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Automatic Power Factor Correction: Low Cost Solution Using Arduino

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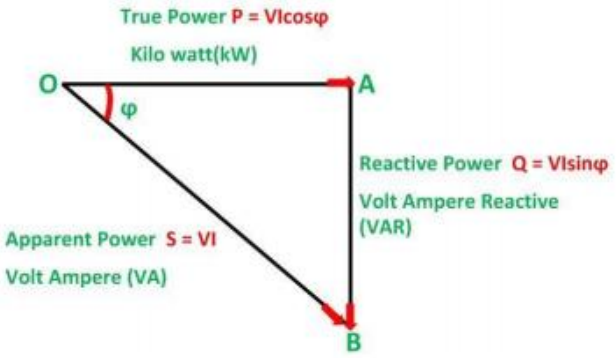
ABSTRACT: There are number of techniques and methods available to improve power factor. Improving power factor involves two parts one is measurement of PF and second is correction of PF. Usually correction is carried by adding capacitors in the circuit. In this paper low cost method is used for measurement of PF. Measured PF is then corrected by accurately calculating capacitor value. In order to improve transmission efficiency, power factor correction research as become a hot topic. Many control methods for the Power Factor Correction (PFC) have been proposed. Power factor correction is the capacity of absorbing the reactive power produced by a load. In case of fixed loads, this can be done manually by switching of capacitors, however in case of rapidly varying and scattered loads it becomes difficult to maintain a high power factor by manually switching on/off the capacitors in proportion to variation of load within an installation. This drawback is overcome by using an automatic power factor correction (APFC) panel and measuring of power factor from load is done by using PIC microcontroller and trigger required capacitors in order to compensate reactive power and bring power factor near tounity.

KEYWORDS: Power factor correction, zero cross detection (ZCD), microcontroller, capacitor Bank, inductive load

I.INTRODUCTION

In the present technological revolution power is very precious. So we need to find out the causes of power loss and improve the power system. In some cases the amount of reactive power consumed might even exceed the amount of active power it generates. This undesirable characteristic places an undue burden on the power network [1]. Due to industrialization the use of inductive load increases and hence power system losses its efficiency. So we need to improve the power factor with a suitable method [2] .The Automatic Power factor Correction (APFC) device is a very useful device for improving efficient transmission of active power. If the consumer connect inductive load, then the power factor lags, when the power factor goes below 0.97(lag) then the Electric supply company charge penalty to the consumer. So it is essential to maintain the Power factor below with in a limit. Automatic power factor correction (APFC) device reads power factor from line voltage and line current by determining the delay in the arrival of the current signal with respect to voltage signal.



This time values are then calibrated as phase angle and corresponding power factor. Then the values are displayed in the LCD module. Then the motherboard calculates the compensation requirement and accordingly switches on different capacitor banks. This is developed by using Ardiuno microcontroller. These values of voltage, current,

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power factor send to PC by using serial interface cable (RS232). PC saves the record of the power factor values, voltage and current values. Automatic power factor correction techniques can be applied to the industries, power systems and also households to make them stable and due to that the system becomes stable and efficiency of the system as well as the apparatus increases. The use of microcontroller reduces the costs.

$$Power\ Factor = \frac{Real\ Power}{Apparent\ Power}$$

The power factor can attain values in the range from 0 to 1. Power factor tends to zero when all the power present is only reactive power and is commonly known as inductive load. Similarly, P F is one when there is only real power present, and it is known as resistive load. Correcting P F is nothing but adjusting the electrical circuit so that the power factor could be changed near to 1. Improving Power Factor near to 1 compensates the reactive power existing in the circuit and then most of the power existing will be real power. Consequently, this lessens the power lines losses. The application of Power factor correction can be associated with an electrical power source to enhance the efficiency of the system along with stabilizing the transmission network. Furthermore, in order to achieve the cost reductions, the improvements can be made through the electricity suppliers charging for single electrical customers. For the improvement of transmission efficiency, power factor correction research is now considered as a hot issue.

II.VARIOUS METHODS FOR IMPROVING POWER FACTOR

2.1 By using Capacitors:

Improving PF means decreasing the phase difference of the voltage and the current. Inductive loads require some reactive power for them to work. The reactive power is provided by bank of capacitors that are connected parallel to load. It can be said that capacitors are a source of local reactive power, and hence lesser reactive power flows from the line. They decrease the phase difference in the voltage and current.

When capacitors are used Losses are low and also requires very less maintenance. Installation of capacitors is easy because of lighter weight and do not require foundation.

