Automatic Power Factor Controller using PSoC3

Sanjeev B. Jamge
Assistant Professor
Dept of Electronics Engineering
Walchand Institute of Technology, Solapur.
Solapur, India

Prajakta A. Devanpalli
PG Scholar
Dept of Electronics Engineering
Walchand Institute of Technology, Solapur
Solapur, India

***Abstract*— In recent years, the power quality of the AC system has become a great concern due to the rapidly increased numbers of inductive loads, electronic equipment, power electronics and high voltage power system. In order to reduce line losses and improve the transmission efficiency, power factor correction research became a hot topic. Many control methods for the Power Factor Correction (PFC) were proposed. This paper describes the design and development of a three-phase power factor correction using PSoC (Programmable System on Chip) micro-controlling chip. This involves measuring the power factor value from the load using current transformer, potential transformer, and zero crossing detector, and the algorithm will be implemented in PSoC Creator IDE (Integrated Development Environment) to switching on and switching off the capacitors in order to compensate excessive reactive power, thus bringing power factor near to unity.**

Keywords*— Zero Crossing Detector (ZCD), Programmable System on Chip (PSoC3), PSoC Creator TM

I. INTRODUCTION

The main objective of this project is to design an energy saving scheme for an industrial distribution network. This can be achieved by decreasing the network losses and improving the main electric load operation to a better efficiency level. The designed scheme is concerned with improving the power factor of the system by adding shunt capacitors to the network at optimal size and location. Industrial power system encounters increase in power losses and increase in the type of load is accompanied with low power factor which leads to huge transfer of reactive power from the utility through the system. The main drawback of this problem is increase in the system losses and reduction in the voltage level. It can result in poor reliability, safety problems and higher energy costs. The lower our power factor, the less economically our system operates. The actual amount of power being used or dissipated in a circuit is called true power. Reactive loads such as inductors and capacitors make up what is called reactive power. The linear combination of true power and reactive power is called apparent power. Power system loads consist of resistive, inductive, and capacitive loads.

Examples of resistive loads are incandescent lighting and electric heaters. Inductive loads are induction motors, transformers, and reactors and capacitive loads are capacitors, variable or fixed capacitor banks, motor starting capacitors, generators, and synchronous motors. Low power factor is not that much problem in domestic's area but it becomes a problem in industry where multiple large motors are used so there is requirement to correct the power factor. Thus Power factor correction is usually achieved by adding capacitive load to offset the inductive load present in the power system. There are many benefits to having power factor correction.

II. POWER FACTOR

It is defined as the cosine angles between voltage and current in an AC circuit. Ideally voltage and current should be in phase. Due to inductive or capacitive loads the line voltage and the current are not in phase. There is generally a phase difference ϕ between voltage and current. The term Cosϕ is called the Power Factor of the circuit. In an AC circuit, if it is inductive the current lags behind the voltage and the power factor is referred to as lagging, however in capacitive circuit, current leads the voltage and power factor is said to be leading. Thus, power factor may also be defined as the ratio of active power to the apparent power. This is perfectly general definition and can be applied to all cases.

From the fig.1

i.e. $(KVA)^2 = (KW)^2 + (KVAR)^2$

$$\therefore \text{Power Factor} = \frac{\text{Active Power}}{\text{Apparent Power}} = \frac{KW}{KVA}$$

$\therefore$ Active Power = VI cos Φ

$\therefore$ Apparent Power = VI

$$\therefore \text{Power Factor} = \frac{VI \cos \Phi}{VI} = \cos \Phi$$

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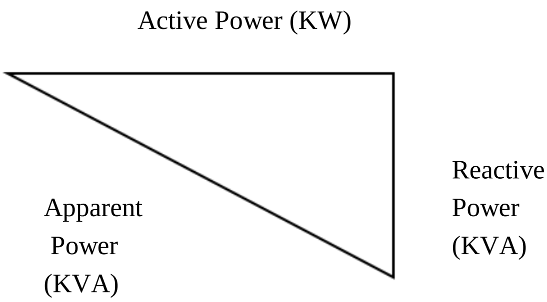

Fig.1. Power factor triangle in terms of power

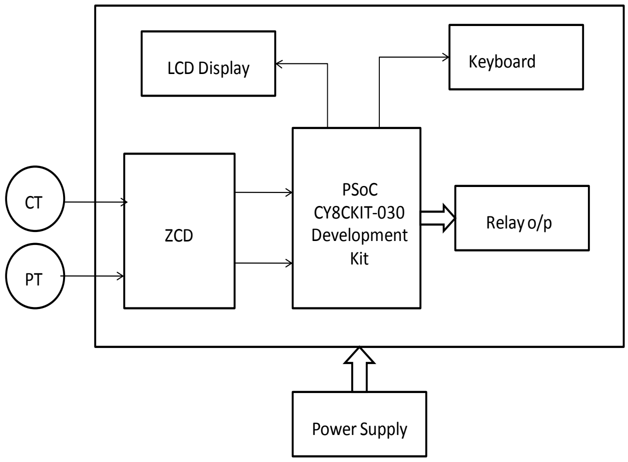

Fig.2. Power Factor Controller Block Diagram

III. BENEFITS OF POWER FACTOR CORRECTION

The advantages that can be achieved by applying the correct power factor correction are:

- Reduction of electricity bills.
- Extra KVA available from the existing supply.
- Reduction of I^2R losses in transformers and distribution equipment.
- Improves Voltage Drop.
- Extended equipment life- reduced electrical burden on cables and electrical components.
- Avoid Penalty for Low Power Factor.

