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Automatic Power Factor Improvement by Using Microcontroller

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Abstract - This paper represents the most effective automatic power factor improvement by using static capacitors which will be controlled by a Microcontroller with very low cost although many existing systems are present which are expensive and difficult to manufacture. In this study, many small rating capacitors are connected in parallel and a reference power factor is set as standard value into the microcontroller IC. Suitable number of static capacitors is automatically connected according to the instruction of the microcontroller to improve the power factor close to unity. Some tricks such as using resistors instead of potential transformer and using one of the most low cost microcontroller IC (ATmega8) which also reduce programming complexity that make it most economical system than any other controlling system

Keywords : *microcontroller atmega8, current transformer, comparator, relay, capacitor, proteus 7.8, matlab.*

I. Introduction

Low power factoroccurs large copper losses, poor voltage regulation and reduce handling capacity of the system. At low power factor KVA rating of the equipment has to be made more, making the equipment larger and expensive [1]. Power factor improvement is important because at high, medium and low power factor the current distortion levels tends to fall into lowTHDI≤20%,medium(20%<THDI≤50%)andhigh(THDI >50%)respectively[2].For the low power quality high financial loss per incident occurs that are given below.

Table I : Example of financial loss due to low power quality incident

Incident	Loss
Semiconductor production(*)	3800000€
Financial trade(*)	6000000€ per hour
Computer centre(*)	750000€
Telecommunication(*)	30000€ per minute
Steel industry(*)	350000€
Glass industry(*)	250000
Offshore platforms	250000-750000€ per day
Dredging/Land reclamation	50000-250000€ per day

The data labeled (*)in the table- I has been concluded after a European wide power quality survey undertaken by the European copper Institute in 2002. Other data is ABB experience data [3].But low power factor can be improved by static capacitors [4], synchronous condenser, phase advancers [1]. In this paper power factor has been improved automatically by using microcontrollerATmega8 with static capacitors

II. Power Factor Improvement Theory

The low power factor is mainly due to the fact that most of the power loads are inductive and therefore, take lagging currents. So capacitors are connected parallel with the load for leading power. It draws current Ic which leads the supply voltage by 90^0 .The resulting line current I^1 is the phasor sum of I and I_C and it angle of lag is ϕ_2 as shown in Fig1(c).It is clear that ϕ_2 is less than ϕ_1 from phasor diagram. So that cosϕ_2 is greater than cosϕ_1 .So that power factor of the load is improved [1].

This is shown in the following phasordiagram

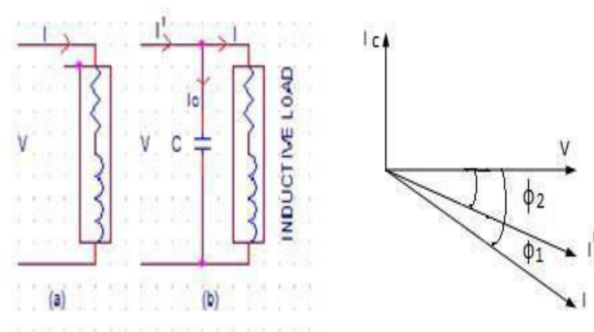

Figure 1 : Power factor improvement circuit and phasor diagram

III. Control Concept

In fig.2 voltage divider rule is used between two resistors for step down voltage. Here magnitudes are different but phase are same between input voltage and the voltage across R2.These wave shapes is shown in Fig.3 Why resistor is preferable to than PT? Suitable calculations are given below.

We know, V=IR (R1=250K, R2=10K, Fig.1)
I=V/R if R=Kilo-ohm (R=R1+R2)

I=Voltage/kilo-ohm=Mili-amp
=230v/260k=0.8846Mili-amp (from fig2
(a)) Power loss $P=I^2*R$
= $(\text{Mili-amp})^2$*kilo-ohm
=0.2035W

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This value is so small and also be negligence. So resistor is preferable than potential transformer in the proposed plan because resistor is low cost than potential transformer.