2.2 By using Synchronous Condenser:

Synchronous Condenser are 3 phase synchronous motor which do not have any load attached to its shaft. The synchronous motor has the feature of working under any power factor which can be leading, lagging or unity that depends on the excitation. In case of inductive type of load, a synchronous condenser is connected at load side and is then overexcited. They behave as a capacitor when they are over excited. When such machine is connected parallel to supply, it takes leading current which partly neutralizes lagging reactive component of the load thus power factor is improved. By using synchronous condenser high Control on power factor and also have higher thermal stability. The faults can be eliminated easily. Losses occur in the motor. It has high maintenance cost.

2.3 Phase Advancer:

This is an A C exciter which is mainly used for improvement of power Factor of the induction motor. Phase advancers are used suitably when synchronous motor use is not admissible. Phase advancers are uneconomical for motors that are under 200HP.

1. Steps for power factor correction

Power Factor is computed as:

$$POWER\ FACTOR = \frac{KW}{\sqrt{(KW)^2 + (KVAR)^2}}$$

If Power Factor Level is less than 0.90 then penalty shall be as per percentage given in MERC order.

- If Power Factor is more than 0.95 and RKVAH Lag consumption >= RKVAH Lead consumption, then incentive is as per percentage given in MERC order.
- If Power Factor is more than 0.95 and RKVAH Lag consumption < RKVAH Lead Consumption, then incentive is not applicable.
- If the RKVAH Lead reading is not available, then the old procedure of power factor consumption will be followed.

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There is Change in percentage of Power Factor penalty and incentive as follows:

Power Factor Incentive:

Table -1: Power Factor incentives

Power Factor	Old %	New %
0.95	0	0
0.96	1	0.5
0.97	2	1
0.98	3	1.5
0.99	5	2.5
1	7	3.5

Table-2: Power Factor Penalty (For Lead as well as Lag):

Power Factor	Old %	New %
0.90	0	0
0.89	2	1
0.88	3	1.5
0.87	4	2
0.86	5	2.5
0.85	6	3

III. FLOW CHART OF PROPOSED SYSTEM

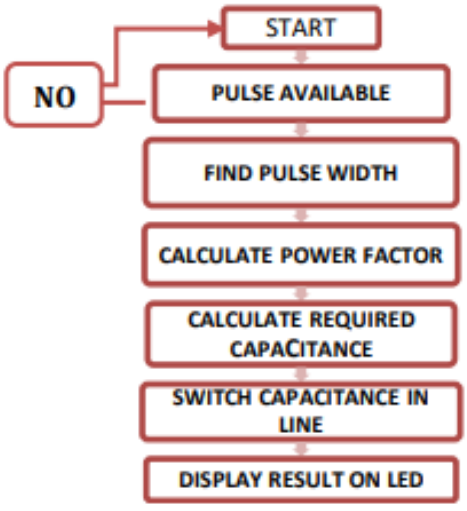

Fig -2: Block Diagram of Automatic Power Factor Correction unit

The complete automatic power factor correction unit consist of following parts:

1. Power supply

Most of time embedded system circuit uses 12 volts. 5-volt DC is used as its operating voltage. It's necessary to change the 230 Volt A C supply to the essential D C supply. Firstly 12 volts ac supply is obtained by using stepdown transformer by reducing the 230 Volt supply to 12 volts. In this project the potential transformer (PT) outputs can be used in its place rather than going for another different step-down transformer. By rectification process, the 12 Volts A C is converted in to a 12 Volts pulsating DC voltage. The pulsating D C is then sent to a capacitive filter for smoothening and a standard 12 Volt DC is obtained as a output.

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2. Potential transformer

It is used to step down or step up the ac voltage levels. Here we use the potential transformer to measure the voltage level of the ac line. These type potential and current transformers are working with the concept of mutual inductance. The current and voltage signal are acquired from the main AC line by using Current Transformer and Potential Transformer. These acquired signals are then pass on the zero crossing detectors.

3. Current transformer

A transformer transfers electrical energy from one circuit to another by the transformer's coils. A varying current is produced in primary winding. It creates a varying magnetic flux in the secondary winding. This varying magnetic field induces a varying emf or voltage in the secondary winding. The varying emf is called mutual induction.Input signal is connected to the step down current transformer .A step down current transformer is used to convert high current in to low current for the use of different electrical circuits The amount of current which is step down depends on the number of turns in primary coil and number of turns in secondary coil and also on the step down ratio.

4. Capacitor bank

Shunt capacitor banks basically is utilized for the improvement of the P F in electrical network. Capacitor banks are also used for the improvement of the voltage stability and decrease network losses. Shunt capacitor banks are not expensive. Shunt capacitors installation can be done easily anywhere on the network. Depending on the necessity of reactive power, capacitor bank which consist of shunt capacitors are made ON or OFF. With the usage of relays the switching can be done by manual way or automatically.

5. Interfacing of Arduino

The Arduino is an microcontroller with simplest form of programming language and easily available sets of programming and header files available on internet. I has a micro controller IC and several input and output terminals available which are easy to make connections to externel connection . it can be connected to a system with a USB cable and can be programmed easily through a common platform given by the Arduino. The 5v power adapter is provided to connect to a main supply after he programming is done.

