A PROJECT REPORT ON

"AUTOMATIC POWER FACTOR CORRECTION" BACHELOR IN ELECTRICAL ENGINEERING

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF THE DEGREE OF BACHELOR OF ENGINEERING

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CERTIFICATE

This is to certify that the project entitled "**AUTOMATIC POWER FACTOR CORRECTION**" is a Bonafide work of **JAMBHALE ASHUTOSH SURESH (15EE12), SAEEDURREHMAN KHAN(13EE41), SHEIKH ALTAMASH ASHFAQUE CHANDNI (16EE33), SHAIKH MOHD SUFIYAN ALI MOHD JAWWAD(17EE43)** Students of B.E.(Electrical Engineering) and is submitted to the University of Mumbai, in partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering in Electrical Engineering from Anjuman-I-Islam's Kalsekar Technical Campus affiliated to Mumbai University.

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DECLARATION

I declare that this written submission represents my ideas in my own words where others' ideas and works have been included, I have adequately cited and referred to the original sources and also declared that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea or data or fact or source in submission. I understand that any violation of the above will be cause for disciplinary action by the institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ACKNOWLEDGEMENT

I have great pleasure in presenting a report on," **AUTOMATIC POWER FACTOR CORRECTION",** which has progressed smoothly because of the efforts and support from a number of people. The satisfaction and the euphoric company of successful completion of any task would be incomplete without mentioning the people whose constant guidance and encouragement made it possible. I take pleasure in presenting before you, project which is the result of a studied blend of both research and knowledge.

I express our earnest gratitude to our internal guide, **Prof. RIZWAN FARADE**, Head of the Department of Electrical engineering, and project guide **Mr. MOHSIN KHAN**, for his constant support, encouragement, and guidance. I am grateful for his cooperation and valuable suggestions.

Finally, I express my gratitude to the principal and all other members who are involved either directly or indirectly in the completion of this project.

LIST OF FIGURES:

Figure 1.1	Block diagram of APFC system	10
Figure 3.1	power factor correction	21
Figure 3.2	Block diagram of APFC system	24
Figure 3.3	Motherboard connection to LCD	25
Figure 3.4	The internal architecture of the Microcontroller	31
Figure 3.5	Pin diagram of 8051 Microcontroller	31
Figure 3.6	Applications of Microcontroller	33
Figure 3.7	Full-wave bridge rectifier circuit	34
Figure 3.8	Full wave center-tapped circuit and output waveform	35
Figure 3.9	Potential transformer	36
Figure 3.10	Connection of potential transformer	36
Figure 3.11	Current transformer	37
Figure 3.12	Pin diagram of relay switches	38
Figure 3.13	Circuit diagram of relay driver IC	39
Figure 3.14	Circuit diagram of Non-inverting amplifier	40

LIST OF ABBREVIATIONS:

1. MPFC - Manual power factor corrector system
2. APFC - Automated power factor corrector system
3. PIC - Program interrupt control
4. µC - Microcontroller
5. I/O - Input/output
6. MCU - Microcontroller unit
7. TS - Toggle switches
8. IEEE - Institute of Electrical and Electronics Engineers
9. IE - Interrupt Enable
10. PT - Potential transformer
11. CT - Current transformer
12. RS - Relay switches
13. GND - Ground
14. INT - Interrupt

ABSTRACT

This project is mainly proposed for reducing the power loss in industries by using power factor compensation through a number of shunt capacitors. Power factor is defined as the ratio of real power to apparent power.
So, the increase in reactive power (real power) increases the apparent power, so the power factor also decreases. By having a low power factor , the industry needs more energy to meet its demand, so the efficiency decreases.

In this system , we proposed the time lag between zero voltage pulse and zero current pulse delay generated by suitable op-amp circuits in comparator mode and fed into two interrupt pins in the microcontroller.
The microcontroller displays the power loss due to inductive load on the LCD.
This process is continuously actuated until the power loss would be zero by using relays which are used to bring the shunt capacitors into the load circuit. an 8-bit microcontroller is used in this project which belongs to the 8051 family.

CHAPTER 1
INTRODUCTION

In the olden days, industries used loads for more power utilization, and the loads which are highly inductive in nature for example like induction motors, AC/DC drives, welding machines, electronic controls, and computers. There may be a few resistive loads such as heaters and incandescent bulbs.

There are very few industries that may have capacitive loads like synchronous motors. Therefore, the net industrial load is highly inductive that leads to a very bad lagging power factor. If the power factor is left which is uncorrected, then the industry will require a high maximum demand from the electricity board and will also suffer a fine for poor power factor.

Usually, standard practice is to connect the power capacitors in the power system at appropriate places so that the inductive nature of the load can be compensated. So, the power factor is used in this project to reduce the power loss in industries and by using the shunt capacitors.

The power factor is about the ratio of real power to apparent power. So it is mathematically represented as KW/KVA where the numerator is active(real) and the denominator is the (active+ reactive) or apparent power. The increase in the reactive power increases the apparent power so that the power factor also decreases. Having a low power factor, the Industry needs more energy to meet its demand, so the efficiency decreases.

1.1. BLOCK DIAGRAM FOR APFC SYSTEM:

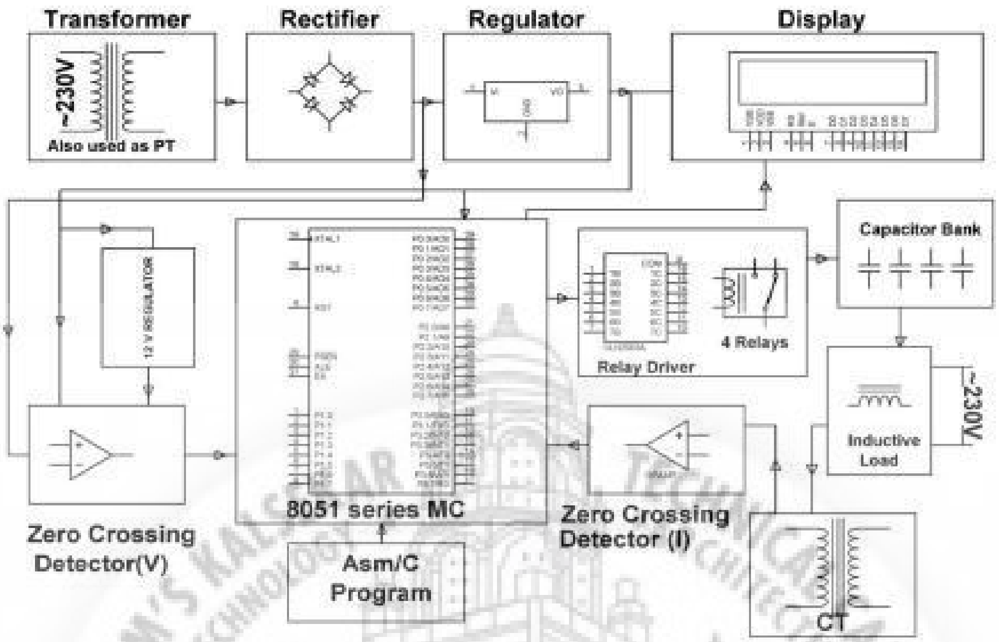


Fig.1.1 Block diagram of APFC system

❖ **Microcontroller:**

Here we are using a PIC16F7X 8-bit microcontroller which is the most elementary part of these whole APFC systems.

- It is used to calculate the phase differences between the square waveforms at the zero-crossing detectors.
- It is used for the power factor and it gives the output power loss which is delayed at LCD.
- It controls the capacitor bank as it is required to compensate for leading or lagging the power factor.

❖ **Rectifier:**

The input from the potential transformer is Rectified and pulsating DC voltage is produced as the output.

❖ **Filter:**

The rectifier gives pulsating DC as the output. filters are used for removing the unwanted AC –components and producing pure DC voltage.

