V which is reduced to some values other input is given through the output of bridge rectifier i.e. the current value measured by the current transformer which is later converted to DC value. When the two values are identical it turns on the respective output. PLC output is given to Relays which in turn switch the capacitor bank. Input to the PLC is given through current transformer which senses the current of the load another input to PLC is manual switching push buttons so there are total 8 inputs including 4 for manual operation and 4 of C.T. Then according to programming in PLC, it gives the output to relays and relays in turn switch the capacitors. The SMPS is used to provide supply to PLC & relays. The condenser banks used are of rating 2.5 μ F,4 μ F,8 μ F,10 μ F. PLC switches the relays which adds the condenser if power factor falls below predetermined value. Capacitors are added according to the value of ϕ

IV. SIMULATION

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Typical uses include:

- _ Math and computation
- _ Algorithm development
- _ Modeling, simulation, and prototyping
- _ Data analysis, exploration, and visualization
- _ Scientific and engineering graphics
- _ Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN. The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB uses software developed by the LAPACK and ARPACK projects, which together represent the state-of-the-art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis.

MATLAB features a family of application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others. The MATLAB system consists of five main parts: Development Environment. This is the set of tools and facilities that help you use MATLAB functions and files. Many of these tools are graphical user interfaces. It includes the MATLAB desktop and Command Window, a command history, and browsers for viewing help, the workspace, files, and the search path.

The MATLAB Mathematical Function Library. This is a vast collection of computational algorithms ranging from elementary functions like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigen-values, Bessel functions, and fast Fourier transforms. The MATLAB Language. This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create complete large and complex application programs. Handle

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 4, April 2018

Graphics. This is the MATLAB graphics system. It includes high-level commands for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level commands that allow you to fully customize the appearance of graphics as well as to build complete graphical user interfaces on your MATLAB applications.

The MATLAB Application Program Interface (API). This is a library that allows you to write C and FORTRAN programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files. Simulation of Inductive Load

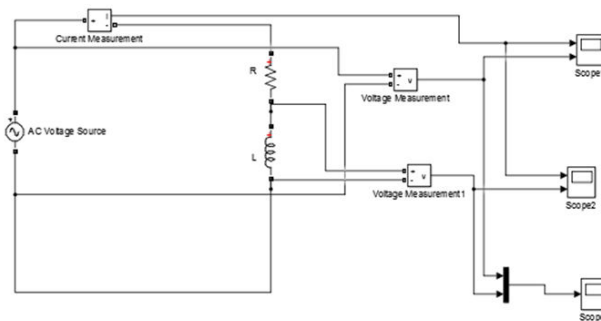


Figure2: Simulation of an R-L Load

For simulation, first represent an inductive load by a resistance in series with an inductor. This serves as a stand in for the motor which is used. Typically almost all motors are inductive in nature. Using the MATLAB library functions select the required blocks such as the inductor, resistor, voltage and current measurement block. The scope is used for the user to get the results. After placing and connecting every component in order, compile and run the simulation after adding values to the inductor, capacitor etc. The simulation result is as follows;

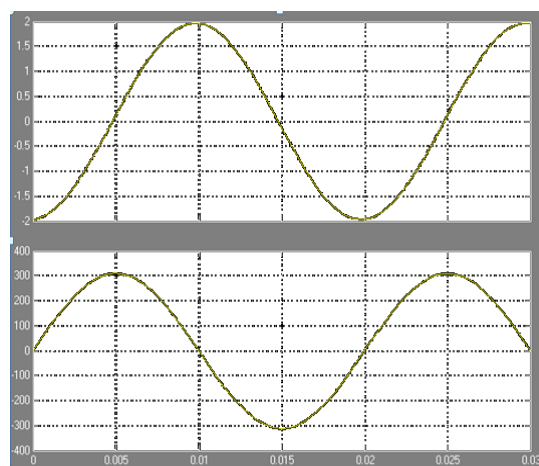


Figure 3: Simulation result of an R-L load

The simulation results of voltage and current are given above. Here see the voltage and current are out of phase. As in the case of all motors, in inductive loads the current lags behind the voltage resulting in them being out of phase. In order to solve the phase difference introduce capacitors in the circuit.

