

# Power Saver for Industries and Commercial Establishments

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**Abstract:** This paper is designed to reduce the power loss in industries by power factor compensation through a number of shunt capacitors. This results in reduction in amount of electrical bill for industries and commercial establishments. Power factor is defined as the ratio of real power to apparent power. Reactive power is the non working power generated by the magnetic and inductive loads, to generate magnetic flux. The increase in reactive power increases the apparent power, so the power factor also decreases. Having low power factor, the industry needs more energy to meet its demand, so the efficiency decreases. In this proposed system the time lag between the zero voltage pulse and zero current pulse duly generated by suitable operational amplifier circuits in comparator mode are fed to two interrupt pins of the microcontroller. Microcontroller displays the power loss due to the inductive load on the LCD. The program takes over to actuate appropriate number of relays at its output to bring shunt capacitors into the load circuit to get zero power loss. In this paper, the 8 bit microcontroller used which belongs to 8051 family.

**Keywords:** Embedded system, Keil compiler, Microcontroller 8051, Power factor, Zero crossing detector.

## Introduction

Today's technologically advanced world is witnessing quite a large number of innovations requiring huge volumes of power, and thus power has become a very precious source. So we need to find out the ways to minimize power loss and improve the efficiency of power systems. In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

The power factor of an AC electric power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number between 0 and 1 [1]. Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power [2].

Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors [3, 6]. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor [4]. The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment. A non-linear load on a power system is typically a rectifier (such as used in a power supply), or some kind of arc discharge device such as a fluorescent lamp, electric welding machine, or arc furnace. Because current in these systems is interrupted by a switching action, the current contains frequency components that are multiples of the power system frequency. Distortion power factor is a measure of how much the harmonic distortion of a load current decreases the average power transferred to the load.

Due to industrialization, the use of inductive load has increased and hence the power systems are losing efficiency. In this paper, the proposed system is designed to reduce the power loss in industries by improving the power factor by adding the capacitive load to equalize the inductive load in the power system.

## Main Components of the Proposed System

### Embedded Systems

An Embedded System is a combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a specific function [5]. An embedded system is a microcontroller-based, software driven, reliable, real-time control system, autonomous, or human or network interactive, operating on diverse physical variables and in

diverse environments and sold into a competitive and cost conscious market as shown in Fig. 1. Embedded systems have a microprocessor/ microcontroller and a memory. Some have a serial port or a network connection.

Embedded system has two types such as high-end embedded & lower end embedded systems. High-end embedded system is generally 32, 64 Bit Controllers used with OS. Examples of this are personal digital assistant and mobile phones etc. Lower end embedded systems is generally 8, 16 Bit controllers used with a minimal operating systems and hardware layout designed for the specific purpose.

