AUTOMATIC POWER FACTOR CORRECTION BY USING CONTROLLER

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Abstract — *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. 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. Whenever we are thinking about any programmable devices then the latest technology comes into fore front. Which is now a day very much popular and are developed with Microcontroller based technology.*

Automatic power factor correction 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 modules. Then the motherboard calculates the compensation requirement and accordingly switches on different capacitor banks.

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.

Keywords: *power factor, APFC, Apparent power, Capacitor bank*

I. INTRODUCTION

In the present scenario of technological revolution, it has been observed that the power is very precious. The industrialization is primarily increasing the inductive loading; the Inductive loads affect the power factor so the power system losses its efficiency. There are certain organizations developing products and caring R&D work on this field to improve or compensate the power factor. In the present trend the designs are also moving forwards the miniature architecture; this can be achieved in a product by using programmable device. Which are Microcontroller based mostly. The advantages of using the microcontroller is the reduction of the cost and also the use of extra hardware such as the use of timer, RAM and ROM can be avoided. This technology is very fast so controlling of multiple parameters is possible; also the parameters are field programmable by the user.

The electrical engineering and its applications are the oldest streams of Engineering. Though these systems are quite reliable and cheaper, it has certain disadvantages. The electro mechanical protection relays are too bulky and needs regular maintenance. The multifunctional is out of question. Recently, the technical revolution made embedded technology cheaper, so that it can be applied to all the fields. The pioneer manufactures of Power system and protection system such as SIMENS, LARSON & TUBRO etc. manufacturing power factor improvement devices on embedded technology.

The Automatic Power Factor Correction device is a very useful device for improving efficient transmission of active power. If the consumer connects 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 device reads the power factor from line voltage and line current, calculating the compensation requirement switch on different capacitor banks.

II .PROBLEM STATEMENT

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.

The presence of reactive power causes the real power to be less than the apparent power, and so, the electric load has a power factor of less than 1. The reactive power increases the current flowing between the power source and the load, which increases the power losses through transmission and distribution lines. This results in operational and financial losses for power companies. Therefore, power companies require their customers, especially those with large loads, to maintain their power factors above a specified amount (usually 0.90 or higher) or be subject to additional charges. Electrical engineers involved with the generation, transmission, distribution and consumption of electrical power have an interest in the power factor of loads because power factors affect efficiencies and costs for both the electrical power industry and the consumers [3] [4]. In addition to the increased operating costs, reactive power can require the use of wiring, switches, circuit breakers, transformers and transmission lines with higher current capacities.

Power factor correction attempts to adjust the power factor of an AC load or an AC power transmission system to unity (1.00) 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 [5] [6].

III. SYSTEM STRUCTURE AND PRINCIPLE

A. POWER SUPPLY:

1. Power supply provides supply to all the chips and peripherals.
2. 230 V AC obtained from the mains is DC converted, rectified and filtered.
3. Regulated supply voltages include 5V, 12V. These voltages are used for the control.

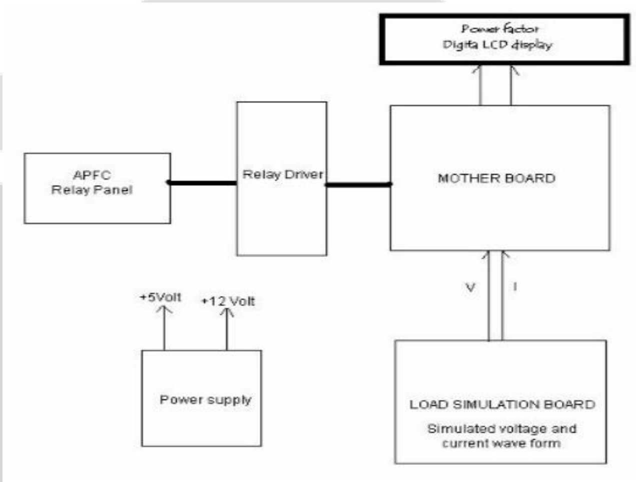

Figure1:block diagram of APFC unit

B. PIC16F877A

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

Features

2 PWM 10-bit
256 Bytes EEPROM data memory
ICD
25mA sink/source per I/O
Self Programming
Parallel Slave Port

C. ZERO CROSSING DETECTOR:

As the name indicates the zero crossing detector is a device for detecting the point where the voltage crosses zero in either direction. As shown in the circuit diagram 2 the first section is a bridge rectifier, which provides full wave rectified output. This is applied to the base of the transistor through a base resistor, R2. The capacitor charges to maximum of the bridge rectified output through the diode, D2. This charge is available to the transistor as VCC. The capacitance value is kept large in order to minimize ripple and get perfect dc. The transistor remains OFF until the Cut-in voltage VBE is reached. During the OFF period of the transistor the output will be high and approximately equal to VCC. Once the transistor is ON and IB increases according to the input wave, the transistor moves slowly towards saturation where the output reduces to the saturation voltage of the transistor which is nearly equal to zero Initially VBE = Cut-in voltage of diode, the capacitor will charge through the diode Vm where Vm is the maximum amplitude of the rectified wave. Now the diode is reverse biased and hence does not provide a discharging path for the capacitor, which in turn has two effects. Variation in VCC. It will provide base current to the transistor in the region where both diode and transistor are OFF.