- **Buzzer:**

The buzzer is used to indicate the information to the user if there is any error or alarm indication.

- **LCD:**

The LCD is used for displaying the status of the APFC system such as leading or lagging and calculating the power factor etc.

CHAPTER 2

INTRODUCTION TO EMBEDDED SYSTEMS

An embedded system is designed to perform one or many dedicated functions, sometimes with real-time computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today as they control many of the common devices we use. Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance.

Some embedded systems are mass-produced, benefiting from economies of scale. Physically, embedded systems range from portable devices such as digital watches and MP3 players to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants.
Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals, and networks mounted inside a large chassis or enclosure.
In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, handheld computers share some elements with embedded systems — such as the operating systems and microprocessors which power them — but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular kind of the application device. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines, and toys (as well as the more obvious cellular phone and PDA) are among the myriad possible hosts of an embedded system. Embedded systems that are programmable are provided with a programming interface, and embedded systems programming is a specialized occupation.

2.1 APPLICATIONS OF EMBEDDED SYSTEM

We are living in the Embedded World. You are surrounded by many embedded products and your daily life largely depends on the proper functioning of these gadgets. Television, Radio, CD player of your living room, Washing Machine or Microwave Oven in your kitchen, Card readers, Access Controllers, Palm devices of your workspace enable you to do many of your tasks very effectively. Apart from all these, many controllers embedded in your car take care of car operations between the bumpers, and most of the time you tend to ignore all these controllers.
Fast applications make you believe that your basic survival is controlled by these embedded products. Now you can agree to the fact that these embedded products have successfully invaded our world. You must be wondering about these embedded controllers or systems.

What is this Embedded System?

These desktop computers are manufactured to serve many purposes and applications. You need to install the relevant software to get the required processing facility. In contrast, embedded controllers carry out a specific work for which they are designed. Most of the time, engineers design these embedded controllers with a specific goal in mind. So these controllers cannot be used in any other place. Theoretically, an embedded controller is a combination of a piece of microprocessor-based hardware and suitable software to undertake a specific task.
These days designers have many choices in microprocessors/microcontrollers. Especially, in 8 bit and 32 bit, the available variety really may overwhelm even an experienced designer. Selecting the right microprocessor may turn out to be the most difficult first step and it is getting complicated as new devices continue to pop up very often.
In the 8 bit segment, the most popular and used architecture is Intel's 8031.
Market acceptance of this particular family has driven many semiconductor manufacturers to develop something new based on this particular architecture. Even after 25 years of existence, semiconductor manufacturers still come out with some kind of device using this 8031 core.

2.1.1- MILITARY AND AEROSPACE

SOFTWARE APPLICATIONS:

From in-orbit embedded systems to jumbo jets to vital battlefield networks, designers of mission-critical aerospace and defense systems requiring real-time performance, scalability, and high-availability facilities consistently turn to the Lynx OS® RTOS and the LynxOS-178 RTOS for software certification to DO-178B. Rich in system resources and networking services, Lynx OS provides an off-the-shelf software platform with hard real-time response backed by powerful distributed computing (CORBA), high reliability, software certification, and long-term support options. The LynxOS-178 RTOS for software certification, based on the RTCA DO- 178Bstandard, assists developers in gaining certification for their mission- and critical systems Real-time systems programmers get a boost with Linux Works' DO-178BRTOS training courses. Lynxos-178 is the first DO-178B and EUROCAE/ED-12Bcertifiable, POSIX®-compatible RTOS solution.

2.1.2 COMMUNICATIONS APPLICATIONS:

"Five-nine" availability, Compact PCI hot-swap support, and hard real-time response...Lynx OS delivers on these key requirements and more for today's carrier-class systems. Scalable kernel configurations, distributed computing capabilities, integrated communications stacks, and fault management facilities make Lynx OS the ideal choice for companies looking for a single operating system for all embedded telecommunications applications—from complex central controllers to simple line/trunk cards.

2.1.3 ELECTRONICS APPLICATIONS AND CONSUMER DEVICES:

As the number of powerful embedded processors in consumer devices continues to rise, the Blue Cat® Linux® operating system provides a highly reliable and royalty-free option for systems designers. As the wireless appliance revolution rolls on, web-enabled navigation systems, radios, personal communication devices, phones, and PDAs all benefit from the cost-effective dependability, proven stability, and full product life-cycle support opportunities associated with Blue Cat embedded Linux. Blue Cat has teamed up with industry leaders to make it easier to build Linux mobile phones with Java integration. For makers of low-cost consumer electronic devices who wish to integrate the Linux OS real-time operating system into their products, we offer special MSRP- based pricing to reduce royalty fees to a negligible portion of the device's MSRP.

2.1.3 INDUSTRIAL AUTOMATION AND PROCESS CONTROL SOFTWARE:

Designers of industrial and process control systems know from experience that Linux operating systems provide the security and reliability that their industrial applications require.
From ISO-9001-certification to fault tolerance, POSIX conformance, secure partitioning, and high availability, they have got it all.

CHAPTER 3
HARDWARE IMPLEMENTATION

3.1. POWER FACTOR:

INTRODUCTION:

This project is mainly proposed for reducing the power loss in industries by using power factor compensation through a number of shunt capacitors. Power factor is defined as the ratio of real power to apparent power. Power factor is about the ratio of real power to apparent power .
So it is mathematically represented as KW/KVA where the numerator is active(real) and the denominator is the (active+ reactive) or apparent power. The increase in the reactive power increases the apparent power ,so that power factor also decreases . Having a low power factor , the industry needs more energy to meet its demand , so the efficiency decreases.

3.1.1 LITERATURE REVIEW:

In olden days industries used loads for more power utilization and the loads which are highly inductive in nature for example like induction motors, AC/DC drives, welding machines , electronic controls , and computers. There may be a few resistive loads such as heaters and incandescent bulbs.
There are very few industries which may have capacitive loads like synchronous motors. Therefore, net industrial load is highly inductive that leads to a very bad lagging power factor. If the power factor is left which is uncorrected , then the industry will require a high maximum demand from electricity board will also suffer a fine for poor power factor.Usually, standard practice is to connect the power capacitors in the power system at appropriate places so that the inductive nature of the load can be compensated. So, the power factor is used in this project to reduce the power loss in industries and by using the shunt capacitors. Power factor is about the ratio of real power to apparent power. So it is mathematically represented as KW/KVA where the numerator is active (real) and the denominator is the (active+ reactive) or apparent power. The increase in the reactive power increases the apparent power, so that power factor also decreases . Having a low power factor , the Industry needs more energy to meet its demand , so the efficiency is decreased.

EXISTING METHOD:

The most common problem for all industrial companies in the power factor correction of electrical loads.

METHOD-1: In earlier days , the power factor correction was done by using the resistive loads which provides the most power loss at the output.

METHOD-2: In the second method, the power factor correction was done by using the capacitive load bank which was done by manual changes but it gives only less amount of increased inefficiency.

PROBLEMS IN ALREADY EXISTING METHOD:

The major problem for industries is to decrease in power lagging and leading the less power loss. The real power is less than the apparent power because of the presence of reactive power and so, the power factor of electric load is less than 1. The current flowing between the power source and the load increases due to the reactive power , which in turn increases the power losses through transmission and distribution lines which results in financial and operational losses for power companies.

PROPOSED METHOD:

In this project we proposed one system . So, that proposed system gives that time lag between the zero voltage pulse zero current pulse delay is generated by suitable op-amp circuits in comparator mode and fed to two interrupt pins of the microcontroller.
Microcontroller displays the power loss due to inductive load on the LCD . Here we are using an 8-bit microcontroller.
The automated power factor corrector (APFC) using a capacitive load bank is helpful in the power factor correction . The proposed automated project includes measuring the power factor value from the load by using a microcontroller. The design of this auto-adjustable power system always preserves unity power factor.
This process takes over to actuate an appropriate number of relays at its output to bring shunt capacitors into the load circuit until to get zero power loss. APFC helps us to correct the power factor which helps to improve efficiency.