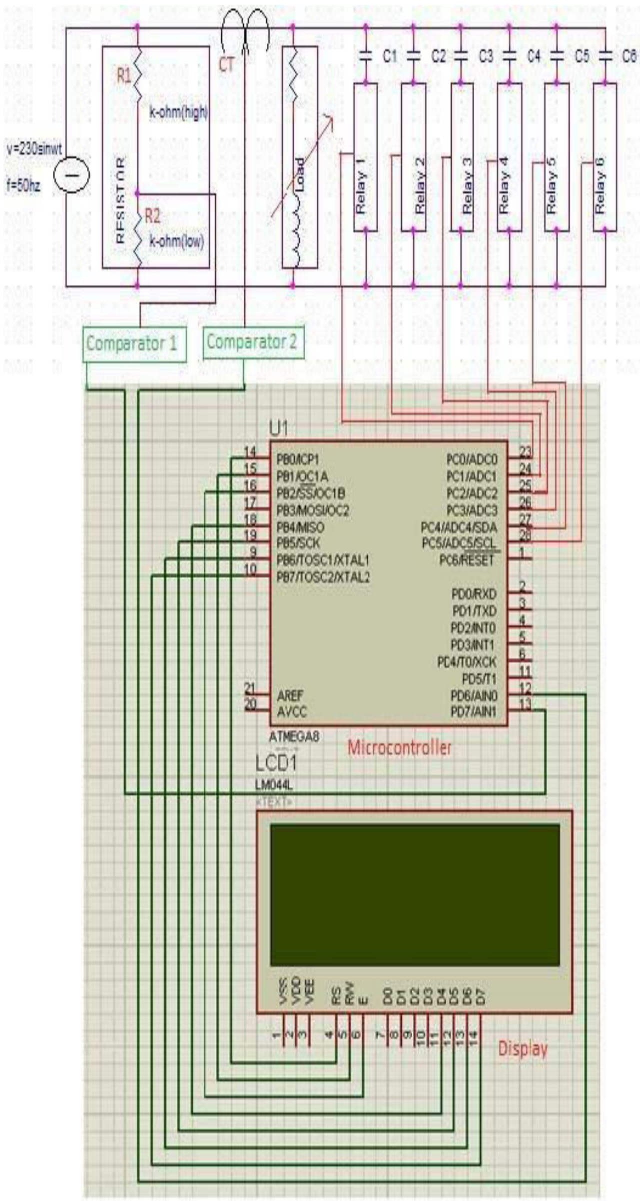

Figure 2 : Microcontroller based circuit diagram

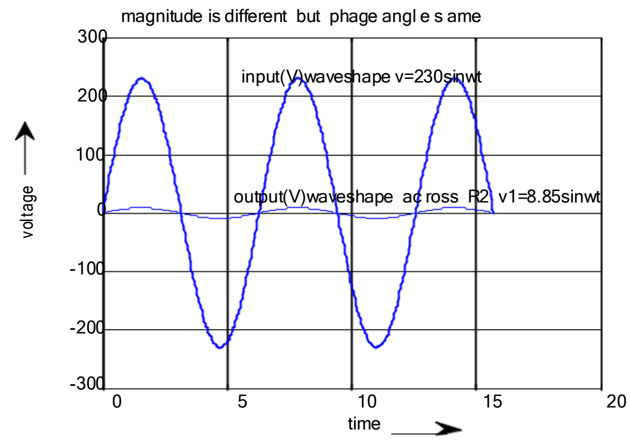

Figure 3 : Input (AC, 230v) and output (V) across R2

Two signals such as voltage signals from applying voltage divider rule between two resistors and current signals from CT are found. These signals are applying between two comparators shown in Fig.2.

IV. COMPARATOR OPERATION

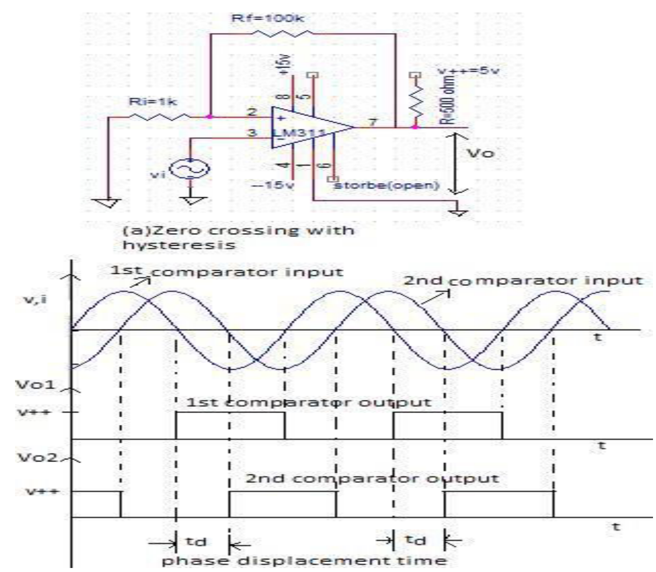

Figure 4 : Comparator and its input, output wave shape

The LM311 series is a monolatic, low input current voltage comparator. This device is also designed to operate at dual Or single supply voltage.

LM311 also acts as a zero crossing detector [5]. When storbe is opened LM311 operates normally. The output voltage is at v++ for negative value of theinput voltage(vi) and 0 for positive value of vi shown in Fig.4.Phase displacement time(td) is also shown in Fig.4.This phase displacement time(td) between two comparators can easily be found by programming with microcontroller. If time (td) is very small, good PF will be found. If (td) is high bad PF will be found. So capacitors are connected across the load to reduce the phase

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V. Microcontroller Operation

Let, CLK_{CPU}=2MHz
Pre- scale=8
CLK_{TIMER} = (2MHz/8) = 250KHz
T_{TIMER} = (1/250KHz)= 4us
So 4us is needed to count pulse 1.
10ms is needed to count pulse= (10ms*1)/4us
=2500
So maximum pulse value=2500

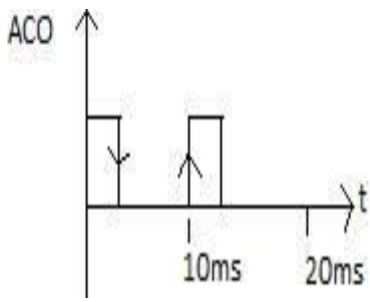


Figure 5 : Analog comparator output of microcontroller

Count the timer value from one falling edge to next rising edge in Fig.5. Now subtract this value from maximum pulses value. This will be the timer value of displacement between voltage and current signal.

