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Automatic Power Factor Correction using Microcontroller

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Abstract-The main aim of this project is to enhance the power quality by constantly monitoring the load p.f. , when the load p.f. drops below a definite value it results in the rise of line current resulting in more line loss and greater voltage drop. So a method is to be developed to improve power factor automatically. Inductive loads are main reasons for low power factor in power systems. Therefore we need to develop a method to improve power factor automatically. Automatic power factor controller project provides solution to this problem. Low power factor creates unnecessary loading on transmission lines. By inserting the capacitances of required magnitude p.f. can be improved therefore improving the efficiency of the system. . In this project, power factor correction unit is developed with microcontroller section, relays, p.t., c.t. and z.c.u.
Keywords-APFC(Automatic Power Factor Compensation), IC, capacitors ,embedded technology ,power factor, ZCD(Zero Crossing Detector, p.f.(power factor), zero crossing unit (z.c.u.), P.T.(potential transformer) and C.T.(current transformer).

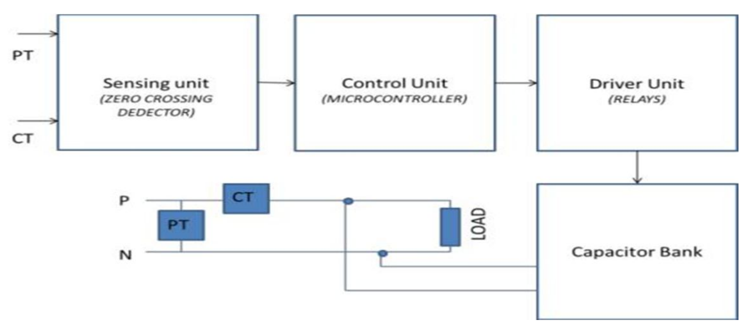
I. INTRODUCTION

In the APFC unit the power factor is sensed from load line by calculating the repress in the arrival of the current with respect to voltage from the power supply with high accuracy by using an internal timer. This time values are then regulated as phase angle and corresponding p.f. Then the microcontroller regulates the needed compensation and introduces the various values of required capacitances for APFC.

APFC 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 from the power supply with high accuracy by using an internal timer. Now the values are then assigned as phase angle and corresponding p.f. Then the required compensation is adjusted and various values of capacitance are introduced. APFC 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 increases. The cost is reduced with the help of microcontroller.

II. CASE STUDY

A. Block Diagram



1) *Zero Crossing Detector:* ZCD is a voltage comparator. Its main purpose is to change the output between positive saturation voltage +Vsat and negative saturation voltage –Vsat.The comparator is basically a op-amp(operational amplifier).It compares two voltages simultaneously varies the output on the basis of comparison. ZCD is a sine wave to square wave converter. The o/p of the comparator can drive various outputs such as an LED indicator, a relay and a control gate. If input voltage is a low frequency signal, then output voltage will be less quick to switch from one saturation point to another. And if there is any distortion in between two input ports, the output may vary between positive and negative saturation voltage V sat. Here IC311 is used as ZCD. In this circuit LM111 voltage comparator IC is used for Zero crossing detector.

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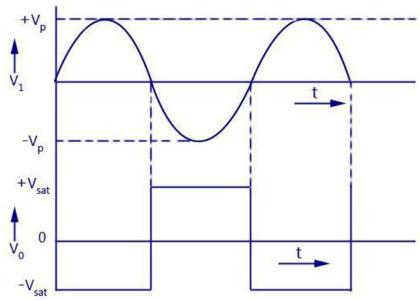
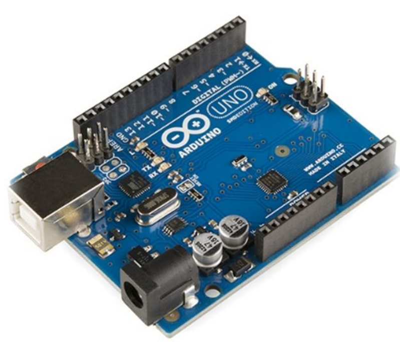
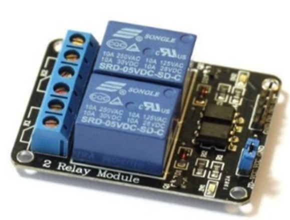
This device is designed to operate from a wide range of power-supply voltages, including ±15-V supplies for operational amplifiers and 5-V supplies for logic systems.



2) *Microcontroller (Arduino):* Arduino Uno includes an ATmega328 microcontroller and it has 28-pins. The pin configuration of the Arduino Uno board is shown in the above. It consists of 14-digital i/o pins. Where in 6 pins are used as pulse width modulation o/ps and 6 analog i/ps, a USB connection, a power jack, a 16MHz crystal oscillator, a reset button and an ICSP header. Arduino board can be powered either from the personal computer through a USB or external source like a battery or an adaptor.it can be operated by providing an external power supply ranging from 7 volts to 12 volts by providing voltage reference through input output reference pin or through Voltage input pin. In the Arduino board Harvard architecture is used in which the program code and program data are provided separate memory slots. It consists of two memories such as program memory and data memory. The data memory stores the data and the flash program memory stores the code. The board features an Atmel ATmega328 microcontroller operating at 5 V with 2Kb of RAM, 32 Kb of flash memory for storing programs and 1 Kb of EEPROM for storing parameters.



3) *Driverunit (relays):* Relays are used to switch the capacitance value by using the output of microcontroller.



4) *Capacitors:* Whenever an inductive load is connected to the transmission line, power factor lags because of lagging load current. For regulation a capacitor of required rating is connected which draws a current leading in nature with source voltage. The final result id p.f. improvement.