3.1.1. INTRODUCTION TO POWER FACTOR:

The power factor is about the ratio of real power to apparent power.
So , it is mathematically represented as KW/KVA where the numerator is active (real) and the denominator is the (active+ reactive) or apparent power. The increase in the reactive power increases the apparent power , so that power factor also decreases. Having a low power factor , the industry needs more energy to meet its demand , so the efficiency decreases.

3.1.2 APFC system:

In this system , we proposed the time lag between zero voltage pulse and zero current pulse delay generated by suitable op- amp circuits in comparator mode and fed into two interrupt pins in the microcontroller. Microcontroller displays the power loss due to inductive load on the LCD. This process is continuously actuated until the power loss would be zero by using relays which are used to bring the shunt capacitors into the load circuit. an 8-bit microcontroller is used in this project which belongs to the 8051 family. 3.1.4 .General description of this APFC system.

- Power Factor Definition: Power factor is the ratio between the KW and the KVA drawn by an electrical load where the KW is the actual load power and the KVA is the apparent load power. It is a measure of how effectively the current is being converted into useful work output and more particularly is a good indicator of the effect of the load current on the efficiency of the supply system.

- All current flow causes losses both in the supply and distribution system. A load with a power factor of 1.0 results in the most efficient loading of the supply. A load with a power factor of, say, 0.8, results in much higher losses in the supply system and a higher bill for the consumer. A comparatively small improvement in power factor can bring about a significant reduction in losses since losses are proportional to the square of the current.

- When the power factor is less than one the missing power is known as reactive power which unfortunately is necessary to provide a magnetizing field required by motors and other inductive loads to perform their desired functions. Reactive power can also be interpreted as wattles, magnetizing or wasted power and it represents an extra burden on the electricity supply system and on the consumer‘s bill.

- A poor power factor is usually the result of a significant phase difference between the voltage and current at the load terminals, or it can be due to a high harmonic content or a distorted current waveform.

- A poor power factor is generally the result of an inductive load such as an induction motor, a power transformer, and ballast in a luminary, a welding set, or an induction furnace. A distorted current waveform can be the result of a rectifier, an inverter, a variable speed drive, a switched-mode power supply, discharge lighting, or other electronic loads.

- A poor power factor due to inductive loads can be improved by the addition of power factor correction equipment, but a poor power factor due to a distorted current waveform requires a change in equipment Design or the addition of harmonic filters.

- Some inverters are quoted as having a power factor of better than 0.95 when, in reality, the true power factor is between 0.5 and 0.75. The figure of 0.95 is based on the cosine of the angle between the voltage and current but does not take into account that the current waveform is discontinuous and therefore contributes to increased losses.

- An inductive load requires a magnetic field to operate and creating such a magnetic field causes the current to be out of phase with the voltage (the current lags the voltage). Power factor correction is the process of compensating for the lagging current by creating a leading current by connecting capacitors to the supply.

- P.F (Cos Ǿ)= K.W / KVA Or P.F (Cos Ǿ)= True Power / Apparent Power.

  KW is Working Power (also called Actual Power or Active Power or Real Power). It is the power that actually powers the equipment and performs useful work.

- KVAR is Reactive Power.

- It is the power that magnetic equipment (transformer, motor, and relay)needs to produce the magnetizing flux.

- KVA is Apparent Power.

- It is the ―vectorial summation‖ of KVAR and KW.

- An induction motor draws current from the supply that is made up of resistive components and inductive components. The resistive components are

  1) Load current

  2) Loss of current.

  And the inductive components are:

  3) Leakage reactance.

  4) Magnetizing current.

- The current due to the leakage reactance is dependent on the total current drawn by the motor, but the magnetizing current is independent of the load on the motor. The magnetizing current will typically be between 20% and 60% of the rated full load current of the motor. The magnetizing current is the current that establishes the flux in the iron and is very necessary if the motor is going to operate.

- The magnetizing current does not actually contribute to the actual work output of the motor. It is the catalyst that allows the motor to work properly. The magnetizing current and the leakage reactance can be considered passenger components of current that will not affect the power drawn by the motor but will contribute to the power dissipated in the supply and distribution system.

- Take for example a motor with a current draw of 100 Amps and a power factor of 0.75 The resistive component of the current is 75 Amps and this is what the KWh meter measures. The higher current will result in an increase in the distribution losses of (100 x 100) /(75 x 75) = 1.777 or a 78% increase in the supply losses.

- In the interest of reducing the losses in the distribution system, power factor correction is added to neutralize a portion of the magnetizing current of the motor. Typically, the corrected power factor will be 0.92 – 0.95

❖ Power factor correction is achieved by the addition of capacitors in parallel with the connected motor circuits and can be applied at the starter, or applied at the switchboard or distribution panel. The resulting capacitive current is the leading current and is used to cancel the lagging inductive current flowing from the supply.

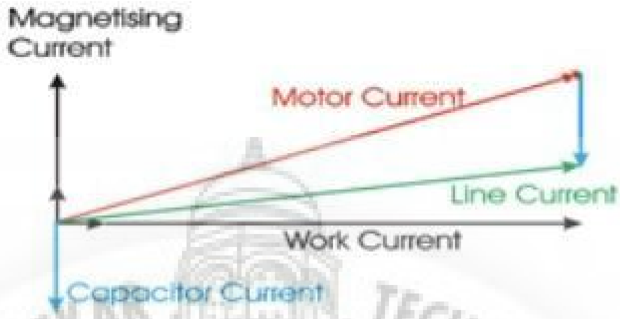


Fig.3.1 Power factor correction

Displacement Static Correction (Static Compensation).

As a large proportion of the inductive or lagging current on the supply is due to the magnetizing current of induction motors, it is easy to correct each individual motor by connecting the correction capacitors to the motor starters.
With static correction, it is important that the capacitive current is less than the inductive magnetizing current of the induction motor. In many installations employing static power factor correction, the correction capacitors are connected directly in parallel with the motor windings.

When the motor is Off-Line, the capacitors are also Off-Line. When the motor is connected to the supply, the capacitors are also connected providing correction at all times that the motor is connected to the supply. This removes the requirement for any expensive power factor monitoring and control equipment.
In this situation, the capacitors remain connected to the motor terminals as the motor slows down. An induction motor, while connected to the supply, is driven by a rotating magnetic field in the stator which induces current into the rotor. When the motor is disconnected from the supply, there is for a period of time, a magnetic field associated with the rotor. As the motor decelerates, it generates voltage out its terminals at a frequency that is related to its speed.

The capacitors connected across the motor terminals form a resonant circuit with the motor inductance. If the motor is critically corrected, (corrected to a power factor of 1.0) the inductive reactance equals the capacitive reactance at the line frequency and therefore the resonant frequency is equal to the line frequency. If the motor is over-corrected, the resonant frequency will be below the line frequency. If the frequency of the voltage generated by the decelerating motor passes through the resonant frequency of the corrected motor, there will be high currents and voltages around the motor/capacitor circuit. This can result in severe damage to the capacitors and motor. It is imperative that motors are never over-corrected or critically corrected when static correction is employed.
Static power factor correction should provide capacitive current equal to 80% of the magnetizing current, which is essentially the open shaft current of the motor.

The magnetizing current for induction motors can vary considerably. Typically, magnetizing currents for large two-pole machines can be as low as 20% of the rated current of the motor while smaller low speed motors can have a magnetizing current as high as 60% of the rated full load current of the motor
Where the open shaft current cannot be measured, and the magnetizing current is not quoted, an approximate level for the maximum correction that can be applied can be calculated from the half load characteristics of the motor.

It is dangerous to base correction on the full load characteristics of the motor as in some cases, motors can exhibit a high leakage reactance, and correction to 0.95 at full load will result in overcorrection under no load, or disconnected conditions.