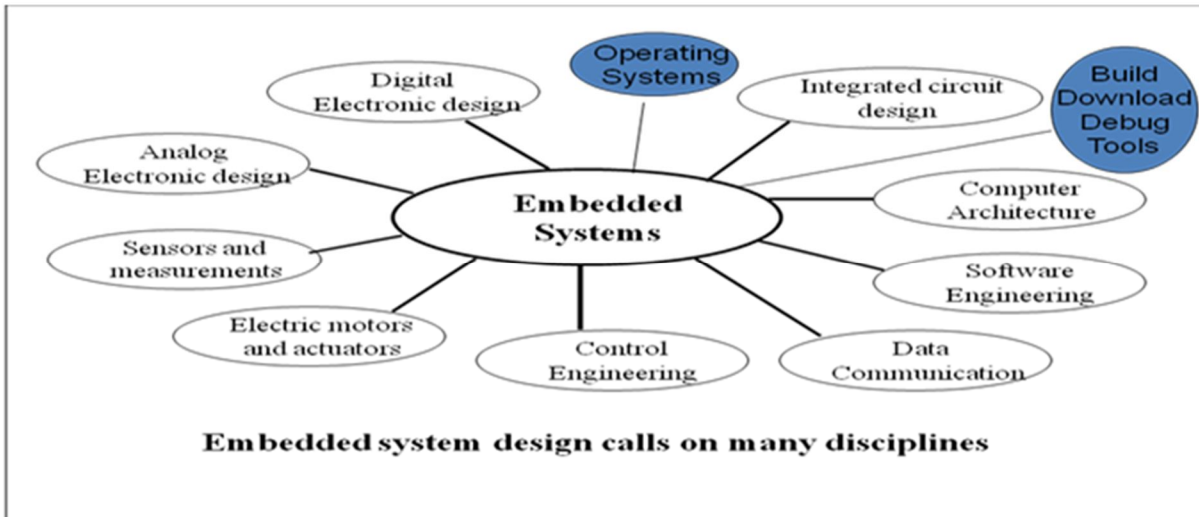


Figure 1: Embedded system design calls

Because most embedded projects have severe cost constraints, they tend to use low-cost processors like the 8051 family of devices considered in this book. These popular chips have very limited resources available most such devices have around 256 bytes (not megabytes!) of RAM, and the available processor power is around 1000 times less than that of a desktop processor. As a result, developing embedded software presents significant new challenges, even for experienced desktop programmers.

### Software Requirements

Keil development tools for the 8051 Microcontroller Architecture support every level of software developer from the professional applications engineer to the student just learning about embedded software development. When starting a new project, simply select the microcontroller you use from the Device Database and the  $\mu$ Vision IDE sets all compiler, assembler, linker, and memory options for you. Keil is a German based Software development company [7].

The Keil ARM tool kit includes three main tools, assembler, compiler and linker. An assembler is used to assemble the ARM assembly program [10]. A compiler is used to compile the C source code into an object file. A linker is used to create an absolute object module suitable for our in-circuit emulator.

### Operation Explanation

#### Circuit Explanation

This circuit consists of DC power supply unit, zero voltage crossing detectors, Micro-controller [9], LCD display, Relays and Capacitor bank and Load circuit as shown in Fig. 2. Let us see how it operates. The required DC power supply for Micro-controller and other peripherals is supplied by the DC power supply.

For the calculation of the power factor by the Micro-controller we need digitized voltage and current signals. The voltage signal from the mains is taken and it is converted into pulsating DC by bridge rectifier and is given to a comparator which generates the digital voltage signal. Similarly the current signal is converted into the voltage signal by taking the voltage drop of the load current across a resistor of 10 ohms. This A.C signal is again converted into the digital signal as done for the voltage signal. Then these digitized voltage and current signals are sent to the micro-controller. The micro-controller calculates the time difference between the zero crossing points of current and voltage, which is directly proportional to the power factor and it determines the range in which the power factor is. Micro-controller sends information regarding time difference between current and voltage and power factor to the LCD display to display them, Depending on the range it sends

the signals to the relays through the relay driver. Then the required numbers of capacitors are connected in parallel to the load. By this the power factor will be improved and saving in power is displayed on the 16x2 LCD.