Simulation of Inductive Load After Correction

To rectify the phase difference seen in inductive loads include a capacitor in series with the RL load. This results in leading currents to be produced. This adds up with the lagging current from before and the net current becomes in phase with the voltage. The simulation is given below.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 4, April 2018

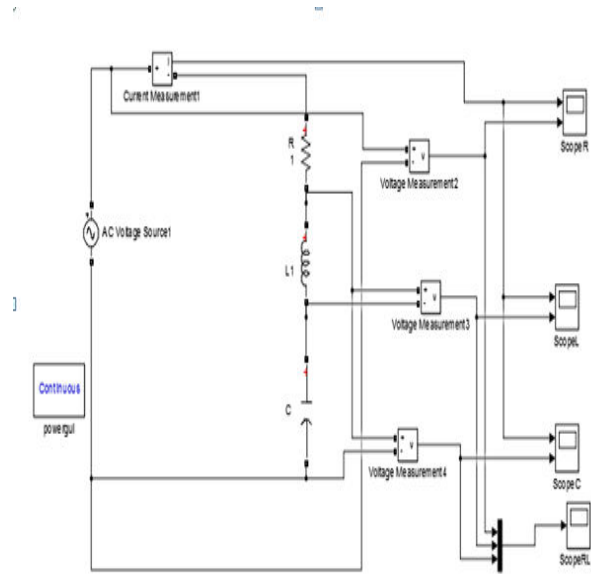


Figure 4: Simulation of an RLC Load

The new result is as shown

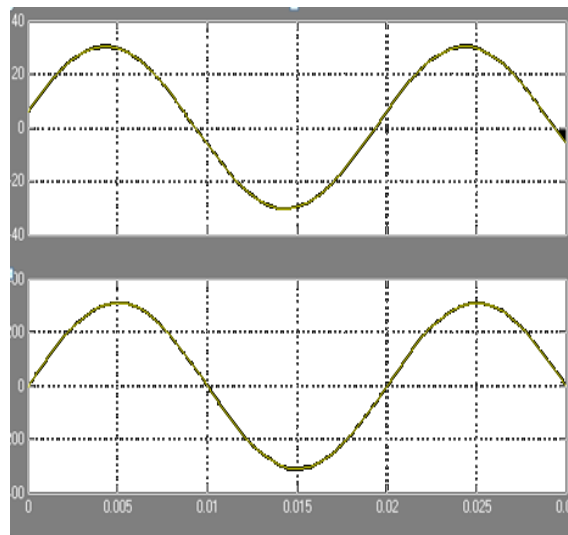


Figure 5: Simulation result of an RLC load

The voltage and current graphs are obtained as shown. Here it is found that the voltage and current are in phase. This is due to the addition of leading component of current to the lagging component. This leads to the net current being in phase with the voltage. Hence power factor is improved.

V. HARDWARE

The circuit consist of PIC based PLC, Current Transformer, Potential Transformer,