Static correction is commonly applied by using an e contactor to control both the motor and the capacitors. It is better to practice using two contactors, one for the motor and one for the capacitors. Where one contactor is employed, it should be up-sized for the capacitive load. The use of a second contactor eliminates the problems of resonance between the motor and the capacitors.

3.1.5. Block Diagram:

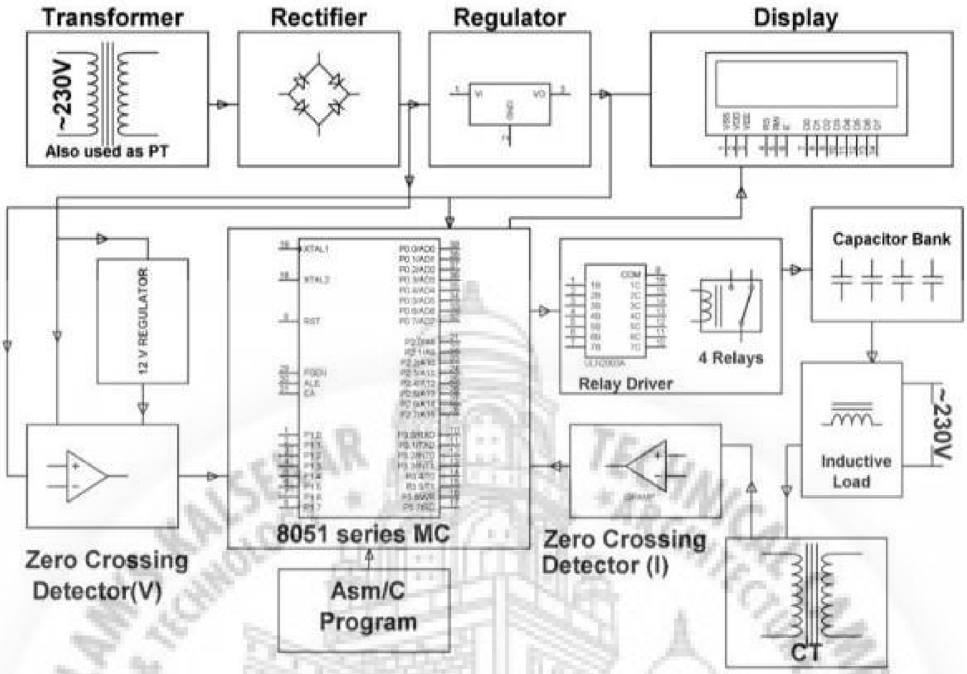


Fig.3.2.Block diagram of APFC system

3.1.6. HARDWARE DESCRIPTION:

The controller operates on +5 V dc, the regulated +v 5 v is supplied to pin no. 40 and ground at pin no. 20. The controller used here needs not to be required to handle high-frequency signals, as a 12 MHz crystal is used for operating the processor. The pin no. 9 is supplied with a +5V dc by using a push switch. To reset the processor, prepared codes are stored in the internal memory of flash memory +Vcc. connected to pin no.31.

Port Assignment:
Port 1:-Firstly Input is given to the
LCD
Port 2:- Then Input to relay driver
Port3.0 & Port3.1:- Input port from the function generator.
Input port increment is P1.6
P1.7 is used as on input port decrement

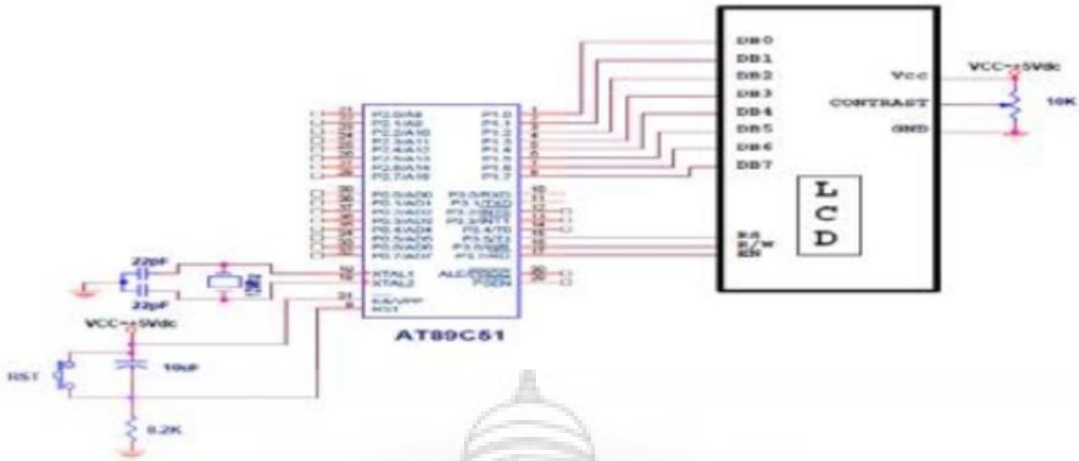


Fig 3.3 Motherboard Connection to LCD

The block diagram of the automatic power factor correction system is shown below. The circuit gets its input from the regulated power supply. The AC input i.e., 230V from the mains supply is step down by using the step-down transformer to 12V and is then fed to a rectifier. The pulsating DC voltage is obtained from the rectifier. So in order to get a pure DC voltage, the output voltage from the rectifier is then fed to a filter so that all AC components present will be removed even after rectification.

3.1.7. FUNCTIONING OF BLOCK DIAGRAM:

Automatic Power Factor Correction (APFC) Panel
Power Factor Improving:

1.Please check if the required kVAr of capacitors are installed.

2.Check the type of capacitor installed is suitable for application or the capacitors are derated

3. Check if the capacitors are permanent The Capacitor is not switched ON.
4. when the load is not working, under such conditions the average power factor is found to be lower side.
5. Check whether all the capacitors are operated in APFC depending upon the load operation.
6.Check whether the APFC installed in the installation is working or not. Check the CT connection is taken from the main incomer side of the transformer, after the fixed compensation of the transformer.
7. Check if the load demand in the system is increased.

8.Check if power transformer compensation is provided.
Thumb Rule if HP is known.

- The compensation for motor

should be calculated taking the details from the rating plate of motor Or the capacitor should be rated for 1/3 of HP Kvar Required For Transformer Compensation:

Transformer		Required Kva
• <= 315 kVA T.C	=	5% of KVA
• 315kVA To 1000 kVA	=	6% of KVA
• >= 1000 kVA	=	8% of KVA

Where to connect capacitor:

- Fix compensation should be provided to take care of the power transformer. Power and distribution transformers, which work on the principle of electromagnetic induction, consume reactive power for their own needs even when its secondary is not connected to any load. The power factor will be very low in such a situation. To improve the power factor it is required to connect a fixed capacitor or capacitor bank at the LT side of the Transformer.

- For approximate kVAr of capacitors required if the installation is having various small loads with a mixture of large loads then the APFC should be recommended. Note that APFC should have a minimum step rating of 10% as a smaller step.

- If loads are small then the capacitor should be connected parallel to load. The connection should be such that whenever the loads are switched on the capacitor also switches on along with the load.

- Note that the APFC panel can maintain the power factor on the L.T side of the transformer and it is necessary to provide fixed compensation for the Power transformer.

- In case there is no transformer in the installation, then the C.T for sensing power factor should be provided at the incoming of the main switch of the plant.

Calculation of required capacitor:

Suppose Actual P.F is 0.8, Required P.F is 0.98 and Total Load is 516KVA.

