PLC Based Automatic Power Factor Correction for MCB Manufacturing Plant

Saurabh P.Pingale[1], Nitin M. Joshi[2], Pankaj D.Patil[3], Sumant G. Kadwane[4]

[1]*Student, Dept. of Electrical Engineering, YCCE, Nagpur, Maharashtra, India*
[2]*Deputy Manager, Dept. of Maintenance, Legrand India Ltd, Jalgaon Maharashtra, India*
[3]*Executive Engineer, Dept. of Maintenance, Legrand India Ltd, Jalgaon Maharashtra, India*
[4]*Professor, Dept. of Electrical Engineering, YCCE, Nagpur, Maharashtra, India*

Abstract - *Corrections of power factor is a method of converting the unwanted result of power-driven loads that cause unity power factor. MCB manufacture plant requires correction of power factor with automatic switching ability owing to dynamic load. Rectification of power factor might be smeared moreover by an electrical energy conduction utility to enhance the proficiency of power system. Herein work of power factor the source link remains unswervingly supervised via the Energy Meter which is linked now corresponding towards the source link. A change in the capacitor bank is essential aimed at modifying the deviation in power factor. The individual capacity Capacitor bank started through PLC, which sets the bank of capacitor corresponding toward load capacity and thus carrying power factor near to one/unity automatically without human intervention. In line with electricity board rules the decisions with respect to RKVAH components have been designed in this work.*

***Key Words*: Correction of Power Factor, Programmable Logical Controller, Capacitance bank switching, MCB manufacturing unit.**

1. INTRODUCTION

The power factor (PF) of an electrical power system is distinct as the proportion of the actual power flowing to the load, to the apparent power in the circuit [1]. Apparent power and real power are indistinguishable solitary after the voltage and current are in phase before connecting load we can observe a power factor is closer to one. A power in a circuit is rarely equivalent towards straight multiplication of the voltages and currents. In mandate for finding out the power of an AC circuit the product of current and voltage essential to be multiplied with power factor [2]. In previous rare eras, a substantial progress in control strategies in power factor correction is being investigated. One of them is Programmable Logic Controller (PLC) has a prodigious use in industrialized automation. Numerous solicitations such as control of electrical machines, distribution networks, manufacturing and process industries, etc. employs PLC as automated and effectual revenue [3-4]. This scheme show, power factor of supply coming from transmission line is unswervingly scrutinized through the Energy Meter which stands in corresponding towards the power supply link. Capacitor bank capacitance is required to be change for improving the deviation of power factor owing towards all load deviation is located out separately. The capacitor bank switching intended for separate load is through PLC built program sense, which links the capacitor bank parallel to the load then in this method acceptance of power factor closer to unity. The program design is complete distinctly in the program design software of PLC by means of Ladder Illustration program writing linguistic [5]. Computerization plays a vigorous part in manufacturing and furthermost the precarious setups in today's world. Subsequently Power Structure is similarly to significant serious substructure [6-7]. Use of computerization systems towards Power system for the automation applications is a trend in the arena of 'Power system Automation' [8-10].In this paper we have present a unique technique of correcting power factor as earlier the power factor is corrected only by injecting current by capacitor bank but there is no any reactive power component comparison takes place but in this scheme we are comparing reactive power components that are RKVAh lag and lead respectively which is very effective way for correcting power factor as per governments norms the PF is measured by RKVAh components only [11-14].

2. NEED OF POWER FACTOR CORRECTION IN MCB MANUFACTURING INDUSTRY

In case of MCB manufacturing Industry the loads which connected are for different processes, therefore loads connected in the plant will be simultaneously starting with reverence by the plant process. Therefore banks of capacitor must be started consequently in reverence with load which keeps power factor to unity. This scheme includes duty of nonstop observing and starting the capacitor banks which is to be done earlier manually. However it is conceivable to sustain respectable PF by means of physical method which has definite disadvantages minimize by taking programmed and smart structure which endlessly observe and yield the act by means of itself deprived of several adjournment. Hereafter there should firm requirement aimed at Computerization in technology of power factor correction.

