

Microcontroller Based Automatic Power Factor Correction

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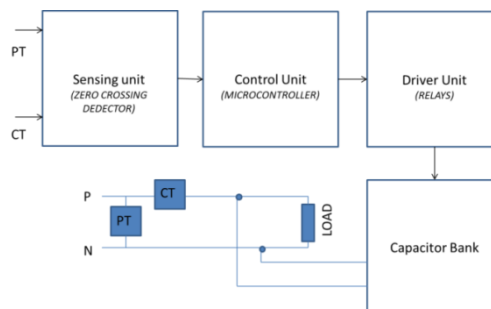
ABSTRACT: In the present technological revolution power is very precious. So we need to find out the causes of power loss and improve the power system performance. Due to industrialization the use of inductive load increases and hence power system losses its efficiency. So we need to improve the power factor with a suitable method. Whenever we are thinking about any programmable devices then the embedded technology comes into fore front. The embedded technology is now a days very much popular and most of the products were developed with microcontroller (ARDUINO) based embedded technology.

KEYWORDS: Automatic power factor correction, embedded technology, Efficiency of the system increases, Improve the power system performance.

I. INTRODUCTION

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 from the power supply with high accuracy by using an internal timer. This time values are then calibrated as phase angle and corresponding power factor. Then the microcontroller 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 increases. The use of microcontroller reduces the costs.

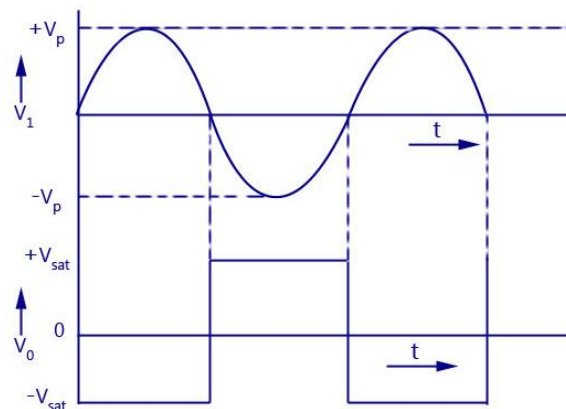
II. BLOCK DIAGRAM



1. ZERO CROSSING DETECTOR

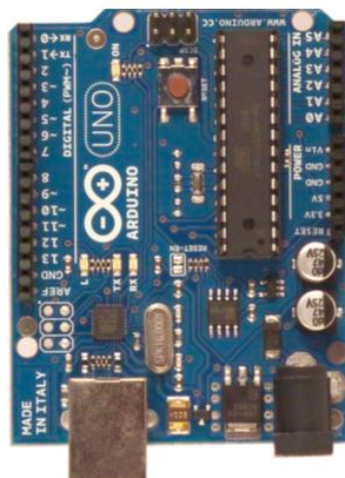
The zero crossing detector is a sine-wave to square-wave converter. The reference voltage in this case is set to zero. The output voltage waveform shows when and in what direction an input signal crosses zero volt. If input voltage is a low frequency signal, then output voltage will be less quick to switch from one saturation point to another. And if

there is noise in between the two input nodes, the output may fluctuate between positive and negative saturation voltage V_{sat} . Here IC 311 is used as a zero crossing detector. In this circuit LM111 voltage comparator IC is used for Zero crossing detector. Features of LM111 are given below: Operates from Single 5V Supply, Input Current 150 nA Max. Over Temperature, Differential Input Voltage Range $\pm 30V$, Power Consumption 135 mW at $\pm 15V$.



2. MICROCONTROLLER (ARDUINO)

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions. We are using the compile software arduino uno to execute the programs and it downloads to the controller board through USB cable. LCD display is used to show the current, voltage and power factor values.



