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Implementation and design of APFC unit for Minimizing Industrial power consumption

[1] N. Deotale,[2] H.B. Sarvaiya [3] Dr. S.B. Deshpande
[1] B.E. Student, Department of Electrical Engineering, Priyadarshini Institute of Engineering & Technology, Nagpur, Maharashtra, India
[2] Assistant Professor, Department of Electrical Engineering, RTMNU, Maharashtra, India2
[3] Professor & Head, Department of Electrical Engineering, RTMNU, Maharashtra, India3

***Abstract*-— Minimizing penalty is an issue related to industrial load is very much highlighted now a days. To overcome the above difficulties various methodologies has been designed and implemented. But few of them are sustain the issue of power consumption to certain extent with protective measurement. In this paper the technique used for design & implementation done with the help of microcontroller based APFC unit with motor load ,the result are verified before and after use of APFC unit. Power supply designs have been modified for necessity for improvement in performance of the system. Improving power factor means reducing the phase difference between voltage and current. Since majority of loads are of inductive nature in industry , they require some amount of reactive power for them to function. This reactive power is provided by the capacitor or bank of capacitors installed parallel to the load. Low power factor is expensive and inefficient. Many utility companies charge the users an additional fee if rate of power factor is less than 0.95. Low power factor also reduces your electrical system's distribution capacity by increasing current flow and causing voltage drops. This fact sheet describes power factor and explains how you can improve your power factor to reduce electric bills and enhance your electrical system's capacity.**

Keywords—Micro-controller PIC 16f877A,Capacitor bank, Relays, APFC unit,Motor load & Proteus software.

I. INTRODUCTION

The low power factor leads to the increase in the load current, increase in power loss, and decrease in efficiency of the overall system. The various conventional methods for the power factor correction are the using static capacitors, synchronous condensers, phase advancers, etc. in all these methods, the switching of the capacitor or variation of the capacitance is manual. In this paper we are using a method of the reactive power compensation by capacitor switching with automatic control using micro-controller PIC 16f877A.

A. The two causes of poor power factor-

In practice, some devices do have unity power factors, but many others do not. A device has a poor power factor for one of two reasons; either it draws current out of phase with the supply voltage, or it draws current in a non-sinusoidal waveform. The out of phase case, known as 'displacement' power factor, is typically associated with electric motors inside industrial equipment, while the non-sinusoidal case, known as 'distortion' power factor, is typically seen with electronic devices such as PCs, copiers and battery chargers driven by switched-mode power supplies (SMPSs).
Electric motors create powerful magnetic fields which produce a voltage, or back emf, in opposition to the applied voltage. This causes the supply current to lag the applied voltage. The resulting out of phase current component cannot deliver usable power, yet it adds to the facility's required supply capacity and electricity costs. Power factors below 1.0 require a utility to generate than the minimum volt-amperes necessary to supply as low as 0.7, the apparent power would be 1.4 times the real power used by the load the real power (watts).

B. Techniques for measuring the power factor

The power factor in a single-phase circuit (or balanced three- phase circuit) can be measured with the wattmeter-ammeter- voltmeter method, where the power in watts is divided by the product of measured voltage and current. The power factor of a balanced polyphase circuit is the same as that of any phase.

C. Why improve the power factor

A high power factor allows the optimization of the components of an installation. Overrating of certain equipment can be avoided, but to achieve the best results, the correction should be effected as close to the individual inductive items as possible.