3. CONTROL CIRCUIT AND BLOCK DIAGRAM

3.1 Connection of Capacitor Bank with the System

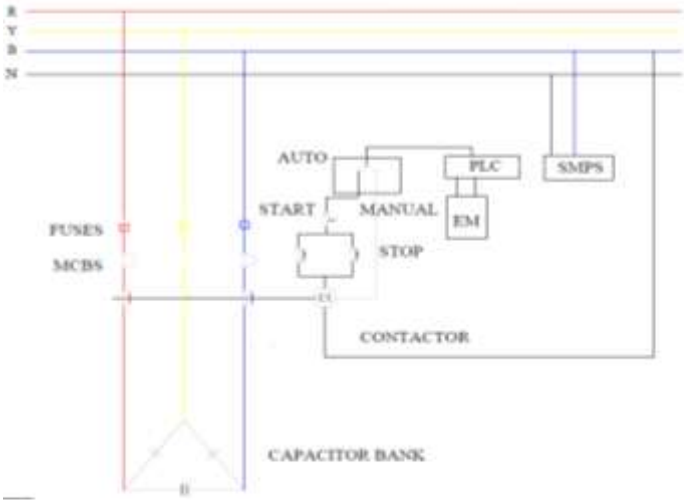

Fig -1: Control Circuit of PFC

To recover the industrial PF, the convenient technique exists to inject the capacitor banks either separately or in groups adjacent to the load epicentres coupled corresponding with loads which are already in system. To permit the programmed process of starting of the capacitor banks, it necessitates a mechanism system which observes and regulates the reactive power compensation by means of necessity. The control circuit of PFC is shown in fig.1 in which we have connected PLC to the energy meter which gives the whole data to the PLC by RS485 and Modbus also; there is auto manual switch which is use for switching ON/OFF capacitors manually. The capacitor bank connected to the PFC is delta connected and is connected to the PFC with protective device like MCB/MCCB.

3.2 Overall representation of the MCB unit with PFC

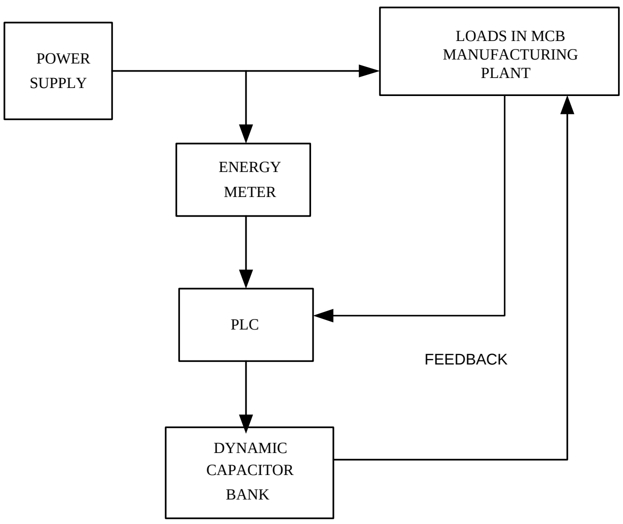

Fig -2 :Overall Block Illustration of the Proposed System

The overall block illustration of the whole proposed system is situated as shown in the fig.2 which contains of Power Supply, Energy Meter, PLC, Dynamic Capacitor Banks, Loads and feedback these are the operating Stages of the Power Factor Correction System. In which we have used the multifunctional energy meter which have a provision of direct communication with Modbus and RS485 which doesn't require any data conversion from analogue to digital as it directly communicate with the system so, for communication with PLC we have used this type of energy meter and PLC can read all the parameters from the energy meter with this communication system. Therefore it is very easy for us to get the data from energy meter also, capacitor bank used in this system are three phase series connected capacitor bank by which we have to compensate the system.

