Power Factor Improvement Based on Micro Controller using APFC Panel

Chanchad Vishal[1] Mehata karan[2] Patel Vihar[3] Vaghela Virbhadra[4] Parita Desai[5]
[1,2,3,4]B.E Student [5]Assistant Professor
[1,2,3,4,5]Department of Electrical Engineering
[1,3,4,5]SAL Institute of Technology and Engineering Research, Ahmedabad, India

Abstract— Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor that is less than unity. Power factor correction maybe applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network or correction may be installed by individual electrical customers to reduce the costs charged to them by their electricity supplier. This paper deals with the implementation of automatic power factor correction (APFC) system using solid state switched capacitors and microcontroller. The main objectives are to reduce the line loss, to reduce reactive power flows on the line and to avoid switching surge overvoltage due to switching on/off the capacitors.

Key words: Power Factor, Solid State Switched Capacitors, LCD, C language, microcontroller, keil language, portious Software

I. INTRODUCTION

Most of electrical energy is produced by thermal power plant but the efficiency of thermal power plant is very low like if input is 100kW of fuel energy , output at appliance around 15-20kW of useful work. Every kW of loss saved in the process drive, 6kW of fuel energy gets saved on the front end. One of the method for energy saving is power factor improvement .Power factor correction maybe applied either by an electrical power transmission utility or correction may be installed by individual electrical customers to reduce the cost charged to them by their electricity supplier. In our project we discuss the design and development of a power factor correction using capacitor and 8085 family microcontroller chip.

Before getting into the details of Power factor correction, let’s just brush our knowledge about the term “**power factor**”. In simple words power factor basically states how far the energy provided has been utilized. The maximum value of power factor is unity. So closer the value of P.F to unity, better is the utility of energy or lesser is the wastage. In electrical terms Power factor is basically defined as the ratio of the active power to reactive power or it is the phase difference between voltage and current Active power performs useful work while Reactive power does no useful work but is used for developing the magnetic field required by the device.

Most of the devices we use have power factor less than unity. Hence there is a requirement to bring this power factor close to unity. Here we are presenting a prototype for automatic power factor correction using 8085 Microcontroller and establish the Power Saver for Commercial and Industries.

II. NEEDS OF POWER FACTOR CORRECTION

Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor that is less than one.

Power factor correction may be applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network or correction may be installed by individual electrical customers to reduce the costs charged to them by their electricity supplier.

An electrical load that operates on alternating current requires apparent power, which consists of real power plus reactive power. Real power is the power actually consumed by the load. Reactive power is repeatedly demanded by the load and returned to the power source, and it is the cyclical effect that occurs when alternating current passes through a load that contains a reactive component.

Power factor correction attempts to adjust the power factor of an AC load or an AC power transmission system to unity through various methods. Simple methods include switching in or out banks of capacitors or inductors which act to cancel the inductive or capacitive effects of the load, respectively. For example, the inductive effect of motor loads may be offset by locally connected capacitors.

III. MAIN COMPONENTS OF APFC

Main components used in this scheme for automatic power factor correction using microcontroller includes following components.

1) Auxiliary power Supply:
   a) Transformer
   b) Bridge rectifier
   c) Voltage regulator IC 7805
2) Microcontroller(AT-megaA8)

3) LCD Display
4) Capacitor Bank
5) Potential transformer & current transformer
6) Relay & relay driver IC
7) Zero Cross Detector