D. Reasons of Lower Power Factor:

Since power factor is defined as the ratio of KW to KVA, we see that low power factor results when KW is small in relation to KVA. Now the question arises what causes a large KVAR in a system? The answer is inductive

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loads.Inductive loads (which are sources of Reactive Power) include:

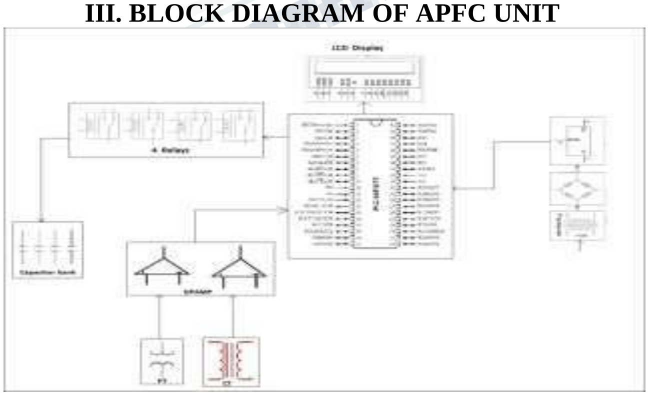
- Transformers
- Induction motors
- Induction generators (wind mill generators)
- High intensity discharge (HID) lighting

These inductive loads constitute a major portion of the power consumed in industrial complexes. Reactive power (KVAR) required by inductive loads increases the amount of apparent power (KVA) in our distribution system. This increase in reactive and apparent power results in a larger angle θ (measured between KW and KVA). Recall that, as θ increases, cosine θ (or power factor) decreases. So, inductive loads (with large KVAR) result in low power factor.

II. OVERVIEW OF DESIGN

The circuit uses standard power supply comprising of a step- down transformer from 230V to 9V,± 15V and 8diodes forming bridge rectifiers that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 1000μF. The filtered dc being unregulated, IC LM7805 is used to get 5V DC constant and IC LM7812, IC LM7912 to get ±12V.A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts. Relays allow one circuit to switch a second circuit which can electrical connection inside the relay between the two circuits; the link is magnetic and mechanical. A micro- controller is an interface between motor load and APFC unit.

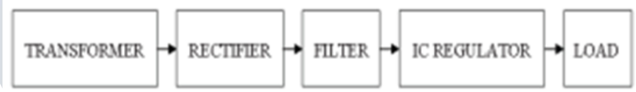
III. BLOCK DIAGRAM OF APFC UNIT



The various modules in the APFC panel are

- Power supply
  - Transformer
  - Rectifier
  - Voltage regulator
- Micro-controller (PIC16f877A)
- LCD display
- Capacitor bank
- Current transformer
- Potential transformer
- Relays and relay driver
- Motor load
- OP-AMP

A. Power Supply



The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies. This voltage regulation is usually obtained using one of the popular voltage regulator IC units. Here are the simulation & hardware design of Power supply units as shown in fig.a(i),fig.a(ii) & fig.a(iii)