4. METHODOLOGY AND CONTROL ALGORITHM

4.1 Methodology

Before passing of MERC order in case no 195/2017, power factor was calculated by following formula.

$$PF = \frac{KWH}{\sqrt{(KWH^2) + RKVAh\ lag^2}} \qquad (1)$$

In this tariff order RKVAh Lead component is added and now POWER FACTOR computation is as below.

Now, in the above referred order MERC had modified incentives and disincentives of power factor. For incentives when avg. PF is more than 0.95 lag and up to 1, incentive is given. Similarly, wherever avg. PF is less than 0.9 (lag or lead) ,penal charges are levied. Therefore, PF is calculated by following formula:

$$PF = \frac{KWH}{\sqrt{(KWH^2) + (RKVAh\ lag + RKVAh\ lead)^2}} \qquad (2)$$

As Lead PF is not liable for incentive, if RKVAh lead is more than RKVAh lag, then, PF incentive is not given.

Therefore, we have used the second formula for designing the ladder logic in the PLC so that we can have perfect results for the power factor correction as energy meter reads the PF by the above formula.

4.2 Control Algorithm

The control program established by means of ladder software development method is situated in the system of an algorithm as follows. The judgment betrothed can fluctuate by an arrangement then too by the situation reflected on behalf of study. As soon as a database established, that one remain replicated by means of appropriate simulating equipment used for entire conceivable circumstances which executed in system previously.

Step-1: Takings input in the circuit for voltage and current.

Step-2: Calculate the power factor by measuring the phase lag.

Step-3: Calculate the reactive power requirement by differentiating from the targeted power factor .

Step-4: From capacitor bank switch ON or OFF appropriate number of capacitors which depending up on reactive power provided by every step.

Step-5: Yet again equate the power factor through directed PF and carry on from step-1.

The fig.3 shows the control algorithm flowchart which has different steps of different operations of control of PFC.

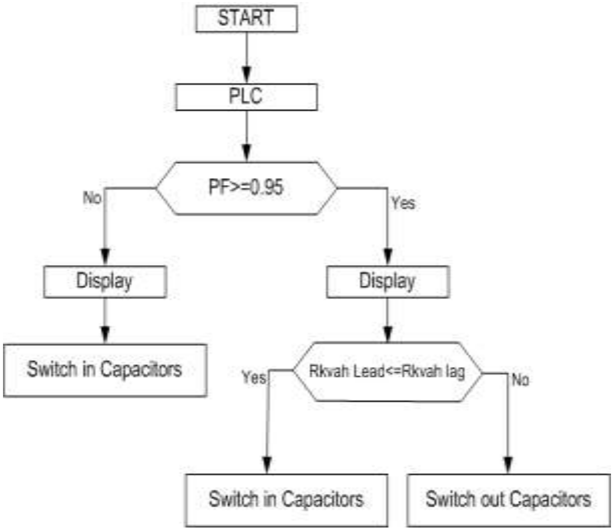

Fig -3: Control Algorithm Flowchart

4.3 Programmable Logical Controller (PLC)

PLC stands smart portion in the structure which remains accountable aimed at whole controller approaches then interchanging action of banks of capacitor in the method. Now in this method, PLC performs a control system of closed loop which takes response by the loads linked to the structure and equipped the mechanism act happening of swapping of the banks of capacitor.

Programmable logical controller used for proposed method is of "RENU ELECTRONICS" which is chosen by number of inputs and outputs ports available in it, by which we can increase the control capacity of controller. In proposed method we have used PLC software named "FLEXISOFT" which is used to make a ladder program of controller and simulation.