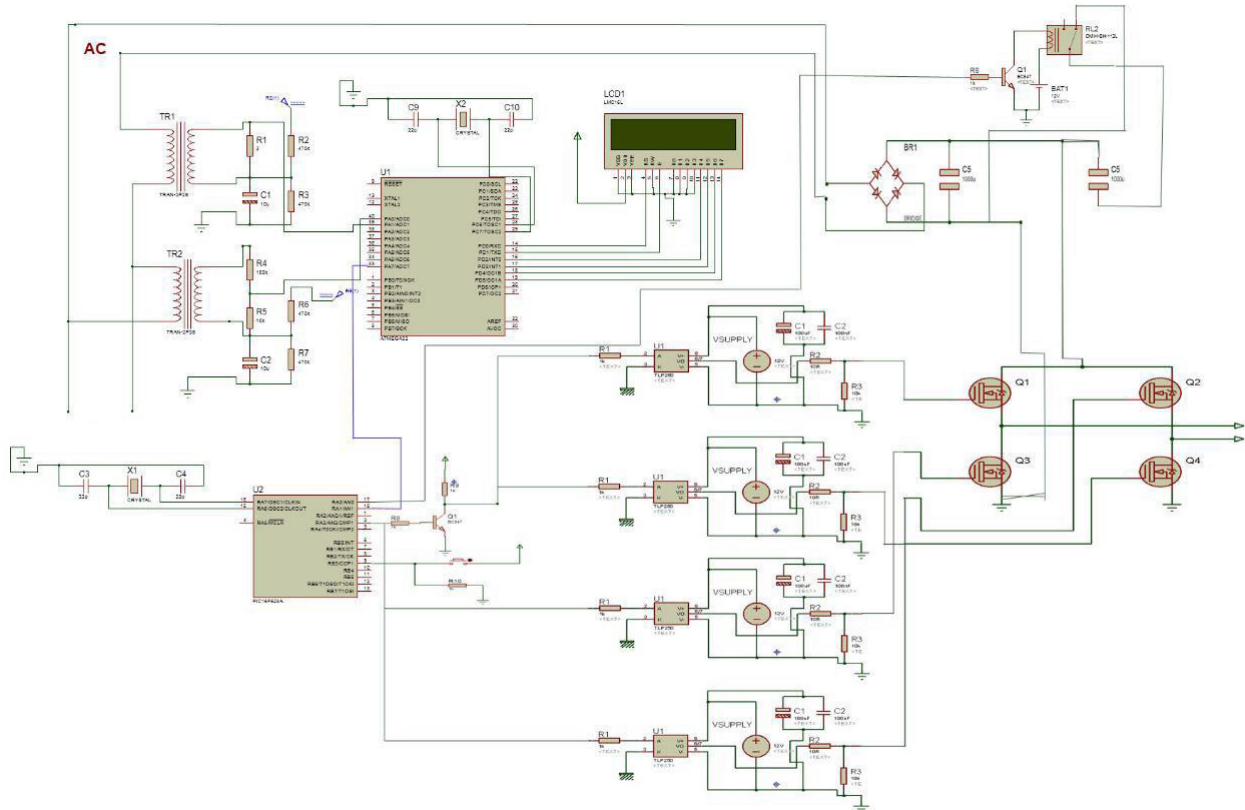


Figure 6: Circuit Diagram for single phase induction motor p.f correction using PLC

VI.CONCLUSION

Low power factor is not that much of problem in residential homes, it does however become a problem in industry where multiple large motors are used. Generally the power factor correction condenser is used to correct the problem. Care should be taken for overcorrection otherwise the voltage and current becomes more due to which the power system or machine becomes unstable and the life of capacitor banks reduces. Here we used the PLC Based system for power factor correction. By using this system we can improve lagging power factor. Thereby system will be safe from different disadvantage of lagging power factor. The power factor control becomes very fast and accurate than other methods & also the electric charges are reduced since the use of microcontroller based PLC reduces the costs. Due to use of PLC, multiple parameters can be controlled and the use of extra hard wares such as timer, RAM, ROM and input output ports reduces. In the world of automation PLC is having a large use in industries, so the power factor correction is also having much importance. So along with other automation process the PLC can be used significantly for correction of power factor.

REFERENCES

- [1] E. Thornton and J. Armintor, The fundamentals of ac electric induction motor design and application, in Proceedings of the Twentieth International Pump Users Symposium. IEEE, 2003, pp. 95 106. N. Catalogue, Power Factor Correction. Electrical Engineering Products Pvt. LTD.: Industrial Switchgear and Automation Specialist (NHP), 2007.



ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Website: www.ijareeie.com

Vol. 7, Issue 4, April 2018

- [2] V W. C. Bloomquist and W. K. Boist "Application of capacitors for power factor improvement of induction motor", A.I.E.E. Trans. PAS, pp.274 -278,1945
- [3] S. R. Doradla and B. K. Patcl "A thyristor reactive power compensator for fast varying induction loads" in Int .Journal of Electronics., pp.763 - 777 , 1981.
- [4] M. A. El-Shirkawi , S. S. Venkata , T. J. Williams and N. G. Butler "An adaptive power factor Controller for three phase induction generators" in IEEE Trans. PAS), vol. 104, pp.1825 -1831,1985.
- [5] D. Burrow and A. Wu "On-Line utility tie power factor control" in Pulp and Paper Industry IEEE Technical Conference,pp.39 -44, 1996.
- [6] Cali , A. Irrera , N. Leotta , N. Messina and U. Vagliasindi "Management of reactive power on a radial M.V. network using an expert system", in ", MELECON_96, Electro-technical Conference,vol. 3, pp.1603 -1606,1996