Now from the main signal we get,

10ms is equal to displacement =3.1416 radian
1us is equal to displacement= (3.1416/10000) radian =0.00031416 radian.
Now Pulse width, t=4us*(2500-clock number)
Theta, θ=0.00031416*4*(2500- clock number)
=0.00125664*(2500- clock number) radian

Here, clock number is a variable depends on signal. So, Power factor = Cosθ can easily be calculated.

Also applying a condition in the programming, if Power factor less than 0.96 then all output ports of the microcontroller will be serially high and connected the capacitors parallel to the load by relay. If power factor is greater than 0.98 then all output ports of the microcontroller will be serially low and disconnected the capacitors parallel to the load by relay. Microcontroller output ports become low or high automatically to keep the power factor from 0.96-0.98 range.

The program flow chart is given in Fig.6.

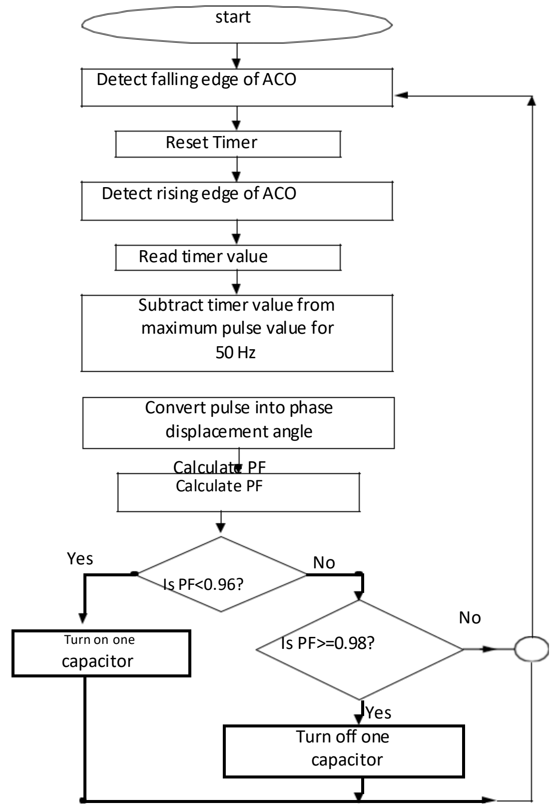


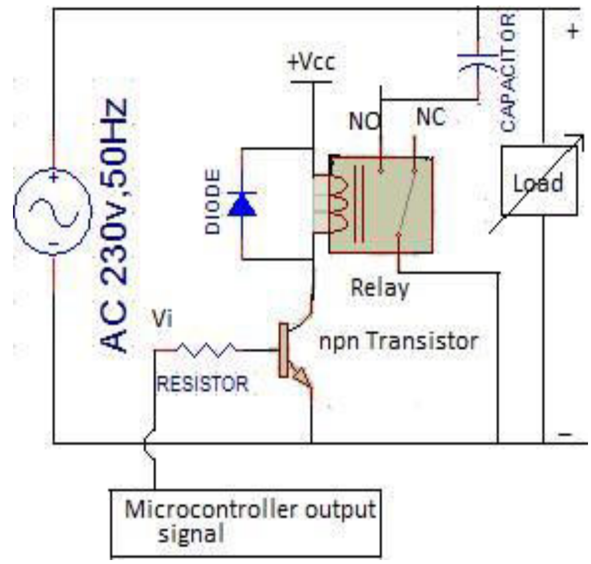
Figure 6 : Flow chart of the microcontroller program

VI. Operation of Relay

If microcontroller output is high then transistors turns on, establishing sufficient current through the coil of the electromagnet to close the relay and capacitor will be connected parallel to the load. Problem can now develop when the microcontroller signal is removed from the base to turn off the transistor and de-energize the relay. Trying to change the current through an inductive element too quickly may result in an inductive kick that could damage surrounding elements or the system itself. This destructive action can be subdued by placing a diode across the coils shown in Fig.6.During the on state of transistor, the diode is back-biased; it sits like an open circuit and doesn't affect a thing. However, when the transistor turns off the voltage across the coil will reverse and will forward-bias the diode, placing the diode in it's on state. The current through the inductor established during the on state of the transistor can then continue to flow through the diode, eliminating the sever change in current level. The diode must have a current rating to match the current through the inductor and the transistor when in the on state. Thus the capacitor is connected parallel across the load by relay without any hazard [6].

IX. Conclusion

This paper shows an efficient technique to improve the power factor of a power system by an economical way. Static capacitors are invariably used for power factor improvement in factories or distribution line. But this paper presents a system that uses capacitors only when power factor is low otherwise they are cut off from line. Thus it not only improves the power



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