IV. BLOCK DIAGRAM OF POWER FACTOR MEASURING SYSTEM

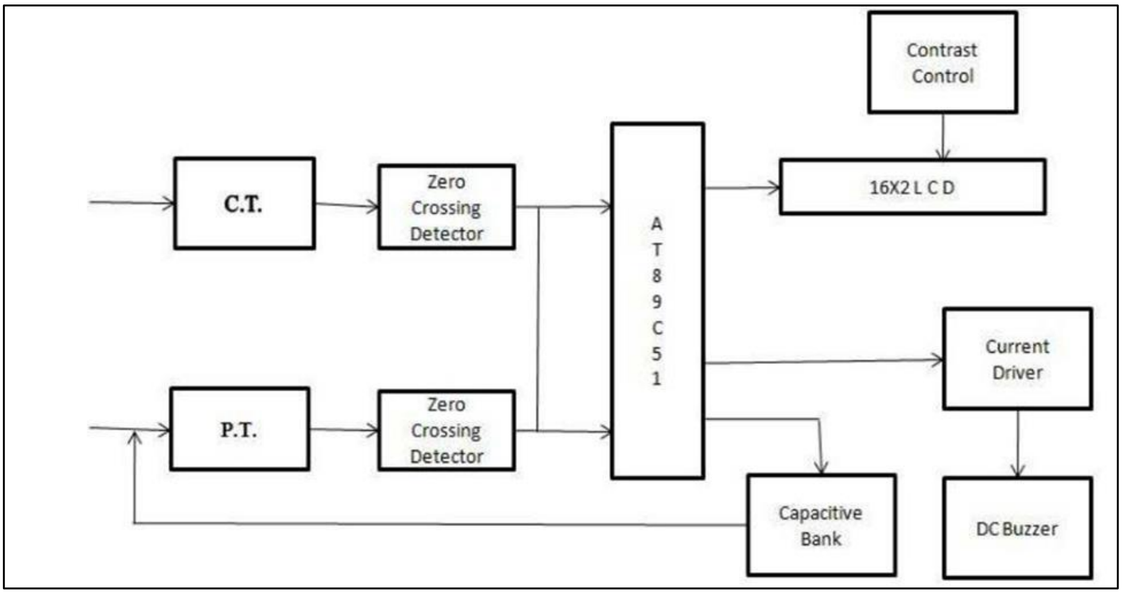

Fig. 1:

V. APFC PANEL METHODOLOGY

Steps for Automatic Operation:

1) Two signals (voltage & current) are introduced in Microcontroller from line by using C.T and P.T
2) Microcontroller calculates phase angle between this two signals by measuring time interval using timer.Microcontroller calculates the power factor by formula (Cos X phase angle)
3) Then it calculates the required compensation.
4) From given compensation it gives signal to Relay.
5) Then Contactors operate on the relay signal.
6) And required capacitors are added in system.
7) As capacitors are added, power factor gets increased.
8) Power factor is displayed on display of panel.

A. Measure time difference between two wave for measurement of power factor:

It is very easy to measure time difference between two waves with the help of hardware external interrupt pin of microcontroller. Hardware interrupt is used to detect zero crossing signals. Microcontroller internal timer is used to measure time. When external interrupt occur on microcontroller pin time will start and after another external interrupt time will stop counting. One interrupt will be generated with the help of current signal and other interrupt with the help voltage signal zero crossing. Timer value will be stored in one variable. This variable value is basically a time difference between two waves. For better results take 20-30 values and take their average.

B. Formula for finding angle using time difference:

So using time difference we can easily calculate phase angle using below given formulas:

Time difference = average values of timer /1000;

In above equation 1000 is used to convert time into seconds because half of the sine wave is about 10us and there will 1000 counts per second.

θ = time difference * 2π ;

Power Factor = cos (θ);

After that time difference is multiplied with 2π to convert it into radians and phase angle in radians. After that by using power factor formula we can easily calculate power factor. All these calculations are done in programming by writing a code in microcontroller.