- Power factor = kWh / kvah
- kW = kVA x Power Factor

  = 516 x 0.8 = 412.8

- Required capacitor = kW x Multiplying Factor

  = (0.8 x 516) x Multiplying Factor

  = 412.8 x 0.547

(See Table to find Value according to P.F 0.8 to P.F of 0.98)

  = 225.80 kVa

- ❖ Since power factor is defined as the ratio of KW to KVA, we see that low power factor results when KW is small in relation to KVA. Inductive loads. Inductive loads (which are sources of Reactive Power) include:

1. Transformers
2. Induction motor
3. Induction generators (windmill generators)
4. High-intensity discharge (HID) lighting

- ❖ These inductive loads constitute a major portion of the power consumed in industrial complexes.

- ❖ Reactive power (KVAR) required by inductive loads increases the amount of apparent power (KVA) in your distribution system. This increase in reactive and apparent power results in a larger angle (measured between KW and KVA). Recall that, as increases, cosine (or power factor) decreases.

- ❖ You want to improve your power factor for several different reasons.

Some of the benefits of improving your power factor include:

1) Lower utility fees by

(a). Reducing peak KW billing demand:

- Inductive loads, which require reactive power, cause your low power factor. This increase in required reactive power (KVAR) causes an increase in required apparent power (KVA), which is what the utility is supplying. So, a facility‘s low power factor causes the utility to have to increase its generation and transmission capacity in order to handle this extra demand.

By lowering your power factor, you use less KVAR. This results in less KW, which equates to dollar savings from the utility.

(b). Eliminating the power factor penalty:

- Utilities usually charge customers an additional fee when their power factor is less than 0.95. (In fact, some utilities are not obligated to deliver electricity to their customer at any time the customer‘s power factor falls below 0.85.) Thus, you can avoid this additional fee by increasing your power factor.

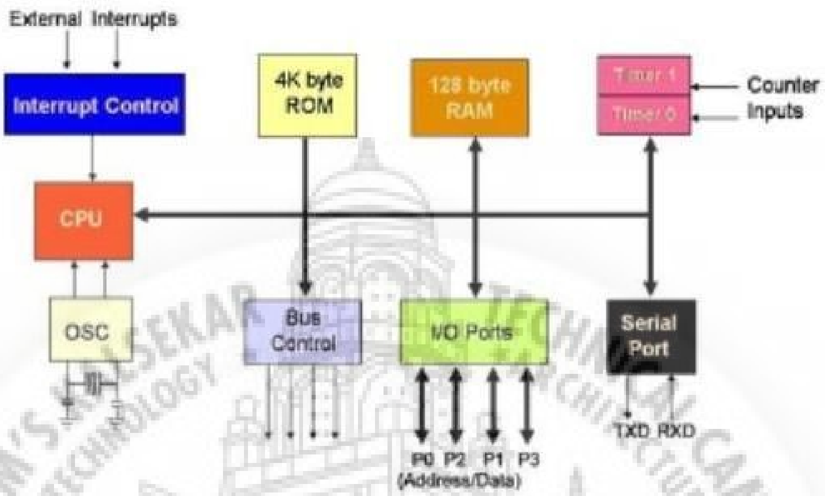
2) Increased system capacity and reduced system losses in your electrical system

- By adding capacitors (KVAR generators) to the system, the power factor is improved and the KW capacity of the system is increased.
- For example, a 1,000 KVA transformer with an 80% power factor provides 800 KW (600 KVAR) of power to the main bus.
- By increasing the power factor to 90%, more KW can be supplied for the same amount of KVA.
- 1000 KVA = (900 KW)2 + (? KVAR)2
- KVAR = 436
- The KW capacity of the system increases to 900 KW and the utility supplies only 436 KVAR.
- Uncorrected power factor causes power system losses in your distribution system. By improving your power factor, these losses can be reduced. With the current rise in the cost of energy, increased facility efficiency is very desirable. And with lower system losses, you are also able to add additional load to your system.
- Increased voltage level in your electrical system and cooler, more efficient motors
- As mentioned above, an uncorrected power factor causes power system losses in your distribution system. As power losses increase, you may experience voltage drops. Excessive voltage drops can cause overheating and premature failure of motors and other inductive equipment. So, by raising your power factor, you will minimize these voltage drops along with feeder cables and avoid related problems. Your motors will run cooler and be more efficient, with a slight increase in capacity and starting torque.
- Induction motors, transformers and many other electrical loads require magnetizing current (kVAR) as well as actual power (kW). By representing these components of apparent power (kVA) as the sides of a right triangle, we can determine the apparent power from the right triangle rule: kVA2 = kW2 + kVAR2.
- To reduce the kva required for any given load, you must shorten the line that represents the kVAR. This is precisely what capacitors do. By supplying kVAR right at the load, the capacitors relieve the utility of the burden of carrying the extra kVAR.

- This makes the utility transmission/distribution system more efficient, reducing costs for the utility and its customers. The ratio of actual power to apparent power is usually expressed in percentage and is called the power factor. Use of capacitor in APFC panel.
- The capacitor should be provided with suitable designed inrush current limiting inductor coils or special capacitor duty contactors. Annexure d point no d-7.1 of IS 13340-1993. Once the capacitor is switched off it should not be switched on again within 60 seconds so that the capacitor is completely discharged. The switching time in the relay provided in the APFC panel should be set for 60 seconds for individual steps to discharge. Clause No-7.1 of IS 13340- 1993.
- If the capacitor is switched manually or if you are switching capacitors connected in parallel with each other then ―ON‖ delay timer (60sec) should be provided and in case of parallel operation once again point No 1 should be taken care of. Clause No-7.1 of IS 13340-1993.
- The capacitor mounted in the panel should have a min gap of 25-30 mm between the capacitor and 50 mm around the capacitor to the panel enclosure.
- In the case of banking, a min gap of 25mm between the phase to phase and 19mm between the phases to earth should be maintained. Ensure that the banking busbar is 1.8 times rated current of the bank.
- The panel should have provision for cross-ventilation, the louver/fan can be provided in the care Annexure d point No d-3.1 IS 13340- 1993 For use of reactor and filter in the panel fan should be provided for cooling.
- The short circuit protection device (HRC fuse / MCCB) should not exceed the 1.8 x rated current of the capacitor.
- In case of detuned filter banks MCCB is recommended for short circuit protection.