Discuss the function used in the programming to determine the power factor.

```
void getpf()
{ \duration = pulseIn(pin, HIGH);
duration1=(duration/1000);
si=(duration1/20);
phi=(si*360);
power_factor=cos(phi/57.2); }
```

Hence the power factor can be calculated by using this function in Arduino programming.

Switching Operation

Once the power factor is calculated then using the value of the power factor we can able to switch upon the various capacitors to compensate the reactive power generated. The function used for the switching operation of capacitor banks are

```
if(power factor < 0.98)
{
digitalWrite(cap1,
HIGH);getsf();
Serial.print("\tThe corrected Power factor is:\t\t\t”);
Serial.println(power factor);
If (power factor<0.98)
```

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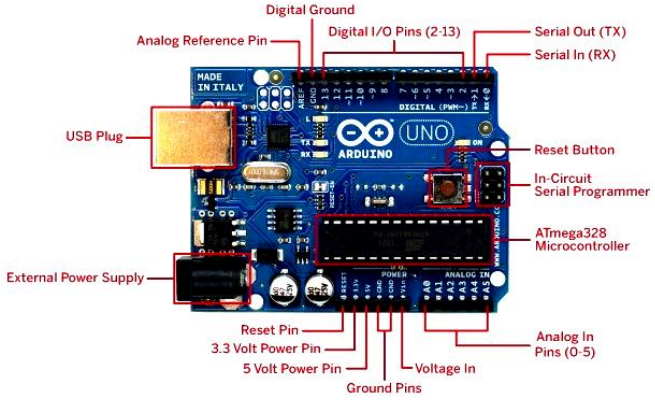
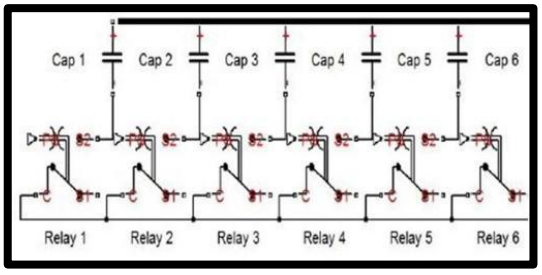
```
{
digitalWrite digitalWrite(cap2, HIGH);
getpf();
Serial.print("\tThe corrected Power factor is:\t\t\t"); Serial.println(power_factor);
if(power_factor <0.98)
{
digitalWrite(cap3, HIGH);
getpf();
Serial.print("\tThe corrected Power factor is:\t\t\t"); Serial.println(power_factor);
```

Hence the power factor is set at 0.98 values and till it reaches he 0.98 the capacitor bank connected will keep on increasing according to the load and vice versa.



6.Relay Unit

Relay unit contains a relay driver and some relays. The relay unit controls the high-power circuit from a low power circuit because microcontroller's output cannot control direct switching of capacitors. Relay is defined as an electrically operated switch. When there is a need to control in a circuit by a low power signal in such cases relays are used. Current that passes from coil of relay generates a magnetic field that gets attracted towards lever and then the switch contacts are changed. Connections of relay's switch are Common, Normally Open (NO), normally closed (NC).Relay coil is not operated by the current provided by the output of microcontroller as current is insufficient. Relay driver ULN2003 is used for the operation of the relay. ULN2003 is a mono-lithic higher voltage and higher current Darlington transistor array.



7. Display Unit

An embedded system communicates directly to a human being by use of input and output devices. It should be noticed that in an embedded system, the interaction is instigated by the microcontrollers. The system uses input and output

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devices those generate direct communications with human being. LCD display can be considered as the most common devices that is connected to the microcontroller. Specifying the types of LCD displays, 16x2 and 20x4 are the most common ones connected to the microcontrollers. These digits
Indicate the numbers of the characters and the numbers of lines. For example, a 16x2 LCD display contains 16 characters and 2 lines made available to use. Similarly, 20x4 LCD display indicates 20 characters and 4 lines made accessible for use. In this project a 16x2 LCD display, is considered.

8. Hardware Implementation

The P C B was made-up as per the diagram and then all the components were soldered. The Potential transformer, Current Transformer, capacitor bank was soldered properly at their respective places. microcontroller was programmed by using a burner. The C T is connected in series with load and capacitor bank. Ardiuno determines both magnitudes and phase difference of AC voltage and current . Based on the measured values using formula P F of load is calculated. The liquid crystal display is used to display the improved P.F.

Fig -3: Hardware of Automatic Power Factor Control

Figure 3 shows the whole hardware of Automatic Power Factor Control Unit used for improving power factor. One of the results is discussed below. Figure 3, when inductive load was applied i.e. Choke is used in this case the measured P.F was found to be 0.85 Lagging (refer the figure 4) and In Figure 5, the P F is increased to 0.99 by adding capacitor in parallel. The result shows the working and idea of Automatic Power Factor Correct ion by using capacitors.