4.4 Calculations

Step.1: Calculation of actual load (KW)

$$Load\ (KW) = Volts\ (V) \times \sqrt{3} \times Current\ (I) \times PF\ (Cos\emptyset)$$

Nominal voltage in Volts = 415V

Non Corrected Current in Amp = 1000 Amp

Non Corrected Power Factor = 0.600

Non Corrected load KVA = 718.8 KVA

Actual Load = 431.3 KW

Step.2: Calculation of required Power Factor correction (KVAr)

$$Power\ Factor\ Correction\ KVAr = Power\ KW\ (Tan\emptyset i - Tan\emptyset d)$$

$$\emptyset i = cos^{-1}\ (initial\ Power\ Factor\ PF)$$

$$\emptyset d = cos^{-1}(Required\ Power\ Factor)$$

Actual Load = 431.3 KW

Non corrected PF $cos\emptyset$ = 0.600

Required PF $cos\emptyset$ = 0.950

Correction Required KVAr = 400 KVAr

Total Capacitor Bank connected to the system is of 433 KVAr.

Step.3: Calculation of Actual Power factor correction KVAr

From (2)

$$PF = \frac{KWH}{\sqrt{(KWH^2) + (RKVAh\ lag + RKVAh\ lead)^2}}$$

Correction Applied KVAr = 400 KVAr

Original Load = 431.3 KW

Non Corrected Power Factor = 0.600

From (2) corrected PF obtained

Corrected Power Factor cosØ = 0.927

5. IMPLEMENTATION AND RESULTS

The outcomes are acquired through putting on the advanced ladder database in FLEXISOFT PLC pretending software suite. This program design software permits handlers in the direction to evaluate the action of the arrangement by means of logic established in ladder. The outcomes acquired with virtual reality are shown in fig.4.This controller created high rapidity reactive power compensation and capacitor bank switching method, switches the essential quantity of compensation of reactive power then consequently it is conceivable towards keeping the insignificant PF through uninterruptedly delivering required reactive power.

The simulation result shows the HMI (Human Machine Interface) in which RKVAh lag and RKVAh lead has been measured as per the MERC rules and therefore there is a switching with(3) respect to the power system of the industry. Also there is an actual power factor matched with the required power factor as shown in the simulation result fig.4.1.

Fig -4.1: Simulation Result

The fig.4.2 and fig.4.3 shows the simulation results of non-corrected and corrected power factor respectively.

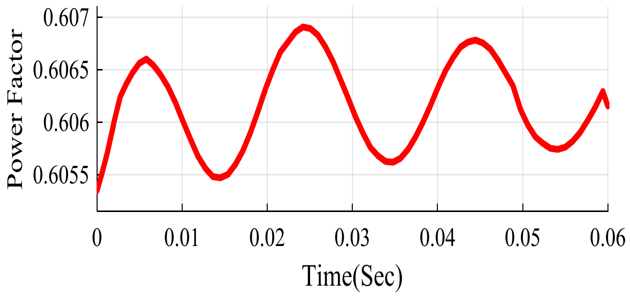

Fig -4.2: Non corrected PF Simulation Result

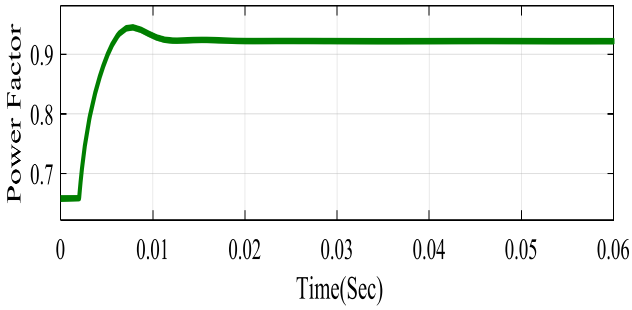

Fig -4.3: Corrected PF Simulation Result

Energy saving for the above power factor correction is as given below.