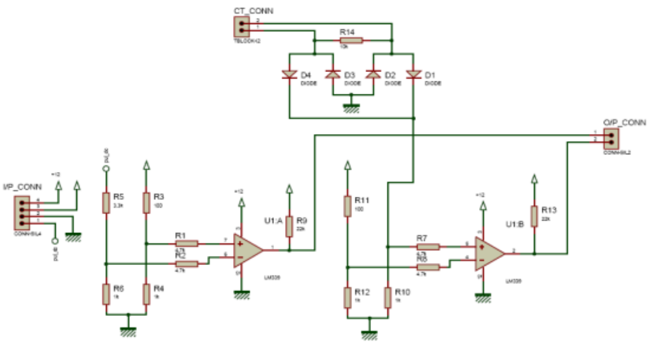

Figure2:zero crossing detector circuit

Thus an output square wave is produced whenever the input voltage crosses zero thereby acting as a zero crossing detector. A zero crossing detector literally detects the transition of a signal waveform from positive and negative, ideally providing a narrow pulse that coincides exactly with the zero voltage condition. At first glance, this would appear to be an easy enough task, but in fact it is quite complex, especially where high frequencies are involved. In this instance, even 1 kHz starts to present a real challenge if extreme accuracy is need.

D. CAPACITOR BANK

Capacitors are commonly used within a lot of power system, especially electronic constructed circuitry. In three phase power system, capacitors normally installed within an isolating non-conductor metal box, which called capacitor bank, they are fixed or switched. Fixed banks are connected permanently to the primary conductors through fused switches. Switch capacitors banks are tied to primary system through automated switch, allowing them to be put on line and taken off line as needed. Distribution power system usually connects capacitor in parallel rather connecting in series. The function of shunt power capacitor is to provide leading KVARS to an electrical system when and where needed. The actual capacitor in farads of a capacitor bank can be calculated using the following equation: [3] C= VAR/2πf*VR2 Where, VAR = capacitor unit var rating C= capacitor in farad F = frequency VR = capacitor unit rated voltage

V. SIMULATION AND OBSERVATIONS

The simulation tool used for the analysis of the APFC system is Proteus VSM. It is an interactive circuit simulation tool in the design environment. It is possible to draw a complete circuit for a micro-controller based system and then test it

interactively, all from within the same piece of software. For the educational user and engineering purpose, ISIS also used for producing attractive schematics. Following figure shows how APFC system looks like when running interactively

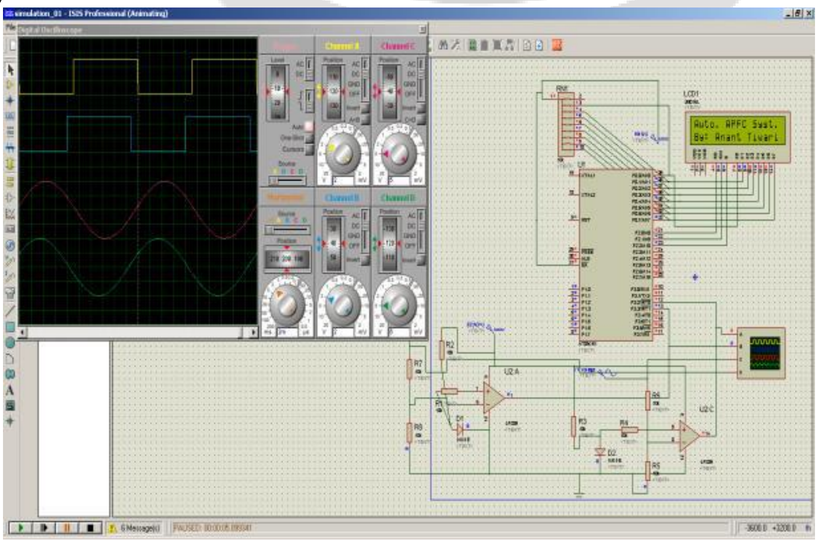

Figure 3: APFC Simulation on Proteus VSM

It shows input waveform of voltage and current with phase difference. Both of the waveforms are fed to zero crossing detectors, which give square waves in digital format. These digital waveforms are used by microcontroller to calculate power factor. Microcontroller takes decision to switch appropriate capacitor bank to compensate for power factor.