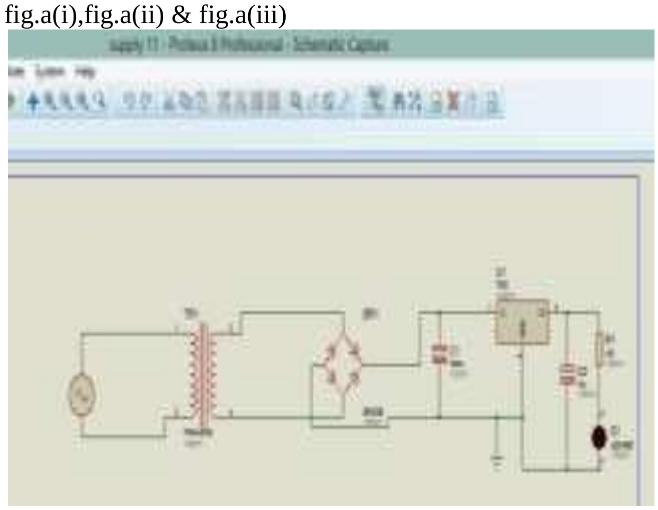


fig.a(i) Simulation of 5V power supply

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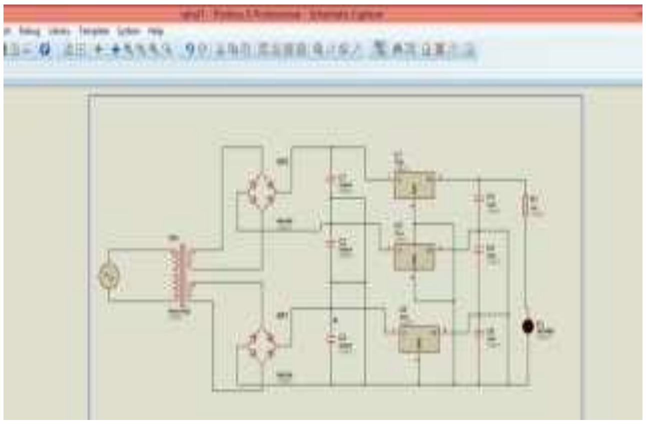


fig.a(ii) Simulation of 12V power supply.

fig.a(iii) Hardware design of power supply.

B. Micro-controller (PIC16f877A)

The PIC micro-controller PIC16f877a is one of the most renowned micro-controllers in the industry.One of the main advantages is that it can be write-erase as many times as possible because it use FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output as shown in fig.b.

fig.b Microcontroller IC

C. LCD display-

LCD stands for liquid crystal display they are used to show status of the product or provide interface for input or selecting some process. In an m*n LCD m denotes number of columns and n represents number of rows.

- Eight(8) data pins D0-D7
- Vcc (Apply +5 volt here)
- Gnd (Ground this pin)
- Rc (Register select)
- Rw (read - write)
- En (Enable)
- V0 (Set LCD contrast)

D. Capacitor Bank-

To reduce losses in the distribution system, and to reduce the electricity bill, power factor correction, usually in the form of capacitors, is added to neutralize as much of the magnetizing current as possible. Capacitors contained in most power factor correction equipment draw current that leads the voltage, thus producing a leading power factor. If capacitors are connected to a circuit that operates at a nominally lagging power factor, the extent that the circuit lags is reduced proportionately. In our unit we have used 4 capacitors of 2.5µf rating respectively these capacitors are added sequentially to the circuit with the help of relays as shown in fig.d(i).

fig.d. Capacitor bank

E. Current Transformer-

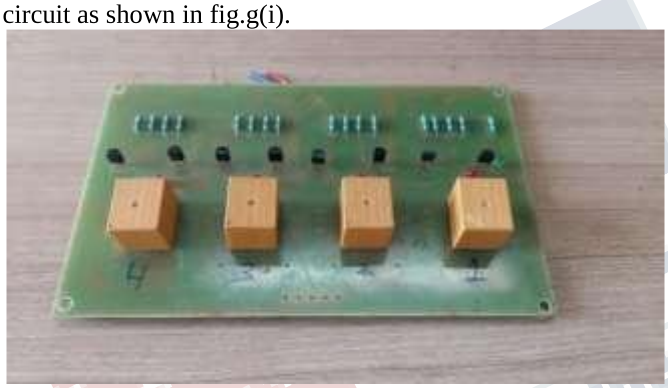
When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer also isolates the measuring instruments from what may be very high voltage in the monitored circuit. In the circuit we have used air core transformer for the measurement of current and also to give input to the OPAMP Air core transformer with ratio 250:1 is used with current rating of 15 amps.

F. Potential Transformer-

Voltage transformers (VT), also called potential transformers (PT), are a type of instrument transformer. The PT is typically described by its voltage ratio from primary to secondary. The potential transformer used is of the ratio 220:6V.

G. Relays-

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions. The relays used in the circuit are single pole double throw relay with rating of 12volt dc. The relays are used as switch to add capacitors in the circuits sequentially. The relays circuit is combined with BC547 NPN bipolar transistors which are used as switch to add and pull capacitors off the circuit as shown in fig.g(i).