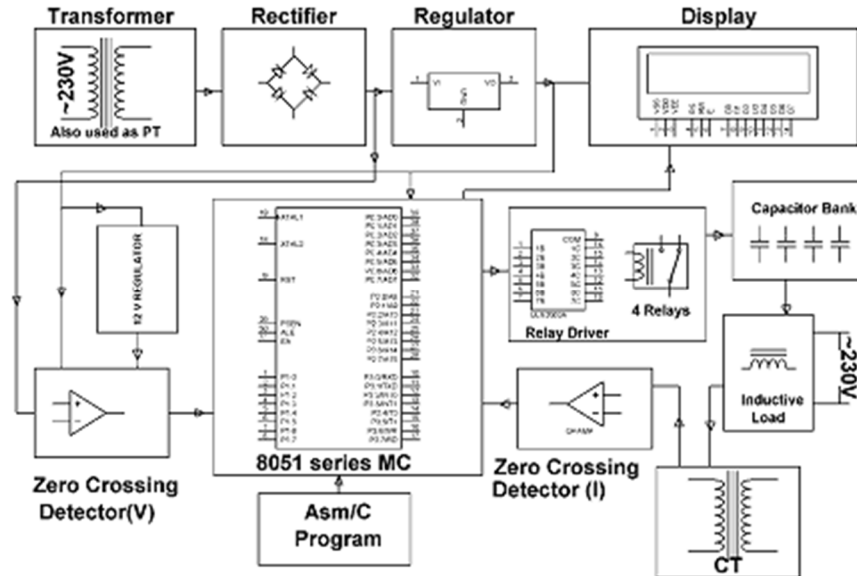


Figure 2: Block diagram of the project

### Connections

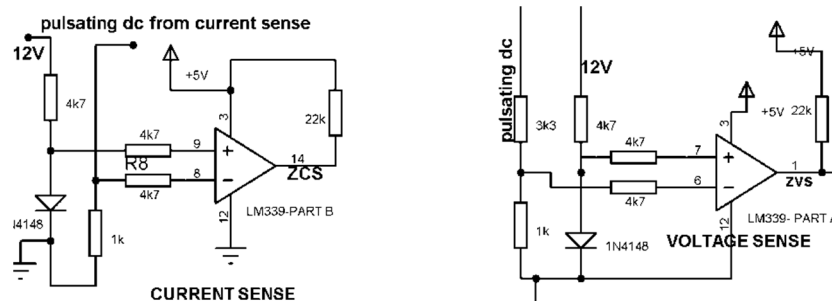
The output of power supply which is 5v is connected to the 40th pin of microcontroller and ground to the 20th pin or pin 20 of microcontroller. Port 0.1 to 0.4 of microcontroller is connected to Pin 1to 4 of relay driver IC ULN2003. Port 0.5 to 0.7 of microcontroller is connected to Pin 4,5 and 6 of LCD display. Port 2.0 to 2.7 of microcontroller is connected to Pin 7 to 14 of data pins of LCD display. Port 3.1 of microcontroller is connected to output of the OP-Amp (A) LM339. Port 3.3 of microcontroller is connected to output of OP-Amp (B) LM339.

### Working

The output of the regulator 7805 is given to the Microcontroller 40th pin. The pulsating dc is fed to R11 and R24 Resistor's. The unregulated voltage is fed to 7812. 7805 output which is 5v is fed to 40th pin of Microcontroller. The output of the 7812 regulator is 12v and is fed to op-Amp. In this circuit we have another bridge rectifier it gives an output as pulsating dc corresponding to the current flowing across the load. The LCD display is connected to corresponding pins. Relay driver drive's relay's and the contacts of relays switch ON the shunt capacitors.

In order to generate ZVS (Zero Voltage Sensing) pulses first we need to step down the supply voltage to 12 V and then it is converted into pulsating D.C. Then with the help of potential divider the voltage of 3 V is taken, which is given to a comparator LM339 part A [10]. The comparator generates the zero crossing pulses by comparing this pulsating D.C with a constant D.C of 0.6 V forward voltage drop across a silicon diode.

Similarly for ZCS (Zero Current Sense) the voltage drop proportional to the load current across a resistor of 10R/10W is taken and is stepped up by a CT to feed to a bridge rectifier to generate pulsating dc for the comparator to develop ZCS as explained above like ZVS. Description of ZVS and ZCS are shown in the Fig. 3 below [8].