VI. RESULTS

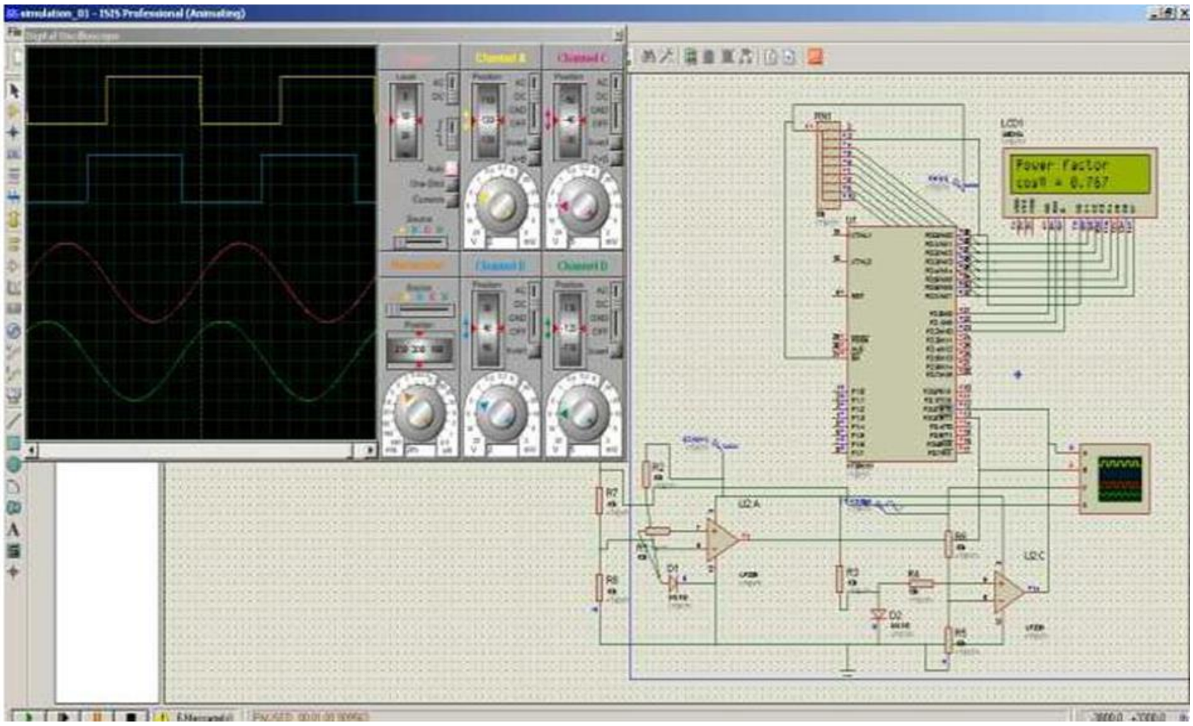

Fig. 1: Poor power factor detection

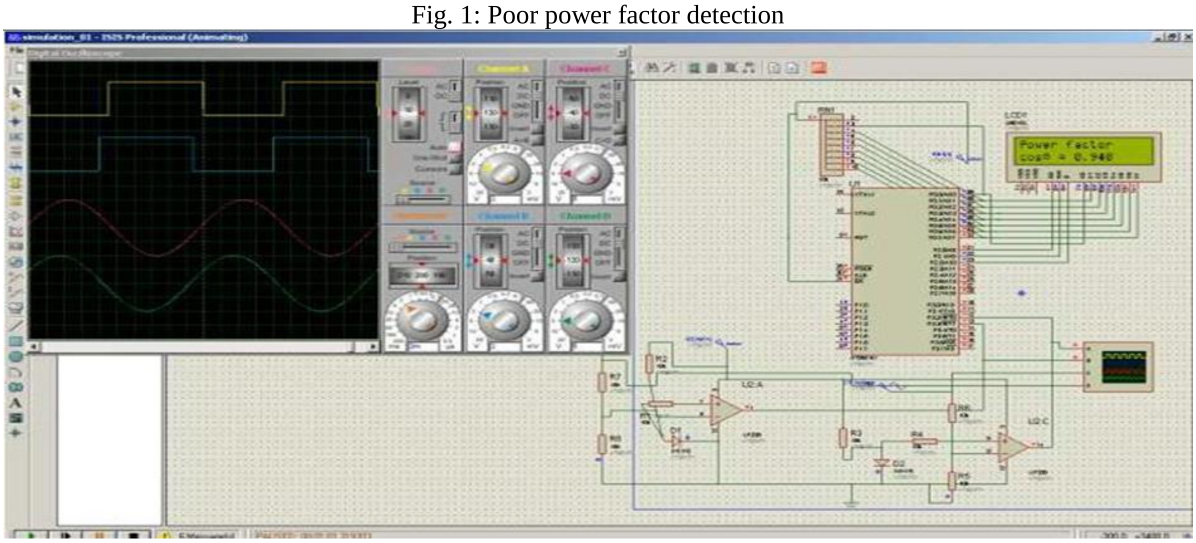

Fig. 2: Improved power factor

Thus we observe that before actual implementation of APFC system in real physical world, we can verify the proof of concept using Proteus VSM.

Pulse gen. (A) Start time	Pulse gen. (B) Start time	t_d (ms)	Clock No.	PF	PORTC Output	Cap. connection serially
4ms	0	3	1749	0.58	High	On
2ms	0	2	1999	0.8	High	On
1.5ms	0	1.5	2124	0.89	High	On
1ms	0	1	2249	0.95	High	On
800µs	0	0.8	2299	0.96	NC	NC
600µs	0	0.6	2349	0.98	NC	NC
400µs	0	0.4	2399	0.99	Low	Off

Table 1: (Multidisciplinary Journal of Research in Engineering and Technology, Volume 1, Issue 1 (April 2014) Pg.73-79)

The above table shows that as we reduce down the start time for the pulse generator, the delay time also gets reduced and thus the power factor simultaneously increases and the capacitors are added respectively.

Comparison of Calculated and Simulated Values of Compensated Capacitors The comparison of calculated and simulated values of compensated capacitors is shown in Table.

Motor	Initial Power Factor	Target Power Factor	K= (tanØ1-tanØ2) (kvar /Kw)	P= VIcosØ1 (W)	Q =K*P (Var)	C (µF)
Motor 1	0.62	0.94	0.90	408.41	367.56	22.11
Motor 2	0.54	0.94	1.20	306.77	368.12	22.15
Motor 3	0.62	0.94	0.90	408.41	367.56	22.11
Motor 1,2	0.58	0.94	1.04	710.62	739.04	44.46
Motor 1,3	0.62	0.94	0.90	816.96	735.25	44.24
Motor 2,3	0.58	0.94	1.04	710.62	739.04	44.46
Motor 1,2,3	0.60	0.94	0.97	1131.48	1097.5	66.03

Table 2:

VII. CONCLUSION

By installing suitably sized power capacitors into the circuit the Power Factor is improved and the value becomes nearer to 0.9 to 0.95 thus minimizing line losses and improving the efficiency of a plant. By using this APFC system the efficiency of the system is highly increased. By the using of solid state switches, it can compare with the mechanical relays, so many reliable and efficient outcome appear. This is the very efficient system for various loads, by using the different sizes of capacitors and triggering the switches which were controlled by the program. Therefore, it is soundly recommended to come out the perfect benefits on the system which will be constructed as mentioned above.

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