3. DRIVER UNIT (relays):

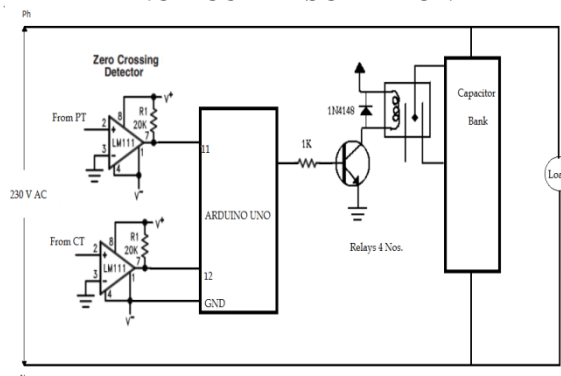
Relays are used to switch the capacitance value by using the output of microcontroller. The relays driver board is shown below:



4. CAPACITORS:

Capacitors are used to increase the real power, it gives a leading power factor load. So we are adding the capacitors in inductive loads. Capacitor is a reactive current generator, so it is used for the power factor correction. It is rated in KVAR.

II. CIRCUIT DESCRIPTION



Circuit model of APFC is shown in Fig.1. This circuit consists of zero crossing detector, 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. Relay driver circuit is controlled by microcontroller for switching the capacitance. Capacitor bank has variable ratings of capacitors in KVAR. These capacitors are parallel connected with source. CT and PT are used to sense the voltage and current waveforms in the circuit.

III. POWER FACTOR CORRECTION

The input to the microcontroller is taken from the zero crossing detectors, whenever there is a positive signal from the potential transformer and counter gets started in milliseconds and when there is a positive signal from current transformer counter will stop. The time period is Δt ,

$$\text{PHASE ANGLE } \varphi^\circ = 360^\circ * f * \Delta t$$

Where,

1. Δt - time delay between voltage and current waveform.

2. f -supply frequency.

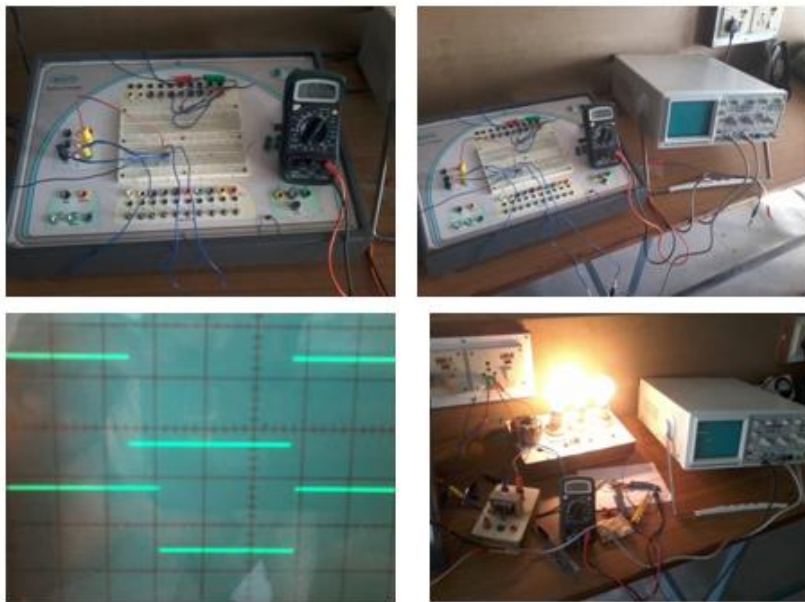
$$POWER FACTOR = \cos\phi^\circ$$

IV. CAPACITOR CALCULATION

When there is an increase in reactive power, capacitance will be added automatically and reduces the reactive power. The capacitance values are 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. The other method is finding the capacitance value using formulas the formulas are given below.

$$\begin{aligned} ORIGINAL PF &= \cos\phi_1 \\ REQUIRED PF &= \cos\phi_2 \\ \phi_1 &= \cos^{-1} \\ \phi_2 &= \cos^{-1} \\ REQUIRED KVAR &= KW * (\tan\phi_1 - \tan\phi_2) \end{aligned}$$

V. HARDWARE ANALYSIS



This images consists of zero crossing detector circuit connection and its output. The output is seen by using CRO. The CRO monitor shows two waveforms the first wave form is voltage waveform and the second one is current waveform.

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