3.1.8. MICROCONTROLLER:

3.1.8.1. PIC I6F7X-8051 MICROCONTROLLER



3.1.8.2. PIN DIAGRAM

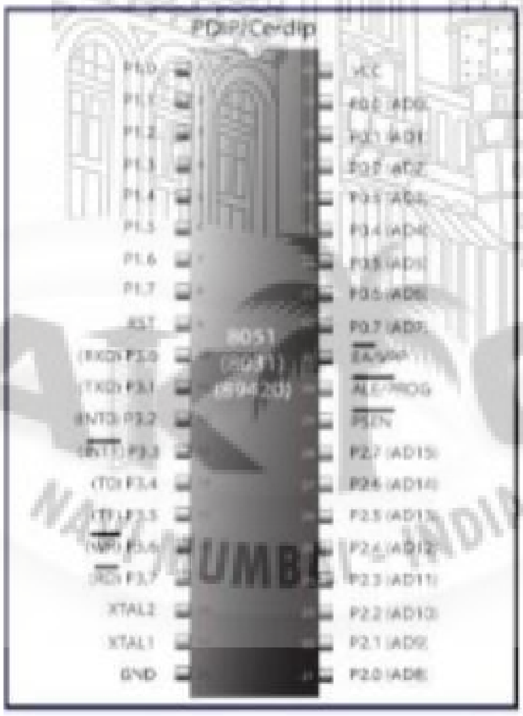


Fig 3.5 Pin diagram of 8051 microcontroller

3.1.8.3. OPERATING MODES:

- ❖ For explaining the pin diagram and pin configuration of microcontroller 8051, we are taking into deliberation a 40 pin dual inline package (DIP). Now let's study through pin configuration in brief:-
- ❖ Pins 1 – 8:- recognized as Port 1. Different from other ports, this port doesn't provide any other purpose. Port 1 is a domestically pulled up, quasi bi directional Input/output port.
- ❖ Pin 9:- As made clear previously RESET pin is utilized to set the microcontroller 8051 to its primary values, whereas the microcontroller is functioning or at the early beginning of the application. The RESET pin has to be set elevated for two machine rotations.
- ❖ Pins 10 – 17:- recognized as Port 3. This port also supplies a number of other functions such as timer input, interrupts, serial communication indicators TxD & RxD, control indicators for outside memory interfacing WR & RD, etc. This is a domestic pull-up port with a quasi bi-directional port within.
- ❖ Pins 18 and 19:- These are employed for interfacing an outer crystal to give a system clock. Pin 20:- Titled as Vss – it symbolizes ground (0 V) association.
- ❖ Pins- 21-28:- recognized as Port 2 (P 2.0 – P 2.7) – other than serving as Input/output port senior order address bus indicators are multiplexed with this quasi bi directional port.
- ❖ Pin- 29:- Program Store Enable or PSEN is employed to interpret signs from outer program memory.
- ❖ Pin-30:- External Access or EA input is employed to permit or prohibit outer memory interfacing. If there is no outer memory need, this pin is dragged high by linking it to Vcc.
- ❖ Pin-31:- Aka Address Latch Enable or ALE is brought into play to de-multiplex the address data indication of port 0 (for outer memory interfacing). Two ALE throbs are obtainable for every machine rotation.

- Pins 32-39: recognized as Port 0 (P0.0 to P0.7) – other than serving as Input/output port, low order data & address bus signals are multiplexed with this port (to provide the use of outer memory interfacing). This pin is a bi-directional Input/output port (the single one in microcontroller 8051) and outer pull-up resistors are necessary to utilize this port as Input/output. Pin-40: termed as Vcc is the chief power supply. By and large, it is +5V DC.

3.1.8.4. INTERRUPT PIN MODES:

- Pins 1 – 8:- recognized as Port 1. Different from other ports, this port doesn‘t provide any other purpose. Port 1 is a domestically pulled up, quasi bi directional Input/output port.

- Pin 9:- As made clear previously RESET pin is utilized to set the microcontroller 8051 to its primary values, whereas the microcontroller is functioning or at the early beginning of the application. The RESET pin has to be set elevated for two machines.

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3.1.8.5. APPLICATIONS OF MICROCONTROLLER:

The microcontroller 8051 applications include a large number of machines, principally because it is simple to incorporate in a project or to assemble a machine around it. The following are the key spots of the spotlight:

1. Energy Management: Competent measuring device systems aid in calculating energy consumption in domestic and industrialized applications. These meter systems are prepared competently by integrating microcontrollers.

2. Touch screens: A high degree of microcontroller suppliers integrate touch sensing abilities in their designs. Transportable devices such as media players, gaming devices & cell phones are some illustrations of micro-controller integrated with touch sensing screens.

3. Automobiles: The microcontroller 8051 discovers broad recognition in supplying automobile solutions. They are extensively utilized in hybrid motor vehicles to control engine variations. In addition, works such as cruise power and anti-brake mechanism have created it more capable with the amalgamation of micro-controllers.

4. Medical Devices: Handy medicinal gadgets such as glucose & blood pressure monitors bring into play micro-controllers, to put on view the measurements, as a result, offering higher dependability in giving correct medical results.

5. Medical Devices: Handy medicinal gadgets such as glucose & blood pressure monitors bring into play micro-controllers, to put on view the measurements, as a result, offering higher dependability in giving correct medical results.

3.1.9. RECTIFIER:

In a Full Wave Rectifier circuit, two diodes are now used, one for each half. A transformer is used whose secondary winding is split equally into two halves with a common center-tapped connection, (C).
This configuration results in each diode conducting in turn when its anode terminal is positive with respect to the transformer center point C producing an output during both half-cycles, twice that for the half-wave rectifier so it is 100% efficient as shown below:

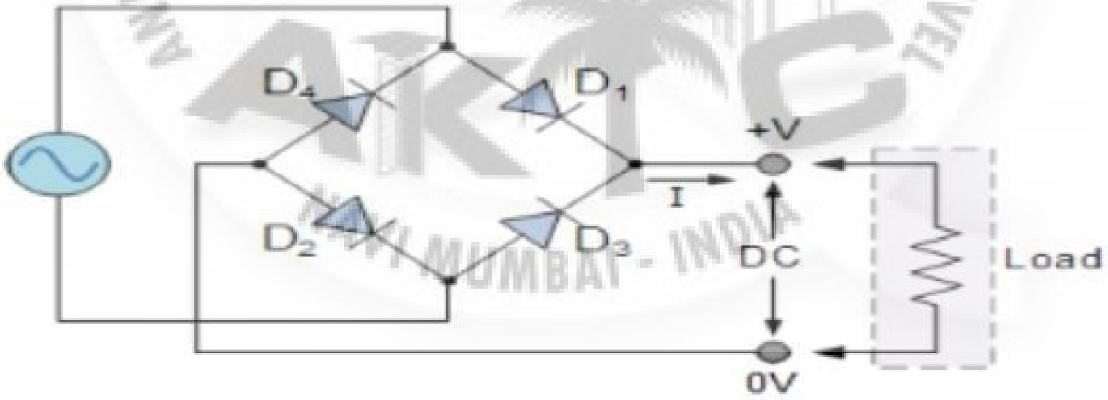


Fig 3.7 Full-wave bridge rectifier circuit.

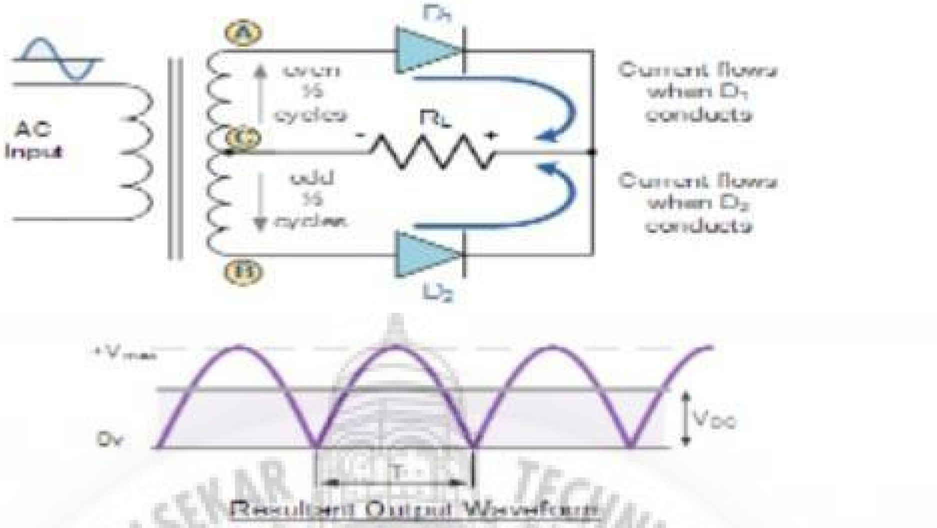


Fig 3.8 full wave center tapped recrifier and out put wave form

The full-wave rectifier circuit consists of two power diodes connected to a single load resistance (RL) with each diode taking it, in turn, to supply current to the load. When point A of the transformer is positive with respect to point C, diode D1 conducts in the forward direction as indicated by the arrows.

When point B is positive (in the negative half of the cycle) with respect to point C, diode D2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined, this type of full-wave rectifier circuit is also known as a ―bi-phase‖ circuit.

As the spaces between each half-wave developed by each diode is now being filled in by the other diode the average DC output voltage across the load resistor is now double that of the single half-wave rectifier circuit and is about 0.637Vmax of the peak voltage, assuming no losses.

$$V_{d.c.} = \frac{2V_{\max}}{\pi} = 0.637V_{\max} = 0.9V_{RMS}$$

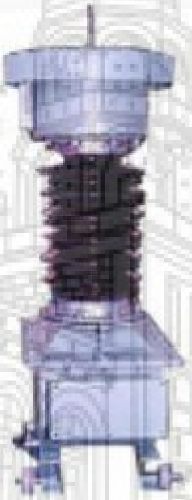
Where: VMAXis the maximum peak value is one-half of the secondary winding and VRMSis the RMS value.