Initial current = 1000Amp

Corrected current = 648 Amp

Reduction in current = 352 Amp

Original load = 719 KVA

Corrected load = 465 KVA

Reduction in load = 253 KVA

6. CONCLUSION

Power factor alteration becomes varied assortment of benefits in industrialized area. The furthermost significant is sinking the energy tariff. Typically for PF correction capacitor banks used are located in a dispersed way through the manufacturing on behalf of improved-excellence enactment. Immobile parallel capacitances be situated slightest exclusive technique towards obtain power factor nearby unity by providing a motionless foundation of foremost reactive power compensation. The solicitation of this notion of mechanization on behalf of starting the capacitor banks can uniform the stationary basis towards performance a dynamic source of compensation of reactive power then it be connected both near to the exceedingly reactive power consuming loads and on the provision of entering. This arrangement has several many arenas alike compensation, control system design and energy saving solutions. Existing systems not having advantage of comparison of RKVAh lead and RKVAh lag which is possible in this scheme and proper correction of power factor takes place as per the rule of electricity board in which lag component is not more than lead component. In earlier systems there was a direct switching in of capacitor without any reactive power component measurement.

REFERENCES

[1] Sameer."PLC based power factor correcteion and SCADA monitoring" IJIRSET Vol.5 Issue 3, March 2016.

[2] Sulthan Mohyuddin, Zameel Anwar, Mohammed Muzammil Ashraf. "A Programmable Logic Controller Based Power Factor Controller for a Single Phase Induction Motor" IJESC Vol.7 Issue 2,2017

[3] Ware, John. "POWER FACTOR CORRECTION." IET Electrical. IEE Wiring Matters, spring 2006. Web. 14 July 2016.

[4] Gaurav S. Chingale,Priya R. Patil and Arvind R. Singh " Power Factor Correction of Three Phase Induction Motor Using Switched Capacitor Banks with PLC" International journal of research in electrical & electronics engineering,Volume2,Issue2,April-June-2014

[5] Naveenkumar R Kulkarni, Prof. H. Vijay Murthy Akhil P Raju" PLC based intelligent power factor correctors for industrial power systems-A case study" IEEE-2015

[6] Bhargav Jayswa1, Vivek Khushwaha and Prof. Pushpa Bhatiya" Simulation & Hardware Implementation of APFC Meter to Boost Up Power Factor Maintain by Industry" IRJET, Volume5,Issue3,March-2018.

[7] K.Mukundan, Pranav Bala, Karthikeyan, Ranjith Kumar and Nagaraj.R "Automatic Power Factor Correction Unit using Arduino"IJIREEICE,Volume6,Issue4,April-2018.

[8] "Power Factor Correction: A Guide for the Plant Engineer" Eaton Corporation, Aug.2014. Web 14 July 2016..

[9] S.Buso.P.Mattavelli.L.Rosetto.and G.Spiazzi."Simple digital control improving dynamic performance of power factor preregulators." IEEE Trans. Power Electr. Vol. 13. No.5. Sept.1998. pp.814-823.

[10] Mandal, Rakendu, Sanjoy Kumar Basu, Asim Kar, and Shyama Pada Chowdhury. "A microcomputer-based power factor controller." IEEE Transactions on Industrial electronics 41, no. 3 (1994): 361-371

[11] .Kulkami, Naveenkumar R., H. Vijay Murthy, and Akhil P. Raju. "PLC based intelligent power factor correctors for industrial power systems-A case study." In 2015 International Conference on Power and Advanced Control Engineering (ICPACE), pp. 75-79. IEEE, 2015.

[12] Mandal, S.K., Pal, S. and Samonto, S., 2015, March. Distributed load control using FLC based MCB. In 2015 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT) (pp. 1-7). IEEE.

[13] Hao, Sheng, and Hu-yin Zhang. "Theoretical modeling for performance analysis of IEEE 1901 power-line communication networks in the multi-hop environment." The Journal of Supercomputing (2019): 1-33.

[14] Prakash, Shikha. "Talking Energy Meter." In 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS), pp. 205-208. IEEE, 2020.

BIOGRAPHIES

Saurabh P. Pingale Pursuing M.Tech in Integrated Power Systems from YCCE, Nagpur also received his bachelor degree in 2017 from SGBAU, Amravati.

Nitin M. Joshi working as a deputy Manager at Legrand India Ltd. Jalgaon, Maharashtra, India.

Pankaj D. Patil working as a executive engineer at Legrand India Ltd. Jalgaon, Maharashtra, India.