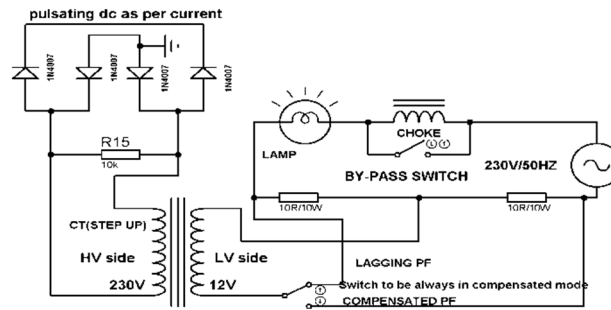


Figure 3: Description of ZVS and ZCS

## Hardware Testing

### Continuity Test

In electronics, a continuity test is the checking of an electric circuit to see if current flows (that it is in fact a complete circuit) [8]. A continuity test is performed by placing a small voltage (wired in series with an LED or noise-producing component such as a piezoelectric speaker) across the chosen path. If electron flow is inhibited by broken conductors, damaged components, or excessive resistance, the circuit is "open".

Devices that can be used to perform continuity tests include multi meters which measure current and specialized continuity testers which are cheaper, more basic devices, generally with a simple light bulb that lights up when current flows.

An important application is the continuity test of a bundle of wires so as to find the two ends belonging to a particular one of these wires; there will be a negligible resistance between the "right" ends, and only between the "right" ends.

This test is the performed just after the hardware soldering and configuration has been completed. This test aims at finding any electrical open paths in the circuit after the soldering. Many a times, the electrical continuity in the circuit is lost due to improper soldering, wrong and rough handling of the PCB, improper usage of the soldering iron, component failures and presence of bugs in the circuit diagram. We use a multi meter to perform this test. We keep the multi meter in buzzer mode and connect the ground terminal of the multi meter to the ground. We connect both the terminals across the path that needs to be checked. If there is continuation then you will hear the beep sound.

### Power on Test

This test is performed to check whether the voltage at different terminals is according to the requirement or not. We take a multi meter and put it in voltage mode. Remember that this test is performed without microcontroller. Firstly, we check the output of the transformer, whether we get the required 12 V AC voltage.

Then we apply this voltage to the power supply circuit. Note that we do this test without microcontroller because if there is any excessive voltage, this may lead to damaging the controller. We check for the input to the voltage regulator i.e., are we getting an input of 12v and an output of 5v. This 5v output is given to the microcontrollers' 40th pin. Hence we check for the voltage level at 40th pin. Similarly, we check for the other terminals for the required voltage. In this way we can assure that the voltage at all the terminals is as per the requirement. Completed power saver device for industries and commercial establishments is shown in Fig. 4.

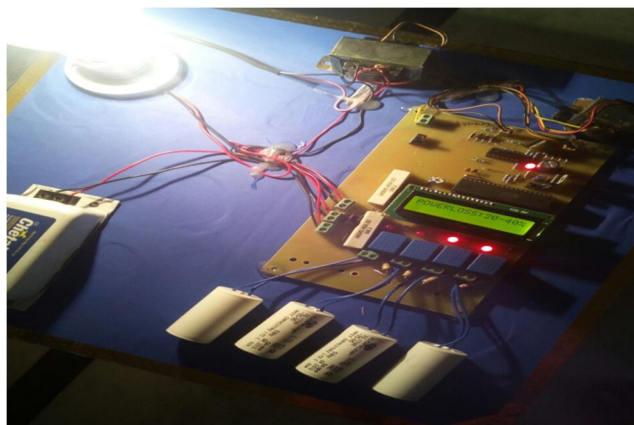


Figure 4: Power saver device for industries and commercial establishments

## Conclusion

This paper is made to read the power factor by calculating the time lag between line voltages and line current from ZVS and ZCS circuits. This time values are then adjusted as phase angle, and then the corresponding power factor values are calculated by a microcontroller. Depending on the power-factor values, the capacitor banks are switched by appropriate relays. These power-factor values are also displayed on the 2x16 LCD modules. This is developed by using 8051 microcontroller. It will reduce the power loss in industries by power factor compensation through a number of shunt capacitors. This results in reduction in amount of electrical bill for industries and commercial establishments.

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