IV. METHODOLOGY

A Power Factor Correction scheme is presented for three phase low power factor loads. This new scheme measure the angle between the voltage of Y and B phase and current of R phase, this will give us a sinϕ relation. Also from the voltage of YB phase and current of R phase we calculate reactive and active power in KVAR and KWA of the system. From these parameters it is easy to estimate the required power factor. The scheme involves the application of bank of capacitors controlled by a micro-controller such as PSoC3 to balance the phases and correct the power factor to higher values.

Hardware :

The proposed work can be explained in the form of block diagram as shown in fig. 2. It comprises of following six blocks.

- Voltage & current measurement unit.
- Zero Crossing Detector (ZCD) unit.
- Keyboard
- Relay Output
- LCD Display
- Programmable System on Chip (PSoC3) unit.

4.1 Voltage & current measurement unit

The AC supply is connected to the resistive and inductive load. Current transformer (CT) is connected series with line, and Potential transformer (PT) is connected parallel with supply line. CT & PT are used to step down the voltage and current level for Zero Crossing Detector (ZCD). The output of CT & PT are given as input for ZCD.

4.2 Zero Crossing Detector unit

The Zero Crossing Detector is a sine-wave to square-wave converter. The reference voltage in this case is set to zero. Thus, the Zero Crossing Detector detects the point where the voltage and current crosses zero in either direction. By using this two waveform we can find out power factor of the line, hence power factor is cos ϕ, angle between the voltage and current waveform is ϕ.

4.3 Keyboard

4 Keys (2 x 2) are provided for the user to set or change the required parameters in the Power Factor Correction, and also allow the user to change into various modes of operations.

4.4 Relay Output

Relay outputs are provided which operate to connect or disconnect the capacitor banks depending upon of the power factor conditions.

4.5 LCD Display

A 16 x 2 alphanumeric display is used for display interface. It displays the various factors like Power Factor, Reactive power, Active power, and Capacitor bank status.

4.6 Programmable System on Chip (PSoC3) unit

It is the heart of the system. After getting all the parameters related to voltage and current it calculates the sin ϕ , cos ϕ , Power factor and the Reactive power. Various controlling actions or measures that have to be taken and directed by the PSoC microcontroller unit.

"PSoC" is an application related review of programmable array systems, the system-on-chip. Cypress's PSoC Creator software is a state-of-the-art, easy-to-use integrated development environment (IDE) that introduces a hardware and software design environment based on classic schematic entry and revolutionary embedded design. The CY8CKIT-030 PSoC3 Development Kit is based on the PSoC3 family of devices. PSoC3 is a Programmable System-on-Chip™ platform for 8- and 16-bit applications. It combines precision analog and digital logic with a high-performance CPU. The following is PSoC kit used in project.

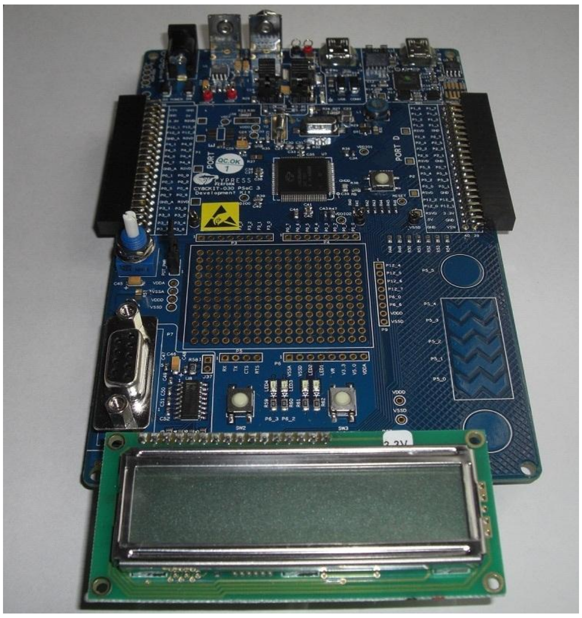

Fig.3. PSoC3 Kit

Software :

PSoC Creator is a successful design tool allows for the rapid development and deployment of both simple and complex designs. It reduces or eliminates any learning curve. It makes the integration of a new design into the production stream straightforward.

PSoC Creator is a full featured Integrated Development Environment (IDE) for hardware and software design. It is optimized specifically for PSoC devices and combines a modern, powerful software development platform with a sophisticated graphical design tool. This unique combination of tools makes PSoC Creator the most flexible embedded design platform available.

V. CONCLUSION

This paper is an attempt to implement the entire system that we talked about using a single System-on-Chip (SoC), such as the PSoC mixed-signal chip with programmable analog and programmable digital logic manufactured by Cypress Semiconductor. The proposed system will be implemented using PSoC Creator Integrated Development Environment (IDE).

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