The peak voltage of the output waveform is the same as before for the half-wave rectifier provided each half of the transformer windings has the same RMS voltage value.

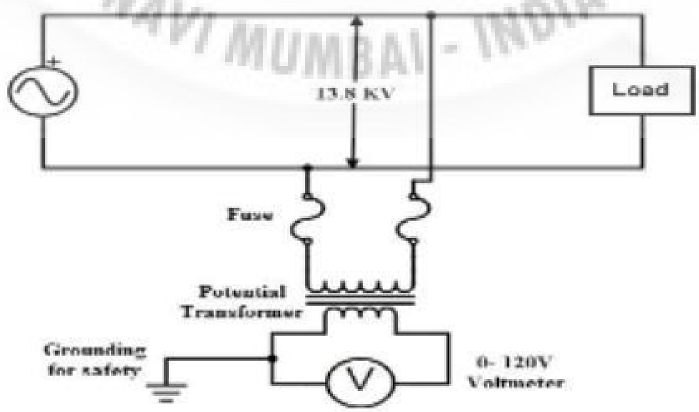
To obtain a different DC voltage output different transformer ratios can be used. The main disadvantage of this type of full-wave rectifier circuit is that a larger transformer for given power output is required with two separate but identical secondary windings making this type of full-wave rectifying circuit costly compared to the ―Full Wave Bridge Rectifier‖ circuit equivalent.

3.2 TRANSFORMERS:

3.2.1 POTENTIAL TRANSFORMERS



The potential transformer is a voltage step-down transformer that reduces the voltage of a high voltage circuit to a lower level for the purpose of measurement. These are connected across or parallel to the line which is to be monitored. The basic principle of operation and construction of this transformer is similar to the standard power transformer. In common, the potential transformers are abbreviated as PT.



The primary winding consists of a large number of turns which is connected across the high voltage side or the line in which measurements have to be taken or to be protected. The secondary winding has a lesser number of turns that are connected to the voltmeters, or potential coils of wattmeter and energy meters, relays, and other control devices. These can be single-phase or three-phase potential transformers. Irrespective of the primary voltage rating, these are designed to have the secondary output voltage of 110 V.

Since the voltmeters and potential coils of other meters have high impedance, a small current flows through the secondary of PT. Therefore, PT behaves as an ordinary two-winding transformer operating on no load. Due to this low load (or burden) on the PT, the VA ratings of PTs are low and in the range of 50 to 200 VA. On the secondary side, one end is connected to the ground for safety reasons as shown in the figure. Similar to the normal transformer, the transformation ratio is specified as V1/V2 = N1/N2 From the above equation, if the voltmeter reading and transformation ratio is known, then the high voltage side voltage can be determined.

3.2.2. **CURRENT TRANSFORMER:**

A current transformer (CT) is a type of transformer that is used to measure AC Current. It produces an alternating current (AC) in its secondary which is proportional to the AC current in its primary.

Current transformers, together with voltage transformers (VTs) or potential transformers (PTs), which are designed for measurement, are known as instrument transformers.

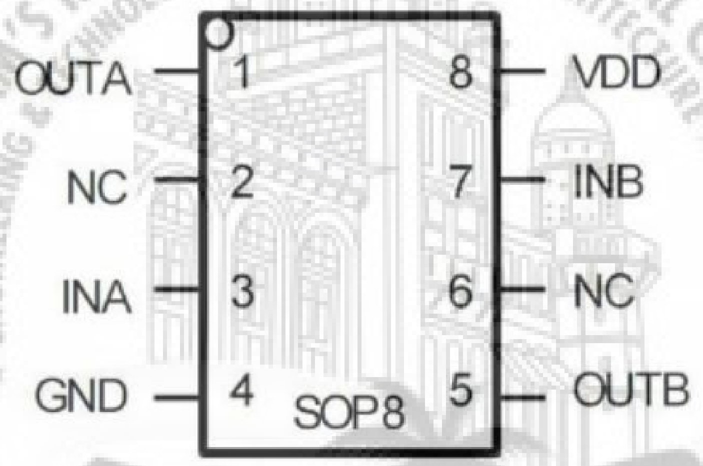
The main tasks of instrument transformers are: − To transform currents or voltages from a usually high value to a value easy to handle for relays and instruments.

− To insulate the metering circuit from the primary high voltage system.
− To provide possibilities of standardizing the instruments and relays to a few rated currents and voltages

When the current to be measured is too high to measure directly or the system voltage of the circuit is too high, a current transformer can be used to provide an isolated lower current in its secondary which is proportional to the current in the primary circuit. The induced secondary current is then suitable for measuring instruments or processing in electronic equipment. Current transformers have very little effect on the primary circuit.

Current transformers are the current-sensing units of the power system. The output of the current transformers is used in electronic equipment and is widely used for metering and protective relays in the electrical power industry.

3.3. RELAY DRIVERS AND SWITCHES:



- A Relay driver IC is an electromagnetic switch that will be used whenever we want to use a low voltage circuit to switch a light bulb ON andOFF which is connected to a 220V mains supply. The required current to run the relay coil is more than can be supplied by various integrated circuits like Op-Amp, etc. Relays have unique properties and are replaced with solid-state switches that are strong than solid-state devices. High current capacities, capability to stand ESD, and drive circuit isolation is the unique properties of Relays. There are various ways to drive relays. Some of the Relay Driver ICs are as below.
- High side toggle switch driver
- Low side toggle switch driver

- Bipolar NPN transistor driver
- N-Channel MOSFET driver and
- Darlington transistor driver
- ULN2003 driver

Relay Driver IC Circuit

Relays are components that permit a low-power circuit to control signals or to switch high current ON and OFF which should be electrically isolated from the controlling circuit.

The Required Components

- Zener Diode
- 6-9V Relay
- 9V Battery or DC Power Supply
- 2N2222 Transistor
- 1K Ohm Resistor
- Second Input Voltage Source

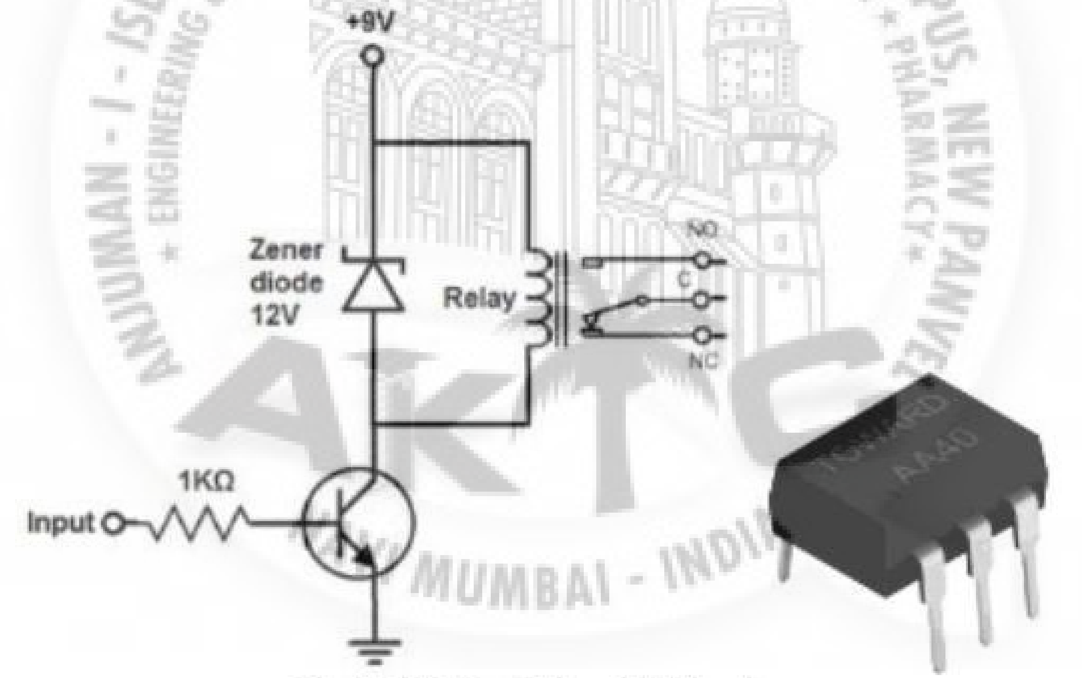


Fig 3.13 Relay Driver IC Circuit

In order to drive the relay, we use a transistor, and only less power can be possibly used to get the relay driven. Since the transistor is an amplifier so the base lead receives sufficient current to make more current flow from the Emitter

of the Transistor to Collector. If the base once gets power that is sufficient, then the transistor conducts from Emitter to Collector and powers the relay.