Fig 4 Measured power factor

Fig 5. Showing corrected power factor on LCD

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IV.CONCLUSION

1. The Automatic Power Factor Detection and Correction provides an efficient technique to improve the power factor of a power system by an economical way.
2. Static capacitors are invariably used for power factor improvement in factories or distribution line. However, this system makes use of capacitors only when power factor is low otherwise they are cut off from line.
3. The power factor of any distribution line can also be improved easily by low cost small rating capacitor.
4. This system with static capacitor can improve the power factor of any distribution line from load side.

V.FUTURE SCOPE

1. Prototype designed GSM system can be used for large rating of APFC system.
2. 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.

REFERENCES

1. Sharkawi, M.A.; Venkata S.S.; Williams T.J.; Butler N.G. "An Adaptive Power Factor Controller for Three-Phase Induction Generators", *IEEE Transactions on Power Apparatus and Systems*, Volume: PAS- 104, Issue: 7, Pages: 1825–1831, July 1985.
2. Kulkarni Kaumudi, Kumbhar Pooja, Patil Priyanka, Prof.Madhuri *International* Namjoshi, "Automatic power factor correction using Ardiuno ",*Engineering Research Journal (IERJ)* Volume 2 Issue 1 Page 13-16, ISSN 2395-1621, February 2016.
3. Anagha Soman, Assistant Professor, Pranjali Sonje, "Power Factor Correction Using Ardiuno",International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 4, October 2013.
4. Aparna Sarkar, Umesh Hiwase "Automatic Power Factor Correction by Continuous Monitoring" *International Journal of Engineering and Innovative Technology (IJEIT)* Volume 4, Issue 10, April 2015.
5. Mr.Anant Kumar Tiwari, Mrs. Durga Sharma, Mr.Vijay Kumar Sharma "Power Factor Correction Using Capacitive Bank ",*Int. Journal of Engineering Research and Applications* ISSN : 2248-9622, Vol. 4, Issue 2(Version 1), pp.393-395, February 2014.
6. K.Mukundan ,Pranav Bala, Karthikeyan.s,"Automatic Power Factor Correction unit Using Arduino",IJIREEICE,Vol.6,Issue-4,April 2018.
7. Saurabh Kumar Sharma,Gaurav Kumar Sharma,Abhijit Sharma,"A review Paper on Automatic Power Factor Correction",IJCRT,Vol.6,Issue-2,April 2018.
8. Ravi Dhameliya,Kaushik Domadiya,Pratik Miyani,"Automatic Power Factor Control Using Arduino",IJAERD,Vol.4,Issue-4,April 2017.
9. Myint Myint Than,"Microcontroller Based Automatic Power Factor Correction System",IJTRD,Vol.4,Issue-1,Jan 2017
10. Bhargav Jaiswal,Vivek Khushwaha,Pushpa Bhatiya,"Simulation and hardware implementation of APFC meter",IRJET,Vol.5,Issue-3,March 2018
11. Myint Myint Than"Implementation of PF correction using Solid State Switched Capacitor",IJIREEICE,Vol.11,Issue-4,Jul 2016
12. V. K. Mehta and Rohit Mehta. Principles of Power System: (including Generation, Transmission, Distribution, Switchgear and Protection). 4th ed. Chapter 9, New Delhi: S. Chand, 2005.
13. Mr.Anant Kumar Tiwari, Mrs. Durga Sharma, Mr.Vijay Kumar Sharma "Power Factor Correction Using Capacitive Bank ",*Int. Journal of Engineering Research and Applications* ISSN : 2248-9622, Vol. 4, Issue 2(Version 1), pp.393-395, February 2014.
14. Kim, T.W.; Choi J.H.; Kwon, B.H., "High-Performance Line Conditioner with Output Voltage Regulation and Power Factor Correction*", IEEE Proceedings on Electric Power Applications,* Volume: 151, Issue: 1, Pages: 91-97, January 2004.
15. Barsoum Nader "Programming of Ardiuno for Power Factor Correction" *IEEE Conference on Modeling & Simulation*, Pages: 19-25, March 2007.
16. P M Patil, ―An active power factor correction technique for single phase AC to DC boost converters,‖ Journal of The Institution of Electronics and Telecommunication Engineers, Vol 43 No. 4. December 2002
17. R M Jalnekar and K S Jog, ―Pulse-Width-Modulation Techniques : A Review,‖ IETE Journal of Research vol. 46, No 3, May-June 2000, pp 70-78.
18. Jian Sun, ―On the Zero-Crossing Distortion in Single-Phase PFC Converters,‖ IEEE transactions on Power Electronics, vol. 14. no. 3, May 2004, pp 685-612.