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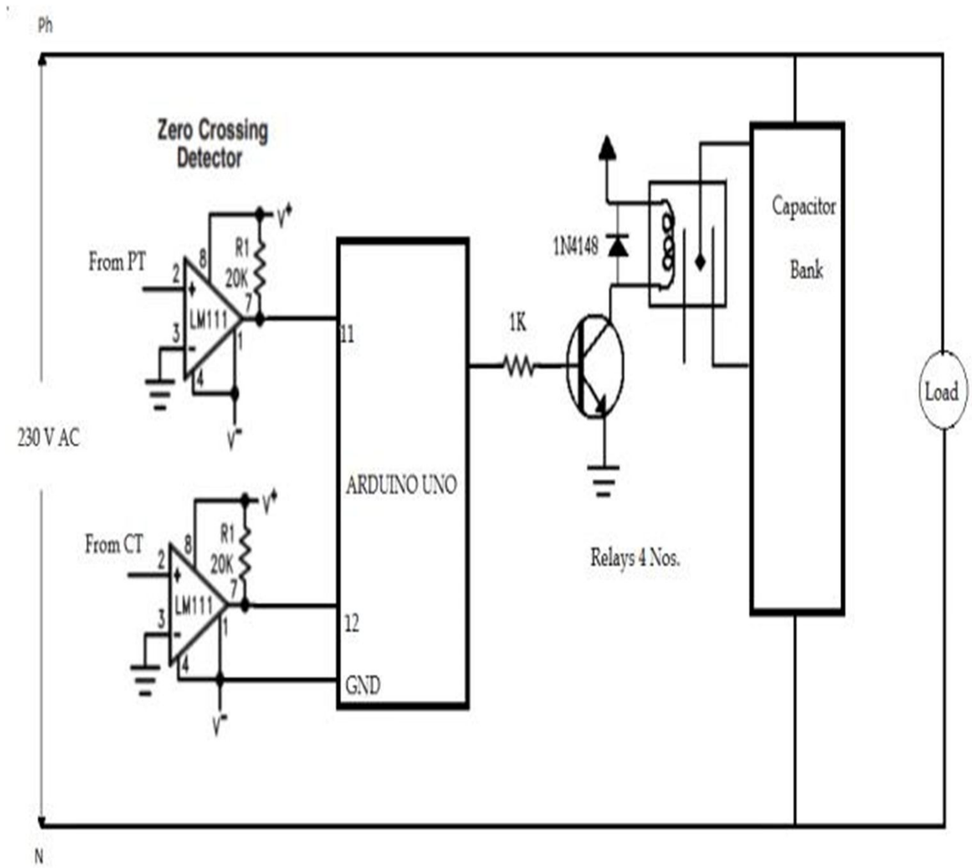
III. CIRCUIT DESCRIPTION



Circuit model of APFC is shown in Fig. The above circuit consists of ZCD, microcontroller, relay driver circuit, capacitor bank, and inductive load. The input power is single phase AC, 50Hz. Arduino Uno is used to calculate the lagging power factor and add the correct capacitance value. The relay driving circuit is operated by microcontroller, inserting the different values of capacitances. Capacitor bank has various ratings of capacitances in KVAR .There is a parallel connection between load and capacitor. The voltage and current in the circuit are analysed by current transformer and potential transformer.

IV. POWER FACTOR CORRECTION

The input power is taken from the ZCD and is provided to the microcontroller, which starts a counter in milliseconds if a red signal appears on P.T. and a positive signal from C.T. counter will stop. The time period is given by ΔT

Phase Angle $\varphi° = 360° * F * \Delta T$

ΔT - time lag between voltage and current waveform.

F-supply frequency

V. CAPACITOR CALCULATION

When the magnitude of reactive power increases, a capacitor of appropriate value is added thus reducing it. The values of capacitor is rated in KVAR. Here there are two calculations for the capacitor calculation first method is to add the capacitance by referring the standard capacitor table, but this method can be suitable for manual operations only. Another method for calculating the value of capacitance is given below:

Original power factor = $\cos\varphi 1$

Required power factor = $\cos\varphi 2$

$\varphi 1 = \cos\text{-}1$

$\varphi 2 = \cos\text{-}1$

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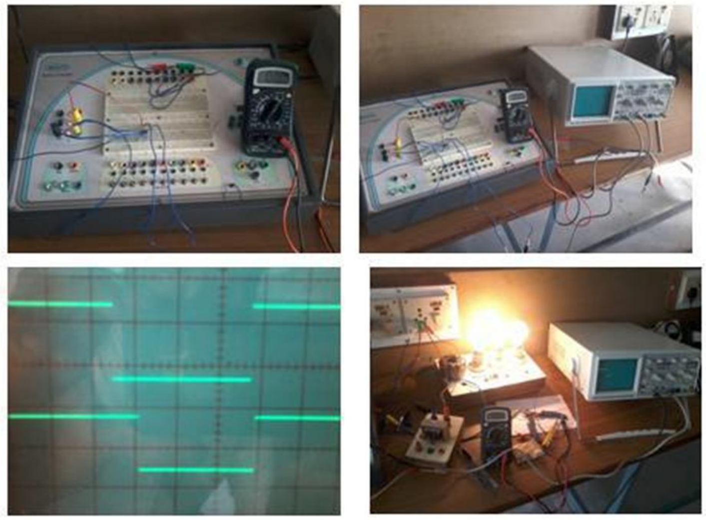
Required KVAR $= \mathrm{KW} * \tan \varphi 1 - \tan \varphi 2$

VI. HARDWARE ANALYSIS



Circuit connection of ZCD and its output are shown in this image. The output is shown on a CRO. Two waveforms are shown by CRO one is current waveform and other is voltage waveform.

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