Figure given next represent the situation when power factor is very poor at 0.767. Low power factor is not accepted as per standard because poor or low power factors affect efficiencies and costs for both the electrical power industry and the consumers. In addition to the increased operating costs, reactive power can require the use of wiring, switches, circuit breakers, transformers and transmission lines with higher current capacities. Poor power factor needs to be compensated by capacitor bank.

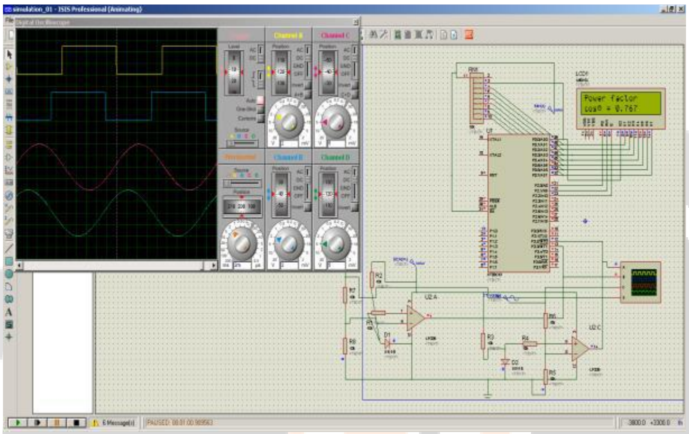

Figure 4: Poor power factor detection

After detecting poor power factor, APFC system switches one capacitor at a time out of a group of eight capacitors. If required goal to achieve power factor is meet then next cycle repeated else switching of capacitor continue till compensation is not under control. Figure given next shows APFC system when system achieves the optimum power factor value of 0.940 as required.

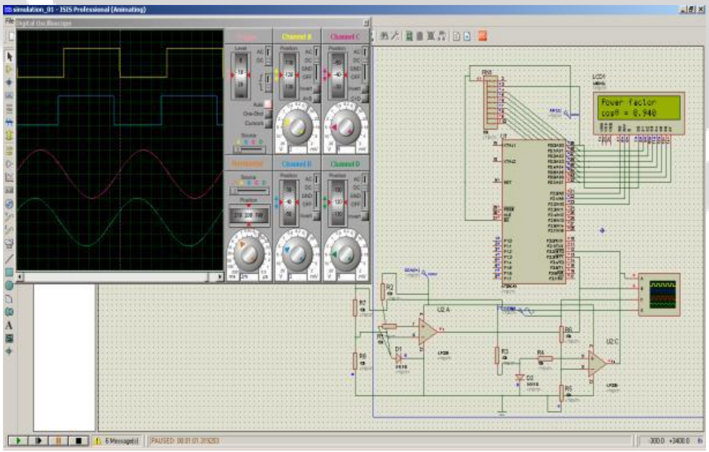

Figure 5: Improved power factor by APFC

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

IV. RESULTS AND CONCLUSIONS

By observing all aspects of the power factor it is clear that power factor is the most significant part for the utility company as well as for the consumer. Utility companies get rid from the power losses while the consumers are free from low power factor penalty charges.

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 [8]. By using this APFC system the efficiency of the system is highly increased.

V. FUTURE ENHANCEMENTS

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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REFERENCES

[1] en.wikipedia.org/wiki/Power_factor_correction

[2] Jones, L. D.; Blackwell, D. (1983) "Energy Saver Power Factor Controller for Synchronous Motors", IEEE Transactions on Power Apparatus and Systems, Volume: 5, Issue: 5, Pages: 1391-1394.

[3] Keith Harker (1998). "Power System Commissioning and Maintenance practice." London: Institution of Electrical Engineers.

[4] Stephen, J. C. (1999). "Electric Machinery and Power System Fundamentals." 3rd.ed. United State of America: McGraw-Hill Companies, Inc.

[5] Barsoum, Nader (2007) "Programming of PIC Micro-Controller for Power Factor Correction" IEEE Conference on Modeling & Simulation, Pages:19-25.

[6] Alexander, C.K. and Sadiku, M.N.O. (2000). "Fundamentals of Electric Circuit" United States of America: McGraw-Hill Companies, Inc

[7] Jos Arrillaga, Neville R. Watson (2003). "Power System Harmonics" 2nd.ed. Chichester: John Wiley.

[8] Ramasamy Natarajan (2005). "Power System Capacitors." Boca Raton, FL: Taylor & Francis.