The Transistor‘s emitter-to-collector channel will be opened even though no flows through the relay coil. The emitter-to-collector channel will be opened and allows current to flow through the relay‘s coil if enough current, voltage applied as input to the base lead. AC or DC Current can be used to power the relay and circuit. Relays are electromagnetic devices that allow low-power circuits to switch a high current ON and OFF switching devices with the help of an armature that is moved by an electromagnet.

Driver Circuit is used to boost or amplify signals from

micro-controllers to control power switches in semiconductor devices. Driver circuits take functions that include isolating the control circuit and the power circuit, detecting malfunctions, storing and reporting failures to the control system, serving as a precaution against failure, analyzing sensor signals, and creating auxiliary voltages.

3.4. OPERATIONAL AMPLIFIER:

Non-Inverting Amplifier:

Figure 13 shows the basic non-inverting amplifier configuration. The negative feedback is maintained and the input signal is now applied to the non-inverting terminal.

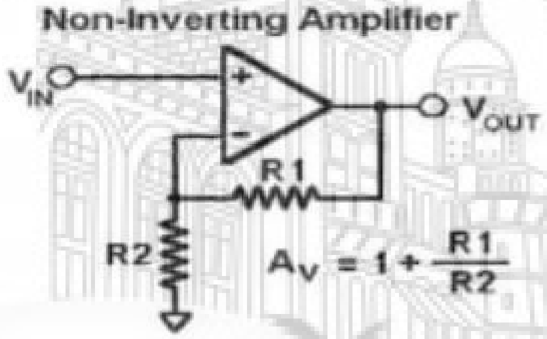


Fig 3.14 Non-inverting amplifier

3.6. CAPACITOR BANKS AT THE LOAD:

The three most common types of load banks are resistive, inductive,

and capacitive. Both inductive and capacitive loads create what is known as reactance in an AC circuit. Reactance is a circuit element's opposition to an alternating current, caused by the buildup of electric or magnetic fields in the element due to the current and is the "imaginary" component of impedance or the resistance to AC signals at a certain frequency. Capacitive reactance is equal to $1/(2\cdot\pi\cdot f\cdot C)$, and inductive reactance is equal to $2\cdot\pi\cdot f\cdot L$. The unit of reactance is the ohm. Inductive reactance resists the change to current, causing the circuit current to lag voltage. Capacitive reactance resists the change to voltage, causing the circuit current to lead voltage.

3.7. LCD – DISPLAY:

LIQUID CRYSTAL DISPLAY (LCD):

LCD Modules can present textual information to users. It‘s like
a cheap―monitor that you can hook in all of your gadgets.
They come in various types. The most popular one is the 16x2 LCD Module. It has 2 rows and 16 columns

CONNECTION OF LCD TO THE MCU

In order to connect LCD to the MCU, you have to first make physical connections between the pins of the LCD and MCU. In order to connect the LCD, you have to use one PORT of the MCU completely for this purpose. Suppose you chose a particular PORT. The LCD module must be connected to the port bits as follows:
[LCD] [MCU]
1 GND- GND
2 +5V- VCC

3 VLC- LCD HEADER Vo

4 RS - bit 0 of that
PORT 5 RD - bit 1
6 EN - bit 2

11 D4 - bit 4

12 D5 - bit 5
13 D6 - bit 6

14 D7 - bit 7

Leave other pins of the LCD open, i.e. do not connect them anywhere.

3.8. **PIR – SENSOR**:

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensor’s range. They are small, inexpensive, low-power, easy to use, and don't wear out. For that reason, they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors. PIRs are basically made of a pyroelectric sensor (which you can see above as the round metal can with a rectangular crystal in the center), which can detect levels of infrared radiation. Everything emits some low-level radiation, and the hotter something is, the more radiation is emitted. The sensor in a motion detector is actually split into two halves. The reason for that is that we are looking to detect motion (change), not average IR levels. The two halves are wired up so that they cancel each other out. If one half sees more or less IR radiation than the other, the output will swing high or low.

Along with the pyroelectric sensor is a bunch of supporting circuitry, resistors, and capacitors. It seems that most small hobbyist sensors use the BISS0001 ("Micro Power PIR Motion Detector IC"), undoubtedly a very inexpensive chip. This chip takes the output of the sensor and does some minor processing on it to emit a digital output pulse from the analog sensor.

For many basic projects or products that need to detect when a person has left or entered the area or has approached, PIR sensors are great. They are low power and low cost, pretty rugged, have a wide lens range and are easy to interface with. Note that PIRs won't tell you how many people are around or how close they are to the sensor, the lens somewhere) and they are also sometimes set off by house pets. Experimentation is key.

CHAPTER-4
SOFTWARE IMPLEMENTATION

4.1 INTRODUCTION:

This is an easy-to-use yet powerful single-board computer that has gained considerable traction in the hobby and professional market. This is open-source, which means the hardware is reasonably priced and development software is free. This programming language is a simplified version of C/C++.

4.2 DIGITAL PINS

In addition to the specific functions listed below, the digital pins on a motherboard connection can be used for general-purpose input and output via the pinMode(), digitalRead(), and digitalWrite() commands.
Each pin has an internal pull-up resistor which can be turned on and off using digital Write() (w/ a value of HIGH or LOW, respectively) when the pin is configured as an input.

This type of program is called ―sketches‖, but here we will just call them programs. In the editing window that comes up, enter the following program, paying attention to where semicolons appear at the end of command lines.

4.3 PROGRAM STRUCTURE:

The instructions you place in the startup() function are executed once when the program begins and are used to initialize. Use it to set directions of pins or to initialize variables. The instructions placed in the loop are executed repeatedly and form the main tasks of the program. Therefore every program has this structure.

CHAPTER 5
RESULTS AND CONCLUSION

5.1 **RESULTS**:

By observing all the above aspects of the power factor it is clear that power factor is the most important part for the utility company as well as for the consumers. Utility companies will be free from the power losses as well as the consumers are free from low power factor penalty charges.

5.2 **CONCLUSION & FUTURE RESULT**:

The Power Factor is improved and the value becomes nearer to 0.9 to 0.95 by installing suitably sized power capacitors into the circuit thus line losses are improved if the system is highly improved. Precautions should be taken for overcorrection otherwise the voltage and current increase due to which the power system or machine will not remain stable and the life of the capacitor bank decreases.

The automatic power factor correction by using capacitive load banks is very efficient as it decreases the cost by reducing the power drawn from the supply. As it operates automatically, no manpower is required and this Automated Power factor Correction by using capacitive load banks can be used for the industries purpose in the future. Further the project can be intensified by using thyristor control switches in place of relay control so that contact pitting is avoided which is often resulted from switching of capacitors due to the flow of high in the rush curve.

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