F. Motor Load-

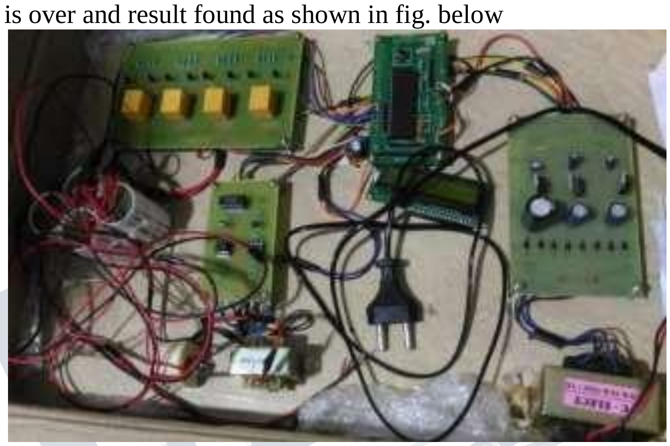
A load that is predominantly inductive, so that the alternating load current lags behind the alternating voltage of the load. An inductive load requires a magnetic field to operate and in creating such a magnetic field causes the current to be out of phase with the voltage or the current lags the voltage. In industries there is abundant use of such inductive loads. A single phase induction motor of 230volt, 0.25HP, 50 Hz is used as an inductive load against which power factor is improved.

G. OPAMP -

OPAMP stands for operational amplifier. An inductive load requires a magnetic field to operate and in creating such a magnetic field causes the current to be out of phase with the voltage (the current lags the voltage). An inductive load requires a magnetic field to operate and in creating such a magnetic field causes the current to be out of phase with the voltage (the current lags the voltage).

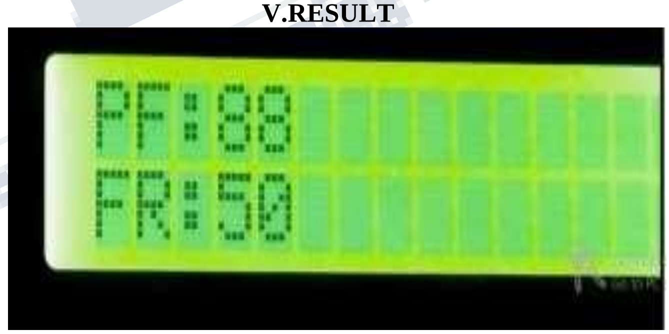
IV. COMPLETE HARDWARE DESIGN

Combining all PCB and component together the hardware design obtain and completed with result before and after including APFC unit. The implementation and design work is over and result found as shown in fig. below

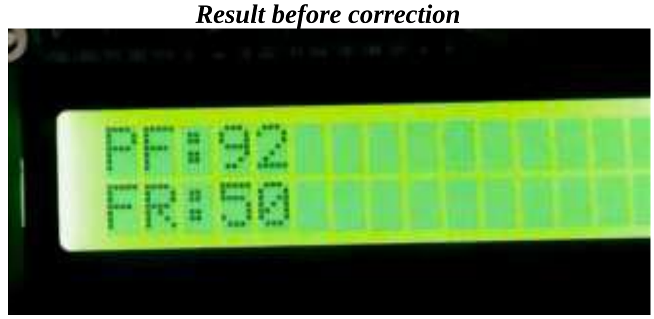


Complete hardware design

V.RESULT



Result before correction



Result After correction

V. CONCLUSION

It can be concluded that power factor correction technique can be applied to the industries, power systems and also house hold to make them stable and due to that the system becomes stable and efficiency of the systems as well as the apparatus increases. The power factor will not be corrected to unity but certainly, will be improved and the apparent power supplied by the AC supply will be reduced. They achieve better power quality by reducing the apparent power drawn from the AC supply and minimizing the power transmission losses. Hence the efficiency of the systems as well as the apparatus increases.

Future Scope-
The automotive power factor correction using capacitive load banks is very efficient as it reduces the cost by decreasing the power drawn from the supply. As it operates automatically, manpower are not required and this Automated Power factor Correction using capacitive load banks can be used for the industries purpose in the future.

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